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Farming through the Auca Runa: Agricultural Strategies and Terraces during the Late Intermediate Period, Altiplano, Peru

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by

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Abstract of the Dissertation

Farming through the *Auca Runa:* Agricultural Strategies and Terraces
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Professor David L. Browan, Co-Chair
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This dissertation examines agricultural strategies farmers employed to cope with the consequences of war and drought in the southern Peruvian Andes during the Late Intermediate Period (A.D. 1100-1450) using paleoethnobotanical data from the fortified hilltop site Ayawiri and findings from excavations of a terrace complex flanking the site. During the Late Intermediate Period, lifeways dissolved into a period of endemic warfare after the collapse of Tiwanaku. At the same time a well-documented, century-long drought surely threatened food security. Interested in how farmers responded to this political and climatic disjuncture, I analyzed 108 flotation samples collected from the residential area of one of the largest hillfort communities in the region. Macrobotanical samples were collected from hearths, houses, kitchens, patios, and middens at Ayawiri. These data indicate that as trade networks broke down and imported lower elevation crops such as maize were no longer options during the Late Intermediate Period, residents turned to locally-grown crops including quinoa, potatoes and other tubers. I conducted multi-variate analysis of *Chenopodium* spp. seeds and found both quinoa and

kañawa in copious quantities. Weedy chenopod seeds were very rare in these samples. These data contribute a deeper understanding of pre-Colonial crop selection, phenotypes, and weed management in the Andes. Macrobotanical data also contribute to an understanding of camelid grazing strategies employed during the Late Intermediate Period. Herds were intensively grazed in fields and foddered on crops and rarely brought to wetland microenvironments.

I carried out excavations and analysis of the form of the terrace complex that flanks the hillfort at Ayawiri to determine when the field complex was constructed and how farmers managed this landscape. Using a combination of ceramic sylistic seriation, AMS dating, and a novel application of optically stimulated luminescence dating I found that the terraces below the site were constructed during the Late Intermediate Period using household labor.

Macrobotanical data and information from the terrace excavations contribute two important conclusions about the impact of drought and consequences of warfare on lifeways during the Late Intermediate Period. First, the adoption of an intensification strategy – terrace farming – and a dependence on only a limited array of cultivars indicate the consequences of warfare profoundly influenced Ayawiri farming strategies. The local community built their fields and grazed their herds near their homes rather than taking advantage of lacustrine or riverine microenvironments, which would have buffered against crop loss due to climate unpredictability. Additionally, I recovered sling stones in the terraces indicating this built landscape served a defensive function. The second conclusion I came to is the expansive terrace system around the site did not require centralized labor to create or farm, but rather was the product of households adapting to the challenges of their time. In sum, this study provides an important understanding of agriculture, land use strategies, and sociopolitical organization of farm labor during the Late Intermediate Period.

Chapter 1. The Research Problem and Organization of the Dissertation

Agriculture has been an arduous undertaking in the central Andes Mountains of South America since its advent in the region over four millennia ago. Agropastoralists have thrived despite persistent cold temperatures, unpredictable annual rainfall, and nutrient poor soils (Erickson 2000; Erickson and Balée 2006:211-212). During the Peruvian Late Intermediate Period (LIP; A.D. 1100-1450; also known as the *Altiplano Period*) farmers' annual struggle to produce enough food was exacerbated by warfare and a prolonged drought (Arkush 2005; Frye 1997; Julien 1983; Thompson et al. 1985). In this dissertation I identify how an LIP community managed their food security when faced with these social tensions and climate fluctuations.

Near the modern border between Peru and Bolivia in the south-central Andean highlands, warring ethnic groups responded to the social hazard of martial conflict during the LIP by strategically constructing defensive hilltop forts called *pukaras* (Guamán Poma de Ayala 1980 [1616]). Several authors have recently highlighted the role of food procurement difficulties and nutritive hardship associated with warfare that have occurred throughout the history of humanity (Ferguson 2006; LeBlanc 2006:455; Milner et al. 1991; Otterbein 1999). When laborers become soldiers and valuable resources are diverted to the war effort, concerns about local food security cause changes in agricultural practice and foodways. Warfare during the Titicaca basin LIP surely caused similar hardships that fundamentally structured economic choices (Arkush

2011:1). Plant agriculture and camelid herding (llamas and alpacas) that took place outside hillforts walls left inhabitants and their economic pursuits vulnerable to enemy attack.

Around the same time that warfare intensified during the LIP, there was reduced precipitation, colder temperatures, and consequent fluctuations in lake levels that altered the *altiplano* environment that probably impacted farming strategies (Abbott et al. 1997; Binford et al. 1997; Calaway 2005; Melice and Roucou 1998; Thompson et al. 1998; Thompson et al. 1986). Climate change during the LIP has been cited as the cause for political balkanization and martial conflict (Seltzer and Hastorf 1990; Stanish 2003). Climate variability increases the probability of crop failure (Arkush 2008; Augustine 2010; Howden et al. 2007), which in turn leads to increased social tensions between populations (Allen 2008; Lape and Chin-Yung 2008; Nel and Righarts 2008). Indeed, archaeologists working in North America have documented how similar climate change and subsequent food shortages incited pre-Colonia warfare there (Kuckelman 2016).

In the Andes, the severities of warfare and the impact of drought on LIP lifeways are currently contested. In this dissertation research, I aim to use human agricultural adaptation as a metric to understand the relative importance of these conditions to peoples' daily lives. These data also contribute to a broader understanding of how people make trade-offs in agricultural strategies to deal with different kinds social and environmental variables.

With this in mind, I frame my research in risk management theory. Researchers have previously focused on risk management strategies that mitigate the impact of natural hazards on subsistence (Browman 1987; Cashdan 1990; Goland 1993; Stone and Downum 1999; Winterhalder 1986). Recently, a few studies have pointed out that populations also adapt subsistence strategies to lessen risks due to social tensions (Bollig 2006; Nel and Righarts 2008;

Postigo et al. 2008; Zori and Brant 2012). In this dissertation I consider the impacts of both environmental hazards (drought) and social tensions (warfare). *Altiplano* peoples calculated their agricultural strategies to account for both types of risk during the LIP. By studying how they responded to these risks we can assess the relative importance of social and environmental concerns during the LIP to ancient farmers.

In order to study LIP agricultural risk management, I conducted analysis of macrobotanical remains and I directed excavations of an agricultural terraces complex at one of the largest known *pukaras* in the northern *altiplano* called Ayawiri. This site is known in other literature and to the local population by several alternative names including Machu Llaqta, Chila, Hatunpata, Ciudad Perdida, and V2 (Vilque site 2). Located on a hilltop west of Lake Titicaca at an altitude of 4,100 masl, Ayawiri is adjacent to the modern community of Chila (Figure 1.1). The site is a hilltop fortress that dates to the Late Intermediate Period (A.D. 1100-1450), and a warring Titicaca basin ethnic group called the Colla lived there (Tschopik 1946:3). Notably, there is a significant Late Formative component at Ayawiri and a minor Middle Horizon occupation; however, the most visible and well understood occupation at the site dates to the LIP and that is the time period targeted for investigation in this dissertation.

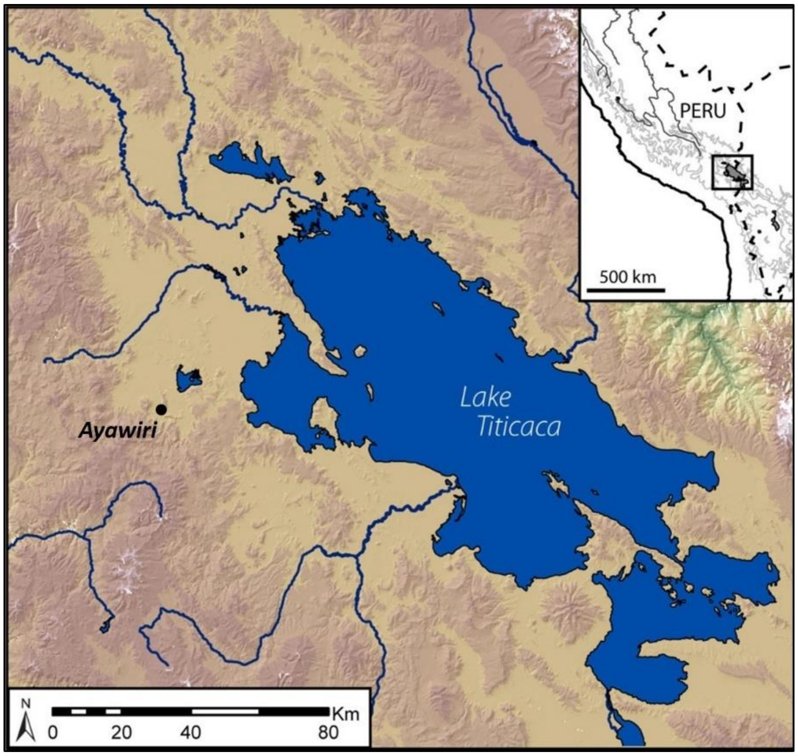


Figure 1.1: Map depicting the location of Ayawiri (rendered by E.N. Arkush).

The hillside surrounding Ayawiri is completely covered in agricultural terraces on the western, southern, and eastern escarpments (Figure 1.2). The close association between hillforts and terraces has been used as indirect evidence to suggest that the Colla people farmed terraces located below *pukaras* during the LIP (Arkush 2005:229-230; Stanish 2003:226). On the other hand, many researchers in the Andes have argued that a centralized political authority was necessary to organize and mobilize the labor required to build terraces and manage production on terraces (e.g. Niles 1982; Treacy and Denevan 1994). My research aims to directly clarify the period of construction and/or use of the Ayawiri terrace complex. It is possible that the terraces were initially constructed early on during the first occupation of Ayawiri during the Late Formative when there was a crescendo of the coalescence of political authority in the Titicaca Basin. Alternatively, the terrace complex could have been built by residents living at the site during political balkanization and martial conflict typifying the LIP. Pinpointing when the terrace complex was built illuminates the socio-political context of this monumental agricultural engineering feat and sheds light on the prehistory of land management strategies broadly in the Titicaca Basin.

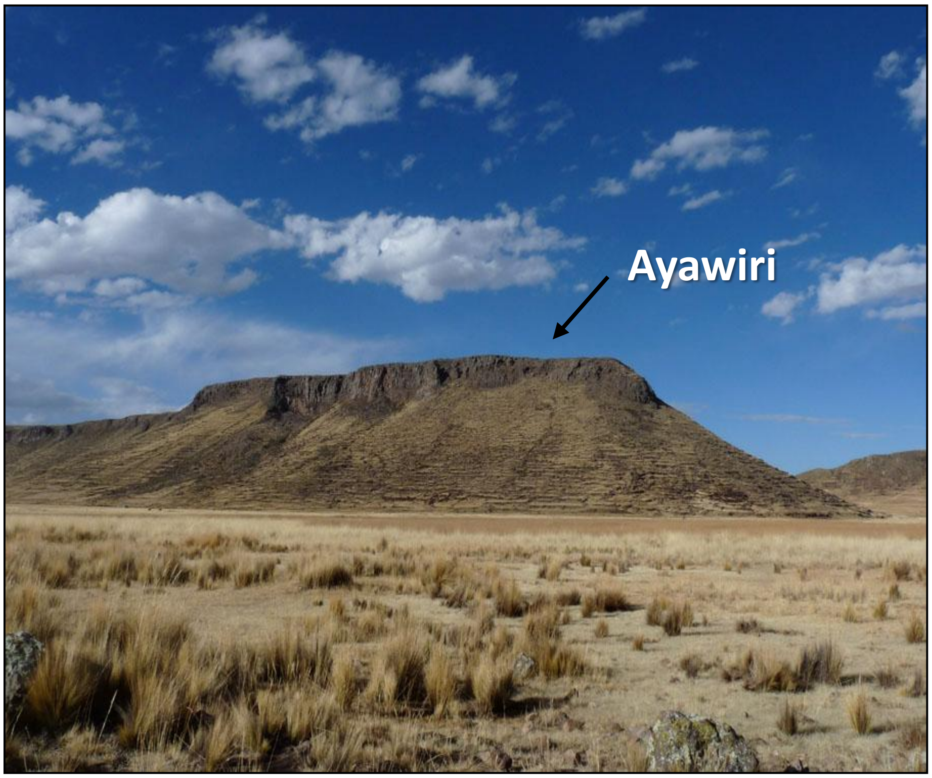


Figure 1.2: Photo of Ayawiri atop the mesa and surrounded by terraces (image courtesy of E.N. Arkush).

In order to meet the caloric demands of the densely nucleated LIP population residing at Ayawiri, a well-adapted subsistence strategy was a surely necessity. While a complex agropastoral subsistence strategy has been documented in earlier time periods in other parts of the *altiplano* (Browman 1986; Bruno 2008; Rumold 2011; Whitehead 2007; Wright et al. 2003), to date, no paleoethnobotanical research has been carried out on the LIP in the region. We know almost nothing about *altiplano* LIP agriculture and very little about the chronology of terraces in the region. In this dissertation I analyze artifacts that represent agricultural production, crop processing, disposal, and landscape use within and around Ayawiri in order to better understanding LIP farming strategies. To examine production, I excavated four terraces on the hillslope below the fortified site at Ayawiri. I employ multiple dating techniques including analysis of ceramics, accelerator mass spectrometry dating (AMS) on wood charcoal, and optically stimulated luminescence dating (OSL) on small grains of naturally occurring quartz found in buried terrace soils to pinpoint the period of construction and use. To examine plant processing and disposal within the *pukara* habitation area, I analyzed charred macrobotanical remains from residential contexts within the fortification at Ayawiri. These materials were recovered during excavations carried out by Proyecto Machu Llaqta at Ayawiri directed by Dr. Elizabeth Arkush from the University of Pittsburg. As a team member of her project, I served as an excavation supervisor and archaeobotanical analyst. To document changes in cropping strategies and landscape use, I compared these data to archaeobotanical studies from earlier time periods in the region (Browman 1989; Bruno 2008; Rumold 2011; Whitehead 2007; Wright et al. 2003). This multi-faceted dissertation project enables me to determine how warfare and/or drought impacted and motivated LIP agricultural strategies.

Research Questions

My dissertation research was guided by four general questions. The implications of these questions are discussed throughout this dissertation.

1) ***What crops were grown during the LIP?***

2) ***When was the terrace complex adjacent to Ayawiri constructed?***

3) ***Where on the landscape did Ayawiri residents graze their camelid herds?***

4) ***How did warfare and drought impact agriculture and lifeways for Ayawiri residents?***

Organization of the Dissertation

This dissertation is organized into ten chapters. Following the introduction in Chapter one, in Chapter Two I describe the geography, climatology, and geology of the *altiplano.* I focus on how these variables shape and condition agricultural practices in the region. I conclude this chapter by assessing several paleoclimate proxies used to reconstruct weather patterns during the LIP.

In Chapter Three I present a general overview of culture history in the *altiplano* that set the stage for life at Ayawiri. I describe the long-term development of both sociopolitical and ritual culture in the region. Then I turn my attention to describing how lifeways changed during the LIP. I conclude by providing a general description of Ayawiri including distinctive architectural and environmental features.

In Chapter Four I turn my attention to describing agropastoral risk management strategies and those employed in the *altiplano.* First I describe the development of plant and animal agricultural in the region that underpins rural and city living in the region even to today. Trade and exchange with distant regions is central to this system. Then I present the ways ancient farmers built fields and domesticated the landscape for agricultural purposes. Lastly I present a model of risk management that explains how Ayawiri farmers may have adapted these age-old farming strategies to cope with social hazards and environmental risks of the LIP. This model was first published by Langlie and Arkush (2016).

In Chapter Five I present the excavation methods implemented during each phase of research including excavations of the fortified residential sector and the terraces. Then I turn my attention to artifact analyses, dating methods, archaeobotanical field methods, and macrobotanical laboratory procedures.

In Chapter Six I present an overview of the types of botanical taxa that I identified in samples collected from the residential area within the fortification walls at Ayawiri. I identify the various pathways through which plant remains entered the site. Then, in alphabetical order by plant family, I detail quantities of each identified plant taxa. Next, I draw on these data to describe the general diet of humans and camelids, food-related behaviors, and the grazing locations of herds. Lastly, I present the results of a multi-proxy analysis of *Chenopodium* spp. seeds where I pinpoint whether seeds found were domestic crops or collected from wild plant stands.

In Chapter Seven I detail the quotidian contexts where macrobotanical taxa were recovered from at Ayawiri. I compare the macrobotanical remains found on structure floors, hearths, patios, and middens to determine use of these spaces. I assess where the plant taxa could have been collected from on the landscape in proximity to the site. Lastly, I describe evidence of intra-site social diversity reflected in the macrobotanical assemblage.

In Chapter Eight I describe the goals of excavating the terraces at Ayawiri. I detail previous research on agricultural landscapes in the *altiplano* and how these data provided the framework for this research. I outline the layout and appearance of the terrace complex at

Ayawiri. Then I turn my attention to describing how sociopolitics of those who built the terraces are inscribed on this landscape.

In Chapter Nine I present the results of the terrace excavations. I focus on describing the stratigraphy that I found and the artifacts that pertain to past lifeways carried out in these spaces. I provide an assessment of the time period when the terraces were constructed and cultivated based on ceramic analysis, AMS dating, and OSL dating. I conclude with a summation describing how the terraces shaped lifeways at the site once they were constructed.

In Chapter Ten I wrap up by synthesizing the findings of my research. I provide an overview of the plant economy at Ayawiri based on the macrobotanical remains that I identified. Then I return to my research questions and describe how the findings of this dissertation answer these questions. I reflect on the effectiveness of the three dating methods I used to identify when the terrace complex was constructed. I suggest future avenues of research prompted by my findings. I conclude by summarizing how Ayawiri residents managed the risks of the LIP through their agropastoral strategies.

Chapter 2. Geography, Ecology, and Climatology

The jutting geography and variable climate throughout the Andean cordillera constrain agricultural potential and the predictability of crop yields which, in turn, coerced ancient farmers to develop novel coping strategies. In Chapter Two, I outline the geography, natural ecology, and climatology of the Andes, focusing on the natural setting of the *altiplano* region where the study area is located. I describe the natural setting as the background for agricultural production. I conclude this chapter with a discussion of the local climate history derived from ice cores, lake sediments, and other paleoclimatological datasets that demonstrate climate occurred affected during the Late Intermediate Period.

The Natural Landscape

The Andes Mountains stretch along the western coast of South America, extending from Colombia to southern Chile. From the arid Pacific coast, the Andes ascend eastward peaking at over 5,500 masl. The rugged character of the Andes affects the structure of the ecological setting. Inter-montane valleys and plateaus are surrounded by snowcapped peaks and rolling hills. The eastern slopes of the Andes descend into cloud forests, terminating their altitudinal gradient in the lush Amazon rainforest. In some parts of the Andes, the mountains jut from sea level to above 4,500 masl in less than 100 km as the crow flies (Aldenderfer 1998:26). In the south-central Andes on the border between Peru and Bolivia, the horizontal extent of the mountains is at its widest measuring 500 km (Brush 1982:19).

It is precisely in this location where the focus of my research is located in a region referred to as the *altiplano* (also known as the Andean Plateau) that spans between the latitudes 14°S and 22°S (Figure 2.1). This flat region extends from the border between southern Peru and western Bolivia southward to the northern portions of Argentina and Chile, covering approximately 200,000 km^2 (Dejoux and Iltis 1992:XV). The flat, treeless plateau is situated at an elevation of about 3,800 masl, and the area is bordered by towering mountains (Brush 1982:19). At the juncture of the northern and southern tips of the *altiplano,* the Andes split into two distinct ranges: the Cordillera Real mountain range (also known as the Cordillera Occidental) to the west and the Cordillera Blanca range (also known as the Cordillera Oriental) to the east. Rolling hills and snow-capped mountain peaks flank the periphery of the *altiplano*, evoking a sense of intimacy and isolation in the landscape.

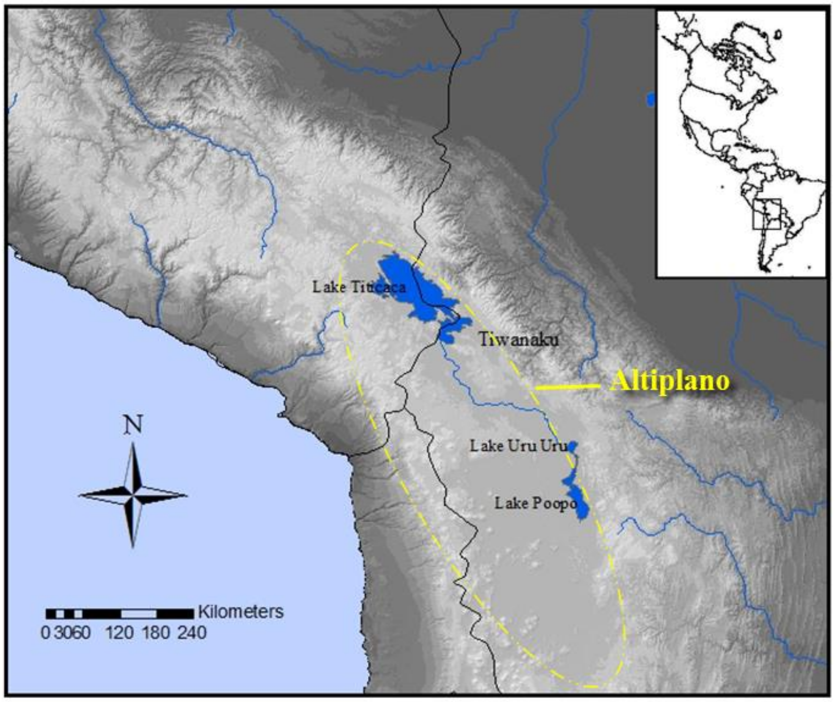


Figure 2.1: Map depicting the location of the *altiplano* and shaded to illustrate the topography of the surrounding Andes mountains.

The craggy geography surrounding the *altiplano* was created during the Miocene when tectonic uplifting formed the mountain ranges that flank the region (Clapperton 1993:94). Within the northern part of the *altiplano,* where my research was carried out, there are several pluvial lakes and rivers that once formed massive paleolakes covering the region as recently as the end of the Pleistocene. These paleolakes were once fed by glacial melt flowing down from the surrounding mountain ranges (Lavenu 1992:5). Geologically the rising and falling water levels of the paleolakes in the region deposited lacustrine and alluvial sediments throughout the landscape. Today, the remaining lakes are fed by rainwater and the *altiplano* drainage basin is endorheic. The fact that water does not drain out of the basin has an insulating effect on the ecology of the region. Two bodies of water located in the northern part of the *altiplano* are particularly relevant to this study: Lago Umayo (also referred to as Laguna Umayo) and Lake Titicaca.

Lago Umayo is located about 10 km northeast of the study site and 17 km northwest of the city of Puno. The lake sits at approximately 3,880 masl, covers about 40 km^2, and reaches depths of about 20 m (Baker et al. 2009:308). This lake is fed by rainfall and runoff flowing into two primary tributary rivers, the Rio Vilque and the Rio Challamayo. The Rio Vilque flows along the western flanks of the terrace complex at Ayawiri before emptying into Lago Umayo. Lago Umayo then slowly drains into Lake Titicaca to the east via the Rio Ilpa.

Lake Titicaca straddles the Peruvian and Bolivian border and is the largest navigable lake in South America by area and volume, covering over 8,000 km^2 of land reaching depths up to 285 m (Dejoux and Iltis 1992:XV). Seasonal rainfall and tributary rivers annually replenish the lake. The lake levels fluctuate on average 1 m, rising during the wet season and falling during the dry season (Baker et al. 2009:310; Melice and Roucou 1998). Only five percent of the excess water from Lake Titicaca drains southward, down the Desaguadero River, and emptying into Lake Uru and Lake Poopó in the southeastern region of the *altiplano* (Dejoux and Iltis 1992:XV). Most water loss of Lake Titicaca is due to evaporation from the combination of the harsh tropical sun and the altitude. The vastness, depth, and hydrology of Lake Titicaca moderates the climate of the basin and creates a unique microenvironment in the adjacent littoral areas that contrasts the surrounding arid landscape.

South American Weather Patterns

As elevation increases in the Andes temperatures and humidity generally decrease (Brush 1982:20). Atmospheric air movement compounds this orographic affect. Two anticyclones--

large areas of high pressure around which air circulates--govern much of the climate of South America. These anticyclones originate in the Atlantic and Pacific and circulate counter-clockwise (Eidt 1968:55). The flow of these air masses is disrupted and transected by the towering cordillera (Brush 1982:19), creating unique microclimates within inter-montane valleys and drastically different weather on the eastern slopes than the western slopes of the Andes.

Along the Pacific coast the Humboldt Current System strongly impacts weather patterns. This oceanic current originates in the waters of the southern Pacific along Chile and flows northward along South America's coast drawing frigid sub-Antarctic waters all the way up to the equator (Thiel et al. 2007). Localized upwelling of cooler deep ocean waters further contributes to colder surface temperatures along the South American coast (Brush 1982:20). Cooler surface temperatures mean that the Pacific anticyclone absorbs little moisture as it sweeps across the ocean. As a result, there is low annual precipitation along the western slopes of the Andes (Brush 1982:20) lending to desert-like conditions of this region.

In the highlands, westerly winds from the Pacific drive weather patterns during the austral winter between April and November (Roche et al. 1991). These winds bring cool dry air and very little precipitation with them. Southerly winds originating in the Antarctic region also blow northward along the cordillera and the eastern slopes of the Andes also during the winter (Browman 2003: 297). These polar advections can bring frigid winds with high velocities that can lower the temperature in the *altiplano* by as much as 20°C in a day. When these winds occur early or late in the winter, they can threaten young seedlings and harvests in the *altiplano*. At the same time, polar advections are important to agricultural security in the region ensuring that temperatures are cold enough to make freeze dried potatoes called *chuño* that can be stored for years without spoiling.

The South American Summer Monsoon (SASM) also contributes to continent-wide, seasonal precipitation cycles (Zhou and Lau 1998). For most of the year the Atlantic anticyclone produces trade winds, originating in the equatorial Intertropical Convergence Zone (ITCZ, also known as the doldrums), carrying warm air and moisture from the Atlantic Ocean, and depositing large amounts of precipitation across the Amazon rainforest (Grodsky and Carton 2003:723). When these air masses, combined with the convective heat and humidity from the Amazon, crash into the orographic pressure of the eastern slopes of the Andes, rainfall cascades across the region (Zhou and Lau 1998). This precipitation supports lush, rain-fed cloud forests along the eastern slopes.

During the austral summer several SASM dynamics coalesce, leading to a distinct wet season in the highlands between December and March (Misra 2007:1). At the beginning of the rainy season in the *altiplano*, a warm-core anticyclone, referred to as the Bolivian High, develops in the upper troposphere over the northwest region of *altiplano* and moves to the southeast (Zhou and Lau 1998:1021), bringing with it seasonal precipitation. During this time, winds in the region blow from the northeast (Roche et al. 1992:68). As this high-pressure system moves out of the *altiplano*, the rainy season ends, and the westerly-southwesterly wind patterns return along with the frigid polar advection winds. Climate scientists are still perplexed about the source and cause of the Bolivian High (Liebmann and Mechoso 2011:138). However, it has been determined that the movement of the Bolivian High is related to the concurrent development of low atmospheric pressure troughs, the Nordestes and the Gran-Chaco Low, over the tropical and sub-tropical south Atlantic near the coast of Northeast Brazil (Marengo et al. 2012:2). The onset and duration of the rainy season is fairly unpredictable since it is caused by a combination of so many atmospheric and geographic variables. One has only to spend a short time in the region to realize the weather patterns and intra-annual climate variability in the *altiplano* are extremely difficult to understand and predict. Climate scientists are still working to identify the dynamics of weather patterns throughout South America.

Climate in the Andes is determined by the combination of the oceanic upwelling, continent-wide interactions of trade winds, localized anticyclone circulation, low-pressure systems, and orographic effects. Emerging research and better digital modeling of weather patterns continue to shed light on the complex interactions of these variables. Nonetheless, the complicated climate of the region means it is difficult for farmers to calculate or predict annual planting and harvest schedules or yields.

Climatological Trends in the Lake Titicaca Basin

Even though the *altiplano* is located within tropical latitudes, the high elevation subjects the region to more typical mountainous conditions, such as intense solar radiation during the day, freezing nights, and low humidity. The median annual temperatures of the *altiplano* range between 7°C and 10°C (Roche et al. 1991:86). Twelve kilometers east of the study site in Puno between 1960 and 1990 the mean annual temperature was 8.5°C (INTECSA 1993). Lake Titicaca absorbs and traps solar radiation in the depths of its waters. The resulting heat of the lake has a temperature regulating effect on the surrounding landscape, and littoral areas, such as Puno, are found to be warmer than models predict (Boulange and Aquize Jaen 1981). Diurnal temperature ranges near the lake fluctuate on average 11.7°C, whereas 25 km west of Lake Titicaca average temperatures from day to night dip 17.8°C (Baker et al. 2009:309-310). In other words, the lake creates a mild microclimate. Even today, farmers take advantage of this phenomenon to grow crops, such as maize (*Zea mays* L.), around lakes in the region that would not otherwise tolerate the freezing nighttime temperatures of the valley.

The orographic effects of the Cordillera Real and the Cordillera Blanca disrupt weather patterns, and the movement of the Bolivian High causes decreasing humidity and dryness within the *altiplano*. The northern *altiplano* is semi-humid, whereas the southern region is increasingly arid (Lenters and Cook 1997). Additionally, the southern *altiplano* receives less annual rainfall than the northern Titicaca Basin. These moisture and precipitation gradients are attributed to the movement of the Bolivian High from northwest to the southeast. Precipitation in the region occurs primarily during the austral summer with 80% falling between December and March (Roche et al. 1992). Within the Titicaca Basin annual precipitation varies greatly from year-to-year, from approximately 500 mm to over 1,500 mm (Roche et al. 1992:87). Additionally, there is a precipitation gradient around Lake Titicaca. Areas around the lake receive more rainfall than distant regions (Baker et al. 2009:309). Just northeast of the study site, Lago Umayo received on average 648 mm of precipitation per year between 1960 and 1990 (Baker et al. 2009:309).

The planting cycles and livelihoods of farmers in the *altiplano*, like farmers everywhere, are at the mercy of natural climate regimes. If there is too little precipitation, crops dependent on sufficient rainfall are at risk of perishing and if there is too much, flooded fields drown out seedlings. At the same time, a single nighttime frost, common in the montane environment, can threaten a farmer's entire harvest. The climate data from the *altiplano* indicate the onset of the annual rainy season is unpredictable and highly variable, making it difficult for farmers to figure out when to plant fields and what crop varieties to plant. Harvest yields are tricky to anticipate due to the uncertainty surrounding the amount of precipitation and variations in temperatures in any given year. These unpredictable inter-annual climate fluctuations lead to crop failure that cause *altiplano* people to rely on their dwindling food stores. Nonetheless, highland farming practices developed over millennia were adapted specifically to cope with the specific aberrations of this climate.

Natural Biotic Zones

Plant and animal communities throughout the Andes are arranged in ecotopes, or small microenvironments, determined by vertical elevation gradients, airflow patterns, precipitation, geology, and human landscape modification (Troll 1950). Through an analysis of various combinations of these factors, geographers and other researchers have worked to cartographically 'slice and dice' the region into a multitude of biotic zones since they first encountered the ecological diversity in the Andes centuries ago. This geographic history still underpins how we divide, map, and think about biotic zones in the Andes today. Here, I outline the cartographic ideals of Andean ecology that concern my assessment of the landscape of the study region.

Background on Biotic Classificatory Systems in the Andes

Cieza de León, a Spanish Conquistador and chronicler who explored South America during the 16th century, delineated and mapped three regions (1554): the coast, the mountains, and the Amazon. This colonial conception of the biotic zones in South America is still cited when researchers discuss these natural and modified landscapes (Zimmerer 2011:126). During the 19th century, Prussian naturalist and geographer Alexander von Humboldt, along with botanist Aimé Bonpland, painstakingly mapped the flora of the Andes as a vertical cross section; their diagram was strongly influenced by de Léon's three-part biotic zone system depicting the

Pacific Lowlands, the Andes mountains, and the Amazon Basin (von Humboldt and Bonpland 1805; Zimmerer 2011:128). Nonetheless, as biologists, meteorologists, and geographers gathered more geographic data and analyzed the Andean landscape, they shed this conception of space to more acutely delineate biotic zones. In an attempt to break geographic practice with colonial legacy, Javier Pulgar Vidal divided the country into eight regions that included an assessment of agricultural limitations, intentionally recognizing the millennia of influence indigenous farmers made on the natural landscape (Pulgar Vidal 1946). Notably, Pulgar Vidal assigned Quechua words to each of the eight biotic zones. Around the same time, Troll (1968) identified 12 unique biotic zones in the Andes based on solely botanical distributions. Pulgar Vidal and Troll's models are the two most widely cited biotic maps of the region, and they have had a lasting influence on how researchers define and conceptualize space in the Andes today. Additionally, due to the strategies chosen, both models delineate biota that trace altitudinal gradients. Since then, newer classificatory systems have been invented using satellite imagery and geographic information systems (GIS), but Pulgar Vidal and Troll's systems still remain relevant. As an archaeologist who studies farming strategies, I subscribe to Pulgar Vidal's foundational conceptions of Andean phytogeography. I do so because in this model he holistically assessed both the natural landscape and agricultural potential. However, due to the particular nuances of the landscape in the *altiplano*, I also draw on other phytogeographic models, as Pulgar Vidal's overview lacks detail at the local level.

Andean Biota

The *altiplano* is located in the grassy Andean ecozones referred to as the *suni* and *puna* (Pulgar Vidal 1946:95-98). These zones are composed of arid, high desert ecosystems generated by high altitude hypoxic air and salinous infertile soil. Today, trees are rare throughout these ecozones except for the occasional native *queñua* trees (*Polylepis* spp.) and clumps of Old World eucalyptus trees (*Eucalyptus* spp.) that were introduced to the region during the Colonial era.

The *suni,* located between 3,800 and 4,000 masl, is considered more amenable to agriculture, and farmers readily grow native varieties of tubers, legumes, and chenopods. The *puna*, located between 4,000 and 4,800 masl, is drier and better for grazing. While Ayawiri is technically located in the *puna,* the terraces are located in the ecotone between the *suni* and the *puna.* This location potentially constricts the agricultural potential of the terraced field systems, yet supports the health of grazing herds.

Prehistory of Climate Change in the South-Central Andes

As established by meteorologists, the intra- and inter-annual climate in the Andes fluctuates considerably. According to paleoclimate scientists, the trends we observe today have occurred over the past 4,000 years in the *altiplano* with only a few major perturbations. Significant deviations from the mean annual precipitation and rainfall patterns have been recorded in several locally sourced paleoclimate records including ice on tops of mountains, sediment in the bottom of lakes the shells of minute aquatic crustaceans, and natural elements trapped in peatlands. Paleoclimate researchers have rigorously reviewed these various lines of evidence to construct a history of weather patterns in the *altiplano*. Here, I compile and outline nearby climate research with the intent to describe a prehistory of weather that affected past *altiplano* famers.

Some of the best manifest and most scrutinized data of climate trends in the region over the last few millennia were recovered from the Quelccaya ice cap located on a plateau atop a mountain 5,650 masl near the Vilanota range located between Cuzco and the *altiplano* (Shimada et al. 1991; Thompson 1996; Thompson et al. 1998; Thompson et al. 1979:1240; Thompson et al. 2006). In 1974 a research team from the Byrd Polar Research Center from the Ohio State University Institute, in collaboration with the Instituto de Geología y Minería, began expeditions to this dome-shaped ice cap in order to study climate change. A few cores were taken and Core 1, a 163.1 m core penetrating the ice cap all the way to the bedrock below, contains a complete annual-to-decadal proxy record of the past 1,500 years (Thompson et al. 1985:973). Since 1974, weather stations have recorded climate trends atop the Quelccaya ice cap as comparative data used as a standard to quantify ice accumulation, construct calibration curves for the cores, and determine whether the climate atop the ice cap can be used as a proxy for temperature, precipitation, and lake levels in the nearby lower elevation Titicaca Basin (Thompson et al. 1979). Sure enough, weather trends, the net mass balance layers of ice, and changes in oxygen isotopes ratios, specifically $\delta^{18}O$, correlate with changes in the 20th century lake level of Lake Titicaca (Baker et al. 2009; Thompson et al. 2006; Thompson et al. 2003). Therefore, researchers believe the ice cores can be used to evaluate past climatological trends.

According to the Quelccaya researchers, their data are accurate to approximately 20-year intervals (Shimada et al. 1991:261) spanning from A.D. 470 to 1984 (Thompson et al. 1986). Since precipitation in the Andes is seasonal, as previously outlined, accumulation of ice during the rainy months is embedded in the stratigraphy of the cores between layers of dust accumulated during the dry months. The net mass balance of layers between dust lenses was measured to determine the amount of precipitation in any given year or decade. These cores reveal a wetter period between A.D. 750 and 1050 and a much drier period between A.D. 1160 and 1500 that was particularly dry between A.D. 1250 and 1310 during the LIP (Thompson et al. 1985:973).

There is recent agreement among scientists that the stable oxygen isotope $\delta^{18}O$ in the Quelccaya ice cores is a reasonable measurement of precipitation amount in the southern Andes (Baker et al. 2009:2009). A drought is also recorded in stable oxygen isotope ratios in the Quelccaya ice cores. Between A.D. 1110 and 1300, $\delta^{18}O$ ratios increase significantly above the mean of the entire 1,500-year sequence of the core, indicating a significant decrease in precipitation (Thompson et al. 2006).

Since Lake Titicaca is annually replenished by seasonal rainfall, changes in lake levels correspond to annual variations in precipitation. Limnological data from sediment cores taken from the southeastern portion of Lake Titicaca provide a paleoclimate history complementary to the Quelccaya climate data. Corresponding to the study period, Abbott and his colleagues (1997:179) documented low lake levels starting prior to A.D. 1100 and lasting until 1300. Although the timing of the onset of this dry period is not well resolved because the lake levels are not well defined in these lake cores, the intensity and duration of drought measured in the core's sediments is consistent with the LIP dry period documented in the Quelccaya ice cores (Abbott et al. 1997:178).

Sediment cores retrieved from nearby Lago Umayo also showed evidence of this extended period of aridity coinciding with the LIP. Baker and colleagues (Baker et al. 2009) looked at the stable oxygen isotopic composition of carbonate fine fraction from lake cores to reconstruct a paleoclimate sequence with centennial-scale resolution spanning from 4,456 B.C. to A.D. 127. When precipitation in the region decreases, Lago Umayo stops flowing into Lake Titicaca and, subsequently, it becomes a closed system with increased salinity (Baker et al. 2009:316). This team of researchers documented an increase isotopic ratio of carbonate sediments, indicating that drought conditions during between A.D. 1100 and 1400 were contemporaneous with an increase in salinous diatoms in the sediment cores.

Outside of the *altiplano*, but nearby, climate scientists have documented similar trends during the LIP. In the eastern Peruvian Andes, researchers looked at $\delta^{18}O$ in a well resolved sediment core from Lago Pumacocha (Bird et al. 2011). This lake has geological, morphological, and liminological features that contributed to the accurate recording of past annual levels of precipitation. Temporally refined through radiocarbon dating a series of wood charcoal fragments from the sediment column, the core from Lago Pumacocha revealed that levels of $\delta^{18}O$ peaked between A.D. 900 and 1100 indicating an extended period of aridity.

Recent research on peatland from the western Andes of southern Peru and northwestern Argentina further corroborates that there was indeed a period of aridity during the LIP. High-altitude cushion peatlands provide fine-resolution records of the past climate due to their “high accumulation rates, range of proxies, and sensitivity to climatic and/or human induced changes” (Schittek et al. 2015:2038). For example, several analyses were carried out on a column of soil from Cerro Llamoca peatland in Peru. These analyses include radiocarbon dating on 50 charcoal samples recovered from 10 cm sections throughout the core that provided a temporal understanding of the column, and analyses of pollen abundances, levels of arsenic, and magnesium/iron ratios from the same sections pointed to changes in the ecology and hydrology of the region over time (Schittek et al. 2014). Researchers found in sections of the core that correspond approximately between A.D. 800 and 1300 that there was a decrease in Poaceae pollen, an increase in Asteraceae pollen, a decrease in arsenic, and a lower ratio of Mn/Fe that was all caused by increased aridity.

A core collected from Quebrada de Pircas peatlands in northwest Argentina showed a similar trend. A research team determined the peatlands were well stratified and analyzed pollen abundances, magnesium/iron ratios, and iron/titanium ratios to determine past changes in precipitation (Schittek et al. 2015). They found that there was a drier period between A.D. 1000 and 1100 indicated by low Poaceae pollen abundances, increased amounts of Asteraceae pollen, accompanied by low Mn/Fe ratios, and a peak in Fe/Ti ratios. There was also a drier period between A.D. 1250 and 1330 marked by a decrease in Poaceae pollen and an increased Fe/Ti ratio.

While these two peatland cores were not recovered from the study region, they provide complementary evidence of an extended period of aridity during the LIP. Furthermore, these data indicate that a decrease in precipitation resulted in ecological changes in hydrology and plant communities in the Andes, whereas ice cores and lake cores only provide evidence of climate changes. Nonetheless, we still do not know how the LIP climate impacted farming strategies and agricultural ecologies.

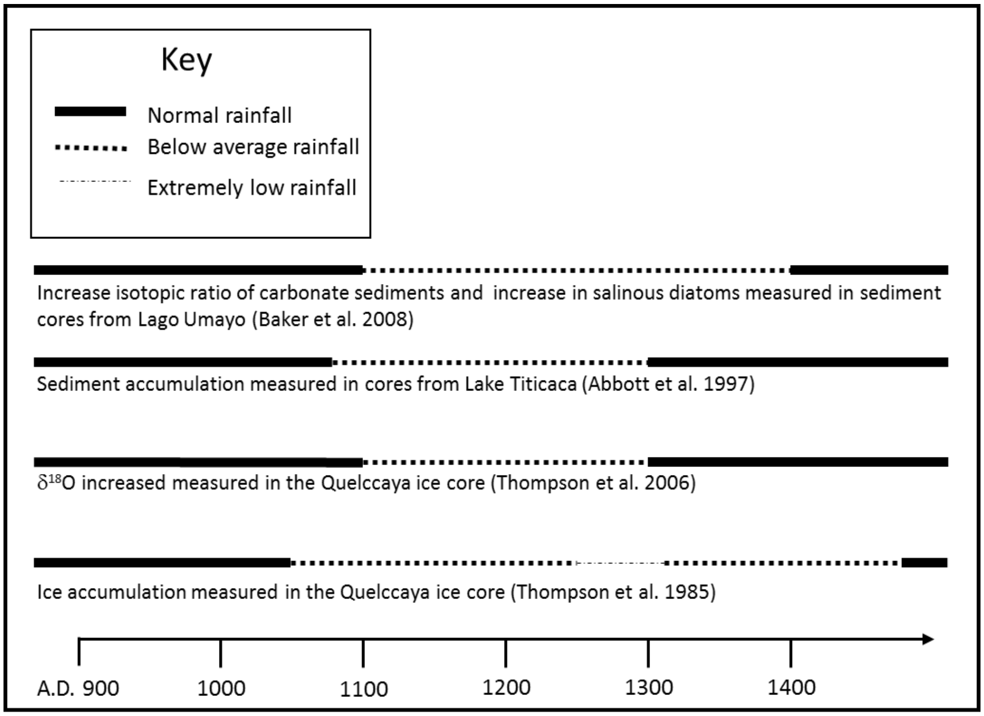


Figure 2.2: Timeline illustrating the onset and duration of drought during the LIP measured in several paleoclimate records from the *altiplano.*

Figure 2.2 summarizes the local paleoclimate proxies in this chapter. Each climate record shows evidence of low levels of precipitation and other climate aberrations during the early part of the LIP in the Titicaca Basin. Without a doubt, severe annual droughts occurred during the Late Intermediate Period. Due to the resolution of the ice and sediment cores used to reconstruct the paleoclimate in the Andes it is still difficult to pinpoint the onset and severity of this extended period of aridity. So, even though measuring ice layer thickness is prone to error and there is not a perfect correlation between rises in lake levels, isotope ratios, and annual precipitation changes (Calaway 2005; Melice and Roucou 1998), independent lines of evidence strongly corroborate an anomalous and dramatic arid time period and change in weather patterns during the LIP that surely affected agricultural production.

Chapter 3. The Temporal Setting of Ayawiri

The goal of Chapter Three is to outline the culture history that underpins life at Ayawiri, drawing on data from sources including archaeology and ethnohistory. First, I focus on constructing a general chronology describing the development of political, ritual, and cultural lifeways in south-central Andes. Then, I turn my attention to a general discussion of primary data about Ayawiri including previous research and excavations, site size, layout, a chronology of occupation history, and the natural landscape that surrounds the site.

Culture History

In the Andes a variety of historical and evolutionary chronologies have been constructed over the years. Pan-Andean historical chronologies are based on ceramic sequences, artistic traditions, and widespread political changes. In contrast, evolutionary frameworks consider localized processes and evolutionary trajectories including the development of economic strategies, religious traditions, and settlement patterns or a combination of these variables (Stanish 2003:85). Over time, evolutionary and historical chronologies have been refined and even combined. To date, there still is not an agreed upon chronology to which all research teams subscribe, even within the Titicaca Basin. Here, I focus on outlining only the chronologies most relevant to this research.

Constructing Temporal Chronologies in the Andes

Rowe, Menzel, and their colleagues (Menzel et al. 1964; Rowe 1960, 1962) developed the most commonly cited historical framework used throughout the Andes based on ceramic sequences found in the Ica Valley located on the southern Peruvian coast. In this chronology, they applied the concept of *horizons* to describe widespread and brisk temporal transformations in artistic traditions, technology, and cultural developments. *Horizons* were punctuated by *intermediate periods* of waning cultural traditions and sociopolitical reorganization. Radiocarbon dating of associated materials established absolute dates for this chronology. The horizons concept has been roughly extrapolated to account for widespread cultural changes throughout the Andes. In this sequence researchers in the Titicaca Basin include Tiwanaku (the Middle Horizon), and Inca (the Late Horizon) (ie. Arkush 2011; Burger et al. 2000; Erickson 1988). Ayawiri dates to the Late Intermediate Period between the Middle Horizon and the Late Horizon Period in this chronology. Building on this, Ponce Sanginés (1972) deemed it necessary to divide up the culture history of the Formative and the Middle Horizon into smaller time periods to better interpret political developments of the Tiwanaku state in the *altiplano.* In this sequence he determined that Tiwanaku I and II corresponded to the latter part of the Formative during the rise of Tiwanaku. Tiwanaku III and IV are characterized by urbanization. Finally, Tiwanaku V corresponds to imperial expansion of Tiwanaku artistic traditions and socioeconomic power into distant regions.

Lumbreras (1974) developed a chronology that was designed to encompass cultural development throughout the Andes including the Titicaca Basin. Although the name of the sequence have been modified for the region, this framework underpins chronologies used by many researchers throughout the *altiplano.* Lumbreras defined seven stages in this sequence including the Lithic, Archaic, Regional Development, Wari Empire, Regional States, and the Empire of Tawantinsuyu/Inca Periods. In this chronology Ayawiri dates to the Regional States Period.

Since widespread ceramic traditions and cultural traditions in the Ica Valley did not entirely correspond to changes in the Titicaca Basin, the Rowe-Menzel system is not fully applicable to the *altiplano.* Additionally, evolutionary developments in the Andes varied from between different geographic locations, so this framework fails to capture regional historical developments. The application of these chronologies is further complicated by independent histories identified by archaeologists in different areas of the *altiplano*. With this in mind, researchers working in the Titicaca Basin today often employ what Stanish (2003:88) terms the *dual chronological system.* Archaeologists working throughout the *altiplano* are borrowing from evolutionary and historical chronologies today to consider localized temporal developments (for examples see Aldenderfer 1998; Hastorf 2008; Klarich 2005; Stanish 2003). Generally, the sequences in the dual chronological system include the Early Archaic, the Late Archaic, the Terminal Archaic, the Early Formative, the Middle Formative, the Late Formative, Expansive Tiwanaku or the Middle Horizon, the Altiplano or the Late Intermediate Period, Expansive Inca or the Late Horizon, and Spanish Colonial. See Figure 3.1 for alternative names and variations in the onset of each of these time periods in different regions throughout the Lake Titicaca Basin.

I subscribe to a dual chronological system that has been refined by researchers working in the northern Titicaca Basin through local ceramic sequences, economic shifts, cultural changes, and radiocarbon dating specific to the study region (ie. Arkush 2011; Klarich 2005; Stanish 2003). Now, I turn my attention to outlining basic economic, political, and cultural developments in the region leading up to the occupation at Ayawiri.

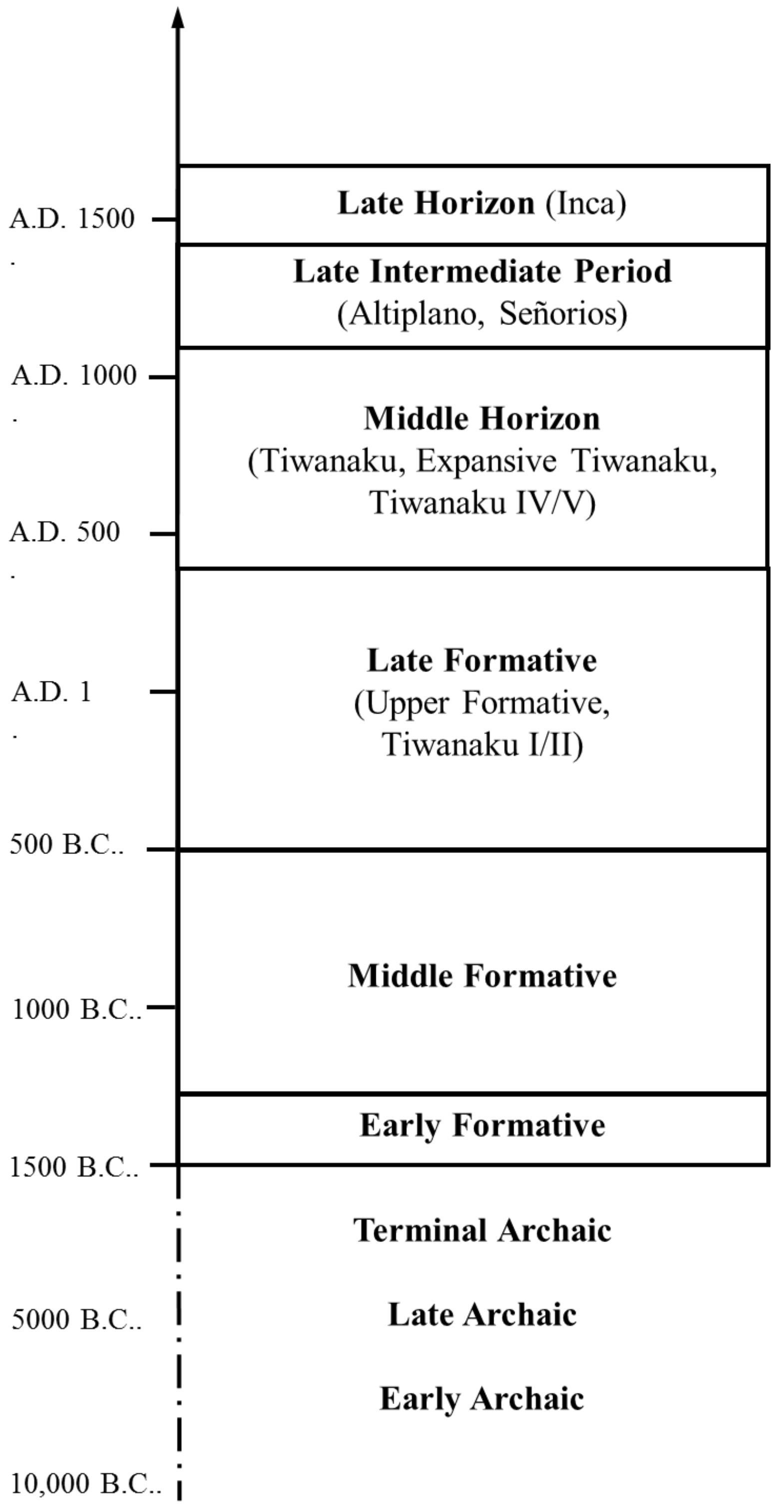


Figure 3.1: Dual chronology system commonly subscribed to in the northern Lake Titicaca Basin.

The Archaic Period

Hunter-gathers traveling from the Pacific coast first explored the south-central Andes as early as 11,500 (Aldenderfer 2008:135). Early explorers made short-term logistical forays into the highlands for raw materials such as obsidian, returning to their permanent residences on the coast (Sandweiss et al. 1998). Bands of hunter-gatherers eventually inhabited the highlands beginning in the Early Archaic (8,000-6,000 B.C.). During the subsequent Late Archaic (5,000-3,000 B.C.) and the Terminal Archaic Period (3,000-1,500 B.C.) diagnostic projectile points multiply in quantity in the hilly flanks of the *altiplano* indicating intensified hunting activities and populations growing in size (Klink and Aldenderfer 2005). Lakeshores were rarely inhabited during this time period based on surveys of littoral areas (Bandy 2006). Complex relationships between groups of hunter-gatherers formed during the Terminal Archaic. In particular, Aldenderfer and his colleagues (2008) found higher amounts of foreign sourced obsidian in archaeological assemblages in the *altiplano* during this time period, indicating substantiated trade networks. They also describe a cold-hammered gold-bead necklace that was found in the burial of an adult-child at the site Jirskairumoko that points to formalized ritual and ascribed status. Indeed, complex relationships and interaction networks preceded settlement in the *altiplano*. Hunter-gatherers' millennia of interactions with and management of local flora and fauna eventually resulted in the domestication of llamas, alpacas, quinoa, potatoes and other tubers during the Middle and Terminal Archaic Period (Pearsall 2008).

The Formative Period

By the Early Formative Period (1,500-1,300 B.C.) inhabitants of the region lived in incipient sedentary settlements throughout the Titicaca Basin. At the same time, the earliest small ceremonial centers were built and ritual life was institutionalized (Hastorf 1999). The first enclosed sunken courts—an architectural form that dominates religious and civic life centuries later in the region—show up during this time period at sites such as Huatacoa in the north Titicaca Basin (2010) and on the southern shores of Lake Titicaca at Chiripa (Hastorf 2003). Within these early ceremonial center, the tradition of ancestor veneration is first documented in the region. In particular, the Taraco Archaeological Project found burials containing multiple individuals in enclosures adjacent to the sunken platform (Hastorf 2008:548).

By the Early Formative in the Titicaca Basin, littoral village residents subsisted on a diet of abundant lake fish and other forage foods, while increasingly supplementing their diet with cultivated plants and animals (Bruno and Whitehead 2003; Hastorf 2008). At the same time, new cooking and serving technologies were employed to cook these foods. Indeed, the earliest evidence for ceramics in the region has been found in the first occupation layers of early villages including Pukara (Wheeler and Mujica 1981), and Qaluyu (Chávez Mohr 1977) in the northern Titicaca Basin, and Chiripa (Browman 1980) in the southern basin.

During the Middle Formative (1,300-500 B.C.) increasing territoriality among early village groups led to the establishment of more than a dozen regional civic-ceremonial centers throughout the Titicaca Basin (Hastorf 2008:548; Stanish 2003:117-120). These centers typically have sunken courts, and a few have raised platforms that facilitated collective and elite activities (Hastorf 2003:551). Clusters of settlements sprouted up around these centers housing growing populations (Hastorf 2008:549). Accompanying these changes was the development of established religious systems (Stanish 2003:109). In particular, stone stelae found at regional centers depicting the faces, bodies, and appendages of Pajano deities indicate a shared religious ideology (also referred to as Yaya-Mama (Chávez and Chávez 1975) or Pa'Ajano) (Browman

1972). These civic and ritual developments are cited as evidence for the emergence of ranked social and political life and the establishment of elite and religious ideology shared among residents living throughout the region (Stanish 2003:132).

By the Late Formative (or Upper Formative from 500 B.C.-A.D. 400) there is an increase in the activities and influence of a few dominant regional centers. While local centers such as Chiripa continued to be important to nearby residents, the power of Pukara and Tiwanaku increased in magnitude (Hastorf 2008:553). Civic-ceremonial activities drew larger crowds to ritual gatherings leading populations to settle nearby. On a hillside at Pukara multiple sunken enclosures were constructed on stepped platform terraces in order to house ritual activities. Similarly, at Tiwanaku, residents built a raised platform adjacent to a stone-lined, enclosed sunken court surrounded by carved anthropomorphic tenoned heads placed in the walls and other powerful iconographic representations of deities indicating ceremonial elaboration (Hastorf 2008:554-555). Long-distance trade, particularly evidenced at large centers including Tiwanaku (Hastorf 2008:554), Pukara (Wheeler and Mujica 1981), and Taraco in the northern basin (Levine 2013), increased during the Late Formative. Notably, elite sectors of Taraco were aggressively burned, and economic activity around the site subsequently declined during the first century A.D. This occurred at the same time Pukara continued to increase its power over the northern Titicaca Basin (Stanish and Levine 2011). All the while, lifeways for residents living in smaller villages and near minor civic-ceremonial centers remained largely the same during the Late Formative (Stanish 2003).

Tiwanaku and the Middle Horizon

Around A.D. 400 Pukara's power waned and civic-ceremonial power shifted predominantly to the southern basin (Klarich 2005). By the start of the Middle Horizon (A.D. 400-1100) Tiwanaku's urban core, located in Bolivia 20 km south of Lake Titicaca in a flat valley, exerted regional influence throughout the *altiplano* and beyond, leading to the establishment of the first archaic state in the south-central Andes (Hastorf 2008:557). The rise and eventual collapse of Tiwanaku was roughly contemporaneous with the developmental trajectories of Wari in the central Andean highlands and Moche on the north coast of Peru (Stanish 2003:166).

Two models that do not necessarily oppose one another dominate theories on the development of Tiwanaku. Trade with distant regions beginning long before the rise of Tiwanaku's importance has been portrayed as the primary mechanism for political centralization (Browman 1984; Stanish 2002). Alternatively, Bandy and Hastorf have proposed that ceremonial and ritual connections to seasonal cycles led to an increase and institutionalization in festive pilgrimages to centralized civic-ceremonial activities (Hastorf 2008:550). With the onset of Tiwanaku's dominant influence, decorated red-slipped pottery suitable for quotidian meals and elaborate feasts became popular and widespread throughout the region (Janusek 2008).

An elaborate, monumental temple complex initially built in the Late Formative was refurbished and expanded under the oversight of elite rulers and architects residing at Tiwanaku during the Middle Horizon (Stanish 2008:23). This complex formed the core of the city's urban center and included the Sunken Temple and Kalasasaya platform. Staircases, portals, and passages into adjacent ritual spaces within these structures set the stage for dramatic ceremonial and religious activities carried out at Tiwanaku (Janusek 2008:110). The Akapana, a massive stepped terrace structure rising into an elevated platform and containing another sunken court within, was built during the Middle Horizon adjacent to the Sunken Temple and Kalasasaya (Janusek 2004b; Manzanilla 1992). Another slightly smaller sunken temple and platform complex called Pumapunka was built several hundred meters away from the Akapana, the Sunken Temple, and the Kalasasaya and was also initially constructed during the beginning of the Middle Horizon (Vranich 1999). In summary, these ritual complexes were the locus of civic-ceremonial activities at Tiwanaku's urban core, and sunken temples were the architectural form that facilitated these activities.

The monumental complexes at Tiwanaku were surrounded by elite residences, artisan communities, and commoner neighborhoods all containing sumptuary goods such as elaborately painted ceramics, ceremonial serving vessels, and large chicha jars for production and consumption of alcoholic beverages (Janusek 2008:146; Stanish 2003:172). A population estimated between 30,000 and 60,000 residents lived in the urban core at Tiwanaku (Kolata and Ponce Sanginés 1992). Based on extensive archaeological surveys the valley around the urban core and the surrounding countryside were densely populated by farmers and pastoralists throughout the Middle Horizon (Albarracin-Jordan and Mathews 1990). Tiwanaku's sphere of influence within the *altiplano* reached all the way down to Uyuni in Bolivia and north to the Juliaca area (Stanish 2003:189). Curiously, Tiwanaku ceramics and other artifacts have rarely been found further north in the *altiplano*, even at Pukara (Klarich 2005:46), indicating the state's influence was weak in the northern region.

At the same time that the urban core was growing, the influence of Tiwanaku outside the *altiplano* amplified. This sociopolitical shift informs the name given to the second half of the Middle Horizon: Expansive Tiwanaku. Building on trade and exchange relationships established during the Formative Period, Tiwanaku's urban center formed the foundation for camelid caravans trading goods across the south-central Andes (Albarracin-Jordan and Mathews 1990:23). With increasing importance put on securing these goods for civic-ceremonial activities, Tiwanaku residents strategically colonized warm valleys on both the eastern and western slopes of the cordillera including those in Cochabamba, Bolivia, and Moquegua, Peru (Goldstein 2005). They brought with them Tiwanaku artistic styles such as geometric patterns and motifs of anthropomorphic deities. These patterns were painted on locally produced and imported quotidian and ceremonial ceramic vessels (Stanish 2003:198). Colonization of distant regions in lower elevations ensured reliable and ubiquitous access to ceremonially important goods. Distant populations with distinct local cultural traits also migrated to and settled in Tiwanaku's urban core (Janusek 2008:23).

Around A.D. 800 Tiwanaku reached its apogee when a massive renovation of civic-ceremonial structures was initiated (Janusek 2008:23). Ranked hierarchy, particularly among political and religious leaders residing in the urban core, reached an all-time high where elite residences were embellished and expanded. Colonists in Moquegua ratcheted up production of maize that was exported to Tiwanaku's urban core where it was processed into chicha beer for religious and elite consumption (Goldstein 2003). Tiwanaku artistic styles, architecture, and lifeways dominated throughout the south-central Andes from A.D. 800 to 1000 (Stanish 2003:203).

Around A.D. 1000 Tiwanaku began to crumble. At the same time, their colony in Moquegua collapsed and Tiwanaku power over the region diminished (Owen 2005). Production of Tiwanaku style pottery decreased over time, and artistic motifs that were passed down through lineages of artisans over millennia fell out of manufacture, signaling the end of a political and economic system (Stanish 2003:207). The collapse of Tiwanaku was a drawn-out and multi-causal process (Janusek 2008:290). Elite residences at Tiwanaku were abandoned one sector at a time (Janusek 2008:294). Within the urban core, even ceremonial spaces were systematically destroyed and razed (Couture 2002; Couture and Sampeck 2003).

In the central Peruvian highlands, the Wari collapse was roughly contemporaneous and tentatively connected to the collapse of Tiwanaku, linking Titicaca Basin culture history into a broader Pan-Andean culture history. By A.D. 1000 many Wari sites were abandoned and populations declined (Covey 2008:292). Wide-spread political disintegration marks the end of the Middle Horizon Period throughout the central and southern Andes.

The Late Intermediate Period in the Land of the Colla

The end of Tiwanaku marks the beginning of the Late Intermediate Period around A.D. 1100. Legends of this era were recorded by several Spanish chroniclers in the 16th and 17th centuries. They wrote down chronicles described by Inca informants about the warring ethnic groups, or legendary *señorios*, of the circum-Titicaca region before the Inca conquest of the region around A.D. 1450. Researchers in the 20th and 21st century have mined these literary works in order to construct a culture history of the region during the LIP (Arkush 2011; Hyslop 1976; Julien 1983; Murra 1968; Stanish 2003). Both Spanish and Inca ethnocentric perspectives bias what was recorded in these reports. For example, the Inca often sought to disparage ethnic groups they conquered (Stanish 2003:207). Furthermore, the centuries that elapsed between the Late Intermediate Period and the colonial era further warped these oral histories (Arkush 2011:16). By calibrating the chronicles with archaeological data, researchers have begun to shed a great deal of light on the LIP.

According to Guamán Poma de Ayala (1980 [1616]) the Late Intermediate Period was referred to by the Inca as the *auca runa*, or the time of war and warriors. From northern Chile and northwestern Argentina all the way to the northern highlands of Peru there is archaeological evidence that populations abandoned valley-bottom urban centers and moved during the LIP to fortified hilltop locations (Arkush 2006; Covey 2008; Parsons and Hastings 1988). Accompanying this shift in settlement pattern, there were dramatic transformations in political power, ritual, craft production, and daily lifeways. These cultural trends are also mirrored in developments in the *altiplano.* Following the collapse of Tiwanaku, most of the population in the region dispersed across the landscape settling in small hamlets and villages (Albarracin-Jordan 1992:277-284; Bandy 2001; Bauer and Stanish 2001; Stanish 1994:322). Warring ethnic groups staked their claims over regions in which they resided. The largest ethnic groups in the Titicaca basin were the Colla, in the northwest basin, and their rivals the Lupaca, who lived in the southwest area of the Titicaca Basin (Arkush 2011:2; Hyslop 1976; Stanish 2003:208). Most chronicles consider the Colla the larger and more powerful of the two groups (Arkush 2011:2-3; Julien 1983:40-41; Tschopik 1946:3).

According to the chronicles, power throughout the Andes was no longer centralized; rather, war leaders, referred to as *sinchis,* only temporarily held sway during periods of war (see Arkush 2008:17). At the same time, the Colla were said to have possessed military power that rivaled the early Inca Empire (Betzanos 1996 [1557]:93). Fifteenth century Inca indigenous informants recounted that before the Inca conquest, a great lord of a hereditary dynasty named Zapana ruled over the Colla (Julien 1983:36-37), and his power as a leader surpassed those of contemporaneous neighboring lords, such as the Lupaca (Arkush 2011:39). The power that Zapana held over the Colla was not dictatorial. Rather, in times of battle Zapana was required to solicit assistance from “subordinate and allied warlords” that were the leaders of their respective hilltop dwelling communities (Arkush 2011:41-42; Cieza de León 1985 [1553]:157). Most of the time, though, independent villages looked after their own well-being. This thread of history indicates that Colla settlements maintained a certain amount of autonomy but were able to amalgamate their power for defensive militaristic activities. There is evidence that warfare in the Andes was carried out only during the dry season after fields were harvested (D'Altroy 2002:207; Rostworowski de Diez Canseco 1999:75). With low labor needs on the home front between planting cycles, farmers transformed themselves into warriors, and *sinchis* temporarily garnered their power to carry out a season of battles. With the onset of the rains, warriors may have then returned their attentions to tending their fields and power was redistributed among community members.

Sacred architectural forms built and used by residents in the region since the Formative Period no longer served ceremonial functions. In fact, Stanish (2003:199) reports that the sunken court at the site Palermo was used as a camelid corral during the LIP. The production of Tiwanaku vessels and motifs that persisted for over a millennium during the Middle Horizon declined through the early part of the LIP and ceased all together by A.D. 1150 (Janusek 2004a:207; Stanish 2003:207). These data signal a departure from long-held ceremonial institutions and an abandonment of previous religious practices and perhaps even beliefs. Additionally, instead of large serving vessels used for communal meals, small cooking pots and serving vessels become standard kitchenware during the LIP (Janusek 2003). The social landscape was fragmented to the point that residents no longer feasted together. Rather, meals were primarily shared among small family groups.

Along the same lines, mortuary traditions changed during the LIP. Residents throughout the *altiplano* began mummifying their ancestors and placing them in above ground structures called *chulpas* (Arkush 2008:27; Stanish 2003:229-235). These structures have small doorways and niches surrounding the base of the inside that served to house several mummy bundles. Arkush (2008:27) suggests that the accessibility of the *chulpas* indicates offerings and ceremonies were regularly carried with the dead. There is a high degree of variability in construction material, size, and form of *chulpas* throughout the *altiplano.* Some structures are round, others are square, some are made of cut stone, and yet others are made of adobe (Stanish 2003:230-231). Often located on prominent escarpments near settlements, *chulpas* may have served as fixed symbols of ancestral claims to territories. Individuals were also interred in cist tombs (one of the few cultural traditions that continued from the Middle Horizon), and groups of individuals were buried in slab-cist tombs during the LIP (Arkush 2011:27). New mortuary practices signaled the ushering in of new belief systems and traditions during the LIP.

Bioarchaeological evidence from throughout the highland Andes indicates increased violence and perimortem trauma during the LIP that conform to legendary descriptions of violent warfare. In the collapsed Wari heartland in the central Andes, researchers report of significant increases in LIP skeletal evidence for warfare including cranial trauma and wounds among men, women, and children (Kurin 2016; Tung et al. 2016). Researchers also note pervasive structural violence as evidenced in a diminished LIP diet as a result of limited access to a variety of foods.

In the southern Andes of the San Pedro de Atacama Desert there is similar evidence of skeletal trauma dating to the LIP (Torres-Rouff and Costa Junqueira 2006). Both ethnohistorical accounts and archaeological evidence indicate Colla and Lupaca history is fraught with inter- and intragroup violence and conflict (Arkush 2005, 2011; Hyslop 1976; Tschopik 1946:3). In the *altiplano* 15% of the adult skeletons found in a cave associated with an LIP Lupaca site show evidence of cranial trauma associated with violence (De la Vega et al. 2005). Similarly, all nine skeletons dating to the LIP found near the western shores of Lake Titicaca show evidence of cranial and post-cranial trauma that appears to be inflicted by sling stones and mace heads (Juengst et al. 2015). Without a doubt, combat during the LIP was violent, bloody, and deadly.

Contemporaneous with this increase in traumatic violence, throughout the highlands during the LIP residents retreated to live in defensive settlements (Arkush and Tung 2013:316-318). These settlements varied in form and size from small refuges to large, permanent, fortified, hilltop villages, and there is little evidence of central planning or forethought in their layout (Arkush 2008; Covey 2008:293). In the Titicaca Basin there was, however, a great degree of planning that went in to where hillforts were built. *Pukaras* are located on prominent hilltops within view of each other. Networks of intervisibility between *pukaras* allowed residents to signal to one another with fire smoke or other methods (Arkush 2008:159-161). Through these visual lines of communication, residents could alert allies living at other *pukaras* to an encroaching enemy, raids, or they could even call for reinforcements. These data indicate the Colla made choices in the location where they lived to decrease the threat of violent conflict.

In the Titicaca Basin, p*ukara* construction, modification, and use intensified towards the latter part of the LIP. Based on a series of 43 radiocarbon dates and a refined ceramic chronology, Colla forts were primarily used from A.D. 1300 to 1450 (Arkush 2011:183-185). These data are consistent with trends throughout the Andes that indicate warfare intensified toward the latter years of the LIP (D'Altroy 2001:89; Hastorf et al. 1989:87).

The Late Horizon Period

The end of the Late Intermediate Period and the beginning of the Late Horizon Period in the Titicaca Basin is marked by the conquest of the region by the Inca around A.D. 1450 (following Rowe 1945:65). Conquered in battle by allied forces of the Inca and the Lupaca, the Colla were forcibly incorporated into the Inca Empire. Around A.D. 1471 the Colla rebelled against Inca subjugation, and intense bloody conflicts reportedly ensued in the region for almost three years (Rowe 1942; Spurling 1992). Tenacious Inca forces eventually prevailed, Colla *pukaras* were abandoned, and remaining populations nucleated in villages located strategically on Inca trade routes (Arkush 2011; Julien 1983; Stanish 1997). The capital city of the Colla region, called Huatuncolla, gained prominence as a way station and center of trade located on the main highland Inca road (Hyslop 1984:120-121; Julien 1983). Surviving Colla people and their offspring participated in the *mit'a* system by provisioning the Inca Empire and their army with surplus foods (Murra 1986:52). Socially, politically, and economically the Colla were integrated into the Inca Empire until the Spanish conquered the Andes approximately 90 years later (Rowe 1945). The power and prestige that the Colla once held in the *altiplano* was said to have been honored in the name for the entire southern quarter of the Inca Empire: Collasuyo or "quarter of the Colla" (Stanish 2003:237).

Ayawiri: The Natural and Cultural Setting

Ayawiri is one of the largest LIP *pukaras* in the Titicaca Basin. Ongoing research at the site has helped to unravel the social, political, and civic-ceremonial lifeways of the LIP. Furthermore, research at the site elucidates the impact of warfare on residents living in the region.

Ayawiri is located in the province and department of Puno. The site is located 6.5 km south of the town Vilque straddling the districts of Tiquillaca and Vilque. The majority of Ayawiri is located on the Tiquillaca side of the district border pertaining to the community of Chila. The UTM coordinates for the site are UTM 365950E, 8249800S (WGS84). The fortress covers over 13 hectares of the southern portion of a flat mesa, and it is walled on the northern side (Figure 3.2). Short walls, terrace walls, and cliff faces define the western, southern, and eastern perimeter of the site. There are three defensive walls measuring between 1.5 m and 2.4 m high protecting the northern approach to the site with staggered entrances that Arkush (2011:84). Parapets and sling stones found along these walls point to the defensive function of the site.

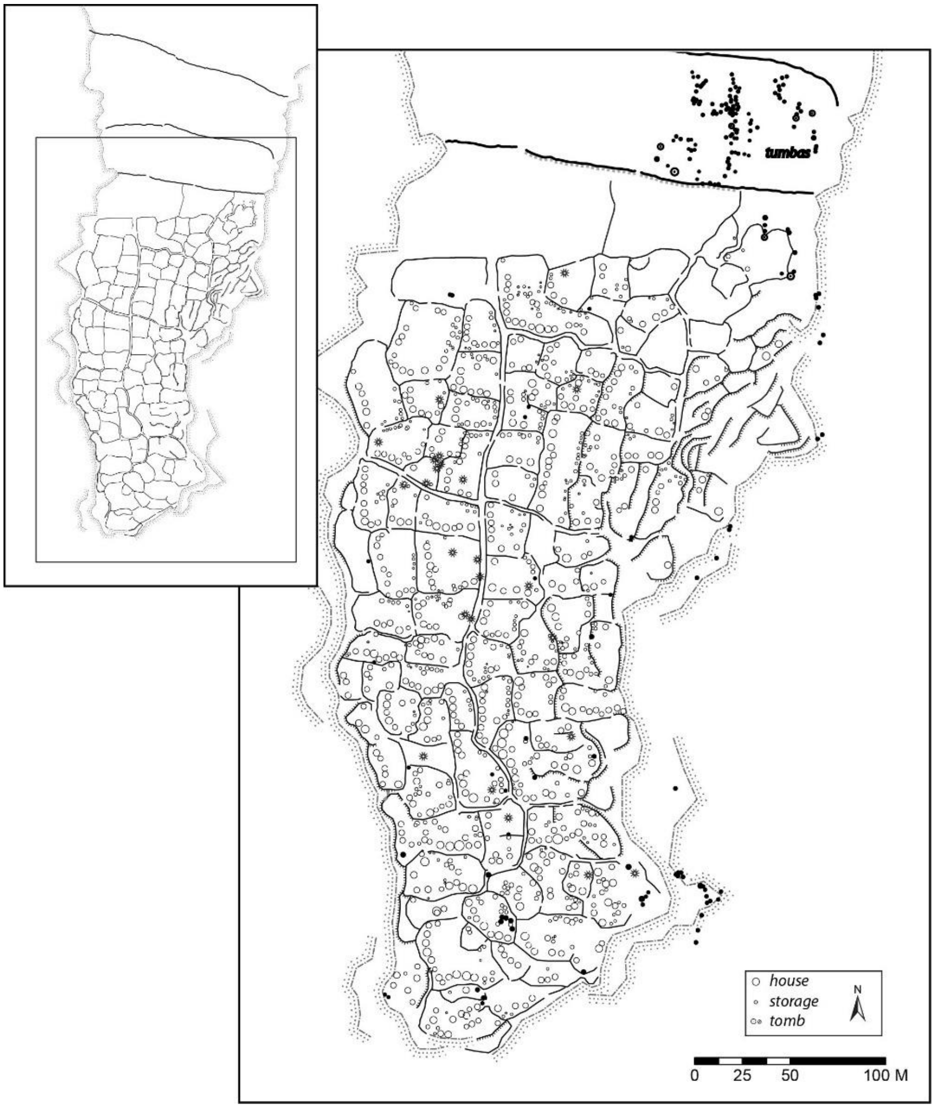


Figure 3.2: Map of the fortified residential area at Ayawiri. Created by Proyecto Machu Llaqta and rendered by E.N. Arkush.

Arkush (2011; 2012) and Proyecto Machu Llaqta have identified over 1,100 LIP structures within the fortification at Ayawiri. These structures are grouped together in approximately 120 residential compounds, divided into sectors by stacked-stone elevated passageways or causeways. One of these causeways runs from north to south, and two more intersect the residential compounds from east to west. The approximately 120 residential compounds are defined by 1 to 2 m stacked-stone walls that encompass on average between four to seven house structures. Although only about 100 compounds contain architecture; the rest are empty. Within the residential compounds, there are surface remains of at least 660 larger structures and 452 small storage structures (Arkush 2011:114; 2015). Structures are clearly identifiable when walking over the site today, due to the prominent remaining circular outlines of stone foundations. Based on the number of identified structures, Arkush (2011, 2015) estimates at least 1,000 to 2,000 Colla people lived at Ayawiri. While the architecture and location of the site ensured the safety of such a large population, there is not a water source within the site's walls. Water, necessary for the survival for camelid herds and humans alike was probably required a constant labor force. Like many other *pukaras* in the region (Arkush 2008:93), residents and their livestock had to travel 20 to 45 minutes to the nearest spring or river for daily drinking water needs.

Previous Research

Ayawiri was first investigated in the early 1970's by Felix Tapia for his Bachelor's thesis (Tapia Pineda 1973, 1993). He excavated 40 structures at the site in five different compounds. However, he did not produce a map of these excavations, so we do not know exactly where he dug. Tapia describes finding abundant charred bone, smashed ceramics, axes, hoes, and round stones that were probably sling stones. Since he found animal bone and broken ceramics without evidence of cooking, he determined that the structures were only used to ritually slaughter animals. Furthermore, he concluded that there was no domestic architecture at the site. While Tapia's interpretations do not hold up today, his descriptions of the stratigraphy and artifacts he encountered provided the framework for research carried out by Proyecto Machu Llaqta at Ayawiri

The site was visited again several times from 2001 to 2003 by Pukaras de los Collas directed by Dr. Elizabeth Arkush who was surveying LIP *pukaras* for her dissertation research (Arkush 2005). She mapped the extent of the site, the defensive walls, the compound walls, the apparent structures, and petroglyphs at the site. She also dug a few test pits in order to recover ceramics used to relatively date the site.

Building on this research, in 2009 and 2010, Dr. Arkush launched Proyecto Machu Llaqta (PML) by conducting full-covered pedestrian survey across 80 km^2 surrounding Ayawiri. In 2011 and 2012 PML carried out excavations in six residential compounds and two cemeteries associated with the site. I participated in these excavations and oversaw recovery of botanical remains. Here I outline general information about the site. In Chapter Six and Seven, I provide details of stratigraphy and particular contexts from these excavations as they relate to the macrobotanical findings included in this dissertation.

Residential Compounds

Many *pukaras* in the Colla region are composed of concentrations of house and storage structures scattered across a hilltop and surrounded by one or more defensive walls (Arkush 2008:98). However, at Ayawiri, there are stacked stone walls that separate groups of house, kitchen, and storage structures. Each compound has on average between four and seven house and kitchen structures and on average four to five storage structures (there are 0.66 storage structures in each compound per house structure, but there's a lot of variability) (see Figure 3.3). This indicates that more than one nuclear family resided in each compound (Arkush 2011:114). House and kitchen structures are situated along the south and western side perimeter of compounds, and storage structures are generally found along the eastern and northern areas.

This layout left open space in the center of each compound that likely functioned as a patio where families interacted with one another and food preparation and craft production activities were carried out. There are several compounds in the northern sector of Ayawiri that lack any sort of architecture. Arkush (2011:107) believes these areas were probably used as corrals for camelids. They could have also been used as small civic gathering space.

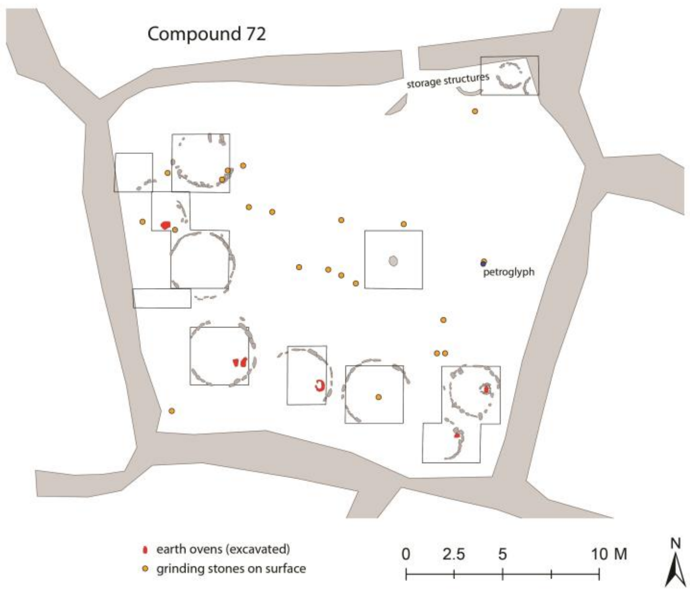


Figure 3.3: Map of a typical compound at Ayawiri (rendered by E.N. Arkush.). Note the structures along the perimeter of the compound and the patio space in the center.

Social Diversity

Prestige goods, collective space, or markers of wealth that were common and discernible in the archaeological record in earlier, hierarchically-organized eras of the *altiplano* are nearly absent at Ayawiri. At the site, there is no evident public space or civic architecture where political leaders would have gathered, except for the cemetery (Arkush 2011). There is no sunken court, elite housing sector, or raised platform. This signifies there is no strong evidence for hierarchically organized political organization at the site. Rather, the space at the site is largely delineated into multi-family household compounds. These data indicate that daily life was predominantly organized at the household level. Sociopolitical relationships at the site were probably negotiated between heads of households and labor needs were doled out among families living together in compounds.

Kitchen Houses, Non-Kitchen Houses and Storage Structures

Within each compound there are larger and smaller house structures and storage structures with distinct compact and, sometimes, clay floors littered with artifacts. Each house in a compound has a specific function. For example, during excavations we found that smaller houses often have hearths and other utilitarian artifacts indicating they are "kitchen structures" (Arkush 2014). Larger houses are devoid of food preparation materials, such as grinding stones, indicating they served a different function than kitchen structures (Arkush 2014). We refer to these structure as "non-kitchen house structures." Some compounds have more than one kitchen structure indicating that perhaps more than one nuclear family resided together. Compound walls potentially demarcated the residence of extended family kin groups. House and kitchen structures are oriented around the perimeter of each compound with the remnant of doorway threshold stones facing inward toward central patios. Each compound has several storage structures that measure less than 2 m in diameter. These structures are composed of a layer of loose, uneven rocks surrounded by a circular stone foundation that was probably covered in a perishable superstructure. The rocky foundation probably ensured drainage and encouraged air circulation around stored crops (Arkush 2014). This feature of the storage structures is particularly important for preventing spoilage of potatoes and other tubers with high water content that are very susceptible to mold growth.

The Cemetery

To the north of the Ayawiri residential sector between fortification walls, there is a cemetery containing more than 120 slab-cist tombs. There is also a cemetery located at the southeastern foot of the mesa in the valley bottom. Excavations carried out in 2011 by Matthew Velasco confirm stylistic and temporal consistency between the artifacts and burial styles in these cemeteries (Arkush 2014). He found that tombs contained one to five individuals with modest grave goods, including complete ceramic vessels. While there is no space large enough to gather the entire community together within the residential sector at Ayawiri, the northern cemetery is large enough to serve this function if an occasion arose.

Artifacts and Ecofacts found at Ayawiri

Artifacts and ecofacts found within the residential sector at Ayawiri elucidate quotidian life during the LIP. For example, grinding stones, utilitarian ceramics, chert blade, and spindle whorls are evidence of normal Andean women's work, consisting of cooking and textile production. Copper and bronze objects such as a chisel, *tupus* (Andean shawl pins), a tumi (an Andean knife), bell-shaped bronze pendandts, and even a ring shaped like a butterfly were found in several kitchen and non-kitchen house structures at the site (Arkush 2014). Camelid bones found in just about every compound at the site (Arkush 2014) indicate that Ayawiri residents were pastoralists and llama meat was an important food source for the community. Additionally, the recovery of a few deer bones and antlers indicate that residents occasionally hunted.

Ecotopes at Ayawiri

Within the immediate landscape surrounding Ayawiri, I have identified three distinct ecotopes (Figure 3.4). These ecotopes will be of relevance as they elucidate human and herd animal landscape use through macrobotanical analysis in Chapter Six and Seven. First, *agricultural terraces* flanking the site, which are still farmed, contain shrub plants and crop weed companions when not in cultivation and crops and weed companions when in cultivation. Indigenous crops grown today, and probably in prehistory, on the terraces include quinoa (*Chenopodium quinoa* Willd.) and tubers such as oca (*Oxalis tuberosa* Molina) and potatoes (*Solanum tuberosum* L.). Today local farmers can be seen herding their llamas and sheep throughout the terraces, particularly on fields left in fallow.

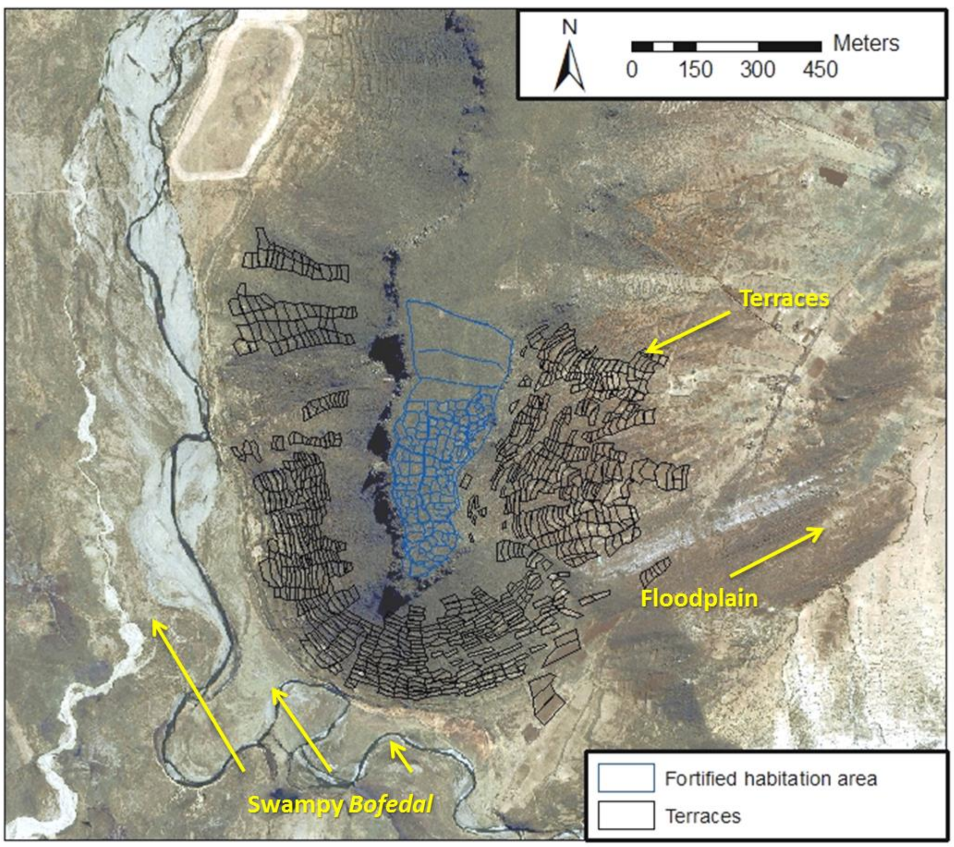


Figure 3.4: Map of the ecotopes surrounding Ayawiri.

Second, to the northeast of the site, there is a floodplain called a *chilapampa* that floods in the rainy season. The saline soils in this valley have very low agricultural potential today. However, relic raised fields are distinguishable in satellite imagery in the distant eastern part of the valley indicating a vast area of this land was cultivated in the past. While no one living near the site today farms in the floodplain, pastoralists frequently graze their herds there on wild vegetation. This area is composed of predominantly of bunch grasses (e.g., *Stipa ichu* (Ruíz & Pav.) Kunth).

Third, to the south and west of Ayawiri, there is a swampy ecotope with a year-round river flowing through it, the Vilque River, which is also abundant in bunch grasses. Parts of this river channel into a rich, swampy *bofedal*, used as a pasture for herd animals today. Modern pastoralists water their llamas and sheep intensively throughout this wetland ecotope. The *bofedal* is rich in riverine plants; however, no Cyperaceae grows there today (Cyperaceae does grow near Lago Umayo, a several hour walk north of the site). Today, a big ranch, the Hacienda Tercumilla, grazes their cattle herds on the shores of this *bofedal*.

The Late Formative Occupation at Ayawiri

Evidence of a Late Formative occupation at Ayawiri was found in strata below the LIP occupation in five of the six residential compounds excavated by team members of Proyecto Machu Llaqta (Arkush 2014). Analysis of artifacts from Late Formative levels revealed that obsidian was much more plentiful during this time period than the LIP at the site. This indicates that long-distance trade or procurement from Chivay, the main obsidian source for the Titicaca Basin, was stronger during the Late Formative.

The most deeply stratified and complex Late Formative occupation at the site was found in the southern part of Ayawiri. In this location excavators uncovered numerous fill events (Arkush 2014). Additionally, they found a floor with a large boulder placed on top of it during the Late Formative that measured over 2 m in diameter. In fill, excavators found evidence of probable feasting remains that included large camelid bones, a deer cranium, burned bone, ash, and carbon. Arkush (2014) determined these Late Formative fill events in the southern part of Ayawiri were often domestic, measured less than 30 cm thick, and were efforts to level the foundations of houses. The team did not find any evidence of typical large-scale Late Formative ceremonial architecture at the site. Nonetheless, it is possible that communal and ceremonial architecture are still buried beneath the apparent and wide-spread LIP occupation.

While we are confident that the Late Formative domestic occupation at Ayawiri spanned across a large portion of the site, the context and nature of this this occupation remains unclear with the available evidence. Furthermore, many of the Late Formative contexts are from fill events, where the architecture and use of that space is still unresolved. Therefore, I have focused the scope of my dissertation research on analyzing materials in order to better understand the LIP occupation at Ayawiri.

Discussion

Archaeologists have just begun to focus on studying the Late Intermediate Period in the Lake Titicaca Basin over the past decade. This in part due to having been deemed an Intermediate Period betwixt and between the reign of the impressive Tiwanaku and the Inca. Recent research, particularly survey and geographic information analyses by Arkush (2005, 2006, 2008a, b, 2010, 2011), have demonstrated the importance of studying the causes of consequences of warfare and the impact the LIP had on later history in the region. In collaboration with Proyecto Machu Llaqta, in this dissertation, I aim to clarify foodways and agricultural strategies at Ayawiri during the LIP.

Chapter 4. Theory: Coping with Risk in the Altiplano and Adapting Farming Strategies during the LIP

In Chapter Four, I present an overview of how residents have adapted to and coped with the risks ever present in the *altiplano*. This chapter begins with a summary of the agricultural and economic history of the south-central Andes. The long process of the domestication of plants and animals in the harsh montane environment was a necessary step in enabling residents to cope with the arduous ecology and the ability to settle on the landscape. The agricultural foundations of life in the region set the stage for the development of long-lasting social complexity. Then, I turn my attention to the importance of zonal complementarity or trade and exchange in the Andes, an age-old insurance policy that ensures residents will survive multiple years of lean yields. Next, I describe the various ways and time periods that *altiplano* farmers domesticated the landscape for agricultural purposes. Central to this discussion is the methods researchers use to date fields. Lastly, I describe risk management theory and how it relates to the research problem at hand.

Sedentary life and the development of cities and sociopolitical authority in the Andes were made possible by the production of an agricultural surplus that fed the ever-growing population. This means the history of agricultural strategies in the *altiplano* has been at the heart of archaeological research projects for decades. Particularly in the last 30 years, researchers have shed light on how ancient farmers coped with the harsh ecology and unpredictable weather in the *altiplano* in three ways. First, several species of indigenous grains and scores of tubers were domesticated in the Andes alongside llamas and alpacas (Hastorf 2008; Mengoni and

Yacobaccio 2006; Pearsall 2008; Piperno and Pearsall 1998). Second, residents in the *altiplano* have engaged in long-distance trade with neighbors and family members (Murra 1972). In years of plenty, symbolically important commodities, such as maize and coca, were traded through supply networks. In lean years, long-distance trade functioned as an insurance policy where residents could acquire basic food staples from trade partners living in ecozones that prospered. Third, an engineered landscape reduced environmental risk and increased predictability in yearly crop yields. Farmers domesticated the landscape and made it more congenial for humans by constructing raised fields, expanding natural stands of water called *bofedales*, improving sunken rain-fed depressions called *qochas* (or *cochas*), and terracing hillsides. Raised fields and to a lesser extent *qochas* have been the foci of several archaeological investigations that relate to the development of sociopolitical complexity (Bandy 2005; Erickson 1992, 1993, 2000; Flores Ochoa 1987:277-278; Janusek and Kolata 2004; Kolata and Ortloff 1996:113: Smith et al. 1968), whereas research on terraces has been largely overlooked in the *altiplano.*

Domestication and Agricultural Intensification in the Titicaca Basin

Crops

The primary native crops grown in the *altiplano* are quinoa, other *Chenopodium* spp. grains, potatoes, and other tubers. Farmers in the region have cultivated these crops for at least 4,000 years (Hastorf 2008; Pearsall 2008; Piperno and Pearsall 1998). Remains of these plants have been well documented in archaeological contexts throughout the Titicaca Basin (Table 4.1).

Table 4.1: Macrobotanical remains from the Lake Titicaca Basin.

	Ubiquity or percentage presence				
Site	Chiripa	Kala Uyuni	Tiwanaku	Tiwanaku	Tiwanaku
Time period	Formative (1500-100 B.C.E)	Formative (1500 B.C.E-C.E. 200)	Late Formative 1 & 2 (200 B.C.E.-C.E. 500)	Middle Horizon (Tiwanaku IV C.E. 500-800)	Middle Horizon (Tiwanaku V C.E. 800-1150)
Number of samples	N=560	N=213	N=24	N=113	N=204
Reference cited	Whitehead 2007	Bruno 2008	Wright et al. 2003	Wright et al. 2003	Wright et al. 2003
Crop plant remains					
Chenopodium spp.	99	94/98*	96	99	92
Tuber fragments	67	92	16	6	3
Maize	0	0.4	20	43	24
Crop companion weedy plant remains					
Fabaceae	59	92	**	**	**
Relbunium sp.	42	71	**	**	**
Rubiaceae	0.18	51	**	**	**
Cactaceae	23	10	**	**	**
Malvaceae	93	97	**	**	**
Verbena sp.	37		**	**	**
Riverine and lacustrine plant remains					
Cyperaceae	64	91	**	**	**
Herbaceous plant remains					
Poaceae	92	98	40	57	26
Plantago sp.	4	11	**	**	**
Other					
Wood	79	99	80	91	88
Dung	13	8	88	98	91

*Includes *Chenopodium quinoa* and *Chenopodium* spp. respectively
**Authors lumped these taxa into single weedy category

Several varieties of chenopods are cultivated today in the *altiplano* including numerous varieties of the globally celebrated species *Chenopodium quinoa* (quinoa) and the drought tolerant *Chenopodium pallidicaule* Aellen (kañawa). Thought to be domesticated in the region approximately five millennia ago (Planella et al. 2015:59), chenopods are thus well adapted to the inter-annual variation in the climate and the harsh ecology of the *altiplano*. Quinoa in particular, was a staple food crop to populations residing on the southwestern shores of Lake Titicaca by 1,500 B.C. (Bruno and Whitehead 2003), and another domesticated variety was grown in the southern *altiplano* by 1,200 B.C. (Langlie et al. 2011). As farmers intensified production during the Formative Period, chenopods' social and ritual importance increased (Bruno 2014; Bruno and Whitehead 2003), and by Tiwanaku times they were one the most ubiquitous and abundant crops recovered from all archaeological contexts (Wright et al. 2003).

Several tubers and roots were domesticated or semi-domesticated as food crops in the Andes, including the potato, oca, mashwa *(Tropaeolum tuberosum* Ruíz & Pav.), ulluco (*Ullucus tuberosus* Caldas), and maca (*Lepidium meyenii* Walp.) (Pearsall 2008). These plants are adapted to environments with poor soils, constant erosion, and unpredictable rainfall and temperatures. These are all environmental characteristics of the steep slopes of the Andes (Flores et al. 2003:161). The domestication of tubers is difficult to document archaeologically, since they preserve poorly and are rarely recovered. Genetic analyses indicate potatoes (Spooner et al. 2005) and oca, a sweet tasting root tuber (Emshwiller and Doyle 2002), originated in northern Bolivia and southern Peru. These studies consistently name the *altiplano* as a geographic locale where domestication occurred. Indeed, native crops were naturally adapted to the climate and ecology of the *altiplano* long before humans began selecting and cultivating them as crops.

After the residents of the *altiplano* were conquered by the Inca around A.D. 1450, people who resided in the Titicaca Basin were famously productive potato and quinoa farmers and camelid herders according to ethnohistoric sources (Murra 1968:52). These commodities were provided as staple finance to the Inca Empire.

Camelids

Along with these crops, two species of camelids were domesticated in the Andes: the llama (*Lama glama* L.*)* and the alpaca (*Vicugna pacos* L.). These animals have long been exploited as sources of meat, hide, fiber, dung for fuel, and beasts of burden (Mengoni and Yacobaccio 2006:228). The wild relatives of domesticated camelids were hunted throughout the Archaic Period of the southern Andes. According to Mengoni and Yacobaccio (2006:239), camelids represented 85-100 % of the faunal assemblage in the south-central Andes from 5300 to 3000 B.P. This close relationship between humans and their prey resulted in camelid domestication. With their larger and sturdier frames and ability to thrive on sparse pasturage typical in the *altiplano*, llamas have been a primary component of the economy in the region since the Archaic Period.

Camelid pastoralism has long shaped lifeways in the *altiplano* including how communities organize daily activities, settlement patterns, and community organization centered around tending to herds. Often anthropologists think of pastoralists as primarily nomadic peoples who mobilize their herds to seasonally graze in the most fertile pastures. However, in ethnographic researchers have found that among pastoralists some groups relocate their herds and settlements several years apart, rather than annually (Gifford-Gonzalez 2005:188). In the *altiplano* today, pastoralists are sedentary and semi-sedentary and they have long supplemented their own and their herds' diets with homegrown crops. Similarly, in lean years, crops can be substituted for llama meat. This crop-meat combination affords farmers in the region higher degrees of inter-annual resilience.

Intensifying Agropastoralism in the Andes

Farmers in the *altiplano* have had two local options to increase their resource base to offset food shortages in lean years. They could intensify crop production or increase camelid herd size. To intensify agricultural production, farming families could bring more land under cultivation or decrease fallow time. Today, farmers in the region prefer to let their fields lay fallow for seven years. To intensify production, they could let fields rest for shorter periods of time between plantings (Guillet 1987:87). While these strategies increase output per unit of land over the short-term, reducing fallow periods in the *altiplano* leaches fertility from already nutrient-poor soils, leading to decreased yields over the long-term (following Boserup 1965). To make this system more sustainable, camelid herding on fallow plots provides much needed fertilizer to soils (Guillet 1987:84). However, if herd sizes are increased too much (or fallows are decreased too much) problems such as overgrazing and erosion can arise (Browman 1987).

To increase herd size, Kuznar (1991) ethnographically documented that herds belonging to extended families were grazed collectively on land belonging to nuclear families. Doing so ensured that pasturage had the chance to rejuvenate between grazing periods. Indeed, herding in the Andes is often organized at the supra-household level because herding a few animals requires the same amount of labor as tending to a herd of hundreds (Browman 1987:139). Indeed, I witnessed two children around the ages of eight years old bringing in a large mixed herd of llamas and sheep near Ayawiri using nothing but slings to drive their animals. At the same time, pastoralists do not want to increase herd sizes too much. Highland pastoralists consciously work to keep herds low enough to prevent overgrazing, erosion and soil compaction (Browman 1987).

Zonal Complementarity: Trade Relations and Insurance

Andean peoples have long been engaged in trade, exchange, importation, and the circulation of goods with family, friends, and neighbors across vertical biotic regions as a type of insurance policy to overcome local ecological and climatic challenges. During lean years, agropastoralists can rely on goods produced in distant productive ecologies. Indeed, Andean political economy frameworks are anchored in the idea that people have participated in a web of trade and exchange with, and colonization of diverse ecologies for millennia. Murra (1968) developed an economic model of accessing and distributing resources based on documented European observations made of indigenous populations, the Lupaca, living in the *altiplano* during the 16th century.

Camelid caravans have played a critical role in these webs of socioeconomic interactions in historic eras, transporting large quantities of bulk goods across the cordillera from the coast to the Amazon traversing numerous vertical ecologies (Browman 1971:193-194). Extending this model back in time, it has been suggested that as the importation and circulation of goods intensified across regions, this system produced complex relationships between individuals and communities and stable pristine states in several locations in the Andes. These caravans formed supply chains across the cordillera starting in the Formative Period. Material goods produced in distant regions have been found in *altiplano* Formative Period contexts including salt, obsidian, and craft items (Burger et al. 2000; Janusek 2008:72; Rivera 2001:21-24; Stanish 2003; Tripcevich 2010). Similarly, *altiplano* goods have been found in distant regions including dry coastal valleys, such as Moquegua, the Atacama Desert of northern Chile, and humid eastern valleys including Huancané and Putina (Goldstein 2000; Mujica 1985). During the Middle Horizon, some researchers believe the role of cities, such as Tiwanaku, was to act as hubs facilitating trade and exchange for traveling llama caravans (Browman 1978, 1981; Ponce Sanginés 1981, 1991). The circulation of goods between the Tiwanaku core and peripheral colonies in the lowlands intensified during the Middle Horizon (Browman 1978). Although llama caravans continue to facilitate low-volume trade and exchange in parts of the Andes today, trains, airplanes, and trucks provide transport in the modern era.

The high altitude, dry and cold weather, and soils with high saline content make it nearly impossible to grow maize, coca, and other symbolically valued plants in the *altiplano,* and thus identification in the archaeological record implicates these perishables were brought into the region by humans via exchange networks. Maize has proved to grow in small quantities in confined ecotopes around Lake Titicaca where nighttime frosts and daytime temperatures are mediated by lake temperatures; however, this does not disprove that it has long been traded into the region from afar. The earliest evidence of maize in the region was identified by Logan and colleagues (2012). They found microbotanical remains in ritual ceremonial contexts, dating back to the Middle Formative Period (800-250 B.C.) recovered from the ceremonial mound at Chiripa. During the Middle Horizon, imported maize was a cornerstone of the local diet for people who resided at Tiwanaku. It was there that researchers found macrobotanical maize remains to be the second most ubiquitous crop type recovered (Wright et al. 2003). These researchers argue the abundance of maize at Tiwanaku could only have been achieved through importation. Maize cupules, glumes, and kernels have been found in elite, commoner, domestic, and sacred contexts at Tiwanaku. Consumed as chicha beer, maize also served the function as an everyday and ritually important beverage. Further research has revealed maize was brought into Tiwanaku from Cochabamba and Moquegua, based on distinct morphologies of cobs and kernels of archaeological specimens recovered from Tiwanaku (Hastorf et al. 2006).

Coca, a mild stimulant, was also imported through trade networks from the eastern slopes of the Andes in the lower elevation *yungas* biotic zone. Coca was an important ritual plant at Tiwanaku (Hastorf 2008:550), and continues to be imported to the region in significant quantities today. Perishable goods likely traded through camelid caravans mostly served ritual and symbolic functions, such as maize partaken in the form of chicha beer, or coca used as a stimulant during community gatherings. However, in lean years when crops failed due to local climatic challenges, *altiplano* residents may have relied on these exchange networks to supplement their basic subsistence needs.

Domesticated Landscape Types in the Lake Titicaca Basin

In order to make the harsh Lake Titicaca Basin ecosystem more amenable to agropastoralism, ancient farmers engineered the environment. Farmers built raised fields and turned ponds into sunken gardens in valley bottoms, they expanded wetlands along lakes and rivers, and they terraced hillsides. These field systems each have unique features that increase crop yields and provide buffers against climatic perturbations.

Raised Fields

The Titicaca Basin is estimated to contain one of the largest concentrations of pre-Colonial raised fields in the New World (Turner and Denevan 1985). In Quechua these fields are called *suka collas,* in Ayamara *waru* (or *waru-waru*), and in Spanish *camellones.* Raised fields are made up of dug out canals and raised platforms of earth artificially elevated above the natural level of soil (Erickson 1992:289). While farmers have abandoned most raised fields since pre-Colonial times, archaeologists have been able to identify approximately 1,200 km^2 of relic-raised fields in the region (Kolata and Ortloff 1996:113). These field systems are primarily located in areas around Lake Titicaca and other ecotopes that are seasonally inundated with precipitation (Erickson 2000:334).

When field systems are flooded, crops are planted on the earthen platforms (Erickson 1985:209). Hydraulic infrastructure and the flooding system of the canals are central to the success of raised field cultivation (Erickson 1993:381). Algae that thrives in the canals can be mucked out and used as fertilizer to increase the fertility of planting beds. Generally, raised fields that have been identified conform to this architectural description; however, the layout of canal networks varies from region-to-region (Erickson 2000:333; Kolata and Ortloff 1996:120).

In the northern part of the Lake Titicaca Basin, researchers have found that raised fields were built during the Formative around 1000 B.C. and cultivation continued until A.D. 1476, coinciding with the arrival of the Inca conquest of the region (Erickson 1993, 2000). Near Tiwanaku in the Southern Lake Titicaca Basin, researchers have found that raised fields were constructed during the rise of Tiwanaku around A.D 600, and use significantly dwindled between A.D. 1000 and 1476 (Janusek and Kolata 2004:420-421; Kolata 1993:293-294). Why were raised fields abandoned in prehistory? Kolata (1993) speculates they were abandoned due to a major drought during the Late Intermediate Period. Raised fields are less productive than previously thought (Bandy 2005; Swartley 2000, 2002). Additionally, a large amount of labor is required to build and maintain raised fields. In the absence of a centralized political authority (like Tiwanaku or the Inca) who organized and mobilized farm labor, perhaps there was no incentive for local residents to continue farming in this costly way.

The attention and scrutiny researchers have paid to raised fields in the last three decades has shed much light on the history and productive potential of the landscape. Erickson (1982, 1985, 1987, 1988a, 1992a, 1992b, 1993) Kolata (1986, 1991), and their colleagues have most prominently led investigations to unravel the pre-Colonial potential of these earthworks. More recently, Swartley (2000, 2002) and Bandy (2005) have contributed a more nuanced understanding of the productive capacity of raised fields. This research provides the foundational data for understanding the agricultural history that underpinned political developments in the region. Additionally, copious research on raised fields provide a theoretical framework for understanding terraces. Furthermore, the methodology previously employed to study raised fields, has afforded insights that guided this research on the terraces at Ayawiri. Throughout this dissertation I reference Titicaca Basin raised agricultural fields research, as it is relevant to the methodologies I employed, and chronological and theoretical interpretations of the Ayawiri terraces.

Qochas (or cochas)

In the *altiplano* any natural or artificial depression in the *puna* that contains water is referred to as a *qocha* and some have been expanded by humans (Flores Ochoa 1987). They are primarily found in isolation; except in the northwest area of the *altiplano* where there is a concentration of *qochas* that has interlocking canal networks (Erickson 2000). A study by Craig et al. (2011) found 11,737 *qochas* in northern *altiplano* region of the Rio Pucara-Azángaro interfluvial zone. Many of these sunken fields are still used by farmers to grow crops and as watering holes for grazing livestock. Like raised fields and terraces, q*ochas* create a small microenvironment on the landscape that protects crops from frosts (Erickson 2000:341).

Qochas are different from raised fields because they rely on rainwater rather than groundwater from springs, lakes, or rivers. *Qochas,* depending on design, permanently or seasonally are filled by precipitation. Q*ocha* agriculture does not require large amounts of labor to construct or maintain. Indeed, individual families claim ownership and manage up to six or seven *qochas* in the Titicaca Basin today (Erickson 2000:341). Craig et al. (2011) found that 94% of the *qochas* in their study area sat on top of lacustrine layers of clay deposited by a

Pleistocene paleolake. This clay created a geologically less permeable stratum upon which precipitations collects in natural and artificial depressions on the landscape.

Research on *qochas* in the northern Titicaca Basin indicates in this region they were initially built, expanded, or exploited during the Middle Formative Period based on the recovery of ceramic sherds stylistically corresponding to this time period (Craig et al. 2011:2906). These *qochas* were being exploited by at least 500 B.C. and these fields were used continuously up until the present day. One of the largest concentrations of *qochas* in the *altiplano* is near the Late Formative site Pukara (Erickson 2000:341). In the lower Tiwanaku Valley *qochas* are found in close proximity to Early and Middle Formative Period sites dating from 1800 to 900 B.C. (Albarracín-Jordan 1996b). The low labor necessary to build, maintain, and farm *qochas* and the small yields from these fields means that there is little chance that state mandate oversaw construction or redistribution of harvests. However, this type of agriculture might have provided complementary food stores to crops produced in large field systems. Q*ochas* have long been used as watering holes for grazing livestock herds and their herders as they travel across the region.

Bofedales

Found throughout the *altiplano*, *bofedales* are managed, and constructed marshes, moors, or grassy meadows with standing or running that water collects in the *puna* (Flores Ochoa 1987:66). In flat locations or depressions in regions with clay soils the drainage is poor. *Bofedales* are formed when run-off of water from rivers and streams, as well as uphill precipitation, snowfields, and glaciers collects in these locations. A reliable water supply encourages natural growth of year-round rich grass stands and sedges that proves essential food sources for grazing herds of camelids in the dry season.

Farmers created and expanded lush *bofedales* throughout the *altiplano* by constructing small irrigation canals. Canal systems are reinforced and water is rerouted over larger areas of land using blocks of sod that take root and form grassy natural water channels (Erickson 2000:342). Silt reservoirs and silt dams are also built to route running water to form *bofedales* (Lane 2009:172-173). These constructed landscapes need to be constantly maintained, and today, *bofedales* canals are cleaned out once a year (Erickson 2000:342). Today, ownership of *bofedales* is distributed amongst families and passed down patrilineally; however, since the labor demands require that silt be regularly removed from the canals, cleaning them requires the cooperation of extended families.

It is thought, based on association with nearby sites, that *bofedales* in the Illave and upper Moquegua River drainages date to the Late Preceramic (2000-1500 B.C.) (Aldenderfer 1998). At the time of Spanish conquest, large *bofedales* supported camelid herds in the Titicaca Basin (Guáman Poma de Ayala (1993[1615:780]) of approximately 1.9 million llamas and alpacas (Graffam 1992:889).

Terraces

Terracing involves excavating steep hillsides otherwise unsuitable for farming, so that flat platforms of earth are formed into viable plots of agricultural land. Terracing guards against erosion, moistens the fields by capturing rain water runoff, protects plants from valley-bottom frosts, and often increases soil nutrients as compared to conventional agriculture methods (Cook 1925:108; Dick et al. 1994; Inbar and Llerena 2000; Treacy 1989:212).

Researchers hypothesize that terraces were first constructed and farmed during the *altiplano* Formative based on their spatial association with sites and they were expanded during the Middle Horizon (Albarracin-Jordan 1996a, 1996b; Isbell 1977; Schreiber 2001; Stanish 2003). If this were the case, then terrace construction and production would coincide with general agricultural intensification that accompanied the rise of regional social complex. However, terrace construction might have been precipitated by LIP warfare and *pukara* habitation. The location of LIP settlements adjacent to hillsides has been used as indirect evidence to suggest that the Colla farmed terraces located below many *pukaras* (Arkush 2005:229-230; Stanish 2003:226). My research aims to directly clarify the period of construction and/or use at Machu Llaqta in order to illuminate the socio-political context of this monumental agricultural engineering feat.

Throughout the Andes and many parts of the non-industrialized world, terraces still provide farmers with stable and sustainable means of agricultural production. Erickson (1992:287) estimates that over 10,000 km^2 of slopes were terraced throughout the Andes in pre-Colonial times. The labor investment required to build and maintain terraces represents a greater amount of person hours than other field system type in the Lake Titicaca Basin (Erickson 2000), yet very little research has been devoted to studying the design or chronology of construction.

Dating the Chronology of Field Systems

Dating the construction, use, and abandonment of any agricultural field system, particularly terraces, is inherently difficult (Treacy and Denevan 1994:105). The contexts of ceramic sherds and charcoal are mixed into the soil matrix by the annual tilling necessary for agricultural production, so using these traditional methods of dating archaeological deposits is insufficient (Kolata and Ortloff 1996:183). Nonetheless, several studies have successfully employed various direct and indirect dating methods. These studies highlight the fact that there is no singular or generally accepted method to date the antiquity of agricultural fields. Some studies employ several dating technologies, whereas others rely on only one. In this section, first, I focus on the methodology employed to build a chronology of raised field construction, use, and abandonment in the Titicaca Basin. These studies provide locally relevant examples of how to date fields. Then I outline the methodologies used to date *qochas* and terraces in the region, and more broadly terraces throughout the Andes.

Methods used to Date Raised Fields

In the Lake Titicaca Basin, there have been scrupulous efforts to reconstruct a chronology of raised field agriculture. These studies have employed multiple lines of evidence. During the conception of my dissertation research, these previous studies provided me with an understanding of which methods were locally viable, and which were problematic. Furthermore, they provide an interpretive framework for understanding the local chronology of agricultural engineering strategies.

On the northwestern shores of Lake Titicaca in Peru, Erickson's research (Erickson 1987; 1993:389; 2000:226) facilitated a chronology for raised field construction. His chronology is based on thermoluminescence dating of ceramics and AMS dates of charcoal collected during excavations of raised field complexes. Erickson's findings lead him to conclude raised field construction and use in the region was initiated around 1000 B.C. and cultivation continued until A.D. 1476, coinciding with the Inca conquest of the region (Erickson 1993, 2000).

On the southern shores of Lake Titicaca in Bolivia, Janusek and Kolata (2004) used AMS dating on mollusk shells and carbon recovered from archaeological excavations of relic raised fields to build a chronology of field construction, use, and abandonment for that region. Based on the ratio of carbon samples dating to different periods, Janusek and Kolata (2004:420-421) conclude that raised fields were initially constructed in the region around A.D. 600, construction and use increased around A.D. 800, and use significantly dwindled between A.D. 1000 and 1476.

In both Erickson's, and Janusek and Kolata's reconstructions, they used datable materials found within the matrix of excavated fields to reconstruct a chronology of construction and use. The problem inherent to these studies is that terrace soils are purposefully overturned by farmers to promote soil fertility, discourage weeds, and encourage crop growth leading to a disruption of the stratigraphy of artifacts. Thus, the stratigraphy and contexts where artifacts, such as ceramics and carbon, were found in the fill of these fields is susceptible to high degrees of mixing. Artifacts could have been deposited in the soils before they were engineered and then mixed into the matrix leading to an erroneous interpretation of the antiquity of field systems. Additionally, some soil may have been brought in from places where older artifacts were buried, such as Formative Period middens. Artifacts from later time periods discarded by passerbys could lead researchers to interpret an incorrect delay in the date of abandonment. While the methodologies used by these studies are susceptible to producing a false date of construction and abandonment, at the very least, they have begun to shed light on the time periods raised fields were in use.

Kolata (1993) also looked at data derived from the Quelccaya ice cores procured from a nearby glacier to pinpoint the history of raised field use in the Titicaca basin. Specifically, he looked at the ice cores for any evidence of significant levels of soil movement in the region. While the ice cores provide a particularly refined regional climatological chronology that I explained in Chapter Two (see Thompson et al. 1998; Thompson et al. 1979), Kolata's (1993) interpretation is particularly novel. He determined that increase in sediment deposition in the cores peaked between A.D. 600 and 920. The increase in soil accumulation is attributed to the dust created by earth-moving that would have been required to construct the apparent raised fields in the circum-Titicaca region (Kolata 1993:285). Additionally, Kolata (1993:293-294) determined that after A.D. 1000 declining precipitation led to problems with the irrigation and groundwater that fed the raised fields. He postulates that raised fields were subsequently abandoned during the fall of the Tiwanaku state. While these interpretations of the Quelccaya ice cores are tantalizing, the data the Kolatas used to make these inferences are indirect and, for the time being, inconclusive. While there were development efforts in the 1990s to bring relic raised fields back into cultivation, these projects failed (Swartley 2002). Today, raised fields are not cultivated in the *altiplano*.

Methods used to Date Qochas

No direct date has been established for the initial construction of *qochas* in the *altiplano*. Based on close proximity to dated archaeological sites, Kolata (1993:294) believes *qochas* in the southern Titicaca Basin were in use during the Middle Horizon. Albarracín-Jordan (1996b) notes *qochas* in the lower Tiwanku Valley are found near sites that were occupied rom the Formative Period (1800-900 B.C.) to the present era. In the northern Titicaca Basin, Craig et al. (2011:2906) found *qochas* in this region were used as early as the Middle Formative around 500 B.C. based on the recovery of ceramic sherds that stylistically date to this time period. *Qochas* were most intensively used during the Late Formative Period based on the recovery of large quantities of Pukara-style ceramics and their use dwindled in later time periods. Nontheless, this team found pottery diagnostic to all time periods thereafter the Late Formative in association with *qochas* indicating perpetual use into the modern era.

Kolata (1993:294) predicts during the drought recorded in the Quelccaya ice core around A.D 1000, the groundwater dried up and *qochas* were no longer productive during the LIP. Nonetheless, many *qochas* are still being productively used by farmers and pastoralists (Craig et al. 2011).

Methods used to Date Andean Terraces

Only one archaeological study that I have found has focused on dating agricultural terraces in the Lake Titicaca Basin. On the Copacabana Peninsula, Chavez (2012) recently excavated and surveyed agricultural terraces. Based on ceramic styles of artifacts he recovered Chavez attributes the inception of terrace construction in this area to the Formative Period. Artifacts found during surface collections provide tenuous data, at best, regarding the antiquity of terraces. These ceramics could have ended up there in a number of ways unassociated with the actual construction and use of the hillside for farming purposes, particularly because a Formative site is located above the terrace complex. Nonetheless, Chavez provides valuable insight into the potential age and use of terraces in the area. At the same time, this study focuses on one terrace complex in the Titicaca Basin, and there are many more throughout the region that remain unstudied.

Elsewhere in the Andes, researchers studying terraces rely on methods similar to those used to date raised fields. A recent study in the Chicha-Soras Valley in the Ayacucho region of Peru, used AMS to date eight fragments of charcoal obtained from the fill of terraces (Branch et al. 2007). Based on the dates obtained, this team believes the agricultural terraces likely date to A.D. 600. In the Colca Valley near Arequipa, Brooks (1998) used seriation of pottery collected from survey to date terrace construction and use between A.D. 600 and 1530. In the same valley, a series of 17 radiocarbon dates on bulk soil from terrace fill confirms that terraces have been in use since A.D. 500 (Sandor 1992). These projects relied on a single artifact or ecofact type to date the antiquity terrace complexes.

AMS dating of bulk soil samples has been one of the preferred methods used by researchers dating terraces (e.g. Sandor 1992). However, this method has been determined faulty by soil scientists. Dating bulk soil samples measures the amount of organic material in a sample and can both overestimate and underestimate the true age of samples due to differences in climate and soil depth (see Wang et al. 1996). Based on this I have chosen not to employ this method in my research.

Hypotheses about the Age Titicaca Basin Terraces

In the *altiplano*, researchers have hypothesized that terraces were first constructed and farmed during the *altiplano* Formative Period based on their close proximity with sites and expanded during the Middle Horizon (Albarracin-Jordan 1996a; Isbell 1977; Stanish 2003). If this were the case, then general terrace construction and use would coincide with general agricultural intensification that accompanied the rise of regional complex society and centralization of political authority. The location of LIP settlements adjacent to hillsides has been employed by a few researchers as indirect evidence that the Colla farmed terraces located below many *pukaras* (Arkush 2005:229-230; Stanish 2003:226). Others believe the Inca were responsible for a majority of terrace construction in the region (e.g. Janusek 2008:184). If built during the Late Horizon Period, there would have been a centralized political authority to organize construction, oversee labor, and schedule production.

Drawing on these hypotheses and what is known about the occupation history of Ayawiri, it is plausible that the terraces at the site were built in the Formative, the Late Intermediate, or the Late Horizon Period. Artifacts found on the surface of the site during survey and evidence found during excavations indicate there was a substantial population residing at Ayawiri or nearby during all these time periods. My research aims to directly clarify the period of construction and use of the terrace complex at Ayawiri in order to illuminate the sociopolitical context of this monumental agricultural engineering feat.

Choosing Safety or Security at Ayawiri

With this agricultural history in mind, I turn my attention to looking at how farmers adapted to both social and climatic challenges in the Lake Titicaca Basin during the LIP. Risk management theory in anthropology examines how individual farmers and groups or people develop novel economic strategies to cope with inter-annual weather variance and difficult environments. For example, in the Cuyo Cuyo region of the Department of Puno, nearby the study region, farmers own and annually cultivate numerous small plots of land in various microenvironments. Indeed, this practice of *field fragmentation* is common throughout the Andes. Many agroecologists originally considered this practice as inefficient because farmers spent an inordinate amount of time and energy traveling and carrying farming tools from one field to another and then hauling harvests all the way home. Time could have been better spent and yields would rise, according to agroecologists, if farmers cultivated bigger plots of land more intensively near the home front. Nonetheless, Carol Goland (1993:318) drew on risk management theory and found that while yields were reduced 7% due to travel time to distant plots, the overall variance in farmers' annual harvest was lessened. In any given year, fields in certain microenvironments thrived while others failed, due to minor differences in the climate.

Traditionally, research on agropastoral risk management has focused on these types of farming strategies that mitigate the probabilistic inter-annual variance in climate, which can lead to crop failure, food shortages, and even starvation (Adams and Mortimore 1997; Augustine 2010; Browman 1987, 1997; Gallant 1991; Halstead 1990; Howden et al. 2007; Marston 2011; O'Shea 1989). This literature focuses primarily on how present and past agropastoralists adapt to the local physical environment, without consideration of the political landscape of an era. In contrast, recent research has highlighted the effects of social realities, such as warfare, on food procurement and nutritive quality (Ferguson 2006; LeBlanc 2006; LeBlanc and Register 2003; Milner et al. 1991; Otterbein 1999; VanDerwarker and Wilson 2016; Zori and Brant 2012).

Building on this work, I assess *both* social hazards *and* environmental risks at Ayawiri. Doing so affords more holistic and realistic insights into risk management employed by past populations. This model of agropastoral risk management was initially laid out in Langlie and Arkush (2016) and is elaborated on in this dissertation. Agropastoral subsistence strategies in the Andes are inherently flexible. In years when crops yields are lean populations substitute camelid meat and vice versa (Browman 1987). With this flexibility, I assert Andean populations are able to adapt to either warfare or climate variability; however, different strategies would be chosen depending on which source of risk was prioritized. The relationship between social and environmental pressures creates a context for trade-offs seen in ancient peoples' economic choices. By observing the specific combination of agricultural strategies implemented during a specific time period, archaeologists can pinpoint whether adjusting to social hazards and environmental risk was prioritized by past farmers.

In this context I distinguish among two kinds of risks: 1) *environmental risk* caused by climatic variability; and 2) *inter-group hazards* caused by conflict between communities or enemies. In reviewing ethnographic and archaeological literature about agropastoralism, it is apparent that strategies adapted to cope with environmental stress are qualitatively different than those adapted to deal with conflict. Thus, I propose that it is possible to measure ancient farmers' perceptions of these stresses in the past, or at least which ones they prioritized in adapting to by identifying which risk management strategies were chosen (Table 4.2).

Environmental Risk

In the frost and drought-prone *altiplano*, perturbations in the climate such as a prolonged drought have a specific influence on subsistence strategies. Ayawiri residents would need to have mitigated the impact that environmental risks had on the inter-annual variability in the food supply. Farmers deal with inter-annual variability logistically both in terms of crop management and choice of field locations.

Inter-group Hazards

The threat of warfare drove resettlement to defensive hilltop fortresses during the LIP, often on marginal lands. This choice of location affected food production strategies. Specific cropping schemes, field locations, and camelid grazing areas could be adjusted to a context of violent conflict if the threat were severe. For example, planting crops and grazing camelids near the site would reduce exposure to enemy attack by reducing time spent outside fortifications (Milner et al. 1991; VanDerwarker and Wilson 2016).

How can we assess the impact of these stresses on the lives of prehistoric populations? Drawing on ethnography, traditional ecological knowledge, historical data, and comparative archaeology, I devised a model to assess the trade-offs between environmental risk and inter-group stress. This model is specific to agropastoralism in the *altiplano*, but has the potential to be adapted elsewhere. The analysis of several behaviors that are sensitive to these risks is targeted including choice of field location, grazing strategies, and types of foods present at the site. These behaviors can be assessed using data gathered from analyses of macrobotanical remains recovered from the residential area of the site, through comparing these data to the landscape surrounding Ayawiri, and through dating the chronology of terrace construction and use at the site.

Table 4.2: The impact of environmental risk and warfare on farming strategies.

		Effects on :	
Strategy		Environmental risk	Inter-group risk of attack
Field location	*Field fragmentation*	↓ risk of crop failure	↑ farmers' risk of attack and crop raiding
	Intensive farming	↑ risk of crop failure and depletes soil nutrients	↓ risk of attack because farmers remain closer to fort
Grazing strategy	*Extensive grazing and on wild plant stands*	↓ risk of crop failure	↑ camelid exposure to theft
	Grazing in fields and on crop plants	↑ risk of crop failure	↓ camelid exposure to theft
Type of foods consumed	*Diverse diet*	↓ risk that harvest will fail	↑ risk of exposure to attack because traversing diverse ecologies
	Constrained diet	↑ risk that harvest will fail	↓ risk of exposure to attack because traversing diverse ecologies

Field Location

Regarding environmental risk, farmers recognize that micro-environmental differences in climate mean that they never know whether a specific crop or variety will prosper in any given year (Baksh and Johnson 1990:212). To deal with this issue, farmers often cultivate fields in various locations, a practice known as *field fragmentation*. In the Andean context field fragmentation appears as a form of spatial diversification that capitalizes on diverse ecotopes to hedge against local climate variability (Browman 1987; Bruno 2011; Chibnik 1990; Goland 1993; Marston 2011; McCloskey 1976; Stone and Downum 1999). Simultaneously farming in multiple ecotopes, such as locating fields in wetlands, at low elevations, and higher up on hillsides, takes advantage of natural microclimates (Browman 1987; Bruno 2011; Marston 2011). In an environment where water is already scarce, field fragmentation would have increased the probability of any individual farmers' crop success, particularly during periods of drought (Stone and Downum 1999:14). If farmers were foddering or grazing their animals on crops, then field fragmentation would also provide food security for livestock.

For the residents of Ayawiri, spatially extensive field fragmentation may have heightened inter-group stresses by increasing time spent outside of defensive zones rendering farmers more susceptible to enemy attack. Furthermore, far-away fields left unattended would be exposed to possible crop theft or damage by aggressive enemies (Netting 1973).

Under similar conditions to the social situation at Ayawiri, warring populations in West Africa intensified agriculture adjacent to areas of settlement nucleation, and farmers abandoned fields near contested frontiers to reduce exposure to inter-group violence (Netting 1973, 1974). Similarly, archaeologists working in North America have found that Pre-Columbian warring peoples' diets were constrained due to "feelings of insecurity resulting in excessive caution when conducting subsistence practices" (Milner et al. 1991:591). The threat of war meant that these people were scared to venture to river valleys and tree groves where tree nuts and other crops grew, so these food items were not a part of their diet.

If inter-group tensions were high and violence was a perceived threat to Ayawiri farmers, then we would expect them to decrease their farming range and intensify agriculture in the ecotope nearest the site. In doing so, intensification near the site would reduce the risk of attack by other groups because farmers can readily retreat to a defensive position within the fort. Nevertheless, intensifying production near the site often causes an increase in environmental risk by degrading soil fertility resulting in a subsequent decline in crop yields (Boserup 1965).

I hypothesize that if LIP Ayawiri residents abandoned frontier zones and intensified agriculture production near the site, they would have done so on the adjacent terraces. This means they would have built and farmed the terraces during the LIP. Alternatively, the terraces could have been built during the Late Formative Period occupation of Ayawiri and then reused during the LIP. Alternatively, it is also possible that the terraces were built during the Late Horizon under the mandate of the Inca who conquered the region and sought to exploit agricultural goods from subjugated populations. Dating the terraces proves critical to understanding intensification and the consequences of warfare at Ayawiri, a topic I will return to in Chapter Eight. Macrobotanical data yield further evidence regarding field location and grazing strategies, a topic I will return to in more detail in Chapter Five. Specifically, abundant and diverse macrobotanical remains that grow in multiple ecotopes would point to an extensive agropastoral land-use strategy, while a low abundance of plant remains from riverine and the valley-bottom ecotopes would point to probable agriculture intensification on the terraces.

Grazing Strategies

Like field location, peoples' choices regarding grazing and foddering camelids would have been made with sensitivity to both environmental and social stresses. In other parts of the world, if farmers' yields are lean, then crops are reserved for human consumption, while domesticated animals are grazed extensively or foddered on wild plants (Boserup 1965; Marston 2011). Extensively grazing animals might also decrease intra-group tensions sparked by grazing on their neighbors' field crops. Unless farmers were actively amending the soil with dung, extensive grazing might decrease cultivated soil productivity. Additionally, extensive grazing would expose livestock to possible raids. Nevertheless, it is worth noting that in comparison to agricultural field fragmentation, grazing on wild stands requires fewer people to be exposed to possible attack outside of defensive hillforts. Depending on the size of the herd, only a single person or a few people need to accompany the herd to pasture (Browman 1987:139), putting very few people in harm's way.

Food Choices

Social and environmental factors affect choices about the varieties of crops grown and types of animal protein consumed by populations. For example, diversification among agropastoralists hedges against the risk of failure of any one crop or loss of herd animals due to climatic forces (i.e. frost or drought) or disease (i.e. nematodes or animal sickness) through the production of multiple agropastoral products with different resistances and different rates of maturation (Browman 1987; Marston 2011). By employing a diverse economic strategy, agropastoralists can readily make seasonal, annual, or inter-annual shifts in time spent herding or farming in order to account for environmental fluctuations as well as social situations. However, inter-group conflict can affect a community's access to fields in distant ecotopes, grazing areas, and hunting grounds. For instance, based on bioarchaeological data, Milner et al. (1991:590) inferred that prehistoric warfare in North America actually decreased the types of plants in local diets because peoples' daily activities were constrained; recent macrobotanical analysis in this region confirms Milner's conclusion (VanDerwarker and Wilson 2016).

Conclusions

To summarize, agropastoralists in the Andes developed an array of crop varieties, land use strategies, and farming systems to cope with the environment. This farming system was developed, passed down from one generation of farmers to the next, and finely tuned over millennia. During the turmoil of the LIP these strategies were surely impacted in specific ways. We know from ice cores and other climate proxy there was a drought during the early part of the LIP. While paleoclimate records provide complementary information about the past environment, they do not reveal how humans responded to climatic fluctuations. We also know that warfare intensified during the latter part of the LIP (Arkush 2008; Arkush and Tung 2013). By assessing strategies chosen by Ayawiri farmers in prehistory, insight can be gained, not into a perfectly rational set of decisions, but into how farmers perceived environmental risk and social hazards in their time. Placed within a paradox of trade-offs, the residents at Ayawiri were forced to develop a specific combination of subsistence strategies. The benefit of engaging in any one risk mitigation strategy may or may not be offset by an equivalent cost. In this dissertation I aim to identify exactly how farmers dealt with environmental risks and social hazards during the LIP. In doing so, an assessment can be made of the impact of the drought and the consequences of warfare on lifeways at Ayawiri.

Chapter 5. Methods

In Chapter Five I describe methods and procedures followed in the field and in the laboratory. This dissertation includes data collected during two seasons of excavations with Proyecto Machu Llaqta at Ayawiri, where I oversaw recovery and subsequent analysis of botanical remains. There is also data from excavations of the terraces adjacent to the site. Here, I outline the excavation methods implemented during each phase of research, permissions received from Peru, artifact analyses, dating methods, archaeobotanical field methods, and macrobotanical laboratory methods. In this section, there is also an explanation of the terms used to describe excavation procedures.

Excavation Methods

In 2011, Dr. Elizabeth Arkush invited me to serve as an excavation supervisor for Proyecto Machu Llaqta at the site Ayawiri while simultaneously overseeing collections and analysis of archaeobotanical remains. These excavations were carried out primarily within the residential sector and the cemetery of the site from June through July 2011 and June through July 2012. During this time a team of researchers originating from the U.S., Peru, Chile, and Colombia conducted a formal survey of the site, and both horizontal and deep penetrating excavations of houses, domestic spaces, and burials at Ayawiri. During July and August 2013, I returned to Ayawiri and directed excavations of the adjacent agricultural terraces.

Permissions

Each phase of excavation required new permissions from the Ministerio de Cultura de Peru. In 2011 and 2012 the project titled *Proyecto Machu Llaqta: Jerarquía Social en la Cuence del Titicaca – Puno (Excavación)* was directed by Dr. Elizabeth Arkush (University of Pittsburgh, R.N.A. CA-0052) and Lic. Rolando Paredes Paredes (R.N.A. DP 90-17). In 2011 excavations were permitted by Resolución Directoral Nacional No 023-2011 (14 June 2011), and in 2012 as part of the Resolución Directoral Nacional No 412-2012 (22 June 2012). In 2013 the project *Proyecto Machu Llaqta: Terrazas Agrícolas en la Cuenca del Titicaca, Puno, Temporada 2013* was permitted by Resolución Directoral Nacional No 036-2013 (25 July 2013).

Excavation Protocol

Excavation methods, procedures, and forms were planned and standardized before excavations began in the residential area of Ayawiri in 2011. For consistency, these same methods were implemented in 2012. These protocols are detailed by Arkush and Paredes (2012) and Arkush and Paredes (2013). I modified these protocols when I dug the terraces in 2013 due to the differences in the goals of the excavations, and because I expected to encounter significantly less complicated stratigraphy and a much lower density of artifacts in the terraces compared to the residential sector. Here, I detail the vocabulary, coding systems, and excavation protocol implemented during the 2011 and 2012 field season (from Arkush and Paredes 2012, 2013). Throughoutn this chapter, I also explain how procedures and protocols were modified during the 2013 terrace excavations.

Excavation Vocabulary and Contextual Nomenclature

We used a locus system to record all contextual information. For this study, a *locus* was the smallest unit of excavation and could be composed of an arbitrary stratum of soil, part of a stratum of soil, a small distinguishable architectural feature such as hearth, or a portion of a floor depending on the context. Loci were laid out in a Harris Matrix (method described by Harris 1975, 2014) for ease of chronological analysis, and helped us determine *ad-hoc* the order strata, architecture, and artifacts recovered from the archaeological record.

During excavations of the terraces, loci were grouped into distinguishable events whenever possible. An *event* was designated as a natural or cultural stratum and could be composed of a soil texture or color change, an architectural component such as a wall, a hearth, or a burial. Grouping loci together into events allowed excavators to swiftly identify how loci, stratigraphy, architectural features, and artifacts were associated with one another in the field during excavations, and later how things related to one another in the lab during analysis.

We used a contextual code during all phases of excavations to record each locus and associated artifacts (e.g. V2-1002/4). This code includes the site designation, the locus number, and a slash number. The first part of the code, V2, refers to Ayawiri (the second site identified by archaeologists working in the Vilque area, and the number is officially registered with the Ministerio de Cultura de Peru). The second part of the code is a unique four-digit number corresponding to the locus, such as 1002. During 2011 loci are in 1000's, loci from 2012 are in the 2000's, and during 2013 loci are in the 3000's. The third part of the code is a unique number placed after a slash that refers to specific bags containing artifact classes from every locus, such as /3. Every locus was geo-referenced using a total station during 2011 and 2012, and entered in the project's geographic information system (GIS). In 2013, the spatial extent of every locus was manually mapped on graph paper and recorded.

Locations within the Residential Zone

The residential area of Ayawiri is divided into residential compounds by stacked stone walls and causeways. During a previous survey, Dr. Arkush assigned each compound a unique number (e.g. Compound #42). These compound numbers were used during excavations in tandem with a letter to designate excavation units (e.g. Unit #44A). Within each compound and excavation unit, Dr. Arkush used the GIS to lay out an alphanumerical grid system to refer to the location of the excavation unit.

Locations within the Terraces

Before excavations of the terraces, I mapped the terrace complex using high-resolution satellite imagery. In ArcGIS, a polygon layer was used to demarcate each identifiable terrace. This map was used to choose four terraces to excavate. Numbers were assigned to the terraces targeted for excavation. Each excavation unit is referred to by which terrace it placed on (e.g. the unit on Terrace-4 is referred to as TZ-4). Based on the layout and height of each terrace, excavators laid out a grid using nails and string in 1 m square units to aid in recording where artifacts were recovered. Within each excavation unit, each 1 m square was arbitrarily assigned a letter (e.g. A, B, C, D).

Logistics of Excavations in the Residential Area

During excavations, all contextual information was recorded on a locus form designed by Dr. Arkush. Initially, in each excavation unit we dug approximately 10 cm arbitrary levels until a natural level, artificial level, or feature was identified. Then, we followed natural or artificial levels unless they exceeded 10 cm in depth, in which case we began a new locus to better see changes in the vertical stratigraphy of the site. Ten-liter buckets were used to collect the matrix removed from each locus. All soil was sifted through ¼ inch mesh screen. The number of buckets removed from each locus was recorded, and can be used to estimate the volume of loci and events, and the standardized quantity of artifacts recovered from each context. After excavations concluded each season, units were backfilled, leaving as little trace as possible of our activities at the site, and preserving unexcavated architecture for future research.

Logistics of Excavations in the Terraces

Initially, in each excavation unit we dug approximately 20 cm arbitrary strata corresponding to single loci. Then, we followed natural or artificial levels unless they exceeded 20 cm in depth, in which case we begun a new locus.

Once an area was selected for excavation, we placed a large nail which served as a temporary local datum near the unit. During excavations all elevations of units were recorded using a string attached to a line level and a measuring tape to measure elevations below the local datum. I used a GPS to record the UTM's and elevation of each local datum.

We backfilled each excavation unit in the terraces after digging concluded. I consulted with the local landowner to plan the logistics of backfilling since we were reconstructing his family's actively farmed fields. Additionally, the landowner has much experience seasonally rebuilding dilapidated terrace walls on his property. He directed the locally hired excavators to first rebuild the primary retaining walls with the largest stones placed near the bottom of the walls and smaller stones near the top. I surmise the larger stones provided the most stability near the bottom of the terrace riser where the load of the soil would have been the heaviest. Near the top the weight of the soil placed on the riser walls was less, so smaller stones were sufficient to provide support. Next, the landowner advised that we place large stones in the bottom of the excavation unit. This would provide a solid foundation and encourage water runoff. Finally, we filled in the excavation unit with the remaining sieved soil, ensuring that our excavation units were compressed to the same level as the surrounding terrace. I documented this process of reconstruction, as it provided me with ethnographic insight into how local peoples are still using and rebuilding the terraces today.

Recording Excavations in the Residential Area

At the termination of each locus, excavators drew a sketch of artifacts *in-situ* and digitally photographed the units. Nails were placed in the corner of each excavation unit, so that they were visible in overhead photographs. An extendable camera boom was used to take overhead photographs. Using a total station, we recorded the location and elevation of nails in each photograph. These total station points were used to geo-reference the termination of all loci and photographs of events in the project's GIS. In conjunction with sketches, these photographs were then used to digitally delineate the location of features and artifacts in the GIS.

Excavators drew and recorded notable events and *in-situ* artifacts on 1 mm graph paper. These notable events included profile and plan views of hearths, architectural elements such as wall stones, burials, and concentrations of artifacts. Profiles of every excavation unit were also drawn on 1 mm graph paper. Notable events and significant *in-situ* artifacts were also digitally photographed, georeferenced, and digitally delineated in the project's GIS.

Recording Excavations in the Terraces

During excavations of the terraces, we followed similar recording procedures. The same locus forms were used, and the same drawing protocol was implemented. Overhead digital photographs were also taken of each unit at the end of every locus. However, we did not geo-reference these photos for two reasons: first, there was very little architecture to photomap within the terraces; and second, I did not have a total station during these excavations. We documented walls and other features on metric graph paper. This was accomplished using metric tape measures and a plumb bob to measure point proveniences using X and Y coordinates from the edges of excavations units. We used a local datum with a string and line level to record the elevations of the loci and features. The local datum was geo-referenced using a hand-held GPS.

Cataloguing Artifacts

During excavations in 2011 and 2012 in the residential area and during 2013 in the terraces, artifacts recovered from the ¼ inch mesh screen, such as ceramic fragments, lithic materials, animal bones, and charcoal, were separated into labeled bags according to artifact type and noted on excavation forms. Every bag was labeled with the site number, associated locus, and unique slash number corresponding to each bag of artifacts (e.g. V2-1101/1 for ceramics, V2-1101/2 for lithics, etc.). Tyvek tags marked with corresponding catalog numbers in permanent marker were placed inside each artifact bag. Soil color, soil composition, general artifact type and density, and any other distinguishable trait of a context were recorded on excavation locus forms.

At the end of each day of excavations, all artifacts recovered *in-situ* and from the screen were brought back to the field laboratory located at the project's temporary residence in Tiquillaca. Each night, excavators ensured that all artifact bags were accounted for, and properly labeled Tyvek tags were placed inside each labeled plastic bag. All artifacts were then washed, dried, counted, weighed, and placed back inside bags by a team of locally hired staff. After excavations, all artifacts were boxed, labeled, registered with the Ministerio de Cultura de Peru, Puno, and curated in the Collasuyo Archaeological Research Institute's storage facility for subsequent conservation and analysis.

Analysis of Artifacts Recovered from the Residential Area

Dr. Arkush compiled, consolidated, analyzed, and managed all databases including the project's GIS. Dr. Arkush also digitally illustrated all maps from the excavations within the residential area. Cecilia Chavez Justo, a regional ceramics specialist, conducted analysis of recovered ceramic sherds and artifacts. Dr. Aimee Plourde oversaw analysis of all animal remains. Dr. Carol Schultz analyzed and interpreted lithic artifacts found at the site. Matthew Velasco oversaw, conserved, and analyzed all human remains found at the site. I oversaw collection and analysis of archaeobotanical remains.

Analysis of Artifacts from the Terraces

I compiled and managed the database of artifacts recovered from the terraces. I also digitally illustrated all maps from these excavations. Cecilia Chavez Justo conducted analysis of all ceramics from the terraces. The full details of Chavez Justo's analyses are presented in Appendix A. In this dissertation I present the results of this analysis relevant to my research questions, including distinguishable ceramic styles (to distinguish time periods of use).

Dating Methods

The long occupation, maintenance, and reconstruction of terraces makes the reliability of dating their construction difficult. As mentioned in Chapter Four, there is no singular universally accepted method or methods to date agricultural fields. Each project does it a little bit differently. After surveying the methods employed by other archaeologists, I think cross-checking independent methods is important because dating the construction, use, and abandonment of agricultural field, particularly terraces, is difficult due to tilling and erosional processes that regularly threaten the integrity of the stratigraphy. To overcome the obstacles associated with dating the construction and use of fields, in this study, I employ three methods: (1) *terminus post quem* dates on ceramics found in distinct strata; (2) accelerator mass spectrometry (AMS) on charcoal recovered from secure contexts during excavations; and (3) optically stimulated luminescence (OSL) to measure the age of strata boundaries. Each method proved to have its strengths, weaknesses, and particular challenges.

Terminus Post Quem Ceramic Dates

Chavez Justo carried out analysis of ceramic sherds from the Ayawiri terraces in the Collasuyo Archaeological Research Institute in Puno, Peru, where she had access to laboratory equipment such as calipers and scales, and her regional comparative collection that she has assembled. Drawing on the locally refined stylistic seriation sequence (first described in detail by

Tschopik 1946:21-44), she assessed features, such as slip, painting style, and paste, to determine the relative time period when diagnostic sherds were produced.

Drawing on Chavez Justo's findings, I assessed *terminus post quem* dates, which literally is translated from latin to "limit after which", of each stratum based on ceramics and drew on dates from the lowest intact levels to identify the earliest possible time period the terraces could have been built. I determined the age of each stratum based on styles of ceramics, and I drew on dates from the lowest intact levels to identify the *terminus post quem,* or the earliest possible date the terraces could have been built. The *terminus post quem* is "a date after which the object must have found its way into the ground" (Hume 1970:11).

Accelerator Mass Spectrometry Dating of Wood Charcoal Dating

Three samples of wood charcoal from secure contexts were analyzed using accelerator mass spectrometry dating (or AMS dating) to assess construction and long-term use of the terraces. During excavations of the terraces I collected carbon from a small burial in the terraces and embedded within the matrix of riser walls. I did not collect carbon from terrace fill because these contexts were subject to tilling, which contributed to mixed stratigraphic contexts. It is worthy of noting that very little charcoal was recovered from the terraces, especially from secure contexts such as the walls. These samples were collected in small clean plastic vials and exported to the US following procedures outlined by the Peruvian Ministry of Culture. Then, I submitted these samples to Direct AMS, a lab located in Bothell, Washington where Dr. Ugo Zoppi oversaw AMS analysis.

Optically Stimulated Luminescence Dating

In an experimental procedure, I collected cores of soil from strata boundaries for optimally stimulated luminescence dating (or OSL dating) to look at the geomorphological history of the terraces. Optically stimulated luminescence dating measures the time since sediments were last exposed to light by looking at the amount of photons still trapped in quartz crystals (Aitken 1998). While this last method is an experimental application of OSL dating, it provides the most direct proxy for sediment deposition and landform manipulation, including the cutting and filling involved in anthropogenic activities and terrace construction.

I followed Dr. Steve Forman's protocol for collecting OSL samples in the field. During excavations I collected bulk soil samples in two-inch-wide plastic plumbing pipes for OSL dating from the paleo-A horizon or the humus layer, where the natural hillside was covered by anthropogenic terrace fill (Roberts et al. 2001:478-480). These pipes were duct taped shut and wrapped in tinfoil. I submitted these samples to Dr. Steve Forman at Baylor University, where he analyzed these samples using a single-aliquot regeneration approach on small quartz buried in the sediments. The single-aliquot regeneration method measures radiation in a single quartz grain, or subsample, whereas the multiple-aliquot regeneration method measures an average date from many subsamples. Recent research proves that the single-aliquot regeneration method, while time consuming, is more accurate (Duller 2008; Wintle and Murray 2006). By cross-checking ceramic, AMS, and OSL data I can better assess the temporal history of the Ayawiri terrace complex. The full details and results of OSL dating are presented in Appendix B.

Paleoethnobotanical Methods

For this dissertation, I analyzed paleoethnobotanical samples that were collected from targeted contexts by excavators of Proyecto Machu Llaqta during the 2011 and 2012 excavations in the residential area at Ayawiri. I floated these samples in the field, exported them, and analyzed samples for macrobotanical remains in Gayle Fritz's Paleoethnobotanical Laboratory at Washington University in Saint Louis. In 2011, 104 soil samples were excavated, processed, floated, and exported. In 2012, 55 soil samples were excavated, processed, and floated; however, only 30 samples, determined to be from contexts of interest, were exported. In this section I outline the field methods, export permissions and procedures, and laboratory methods employed to analyze macrobotanical remains from Ayawiri.

Paleoethnobotanical Field Methods

Before excavations began in 2011, a standardized paleoethnobotanical procedure was designed as a part of Proyecto Machu Llaqta's excavation methods. In a *blanket sampling* strategy, excavators collected soil samples for flotation from almost every feature and depositional event (Pearsall 2000:66-67). This strategy is practical and allows me to determine *ad hoc* which contexts are important for analysis.

Paleoethnobotany Sampling and Recovery Methods

Excavators collected on average 10 L samples of soil for macrobotanical analysis whenever possible. However, if contexts were smaller than 10 L, such as hearths, the maximum volume of soil was collected. Excavators used pre-measured buckets to determine the volume of samples. Soil samples for flotation were then placed in plastic bags, and two Tyvek tags that included provenience information were placed inside the bags. The Tyvek tags ensured that provenience information would not be lost in the float tank. Prior to flotation, provenience information for each float sample was recorded first on the excavation form, where each flotation sample was assigned a unique slash number. Excavators also noted the quadrant from which the flotation sample was taken. The volume of each sample was recorded on the excavation form. With a permanent marker, excavators recorded the site number, locus and slash number, unit, quadrant, and volume of each soil sample on every Tyvek tag placed inside soil samples. Finally, the locus and slash number was written with a permanent marker on the outside of every soil sample bag for posterity. This system ensured spatial information was collected for each sample and allowed excavators to collect more than one soil sample from each locus.

In 2013 I collected and floated 10 L soil samples from the fill of the terraces. I scanned these samples using a 10-40X stereoscopic light microscope during excavations at the Collasuyo Archaeological Research Institute in Puno, Peru. I found there was no carbonized macrobotanical remains in these samples. I chose not to intensively sample the terraces based on the lack of macrobotanical remains in these initial few samples and based on the assumption that soil samples from the terraces would be highly disturbed and mixed contexts.

Flotation Methods

In 2011, I processed and floated macrobotanical samples in the patio of our field lab house in Tiquillaca. Due to excessive water and silt accumulation in the patio of our lab in 2011, samples were floated in a stream a stream near Tiquillaca in 2012. For the duration of the project, I used a modified version of Watson's (1976:79-80) SMAP machine, as described by

Fritz (2005:780-784) and Pearsall (2000:29-33), to float the samples; however, in 2011 I used a settling tank to recycle the water. This flotation machine was made out of 50-gallon plastic trashcan with a sluiceway fashioned out of a small bucket attached to the top. For the inner-barrel I cut the bottom out of a small plastic trashcan and attached steel geological mesh with an aperture of 0.425 mm to the bottom. The inner barrel also had a sluiceway that nested nicely inside the outer barrel. The inner barrel was suspended inside the outer barrel by two wires and could be easily manipulated and lifted by its two handles. Water was pumped into the machine through a garden hose attached to a one-inch plastic pipe and showerhead with ¼ horsepower water pump. The gentle agitation of water flowing upwards through the mesh of the inner barrel broke up the soil. Silt and other residues smaller than 0.425 mm sank through the mesh of the inner barrel and collected in the basin of the outer barrel. The water agitation caused buoyant organic materials to siphon through the sluiceways of the tank, where these materials were captured in chiffon fabric. This *light fraction* was tied and hung to dry on a clotheslines located in a shaded portion of our patio in Tiquillaca. Non-buoyant soil residue and artifacts larger than 0.425 mm were captured in the inner barrel's mesh. This *heavy fraction* was poured out of the drum onto labeled bags and laid out to dry. After samples dried, the light fraction and the heavy fraction were put in separate plastic bags, and labeled in permanent marker with respective locus and slash numbers, and the Tyvek tags filled out during excavations were placed inside each bag.

The heavy fraction was analyzed in the temporary field lab by locally hired staff, and is now curated with other artifacts recovered from our excavations at the Collasuyo Archaeological Research Institute located in Puno, Peru. While ceramics, microdebitage, and other artifacts were recovered from the heavy fraction, no macrobotanical remains were found in this fraction. The light fraction containing carbonized macrobotanical remains, other residues, and buyoant artifacts that floated during processing were exported to the U.S. for detailed analysis.

Macrobotanical Export Permissions

Following excavations in 2011 and 2012, soil samples targeted for macrobotanical analysis were exported from Peru and imported into the U.S. This process required permission from both governments. Permission to export these samples was solicited from and granted by the Ministerio de Cultura de Peru. The U.S. Department of Agriculture granted permission to import the samples into the U.S.

Paleoethnobotanical Laboratory Methods

After light fraction arrived in the U.S., I began to analyze the samples in the Paleoethnobotany Laboratory at Washington University in Saint Louis, directed by Dr. Gayle Fritz. To sort these samples, I followed Dr. Frtiz's standard protocol. To identify specimens I used the comparative type collection in Dr. Fritz's lab and photos of *altiplano* seeds and plants from Dr. Christine Hastorf's database and two dissertations (Bruno 2008; Whitehead 2007).

Due to the sheer density of seeds in macrobotanical samples recovered from Ayawiri, it was not possible or necessary to analyze every sample, so I strategically selected samples from targeted contexts such as kitchens, and hearths. I also selected samples from a diversity of contexts in order to grasp the array of plant use at the site.

Before analysis, I measured the total weight of each sample to the nearest 1/100th gram. I recorded the weight and the contextual information from the outside bag of each sample on a sorting form. I then poured the sample through a graduated series of nested USDA geological sieves. This process separated the samples into four fractions: larger than 2.00 mm (from the 2.00 mm mesh sieve), larger than 1.00 mm (from the 1.00 mm mesh sieve), larger than 0.5 mm (from the 0.5 mm mesh sieve), and smaller than 0.5 mm (from the pan). I recorded the weight of each of these fractions to the nearest 1/100th gram, labeled, and placed them in a tin for sorting.

To conduct analysis, I used a stereoscopic light microscope with a magnification range of 10-40X. For the sorted fraction that was larger than 2.00 mm, I sorted all identifiable carbonized organic fragments, including woody fragments, seeds, and parenchyma (plant storage tissue that, in this case, mostly represents charred tubers). For fractions smaller than 2.00 mm, I sorted and identified carbonized seeds and looked at materials not represented in the larger fraction, had any such as squash rind, been present. I scanned the fraction in the pan (specimens smaller than 0.5 mm); however, I did not quantify this fraction. Since the screen in the inner barrel of the float machine also had 0.425 mm apertures, seeds in less than 0.5 mm fraction were likely contaminated between samples and, possibly, from river water.

Only carbonized seeds and other charred plant remains were systematically removed in this project. Uncarbonized plant remains, seeds included, were not systematically removed, on account of the identification of bioturbation during excavations (Arkush and Paredes 2012, 2013). Additionally, due to the extreme oscillations in annual temperature and seasonality of rainfall in the *altiplano*, it is unlikely that uncharred organic plant remains would preserve, and the antiquity of these materials cannot be verified. I kept and curated organic non-carbonized materials, other small artifacts (such as bone), and macrobotanical residue in separate plastic bags to store in perpetuity along with the sorted macrobotanical remains.

Woody specimens smaller than 2.00 mm were not removed, because it is difficult to identify wood to genus and species below this fraction. Furthermore, there have been no studies of local wood to date that enable taxa-level wood identification. Often archaeologists think of wood as a derived from trees; because trees are scarce in the *altiplano* the wood in this study is likely from shrubs. Parenchyma was not sorted from below the 2.00 mm fraction. Wood fragments (larger than 2.00 mm) and parenchyma fragments (larger than 2.00 mm) were identified and counted. Seeds were identified and counted as closely as possible to scientific family, genus, and species. I fully sorted all but two macrobotanical samples, both of which contained enormous amounts of seeds. I used a riffle box to sort a manageable fraction of the dense samples and then I used these counts to extrapolate how many specimens were in the entire samples. I chose to fully sort almost every sample (except caches dense in seeds) because I was looking for evidence of rare and imported taxa that would only be present in small numbers.

All counts and weights of macrobotanical remains were recorded on sorting forms, along with relevant site and sample information (i.e. context of sample, locus, volume, etc.). Other pertinent data were also noted on the sorting form, such as the presence of small bones and/or other small artifacts. Finally, these data were entered into a Microsoft Excel spreadsheet. Identified macrobotanical specimens were labeled and placed in gelatin capsules or small tins and curated along with the rest of the sample in the original bag.

Paleoethnobotanical Methods of Quantification

This study utilizes four primary quantitative methods of analysis: frequency, ubiquity, density, and diversity. These measures are employed to identify and compare depositional events at the levels of context, unit, site, and intra-site analysis.

Density [Standardized Absolute Counts]

Density is the measure of the sum of the specimens of a taxon divided by liters of soil floated (Miller 1988:72-73; Pearsall 2000:196). This measurement accounts for the variance in soil sample size (Miller 1988:73). In comparison to ubiquity, it presents a more complete expression of taxa distribution throughout the sites because it measures the quantity of plant usage or deposition in discrete contexts. Density can also be used to reveal intensity of deposition, which Pearsall (1983:129) directly correlates with intensity of occupation. I use this measurement to look at intensity of deposition between contexts and between sites. I calculated density by adding the count of a plant taxon for each locus (absolute count) and dividing by the soil volume (liters floated).

Ubiquity [Expressed as Percentage Presence]

Ubiquity is an index of absence and presence. Ubiquity expressed as percentage presence is measured by adding the total number of samples a taxon is present in, dividing it by the total number of samples, and multiplying by 100. Ubiquity disregards absolute counts and, therefore, reduces the impact of preservation and recovery issues (in comparison to standardized density) (Miller 1988:60-61). In accordance with Popper, I use this measurement to quantify variations in the presence and absence of taxa between contexts and between sites.

Percent Frequency

Frequency measures the percent of each seed type in the analyzed assemblage. I calculated frequency by summing the seeds of a taxon (for a site or a context) and dividing by the total number of seeds analyzed for an assemblage.

Diversity

This measurement accounts for total number of species and the relative evenness of each species (Pearsall 2000:209). "High diversity results when a large number of species are evenly distributed, that is, when it is difficult to predict what a randomly selected item would be. Low diversity in the number of species present is low when one or a few species account for most of the population" (Pearsall 2000:210). I measure diversity by looking at the number of species present in each sample or context, and comparing it to other similar samples or contexts at the site. I also compare diversity of plant taxa found at Ayawiri to studies carried out by paleoethnobotanists working at other sites in the region dating to different timer periods. Ayawiri residents should have had access to and used similar plants as residents who lived in the region during earlier time periods, so a comparison shows changes in plant use over time.

SEM Methods

I employed scanning electron microscopy (SEM) to carry out detailed analysis of seeds in two ways. First, I took photos of the best preserved seeds of each taxon identified in this study. These photos ensure other researchers will be able to compare and contrast morphological features, such as testa texture, shape, and size, of the seeds I identified from Ayawiri.

The second analysis I used SEM for was on chenopod seeds. Researchers working in both North and South America have proven the use of SEM in determining the domestication status of archaeological chenopod seeds (Bruno 2006; Bruno and Whitehead 2003; Fritz 1986; Fritz and Smith 1988; Gremillion 1993; Langlie et al. 2011; Smith 1985a, b; Wilson 1981). The precision afforded by SEM enable researchers to measure testa thickness in micrometers. Indeed, these studies have shown that the process of domestication and human selection results in a decrease in testa thickness that sometimes negatively correlates with seed diameter size. In Chapter Six, I detail how selection impacts the morphology of chenopods and the morphological difference between wild and domesticated seeds. Here, I describe the methods I used to carry out this analysis.

I analyzed the seed diameter, margin configuration, seed coat texture, and beak prominence of 997 *Chenopodium* spp. seeds from Ayawiri. I gathered these data using a light microscope under magnification of 10-40X. In order to identify diversity of chenopods across the site, I selected 10 of the best chenopods from every analyzed macrobotanical sample for this analysis. However, when there were fewer than 10 chenopods, I analyzed as many seeds as possible. Generally, I chose to analyze an equal number of chenopods from the > 0.5 mm fraction and the > 1.0 mm. I also tried to select chenopods with seed coats intact for this analysis whenever possible.

I conducted chenopod analysis using the same classifications as Bruno (2006) and Langlie et al. (2011). Using a light microscope with a built-in ocular micrometer, I measured the chenopod seed diameter in millimeters from just adjacent to the radicle across the seed.

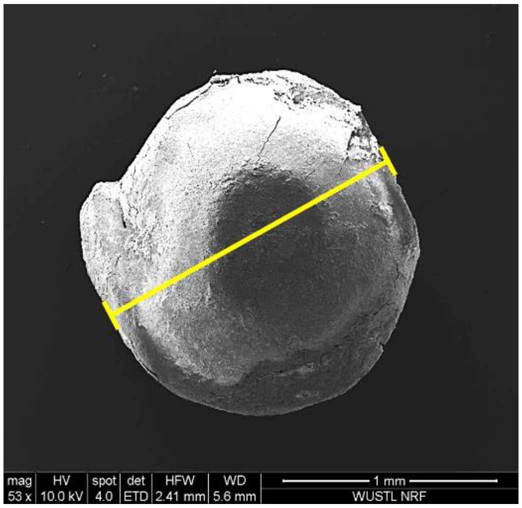


Figure 5.1: SEM photo depicts location where the diameter of chenopod seeds was measured.

I assessed the beak prominence and testa texture. Following the same four categories of beak prominence established by Gordon (2006) in her assessment of Mesoamerican chenopods, in this study seeds were categorized as having beaks that are *very weak, weak, prominent,* and *very prominent* (see Figure 5.2).

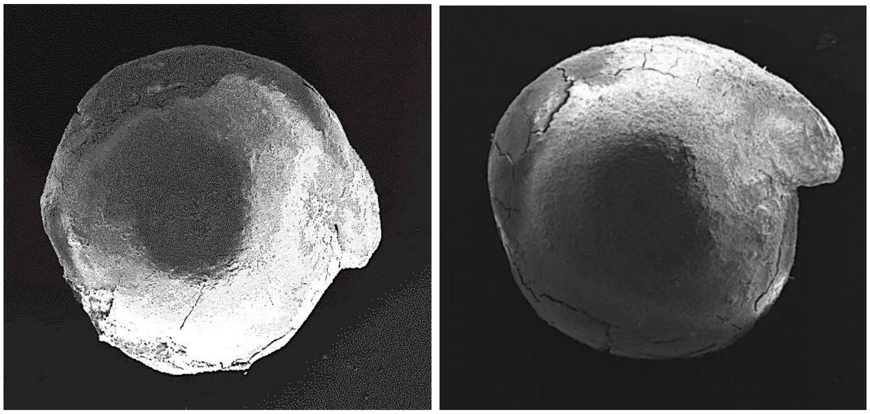


Figure 5.2: SEM images of Ayawiri archaeological examples of chenopods with a weak beak (left) and a very prominent beak (right).

I identified three testa textures including *smooth*, *reticulate,* and *canaliculated.* I also took notes on whether a seed possessed the remnants of a pericarp or whether it was shiny; I was curious as to whether these features co-varied with any other attributes. Then, I flipped the seed on its side to assess the margin configuration. I identified four margin configurations including *biconvex, equatorially banded, rounded,* and *truncate* (see Figure 5.3).

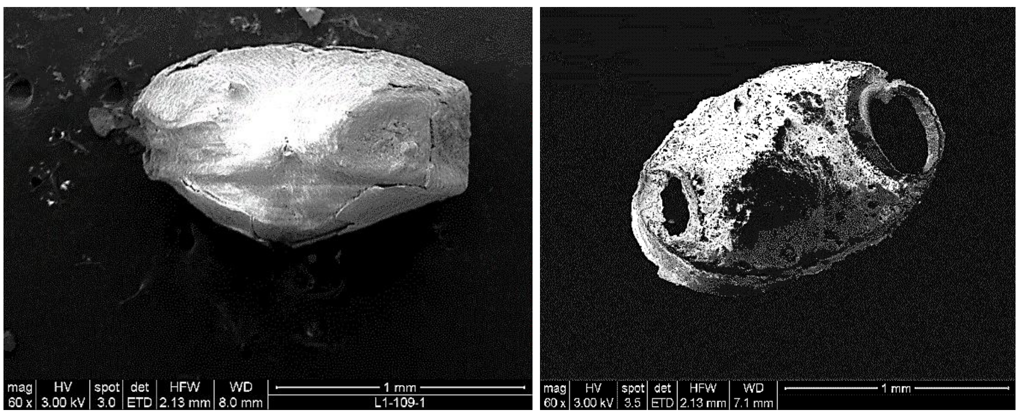


Figure 5.3: SEM images of Ayawiri archaeological examples of the margin configuration of a truncate chenopod (left) and a rounded margin configuration (right).

I also analyzed the testa thickness of 73 chenopod seeds using an FEI Company, Nova Nano 230 Field Emission brand scanning electron microscope, located in the School of Engineering at Washington University in Saint Louis. I used the software measuring capabilities of this microscope to obtain testa thickness in μm's (see Figure 5.4).

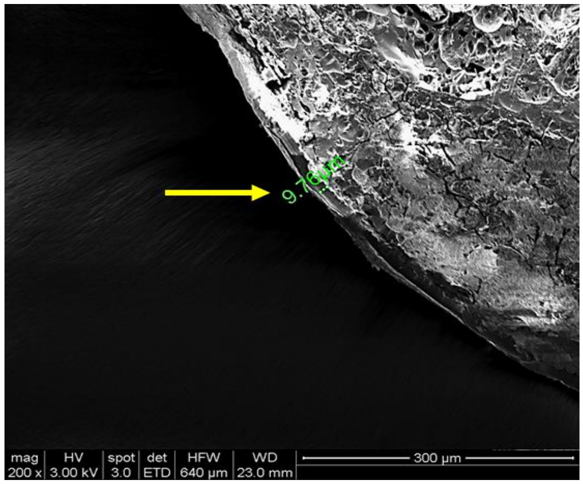


Figure 5.4: SEM image of Ayawiri archaeological example of the measurement of the thickness of a chenopod testa (n = 9.76 µm).

In order to expose the testa of each seed I used a very thin razor blade to cross-section the seeds. While using a razor blade to cu the seed coat tends to destroy part of the seed, doing so exposed a portion of the testa that was easier to measure. I often did not sputter coat the seeds, because I was able to measure the testa thickness without doing so. I followed a quantitative procedure outlined by Bruno (2006) and Bruno and Whitehead (2003) to compare seed diameter to testa thickness.

Chapter 6. Macrobotanical Taxa

In Chapter Six I present an overview of the macrobotanical data analyzed from the residential sector at Ayawiri. First, an outline is provided of the three potential sources of deposition at Ayawiri. Then, the macrobotanical taxa are presented in alphabetical order by family. Drawing on these data I provide a brief examination of diet, behaviors, and grazing strategies. Lastly, I present the results of a multi-proxy *Chenopodium* spp. analysis.

In total, I analyzed 108 flotation samples (1025.2 L of soil) collected from LIP contexts at Ayawiri. Every sample included in this study dates to the LIP, according to analyzed ceramics, stratigraphy, and in some cases, AMS dates (Arkush 2014; Arkush and Paredes 2012, 2013). In total, this study includes 1,038,288 macrobotanical specimens (this is an extrapolated number based on weight). Of these specimens, approximately 1,036,215 are seeds (see Appendix C).

Sources of Deposition

Here, I provide a synopsis of the taphonomic processes impacting macrobotanical specimens recovered from Ayawiri. As Thery-Parisot et al. (2010) point out, it is important to consider both the natural and anthropogenic processes that lead to the preservation of archaeological artifacts. A consideration of the sources of deposition and pathways to preservation supports a critical analysis and interpretation of macrobotanical remains.

Today, no humans reside in the residential sector at Ayawiri, nor do they use this space for growing crops. However, a woman uses the site seasonally to graze her mixed herd of camelids and sheep. Herding activities cause trampling, compaction, and minimal disturbance to the surface at the site. There is no evidence that she carries out any burning or soil turning activities in the residential sector that could potentially contaminate macrobotanical samples, but previous inhabitants may have done so. The well-buried LIP habitation strata Proyecto Machu Llaqta encountered at Ayawiri support the fact that these macrobotanical samples have remained undisturbed since they were originally deposited. With this in mind, there are three possible sources of prehistoric macrobotanical deposition: direct resource use; indirect resource use; and seed rain, all of which I discuss in relation to this study (following Minnis 1981).

Direct Resource Use

Direct resource use is the result of intentional "collection, processing, and use/consumption" of the plant part, such as the seed or tuber, that is deposited in the archaeological record (Minnis 1981:145). There are many instances that a macrobotanical remain intended for human consumption can end up being burned and thus preserved in the archaeological record. For example, parching water from quinoa in order to store the grains can result in a burned mess, if not carefully attended. This is direct resource use because the chef had intended to use the seeds in a recipe. Hearths are locations where we would expect to find evidence of direct resource use, because many seeds intended for food are accidentally burned in these locations. And in fact, Proyecto Machu Llaqta excavators found the remains of numerous clay hearths at Ayawiri. Small grains are susceptible to accidentally falling into fires and are often preserved through charring in this manner. However, due to their water content, fresh tubers and fruits used as direct resources rarely preserve through charring; they more often sizzle and burn to ash. Direct resource use of macrobotanicals can be identified in primary or secondary contexts. A hearth is a primary context, whereas a midden where food waste is disposed of, is a secondary context.

Indirect Resource Use

Many plants that end up preserved in archaeological contexts were never intended to be eaten by humans. Even if found in a culinary context, archaeologists cannot assume macrobotanical remains are evidence of inclusion in the human diet. Indirect resource use of plants is the "result of the use of the plant, not the seed" for a purpose other than human food (1981:145). Indirect resource use can be found in both primary contexts (in hearths) and secondary depositional contexts (in pits). In particular, plants used for architecture, such as thatching for roofs, and beams for structural support are in this category. Plants used for fuel, such as shrubs and trees, are other examples of indirect resource use. In both these cases, seeds can be accidentally charred, but they were never intended to be consumed by humans. They were only a by-product of another use.

In this study, dung used for fuel is indirect resource use of plants. Miller (1984) notes in high altitude areas around the world where trees that produce firewood do not grow and there is insufficient oxygen to fuel fires, dung is often used for fuel. As a highly volatile fuel, the dung of herbivores provides a steady source of low-smoke and high-heat flames used for cooking, craft production, and to generate heat in cold climates. While humans likely consumed some of the wild taxa found in archaeological contexts where dung was also burned, some researchers argue "most of the actual specimens of these taxa became charred through the burning of dung as fuel" (Miller 1996:524).

A portion of the macrobotanical remains recovered from Ayawiri represents the remnants of dung burned for fire fuel. This conclusion is based on the eight criteria outlined by Miller (1996) and Spengler et al. (2013): 1) Alternative fuel is rare and insufficient in the *altiplano*; 2) based on zooarchaeological analysis (conducted by Dr. Aimee Plourde) of animal bones recovered during excavations from the site, camelids were a large part of the Ayawiri economy and produced suitable dung for burning; 3) burned fragments of dung and herbaceous seeds were ubiquitous; 4) many seeds were poorly preserved or fragmented, likely as a result of mastication or digestion; 5) many seed assemblages were mixed and heterogeneous; 6) samples analyzed were recovered from domestic use or refuse areas rather than storage contexts; 7) there is an ethnographic history of dung used for fuel in the region. Today, dung is still used by residents living near Ayawiri and throughout the Andes to fuel cooking and warming fires. Sillar (2000) notes in the Cuzco region that potters still prefer dung fire fuel for ceramic craft production because it provides more even burning. Lastly, 8) there is a long archaeological history of dung fuel use throughout the *altiplano*. Browman (1989), Bruno (2008), and Whitehead (2006, 2007) identified charred camelid dung from Formative Period archaeobotanical samples recovered from sites located in the Titicaca Basin. Evidence of dung fuel use was pervasive at nearby Tiwanaku in various cultural contexts (Hastorf and Wright 1998; Wright et al. 2003). These archaeological data are evidence that dung has long been used for fuel in the region. In addition to seeds burned in dung, thatch roofing and woody shrubs used for supplementary fire fuel are another form of indirect resource use in this study.

Seed Rain

This source of deposition is defined as "accidental preservation of the prehistoric seed rain unrelated to any use of the seeds or plant" (Minnis 1981:145). Wind is often a source of seed rain, because many plant seeds have natural aeolian dispersal mechanisms that can transport them directly into anthropogenic environments. Minnis distinguishes seed rain as plant remains not used by humans that accidentally blow into fires. For example, a strong wind may carry small seeds a short distance across the site, if they are blown into an open-air fire and are preserved through charring, it may be impossible to distinguish seed rain from direct or indirect resource use. Seed rain should not be ruled out as a possible pathway to macrobotanical preservation.

Botanical Taxonomy of Identified Plant Remains

In this section I present the types of macrobotanical remains found during analysis. The morphological features are described that aided in identification. Botanical descriptions and ecological information on the local taxa are provided. I also provide information on when and where relevant taxa were found by archaeologists working in the region. General statistics and interpretations are presented on the use of each taxon at Ayawiri. This information is synthesized in Table 6.1. Taxa that could not be identified to family, such as unidentifiable seed fragments, wood, and dung are presented at the end of this section. Seeds that could not be identified are referred to as *unknowns.* U*nknown seeds* possess potentially diagnostic characteristics such as a clear seed shape or a distinct seed coat texture. I assigned each morphological *unknonwn* seed type a unique number so that, if they are identified in the future, they can be readily quantified, and the ecology and uses of these plants can be assessed.

Table 6.1: Summary table of macrobotanical remains from Ayawiri. (N=108 samples, 1025.2 L of soil).

Family	**Order**	***Genus species* or morphotype**	**Common name**	**Absolute count (*projected count)**	**Standardized density (count/liter)**	**Ubiquity (expressed as % presence)**
Amaranthaceae						
		Chenopodium spp.*	quinoa, kañawa	1035585	1010.13	97%
Brassicaceae						
		Brassica Type #2		5	< 0.01	5%
Cactaceae						
	Cactoideae		cactus	28	0.03	3%
	Opuntoideae	*Maihuenoposis* cf. *boliviana*	cactus	1	< 0.01	1%
Cyperaceae						
		Type #1	cf. totora	7	0.01	6%
		Type #2	cf. totora	2	< 0.01	2%
Fabaceae						
	Leguminoseae	*Trifolium amabile*		49	0.05	24%
Malvaceae						
		Type #1	mallow family	93	0.1	36%
		Unknown	mallow family	16	0.02	9%
Plantaginaceae						
		Plantago sp.		1	< 0.01	1%
Poaceae						
		Type #1	grass	80	0.08	21%
		Type #2	grass	102	0.1	30%
		Type #3	grass	3	< 0.01	1%
		Type #4	grass	12	0.01	10%
		Type #5	grass	10	0.01	8%
		Type #6	grass	6	0.01	5%
		Unknown	grass	150	0.15	27%
		cf. *Piptochaetium* sp.	grass	1	< 0.01	< 1%
Rubiaceae						
		Relbunium sp.		8	0.01	6%
Solanaceae						
		cf. *Solanum* sp.	potatoes	4	< 0.01	2%
Verbenaceae						
		Verbena sp.		3	< 0.01	2%
Unknown seeds				14	0.01	13%
Unidentifiable seed fragments				35	0.03	11%
TOTAL SEEDS*				1036215	1010.74	N/A
Other botanical specimens						
		Tuber *Solanum tuberosum* +	potates	28	N/A	N/A
		Parenchyma > 2 mm*	cf. tuber tissue	375	0.37	28%
		Peduncle		1	< 0.01	< 1%
		Wood > 2 mm		1667	1.66	80%
TOTAL BOTANICAL SPECIMENS* (Seed + Other)				1038288	1012.76	N/A
Other						
		Dung > 2 mm	cf. camelid	15	0.03	4%
Bone						
		Charred*		1270	1.21	25%
		Uncharred*		334	0.32	17%
		Eggshell		3	< 0.01	< 1%

Projected total*
Found during excavations+

Amaranthaceae

I identified approximately 1,035,585 chenopod seeds in Ayawiri macrobotanical samples (standardized density = 1010.13 seeds/liter and 97% presence). This number includes a projected total weight of two very dense caches of seeds and 106 samples that I fully sorted. While once classified as the Chenopodiaceae family, today botanists consider *Chenopodium* spp. in the Amaranthaceae family. Chenopods have been domesticated in several locations throughout the New World. However, the staple crop quinoa and the lesser known kañawa (sometimes spelled *cañihua*) were domesticated in the Andean highlands near the study region. This genus contains several other wild and domesticated species and countless varieties native to the *altiplano*. Recently, Dr. Maria Bruno, Dr. Christine Hastorf, and I have pursued research on defining the multiple morphological characteristics of modern chenopod species fruits in the south-central Andes (Bruno 2006:43; Bruno and Whitehead 2003; Langlie et al. 2011). Bruno analyzed both modern domesticated and wild varieties including *Chenopodium quinoa* (quinoa), *Chenopodium quinoa* var. *melanospermum* Hunz. (quinoa negra), *Chenopodium pallidicaule* (kañawa), and *Chenopodium ambrosioides* L. (paiko). We have identified evidence of domestication and unique morphological varieties dating to the Formative Period. Identifying domesticated, weedy, and wild varieties of chenopods in the archaeological assemblage is an integral part of reconstructing the diet of ancient Andean peoples and how they exploited their landscape. For example, were Ayawiri residents farming or collecting wild plants? Were their herds grazing in fields on crops and weeds, or on wild plant stands? Detailed analysis of chenopod seeds is essential in answering these questions.

Martin and Barkley (1961) describe chenopod fruits as “circular-lenticular…[with] a notch or groove at one point on the margin [that] varies from evident to obscure.” Chenopod fruits have a central perisperm with an embryo wrapping around the periphery terminating in what is referred to as a beak (where the radicle and seed leaves meet) (Figure 6.1). The seeds are wrapped in papery thin pericarp. Chenopod plants range in size from a few centimeters to a couple meters tall with indehiscent flowers. A single inflorescence typically contains tens of thousands, maybe hundreds of thousands of dry fruits. The exceptional health benefits of quinoa have supported this pseudocereals' recent popularity in the culinary world. Indeed, quinoa is gluten-free, has a high protein content, and a full suite of essential amino acids (Vega-Gálvez et al. 2010).

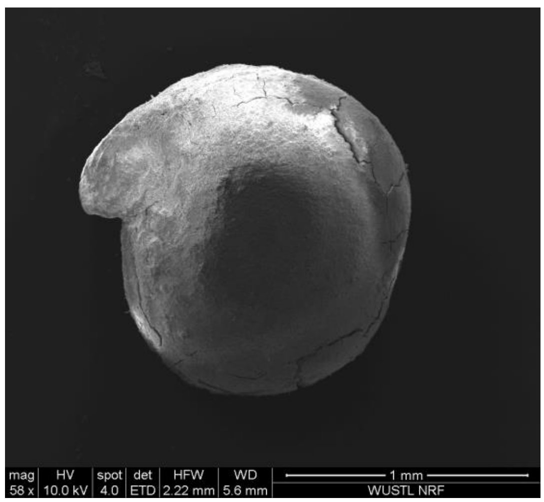


Figure 6.1: SEM image of archaeological *Chenopodium* sp. seed. This seed has a prominent beak, smooth testa texture, and rounded margin configuration. There is no pericarp covering this seed.

Quinoa is the best known domesticate in this genus. Today, quinoa is grown and consumed throughout the Andes, and increasingly, it is consumed throughout the modern world (Hellin and Higman 2003:90). Today, there are entire cookbooks dedicated to quinoa recipes. Current research indicates that quinoa cultivation in the Titicaca Basin dates to at least 1,500

B.C. (Bruno 2006:43; Bruno and Whitehead 2003). However, it is thought that early experimentation with quinoa cultivation began around 3,000 B.C. (Pearsall 2008).

Researchers have paid far less attention to a second Andean chenopod domesticate, kañawa. However, Bruno is currently working on deciphering its unique characteristics that resulted from human selective pressures. Kañawa thrives in drier conditions than quinoa and is more drought tolerant.

Chenopodium quinoa var. *melanospermum* is known commonly as *quinoa negra*, or in local dialect, *ajara*, due to its black color. This species often grows as a weed in quinoa fields and can be seen in packaged quinoa (its black color standing out). Today food retail stores are marketing quinoa negra as a unique health food. *Chenopodium ambrosioides*, called *paiko,* is a wild chenopod that has not exhibited traits of human selective pressures, but is widely used as medicine.

Wild Andean varieties of chenopods thrive in disturbed ecological zones (Bruno 2006:32). Camelid herding creates opportune environments for chenopod cultivation, because the feces enrich the infertile highland soils, encouraging the plant to grow in anthropogenic environments. In fact, Kuznar (1993) points out the co-evolutionary relationship between camelids, humans, and chenopods in the Andes probably resulted in the plant specie's domestication. Chenopod seeds are generally durable, and the way they are treated culinarily lends to their high preservation rates. The seeds are parched or dried over low heat in ceramic vessels prior to storage (Browman 1989:165). *Chenopodium* spp. seeds can be charred during parching, they can spill into the fire during cooking, or be disposed of in fires if there is unwanted leftovers.

Chenopods have been recovered from archaeological sites in Ecuador, the Peruvian Coast, Central Chile, Argentina, Bolivia, and the Peruvian highlands. However, some of the best studies that incorporate multiple morphometric analyses are from the *alitplano.* Here, I focus on local studies, because they are the most relevant to this study.

Humans initiated the domestication process of chenopods during the Archaic Period as early as 3,000 B.C., when they began to increase management of wild stands, cultivation, and intensification of chenopod production (Bruno 2006:43). In an effort to document this early domestication, Eisentraut (1998) studied archaeobotanical samples from sites west of Lake Titicaca spanning the Late Archaic and Early Formative (5,000–1,000 B.C.). She identified a mixed economy including a wild and domesticated plant assemblage. Along with several wild chenopod species, domesticated and weedy quinoa (black quinoa) seeds were identified. While some chenopods came from Archaic Period strata, direct dates on grains returned a much younger date during the Formative Period (740 ± 50 B.C.).

The earliest directly dated evidence of domesticated chenopod cultivation is documented at the Formative Period site Chiripa, located on the southern shores of Lake Titicaca. Measurable phenotypic change in chenopod seeds associated with human selection pressures noted in samples from the Early Formative Period around 1500 B.C. at this site (Bruno and Whitehead 2003:350). Importantly, these seeds were directly dated using AMS. During the Middle Formative Period (800-200 B.C.) Bruno and Whitehead attribute a decrease in chenopods with thick-testa morphotypes to weeding practices associated with intensification. Additionally, they found chenopods in ritual contexts, indicating its importance in both the quotidian economy and in ceremonies. In the central *altiplano* at the Wankarani site, La Barca, a unique semi-domesticated, morphological chenopod seed type found in a Formative Period hearth was excavated by Dr. Marc Bermann and William Castellón Condarco (Langlie et al. 2011). This morphological type dates to 1300 B.C. While this morphological type has not been identified in living populations of quinoa, we suspect there was introgression between this chenopod and wild chenopod populations, or it went extinct in prehistory. A second semi-domesticated chenopod was identified at La Barca that appears to be the ancestor of kañawa. These studies reveal that chenopods were cultivated across the *altiplano* region during the early part of the Formative Period.

The importance of chenopod crops in the *altiplano* only grew through time. At the site of Tiwanaku and other nearby sites dating to the Middle Horizon Period, Wright et al. (2003) found chenopods in ritual and quotidian contexts. She did not carry out multi-variate analysis of these chenopods. A multivariate study of these chenopods would be valuable to determine the extent of morphological change seeds underwent during this time period. Additionally, these data would provide insight about the varieties grown and the weeding strategies carried out during this vibrant cultural time period.

While no previous research has been conducted on LIP chenopods from the Titicaca Basin, recent examination of the color of desiccated seeds from storage contexts in the southern *altiplano* region of Lípez, Bolivia show that a wide variety of chenopods were being cultivated there during this time period, with several different colors of chenopods present in food stores (López and Nielsen 2013). Following the LIP, quinoa was a staple crop for citizens of the Inca Empire. The Jesuit priest Father Bernabe Cobo observed while visiting the Andes in the 17^{th} century that quinoa was supremely important in the form of chicha beer. He elaborates that at the time of conquest chicha, whether made from quinoa, maize, or molle berries (*Schinus molle* L.) was “the height of their glory… [Andean people] never celebrate an event, whether joyful or sad, in any way other than by dancing and drinking to excess" (Cobo 1979:135). I have found that *altiplano* residents prefer to make chicha out of quinoa rather than imported crops, probably because quinoa is readily available to them.

In sum, chenopod crops have nourished people living in the Lake Titicaca Basin since the Formative Period. Quinoa's importance in rituals and quotidian lifeways has been well-documented. This leads me to ask two questions: 1) was it was even possible to grow quinoa during the LIP in the Titicaca Basin due to the drought? and, 2) following the collapse of Tiwanaku did the importance of quinoa in the region continue?

The total numbers of chenopod seeds in this study include two dense caches of charred chenopods and whole tubers. These caches were pits found directly below house floors and the contents consisted of chenopods and tuber that were completely carbonized. The degree to which the caches were carbonized and the excellent preservation of morphological details of the seeds indicate the fire was low and slow. There are a few possible interpretations of these caches. The first is that these crops are the remnants of accidentally or intentionally burned storage pits. But if this were the case, we would not expect such excellent preservation, rather the contents would have burned to ash. The second possibility is that these pits were earthen ovens, similar to *huatyas,* a method of cooking still practiced in the region today. However, if this were the case, then we would expect the oven to have been cleaned out. The third and most likely scenario is that the caches were sub-floor offerings placed there before or during the occupation of the house, and the fire was dampened by intentional burial before the contents completely burned.

The high ubiquity and density of chenopods points to the plant's critical importance to each and every household at Ayawiri. Even though politics, social life, and the climate changed dramatically from the Middle Horizon to the LIP, the importance of chenopods in local peoples' did not. In fact, the percent presence of chenopods at Ayawiri (97% in Table 6.1) is even higher than the 93% frequency that Wright et al. (2003) found at Tiwanaku during the Middle Horizon.

Identifying signatures of domesticated versus wild or weedy chenopod seeds entails a detailed multivariate approach that includes the use of scanning electron microscopy analysis of the above-described attributes. The details of my SEM analysis of the Ayawiri chenopods are presented at the end of this chapter.

Brassicaceae

I identified five Brassicaceae seeds in Ayawiri macrobotanical samples (standardized density = <0.1 seeds/liter and 5% presence). Brassicaceae is the mustard family, and the seeds I found in this family appear to be *Lepidium* sp. The morphology of this seed type is exactly the same as a morphological type identified by Bruno (2003) on the southern shores of Lake Titicaca at Formative Period sites. Bruno (2008:224-225) refers to this taxon as Brassicaceae Type #2. Previously, Eisentraut (1998) and Wright et al. (2003) identified this morphological type as *Rubus* sp. However, after careful analysis, Bruno determined this was an incorrect identification. I use Bruno's designation, so that, if the species is eventually identified, we will be able to expediently compile our data on this taxon from throughout the region. Brassicaceae Type #2 seeds have an ellipsoid shape formed by an elongated and folded embryo. The seed is covered by a dried seed coat that is D-shaped with an ovoid cross-section. There is a distinct, elongated, and hollow hilum on one side of the seed coat. Additionally, the seed coat has very prominent reticulations. These seeds measure approximately 1.6 mm in length and 1.1 mm in width.

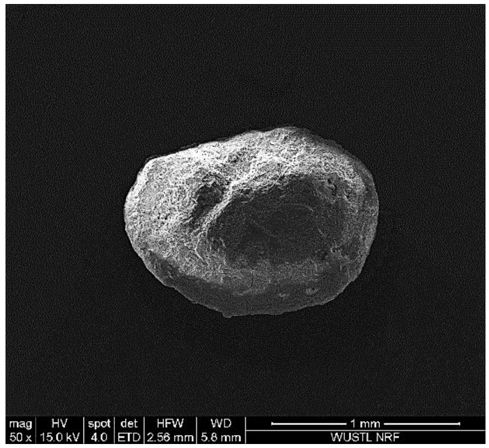


Figure 6.2: SEM image of archaeological Brassicaceae Type #2 seed.

Two native wild mustard species have been identified in botanical surveys in the *altiplano*, including *Lepidium chichicara* Desv. (Sempertegui et al. 2005:68) and *Lepidium bipinnatifidum* Desv. (Bruno 2008:225; Pestalozzi Schmid et al. 1998:144-145). The latter species has been noted to have medicinal properties in Peru (Brack Egg 1999:928). While both species grow well as weeds in fertile, disturbed soils, it has been noted that they are toxic to animals in large enough quantities.

While Brassicaceae Type #2 currently cannot be identified to species, there is a domesticated Andean crop in this genus. *Lepidium meyenii* is root crop called maca (Flores et al. 2003:163). While maca is mostly grown as a cash crop in the central Peruvian highlands today, its wild ancestors still grow throughout Peru, Bolivia, and Argentina (Balick and Lee 2002:96). Today, maca is globally sought after for its medicinal values. The powder produced from its dried roots is mixed into beverages and used as a stimulant and enhancer of male libido. Maca is also sold in sporting goods stores and marketed to improve athletic performance.

While I only found a small amount of Brassicaceae Type #2, it is a seed type commonly found in archaeological samples throughout the *altiplano* (Bruno 2008; Eisentraut 1998; Wright et al. 2003). Perhaps this plant was once cultivated for its edible roots, although we would not expect the seed to preserve in cooking fires if this were the case. A more likely scenario is that camelids foraged for the wild species that currently grows in the study region, and the seeds were carbonized in dung used for fuel. The fact that Brassicaceae grows locally as weeds supports this hypothesis. The extremely low occurrence of this seed may be attributed to the fact that the local *Lepidium* sp. plants are toxic, so foraging camelids avoided it.

Cactaceae

I identified 29 Cactaceae seeds in Ayawiri macrobotanical samples (standardized density = 0.03 seeds/liter and 3% presence). In this analysis, I identified one type of cactus seed in the Opuntoideae sub-family and another in the Cactoideae sub-family. For analytical purposes, I grouped these types into their common family because they were similarly consumed by humans or camelids. Several cacti have been identified during botanical survey in the *altiplano* including *Echinoposis maximiliana* Heyder, *Opuntia boliviana* Salm-Dyck, *Opuntia soehrensii* Britton & Rose, and *Trichocereus pasacana* (Sempertegui et al. 2005).

Opuntoideae seeds are “comparatively large … flattish-subcircular … with a distinct groove parallel to the margin[s]” (Martin and Barkley 1961:184). Bruno (2008:227) collected a cactus in northern Bolivia, on the Taraco Peninsula, identified as an Opuntoideae, *Maihueniopsis* cf. *boliviana* (Sam-Dyck) Kiesling and described the seeds as “round or globular in shape and have three thick ridges that meet at a single point.” In both description and photographic comparison, this species appears most similar to the Opuntoideae type from Ayawiri. The *Opuntia* sp. seeds I identified measure between 3.2 and 4.1 mm (Figure 6.3). The identified archaeological Cactoideae seed is large and globular with a smooth seed coat. They measure between 2.6 and 3.1 mm (Figure 6.3). Currently, I am only able to correlate this seed to scientific sub-family.

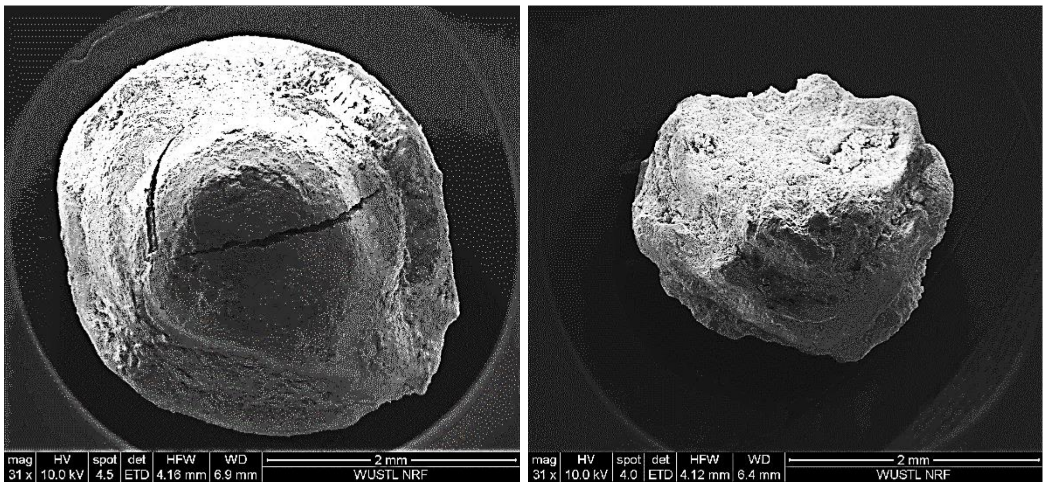


Figure 6.3: SEM images of archaeological Cactaceae seed (left) and *Opuntia* sp. seed (right).

Cacti in the *altiplano* are generally low-lying, growing only a few feet tall. They produce small edible fruits sought after by local people and animals. Ecologically, cacti are found in just about every ecotope in the *alitplano.* Since they take so long to mature, they primarily grow in relatively undisturbed locations. This does not mean that cacti do not grow in anthropogenic environments; rather, they grow in locations that escape regular cultivation or foot traffic. For example, I found cacti growing in between the stacked stone terrace risers at Ayawiri and within the abandoned fortified residential compounds at the site.

The cactus family has several known direct and indirect uses in the Andes. Direct uses include consumption of their sweet fleshy fruit. Indirect uses include the use of spines for tools, the dried stems for fuel (specifically in the Oruro region), and as a hedge plant to keep animals away from granaries (Browman 1989:153; Whitehead 2007:176). The seeds of the fruits would not be carbonized if the spines were used for tools or if the dried stems were used for fuel, because these uses do not involve contact with fire. Thus, I rule out this source of preservation and deposition at Ayawiri. However, this does not necessarily rule out the possibility that cacti were used in this way by Ayawiri residents.

Browman (1989:153) notes that "cactus fruits have been exploited for food at least [for] 10,000-8000 years" in the Central Andes. Bruno (2008:226) adds that camelids forage for cactus fruits, and Hastorf and Wright (1999:218) identified charred cactus seeds in modern camelid dung burned for fuel. I am currently unable to determine the difference of the intended resource use of this plant; however, based on these ethnographic and research data, the presence of cactus in this assemblage could be attributed to both humans and camelid dung burned for fuel. Humans consumed the fruits and, either deliberately or unintentionally, disposed of the seeds in fires, which led to their preservation and recovery. Or, foraging camelids consumed cactus fruits, and seeds were preserved through the process of dung burning.

Cactus seeds have been found by every archaeobotanical analyst working in the *altiplano* (Browman 1989; Bruno 2008; Eisentraut 1998; Whitehead 2007; Wright et al. 2003) indicating that humans living in the region have long used this plant since the Archaic Period. However, differences in density and ubiquity between each assemblage point to differential use or availability through time. The comparatively low density and ubiquity of cactus seeds compared to other assemblages indicate Ayawiri residents did not rely on cactus as much as at other sites. Perhaps this was because their farmlands and the site itself was so disturbed by anthropogenic activities, so there were very few cacti growing nearby during the LIP. Or perhaps, the LIP drought decreased flowering of cactus plants leading to lower availability of fruits.

Cyperaceae

I identified 9 Cyperaceae seeds in the Ayawiri macrobotanical samples (standardized density = 0.02 seeds/liter and 7% presence). Plants in the Cyperaceae family are generally referred to as sedges. The seeds or dried achenes of sedges are "ovate in outline and ... plano-convex to lens shaped … [with a] blunt or pointed style base (Martin and Barkley 1961:137)." Unable to differentiate species, Bruno (2008:233) argues that the four distinct morphological types of Cyperaceae seeds she identified from archaeological contexts on the Taraco peninsula were *Schoenoplectus* sp., *Carex* sp., or *Scirpus* sp.

I distinguished only two morphological seed types of Cyperaceae from Ayawiri samples (Figure 6.4)(see Appendix D for seed measurements). The first type is lanceolate shaped, plano-convex in cross-section, with a blunt base. The surface of these seeds has slight reticulations, although some were too charred to identify the surface texture. These seeds measure between 1.1 and 1.7 mm in height and between 0.8 and 1 mm in width. The second Cyperaceae seed type is lanceolate to ovate shaped, and has three ridges that extend from the blunt base to the top of the seed. These ridges give the seed a triangular shape in cross section. The surface texture of these seeds is reticulate, although a few were so charred that texture was hard to identify. These seeds measure between 0.9 mm and 2.0 mm in height and 0.6 and 1.0 mm in width.

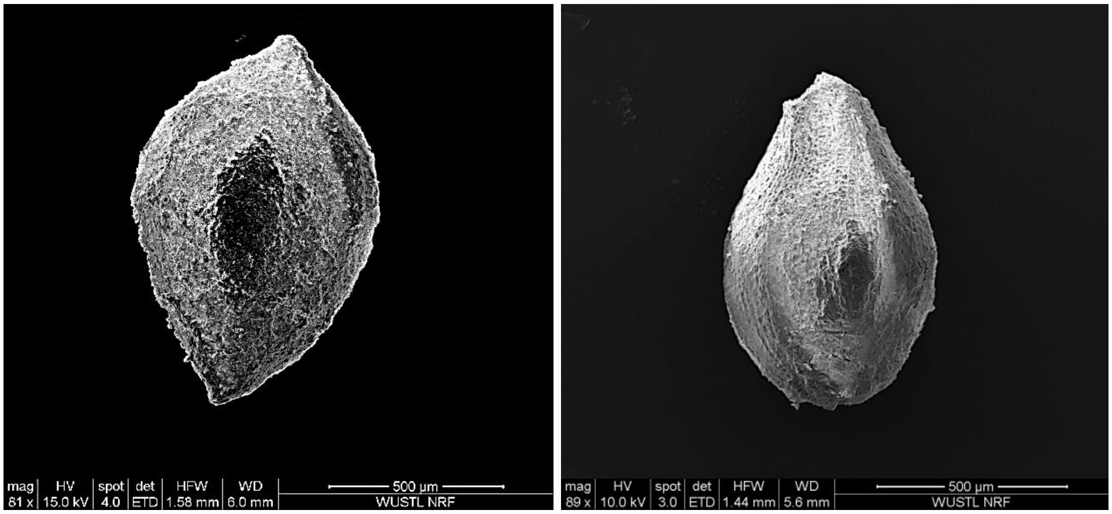


Figure 6.4: SEM image of archaeological Cyperaceae seeds.
Type #1(left) and Type #2 (right).

Schoenoplectus californicus (C.A. Mey.) Soják is a Cyperaceae species cultivated in the Andes that has many economic uses. Commonly called *totora*, it grows in littoral areas in shallow stands of water (Bruno 2008:233). Totora is a perennial aquatic sedge (Banack et al. 2004:11), and ethnographic research has established that stands are intensively managed and cultivated in the region (Banack et al. 2004:12; Orlove 1991:6). Today, totora is commonly consumed as food (Browman 1989:150-151; Bruno 2008:234); the white, juicy rhizome located at the base is the part of the plant that is eaten raw. It does not have much nutritional value, but it has a very fresh tasting flavor. Since totora is consumed raw, it is highly unlikely that the seeds would be charred from this behavior. Totora is also used as thatching for roofing material, boats, mats, tools, cordage, and animal fodder (Browman 1989:151; Whitehead 2007:207; Orlove 1991:6). Indirect resource use as building materials and animal dung burned for fuel are the most likely scenarios by which Cyperaceae was burned and preserved at Ayawiri.

In addition to totora, Bruno (2008:256) found that several other Cyperaceae species grow in the *altiplano* including *Carex* cf. *maclaviana* d'Urv., *Eleocharis albibracteata* Nees & Meyrn ex. Kunth, *Carex* cf. *pinetorum* Liebm., *Cyperus sesierioides* H.B.K., *Scirpus deserticola* Phil., and *Scirpus rigidus* (Steed.) Boeckl. Species from all of these genera grow well in wet soils and ecotopes partially or seasonally inundated in water.

Inability to identify whether Cyperaceae seeds are from wild or managed stands makes it difficult to assess what it was used for. Research conducted by Hastorf and Wright (1998:218) note the presence of charred Cyperaceae seeds in modern camelid dung burned for fuel. Herds forage for Cyperaceae plants, but I cannot determine if these seeds are totora.

Particularly in the *altiplano*, 12 seeds are an unusually small quantity of Cyperaceae seeds in an archaeobotanical assemblage. At other sites in the region, Cyperaceae was found in up to 91% of the samples. This is likely due the location of Ayawiri on top of a hill, rather than near the lake. Furthermore, Cyperaceae does not grow in the wetlands near the site today. If Cyperacee did not grow in the wetlands near the site in the past, then Ayawiri residents would have had to travel a couple hours by foot to Lago Umayo to obtain these plants. Since only a few Cyperaceae seeds managed to get deposited here, these data indicate that sedges were not regularly accessible or used by Ayawiri residents during the LIP. Based on these findings, camelid herds were rarely foddered on sedges, and thus the seeds rarely preserved through dung burning.

Fabaceae

I identified 49 Fabaceae seeds in Ayawiri macrobotanical samples (standardized density = 0.05 seeds/liter and 24% presence). Fabaceae is the legume, pea, or bean family. Throughout the world, legumes have been domesticated as food crops. In fact, several wild, cultivated, and domesticated legumes grow in the *altiplano* today. Additionally, livestock often consume wild legumes in the Andes (Brack Egg 1999). Hastorf and Wright (1989:218) found that wild legumes are a common plant taxon in camelid dung burned for fuel. On southern shores of Lake Titicaca, Bruno (2008:235-237) identified a small legume type in Formative Period assemblages as the taxon *Trifolium amabile* H.B.K. Today, there are *Trifolium* spp. species that grow readily and vigorously in disturbed and agricultural soils in the region, which lends evidence to cultivation activities (Bruno 2008:236). The bean crop *tarwi* (*Lupinus mutabilis* Sweet) is native to the highland Andes. Although not regularly found in archaeobotanical assemblages, farmers cultivate tarwi in the region today. Another species of legume commonly used for firewood in the region is *Adesmia spinosissima* Meyen ex Vogel (Bruno 2008:237). Whether cultivated or wild, these species all grow in anthropogenic and disturbed environments.

The distinct Fabaceae seed type I identified as *Trifolium amabile* is a wild legume that is morphologically identical to a type found in other archaeobotanical assemblages throughout the region. These seeds are oblong and rounded in cross-section, and the prominent radicle gives the seed a mitten shape (Figure 6.5). These seeds measure between 0.7 and 1.3 mm in length and 0.4 and 0.7 mm in width.

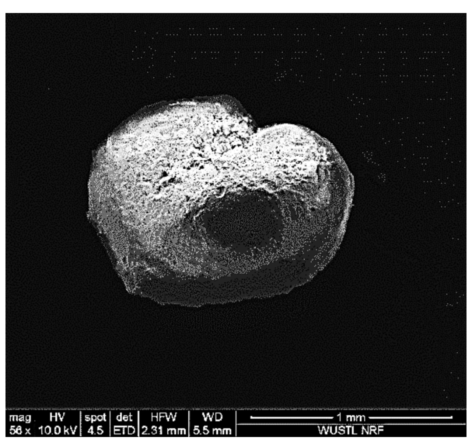


Figure 6.5: SEM image of archaeological Fabaceae seed.

Trifolium amabile seeds have higher ubiquity values compared to other plant remains in the Ayawiri assemblage. However, when I compare this ubiquity value to other archaeobotanical assemblages in the Titicaca Basin, it is still low for this taxon. Bruno (2008) and Whitehead (2007) found Fabaceae seeds in 48% to 92% of all the Formative Period samples they analyzed. These seeds probably entered the site as an indirect resource through camelid dung burning. I think camelid herds had less access to this weedy legume than at other *altiplano* sites due to the marginal ecological grazing grounds the Colla used at Ayawiri.

Malvaceae

I identified 109 Malvaceae seeds in Ayawiri macrobotanical samples (standardized density = 0.12 seeds/liter and 40% presence). Malvaceae is commonly referred to as the mallow family and has been domesticated several times throughout the world. For example, cotton and cacao are mallows. However, there is no evidence that any Malvaceae species were domesticated or cultivated in the ancient *altiplano.* Malvaceae seeds are easily identified by their distinct curved lunate to reniform shape.

I identified two distinct morphological types of Malvaceae seeds (Figure 6.6) (see Appendix E for seed measurements), and I created a third category of unknown Malvaceae seeds that have surface treatments that are poorly preserved or undetectable. Malvaceae Type 1 seeds are lunate, rounded on one end, and come to a point at the opposite end. These seeds have smooth surface treatment and their height measures between 0.8 and 1.5 mm and their width measures between 0.4 and 1.4 mm. Malvaceae Type 2 seeds are exactly the same shape Malvaceae Type 1; however, Malvaceae Type 2 has a pitted surface. These seeds measure 1.0 mm in height and between 0.9 and 1.0 mm in width. Malvaceae Type 3 seeds are also the same shape as Malvaceae Type 1 and Type 2. Due to charring, I could not confidently distinguish a surface treatment on the seed coat. They measure between 1.0 and 1.4 mm in height and 0.8 and 1.0 mm in width. Lack of distinguishing characteristics between species does not currently permit genus level identification of Malvaceae seed types.

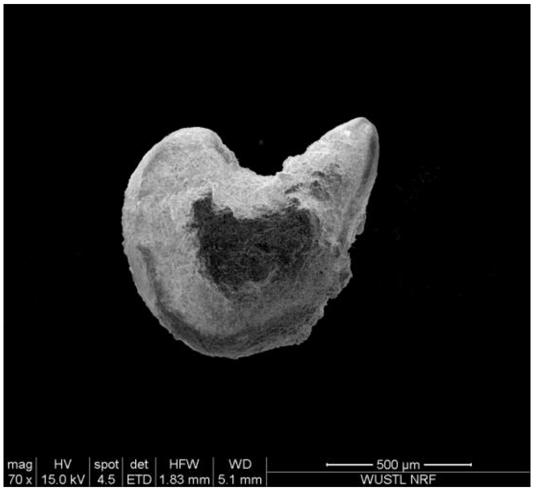


Figure 6.6: SEM image of archaeological Malvaceae Type #1 seed.

Several species of Malvaceae grow in the *altiplano*. Bruno (2008:240) collected and identified modern *Urocarpidium shepardae* (I. M. Johnst.) Krapov from the Taraco Peninsula. Browman (1989:152) notes that *Notoriche* sp. and *Malvastrum* sp. grow well in "disturbed areas" (irrigation ditches and fallow fields) around Lake Titicaca. And, in fact, almost all *altiplano* Malvaceae species thrive in disturbed and enriched soils (Browman 1989:151-152; Bruno 2008:241; Sempertegui et al. 2005:80) acting as camp followers in the region. Additionally, Hastorf and Wright (1998:218) identified charred Malvaceae seeds in modern dung burned for fuel. This indicates that grazing camelids consume mallows in the Andes, and their dung burned for fuel likely preserved the seeds in many archaeological contexts.

The presence of this taxon at Ayawiri indicates two things. First, Malvaceae seeds correlate with nearby enriched soils or agricultural fields. It is reasonable to infer that mallows grew as weeds on agricultural terraces or fallowed fields near the site. Second, ethnoarchaeological work by Hastorf and Wright (1998) lends support to the idea that Malvaceae seeds were likely carbonized and deposited at Ayawiri in camelid dung burned for fuel. Compared to other taxa at Ayawiri, Malvaceae seeds have a very high ubiquity value (26%). However, this percentage presence is low compared to the 76% to 93% ubiquity Bruno (2008), Whitehead (2007), and Langlie et al. (2011) identified at Formative Period *altiplano* sites. I believe this indicates Ayawiri residents were intensively weeding their fields, and/or camelids ate most edible greens before the plants produced seeds. Additionally, fallow periods may have been decreased to feed the large population living at the site so camelids had less access to this plant on grazing grounds.

Plantaginaceae

I only identified one *Plantago* sp. seed in Ayawiri macrobotanical samples. This taxon is a member of the botanical family Plantaginaceae commonly called the plantain family. The morphology of the identified *Plantago* sp. seeds are ovoid and rounded in cross-section, and they are "hollowed out like a boat" lengthwise on one side (Martin and Barkley 1961:199). The seeds are oblong and compressed lengthwise. The identified seed measure 1.0 mm in length and 0.5 mm in width.

Young, tender leaves of *Plantago* spp. are sometimes eaten by humans in small amounts throughout the Andes (Brack Egg 1999:398). This genus has also been used for medicinal purposes. In particular, *llanten*, a variety of *Plantago* sp. identified in the modern period in the northern *altiplano* region around Lake Titicaca, has several medical uses, and it has been noted that the presence of this taxon in the archaeological assemblage at Chiripa could be attributed to its medicinal value as early as 1300 B.C. (Browman 1989:152-153). Several other species of *Plantago* have been collected during botanical survey in the region, including *Plantago australis* Lam. (Bruno 2008:243), *Plantago orbignyana* Deone, *Plantago sericea* Ruiz & Pav. (Pestalozzi Schmid 1998:173-174), and *Plantago tubulos* Decne (Pestalozzi Schmid 1998:173-174). The species *Plantago sericea* R&P also grows in the central *altiplano* (Sempertegui et al. 2005:27). Generally, the preferred habitat for this genus is in undisturbed soils (Bruno 2008:244).

I only found one *Plantago* sp. seed at Ayawiri. This seed type is generally found in low densities and ubiquities at archaeological sites in the region. For example, Whitehead (2007) found Plantaginaceae seeds in only 4% of the samples he analyzed from Formative Period Chiripa. It is possible that Ayawiri residents ate the young leaves of *Plantago* sp. plants. However, when harvested at this young stage, the plant does not yet possess seeds. So, it is highly unlikely that human consumption of the plant is responsible for the seed found at Ayawiri. *Plantago* sp. plants may have been used for medicinal purposes at Ayawiri, although this is difficult to determine based on the single seed I found. It is more likely that camelid herds were taken to undisturbed areas for grazing, and llamas foraged and consumed these plants. Then the camelid dung was collected and used for fuel at Ayawiri, subsequently charring and preserving the *Plantago* sp. seed at the site.

Poaceae

I identified 364 Poaceae seeds in Ayawiri macrobotanical samples (standardized density = 0.35 seeds/liter and 61% presence). Poaceae, or the grass family in the *altiplano*, is represented by a relatively large and diverse group of native wild species. There is no evidence that any grasses were cultivated in the region in prehistory (except for maize in very small amounts in littoral areas of Lake Titicaca). The specimens I grouped into Poaceae vary greatly in morphology and size. I was able to group the grasses into six distinct morphological types, and the seventh Poaceae category, referred to as Poaceae Unknowns, includes seeds that possess no distinctive traits. I measured the height and width of 156 grass seeds (see Appendix F for the full report of these measurements). Here, I provide general descriptions of each of the morphological types that I recognized in the Ayawiri assemblage.

Poaceae Type 1 is tear-drop shaped and generally measures 1.5 mm in length and 0.4 mm in width. It has a smooth surface (Figure 6.7). Poaceae Type 2 is oblong and rounded in cross-section. It has a distinct lunate shaped base where the embryo broke off and a smooth surface (Figure 6.7). This seed type measures approximately 1.3 mm in length and 0.5 mm in width.

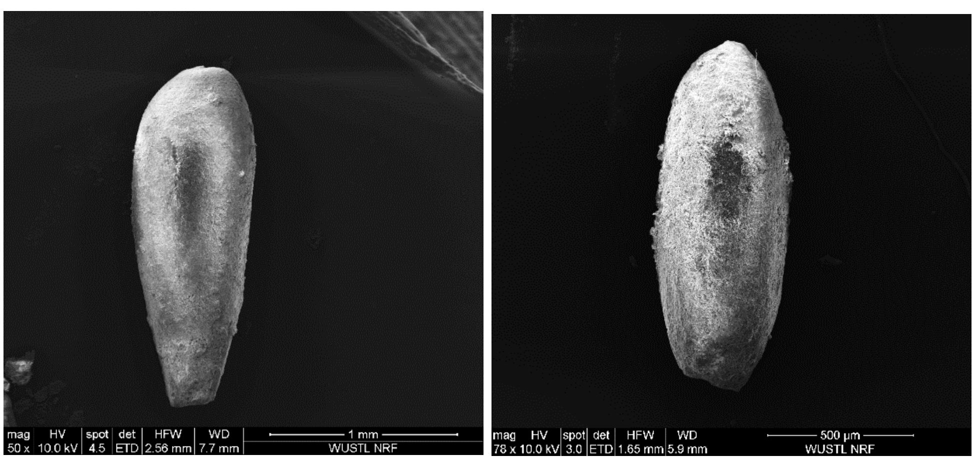


Figure 6.7: SEM Image of Poaceae Type #1 (right) and Poaceae Type #2 (left).

Poaceae Type 3 is long and rod shaped (Figure 6.8). This seed type has an angled attachment scar at its base where its embryo broke off. This seed type measures approximately 2.0 mm in length and 0.5 mm in width. Poaceae Type 4 is oblong and rounded (Figure 6.8). It measures 2.0 mm in length and 0.5 mm in width.

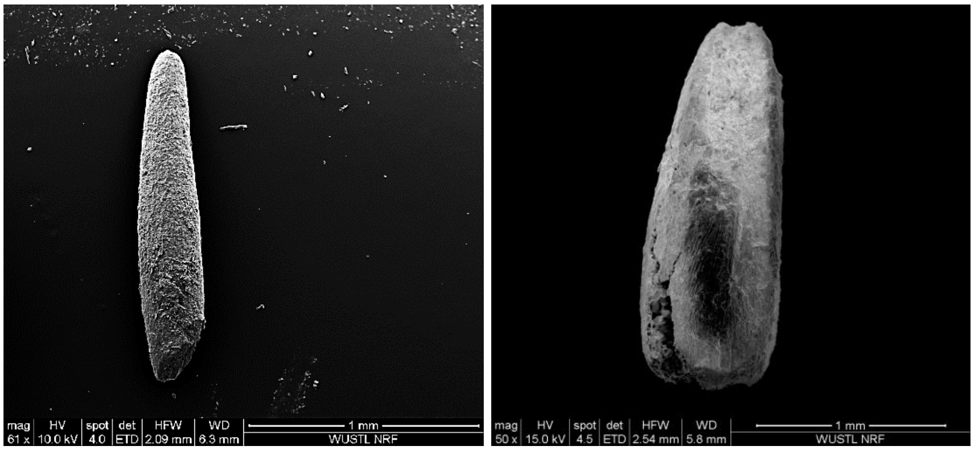


Figure 6.8: SEM image of archaeological Poaceae seed Type #3 (left) and Type #4 (right).

Poaceae Type 5 is larger measuring between 1.6 and 5.0 mm in length and 0.7 and 1.1 mm in width. This seed type has a ventral sulcus, or groove, characteristic of the grass genus *Stipa* sp. (Figure 6.9). Poaceae Type 6 is ovoid and flattened on one side. This seed type also has a ventral sulcus and measures about 1.0 mm in length and 0.5 mm in width. I identified one seed as *Piptochaetium* sp. This seed is rounded and lenticular with nodules at both ends (Figure 6.9). The surface is striated, and the striations run lengthwise curving toward the nodules. There are a few, very small raised bumps or protrusions along these ridges. This seed type measures 1.7 mm in length and 0.7 mm in width. Poaceae Unknowns comprises all of the seeds that are morphologically identifiable as grass; however, they are fragmented or lacked distinct shapes, surface textures, or other features that would aid in identification.

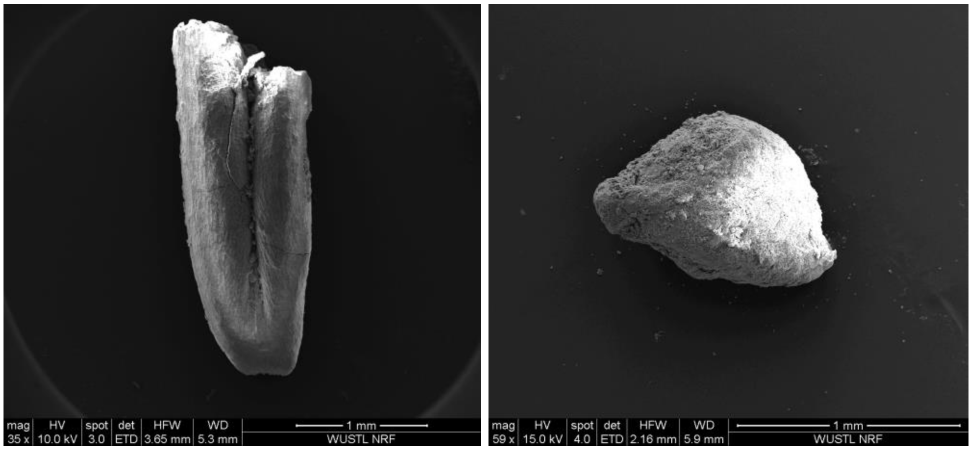


Figure 6.9: SEM image of fragmented archaeological Poaceae seed Type #5 (left) and *Piptochaetium* sp. seed (right).

On the northwestern side of Lake Titicaca near the study region, 24 genera including 85 species of grass have been identified (Whitehead 2007:222). At least 23 species of grasses have been identified growing along the southern shores of Lake Titicaca, some of which are introduced Old World grasses (Bruno 2008:246). Grass species identified in a botanical survey of the central *altiplano* include: *Nasella meyeniana* (Trin&Rupr.) Parodi, *Asistida enoides* Hack., *Bromus catharticus* Valh., *Eragrostis uvula* (Schrad.) Needs., *Chondrsum simplex* (Lag.) Kunth, *Dactylis glomerate* L., *Fistula orthophylla* Pig., and *Bromus catharticus* Valh. (Sempertugui et al. 2005). Notably, a group commonly referred to as the "ichus" thrive in drier areas in the *altiplano*. This group includes the species *Stipa ichu, Stipa leptostachya* Griseb., and *Stipa pseudoichu* Caro. Due to similarities in morphologies and sheer number of species in the *altiplano* grasses, I was only able to identify the grasses to family or genus.

The *ichus* are a documented camelid forage food in the *altiplano* (Bruno 2008:246). They are also used as fodder, fuel, rope, and fiber (Whitehead 2007:224). The plethora of other grass species are also used for animal forage, fodder, basketry, and construction material (for thatching and roofing material) (Bruno 2008:246-247; Whitehead 2007:224). The identified charred Poaceae seeds may have been used as construction material that was accidentally or intentionally burned as fuel. A more likely scenario is these seeds were charred in camelid dung burned for fuel or attached to dried grass stalks used for fuel.

Rubiaceae

I identified eight *Relbunium* sp. seeds in Ayawiri macrobotanical samples (standardized density = 0.01 seeds/liter and 6% presence). The Rubiaceae family is commonly referred to as the bedstraw or coffee family. The *Relbuniusm* sp. seeds I distinguished are oval, plump, and D-shaped in cross-section. They have a rough, puckered surface. The ventral side of the *Relbunium* sp. seeds are hollowed out like a boat (Figure 6.10). They measure approximately 1.6 mm in length and 0.8 mm in width.

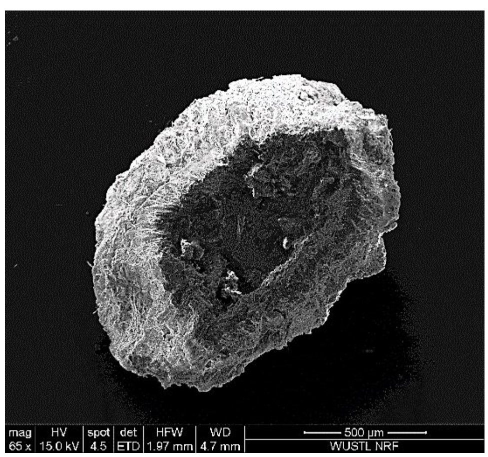


Figure 6.10: SEM image of archaeological *Relbunium* sp. seed.

In botanical surveys in the region, several *Relbunium* spp. have been collected including *Relbunium ciliatum* (Ruiz & Pav.) Hemsl, *Relbunium* cf. *richardianum* (Gill ex Hook & Am.)

Hicken (Bruno 2008:255). These plants are small shrubs. Additionally, approximately 20 *Relbunium* spp. have been identified throughout the Andes (Niemeyer and Agüero 2015).

Relbunium sp. plants were one of the main sources of red dye used in textile production throughout the pre-Colonial Andes (Cardon and Higgitt 2007). The roots of these plants are pounded and macerated to release the chemical purpurin. This chemical is then used to dye wool and cotton textiles a reddish color. *Relbunium* spp. have also been noted as camelid forage foods. Hastorf and Wright (1998:221) found copious amounts of *Relbunium* spp. seeds in dung collected from the *altiplano*, even though it is not a ubiquitous plant growing in the region. These researchers believe these date indicate that llama herds seek out this plant during foraging.

The comparatively higher ubiquity of Rubiaceae seeds at other sites in the *altiplano* has been attributed to dung burned as fuel; although, the plant's use as a dye has not been ruled out (Bruno 2008:254-255; Whitehead 2007:202). If it were a sought-after camelid forage food, we would expect to see a high percent presence at Ayawiri. We would expect this plant to show up in only a few samples if it was used as dye. Indeed, twenty-four seeds are a significant number in only two samples from Ayawiri, which might indicate a specific use as dye during the LIP. However, since the root is the part of the plant used for dye, the seeds might be remnants of seed rain.

Solanaceae

I identified four cf. *Solanum* sp. seeds in Ayawiri macrobotanical samples (standardized density = <0.01 seeds/liter and 3% presence). Solanaceae is commonly referred to as the nightshade family. It is one of the most important economic plant families in the Andes that include the food crops potatoes and chili peppers. Chili pepper plants cannot grow in the high elevation and harsh environment of the *altiplano.* Potatoes, however, were domesticated in the highland Andes for their tubers (Flores et al. 2003; Pearsall 2008:107). Indeed, potatoes are adapted to environments with poor soils, constant erosion, and unpredictable rainfall and temperatures, characteristic of the steep slopes of the Andes (Flores et al. 2003:161).

The *Solanum* sp. seeds I distinguished are obovate and lenticular in cross-section with sharp margins. They have a slightly reticulated surface. These seeds measure approximately 1.0 mm in length and 0.6 mm in width.

Floristic taxonomists have found that the potato was domesticated from the wild extant species *Solanum brevicaule* Bitter. Today, there are numerous varieties of this wild nightshade found growing across the Andean highlands. Additionally, Bruno (2008:257) found feral or wild *Solanum tuberosum* growing along the edges of cultivated fields near Lake Titicaca. Getic work has clarified that there was a single domestication event or monophyletic origin of *Solanum tuberosum* from *Solanum brevicaule* in the central Peruvian highlands (Spooner et al. 2005). Human selection over the past few millennia in the Andes, led to a high diversity of varieties of potatoes. In fact, the International Potato Center in Lima has identified at least 3,500 native potato varieties (Huamán et al. 1997:23). Indeed, potato varieties grown in the *altiplano* today range just about every color of the rainbow and are a myriad of sizes. Due to the high phenotypic plasticity of potatoes, many varieties have been bred to withstand various conditions including drought, salinous soils, and different elevations. Other varieties were bred for their size, shape, color, and taste profiles. Today, farmers in the *altiplano* grow several varieties of potatoes in the same field, or in the same season to ensure crop yields in the event of unfortunate weather or other conditions. See Figure 6.11 for two examples of potato varieties grown on the terraces at Ayawiri today.

Figure 6.11: Photos of two varieties of potatoes grown on the Ayawiri terraces today.

The seeds of wild and domesticated *Solanum* sp. cannot be distinguished. This is due to the fact that humans selected for variations in tuber morphology, not the seeds. The fruit of potato plants is not eaten by humans because it contains high levels of the toxic glycoalkloid solanine characteristic of the Solanaceae. The tuber is the part of the potato that is consumed and used to propagate the plant. However, in wild and some domesticated varieties of potatoes the tuber also contain poisonous levels of glycoalkaloids. Demonstrative of the effects of human selection, a domesticated potato has on average fifteen to twenty times less glycoalkoloid content than its wild ancestor (Johns 1989). Today, in the *altiplano* residents still eat varieties of potatoes with remarkably high levels of toxins, because they prefer the bitter taste that is a result of the glyoalkaloid solanine (Browman and Gundersen 1993; Johns et al. 1989:509). To avoid dying and stomachs, these people consume clay that has been transformed into a gravy-like sauce along with the bitter-toxic potatoes (Browman and Gundersen 1993). The practice of consuming soil to aid in digestion is called geophagy. Johns and his colleagues (1989) found in experimental research that clay binds to the solanine, allowing the poisonous potatoes to past through human digestion systems without causing illness (Johns et al. 1989). Additionally, the common highland practice of freeze-dying potatoes in the altiplano also rids potatoes of this harmful chemical (Johns et al. 1989:509). The cold nights and warm sunny days of the Andes facilitate this cultural practice. Freeze-dried potatoes called *chuño* are a staple in the diet of modern *altiplano* residents.

Thus, it is unlikely the *Solanum* sp. seeds I found were not brought to the site for food. These seeds likely arrived at Ayawiri in camelid dung burned for fuel. Alternatively, based on the low density of this taxon, the seeds could also have arrived via seed rain.

Verbenaceae

I identified three Verbenaceae seeds in Ayawiri macrobotanical samples (standardized density = <0.01seeds/liter and 2% presence). The Verbenaceae family is also known as the verbena or vervain family. The seeds I found are *Verbena* sp. Morphologically they are oblong and round and plump in cross section. The dorsal side of the seed is smooth and slightly indented (Figure 6.12). The ventral side has large reticulations. These seeds measure 1.4 mm in length and 1.6 mm in width.

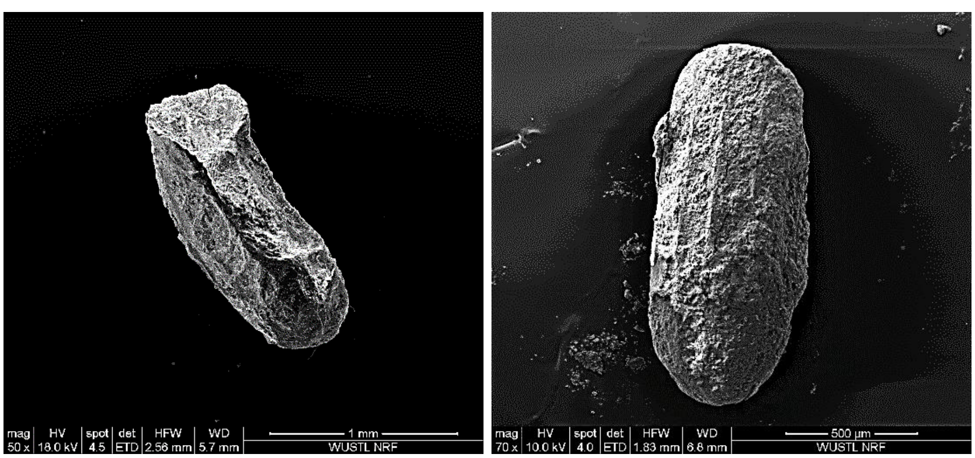


Figure 6.12: SEM of archaeological *Verbena* sp. seed dorsal side (left) and ventral side (right).

Several verbena species have been collected in botanical surveys in the region in including *Verbena microphylla* Kunth, *Verbena* cf. *bangiana* Moldenke, and *Verbena weberbaueri* Hayek (Bruno 2008:260). In the *alitplano*, verbena plants grow as weeds in agricultural fields and on hilly slopes (Bruno 2008:260). There are no recorded uses of verbena plants in the region.

The low density and ubiquity of verbena seeds indicate it was not an economically important plant. With no known uses, this plant was likely brought to the site in dung burned for fuel. Or, perhaps it entered and preserved at the site as seed rain.

Potatoes, Tubers, and Parenchyma

I identified 375 parenchyma fragments in Ayawiri macrobotanical samples (standardized density = 0.37 fragments/liter and 28% presence). No fewer than 17 species of roots and tubers belonging to at least nine plant families were domesticated in the Andes (Flores et al. 2003:161). These include the potato (*Solanum tuberosum*), oca (*Oxalis tuberosum*), mashwa *(Tropaeolum tuberosum*), ulluco (*Ullucus tuberosus*), and maca (*Lepidium meyenii*) (Flores et al. 2003; Pearsall 2008:107). All of these tubers and roots are boiled and/or mashed in preparation for consumption. Due to this preparation method and the water content of tuber and root crops, they are rarely preserved in the archaeological record. Tuber and root fragments do not regularly fall into the fire and char the way seeds do. Pearsall (2000:157) states that “the most likely source … of tubers are those discarded as spoiled … and any accidentally charred during roasting.” In this study, I found evidence of root and tuber crops in three forms: first, I found the aforementioned seeds; second, I found whole charred potatoes; and third, I found charred parenchyma or plant storage tissue that I identified as tubers or root crops based on the morphological structure of the specimens. Here, I focus on the charred potatoes and parenchyma.

During excavations two caches of charred potatoes were found in house floors. From these caches, I have identified and analyzed 28 charred, almost complete, small potatoes that measure between 1.5 and 7 cm in diameter. The remainders of periderm or skin can be seen under the microscope on several of these specimens. Additionally, I identified axillary buds on a few specimens that are morphologically similar to potatoes (Figure 6.13). Why were these potatoes so perfectly preserved through charring? I think these potatoes were charred stores of freeze-dried potatoes, or c*huño*. Without their water content, potatoes easily burn and preserve the same way as seeds.

Figure 6.13: Photo of carbonized archaeological potato depicting the intact periderm and axillary bud.

The potato's wild ancestors have high levels of toxic chemicals. Wild and even some domesticated varieties of potatoes contain poisonous levels of glycoalkaloids. Freeze-dried potatoes can be stored for up to five years (D'Altroy 2002). These potatoes are then reconstituted in soups and stews, retaining much of their caloric and nutritional benefits. *Chuño* is a staple in the diet of modern Aymara peoples. It is not surprising that Ayawiri residents would be storing *chuño* in their homes that would have been then preserved through an accidental or intentional fire.

Although it is easy to identify carbonized parenchyma, it is extremely difficult to determine the family, genus, or species of the tuber. Hundreds of colloquial varieties of roots and tubers of varying morphologies are known in the Andes, which make it even more difficult to identify the scientific genus and species of parenchyma/tuber fragments. An organized cellular structure and non-uniform shape help distinguish at the very least a degree of identification of carbonized parenchyma/tubers fragments (Pearsall 2000) (Figure 6.14). Future research using more advanced techniques and technologies, such as scanning electron microscopy, may reveal the identities of the tuber taxa found at Ayawiri.

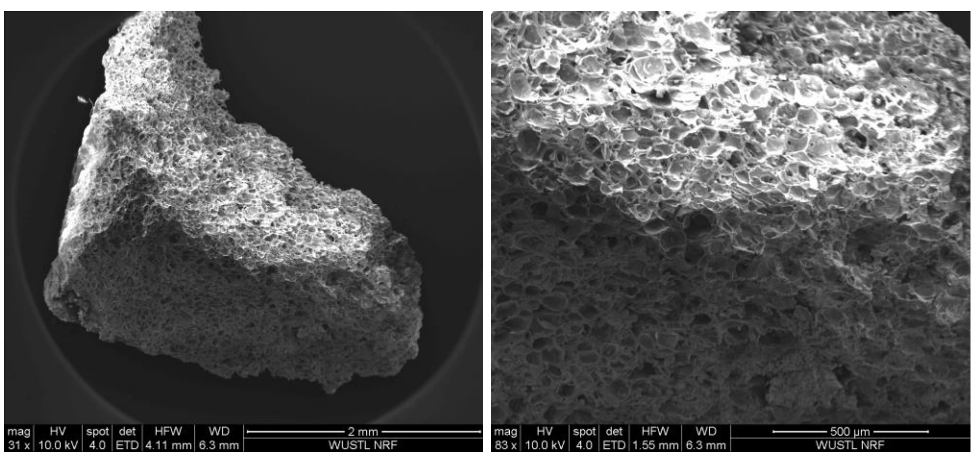


Figure 6.14: SEM images of archaeological parenchyma from Ayawiri.

Unfortunately starch grain analysis currently does not permit differentiation of Andean tuber cultivars. A study by Rumold (2010) sought to determine morphological differences in starch grains that could be used to distinguish potatoes from oca and ulluco. However, she found considerable overlap in the size and shape of starch grains of these tuber genera. Therefore, starch grain analysis of tuber crops is currently very limited in its utility in the Andes.

The amount of parenchyma I found is not an unusually small or large quantity of parenchyma to be preserved in a site in the region. Parenchyma has been found in anywhere from 3% (Wright et al. 2003) up to 96 % of the samples (Bruno 2008) from other sites. Based on the identification of whole potatoes and charred *Solanum* sp. seeds, I conclude that at least a portion of the parenchyma found are from potatoes. The identification of a charred *Lepidium* sp. seed, raises the possibility that Ayawiri residents were growing and using maca. The parenchyma found was likely brought to the site for intended for direct resource use for consumption and was charred in cooking accidents, as sub-floor offerings, or disposed of as refuse in fires.

Peduncle

I found a single charred peduncle, or stem that supports a fruit or inflorescence. The stem is small measuring about 2.2 mm in length. It does not have any morphologically distinct characteristics that would aid in identification. Since plants that are burned in dung are partially masticated and digested before they are used for fuel, it is unlikely that a small fragile peduncle would have survived the digestive tract of a camelid or other animal. This leads me to rule out that it was burned in dung for fuel. Rather, this stem was probably burned with the rest of this plant to stoke or fuel a small fire.

Wood

I identified 1,667 fragments of wood weighing 20 g in Ayawiri macrobotanical samples (standardized density = 1.66 fragments/liter and 80% presence). Today, trees are sparse in the *altiplano*, and palynological studies from lake sediments indicate that this pattern was well established long before the Late Intermediate Period (Gosling and Williams 2013; Paduano et al. 2003). Indeed, the landscape surrounding Ayawiri is almost completely devoid of trees except for a few growing near the base of the terrace complex. I identified these as *Polylepsis* sp. locally referred to as *keñua*, *kewiña*, and they have long been used for fuel (Ansión 1986). However, there are only a few of these trees. This small population of *Polylepis* sp. trees would have been insufficient to provide for the fuel needs of the large LIP population residing at Ayawiri. In the Rosaceae family, *keñua* trees are knotty and soft. This makes them unsuitable for creating long-burning and hot fires or for construction material.

On the other hand, woody shrubs predominate the flora in the region and are common on agricultural terrace margins, on the steep hillsides, and on the top of the mesa just north of Ayawiri. These shrubs are referred to locally as *tholas* and include the species *Baccharis microphylla* Kunth and *Tetraglochin cristatum* (Britton) Rothm. (Bruno 2008; Wright et al. 2003). Due to the scarcity of trees in the *altiplano*, woody shrubs were likely used as a complementary fuel source in prehistory throughout the region (Bruno 2008). Browman (1989:155) notes that roots of tholas are occasionally consumed as a famine food, the leaves are used in teas and tonics, and they have a few medicinal uses. The recovered woody fragments may be the result of direct resource uses; however, it is more likely woody products were used to fuel fires.

Many of the woody specimens I examined from Ayawiri are very small fragments barely larger than 2 mm. While this could be a taphonomic issue where carbon was pulverized due to trampling or during excavations, I think the specimens are all small because they are from burned shrubs. Trees often produce larger fragments of wood. This indicates Ayawiri residents were stoking their fires with the branches of dried woody shrubs. Based on comparable ubiquities of wood recovered from Ayawiri to other sites in the region Ayawiri residents were using shrubs for fuel in a similar manner to earlier time periods.

There has not been any research conducted in the region on the anatomy of shrubs or trees. At this time, paleoethnobotanists working in the region are unable to differentiate or discuss a taxonomic identification of trees or woody bushes.

Dung

I identified 15 dung fragments in Ayawiri macrobotanical samples (standardized density = 0.03/liter and 4% presence). The sheer presence of charred dung fragments indicates that it was used for fuel. I did not identify any complete dung pellets; however, there were several fragments that appeared characteristically dung-like. These fragments were identified by their unorganized cellular structure, brownish-black color, and contents of organic fragments. The comparatively small amounts of dung in the analyzed samples may also be attributed to recovery methods. Charred dung is fragile and may have disintegrated to unidentifiable even smaller fragments during recovery, flotation, and even laboratory sorting procedures.

Bone: Charred and Uncharred

While analyzing the light fractions, I found small fragments of charred and uncharred bone. I separated these from the greater than 2 mm fraction because they shed light on meat processing and cooking activities. I found 1,270 fragments of charred bone in Ayawiri macrobotanical samples (standardized density = 1.21 fragments/liter and 25% presence) and 334 fragments of uncharred bone (standardized density = 0.3 and 17% presence). There is a considerably higher and more ubiquitous amount of charred bones than uncharred bone. This is perhaps a taphonomic issue, since burned bone is lighter and more likely to float, or maybe this indicates that residents were doing more cooking at the site than processing. The residential sector at Ayawiri is crowded and cramped. Perhaps butchering of entire camelids took place offsite, whereas roasting small cuts of meat and boiling bones in soup was carried out within households. These are hypotheses beyond the scope of this dissertation that zooarchaeological data that is currently being analyzed might be able to address.

Human and Camelid Diet and Behaviors

I assessed the identified macrobotanical taxa in terms of human use. I compare these to other local macrobotanical datasets from different time periods to understand changes in plant use during the LIP. Then, I follow a method detailed by Marston (2011) and Langlie and Arkush (2016), where I query the macrobotanical data to better understand landscape use by Ayawiri pastoralists. With the taphonomic understanding that charred herbaceous seeds are fuel remains, nuanced questions of grazing behaviors can be answered using macrobotanical remains (Miller 1996). Thus, analysis of macrobotanical remains from Ayawiri potentially elicits information about the diet of humans, their animals, and the ranging behaviors of ancient herds.

Evidence of Human Diet, Food Plants, and Utilitarian Plants

The taxa I identified that Ayawiri residents likely consumed include chenopod crops, cactus fruits, and potatoes. There is weak evidence that they also consumed totora rhizomes, plantago greens, maca, and other tubers. These plants are a part of a standard diet in the region even today (however, Old World domesticates such as wheat, barley, and rice have been incorporated into cropping schemes and the diet throughout the *altiplano* since the Colonial era). Each of the indigenous crops found at Ayawiri can all be locally produced and they have been found at nearby archaeological sites dating to the Formative and Middle Horizon Periods. There is no evidence that new crops were introduced into the agricultural system of the diet during the LIP. Based on the absence of foreign plant products at Ayawiri, there is evidence that certain crops fell out of favor or were no longer available during the LIP.

I found *Chenopodium* spp. to be the most ubiquitous and abundant seed taxon at Ayawiri. Without a doubt, residents relied on chenopod grains as a primary ingredient in their meals. The caches of this crop indicate that people depended on stores of quinoa. Similarly, the caches of potatoes and the many parenchyma fragments are strong evidence that roots and tuber crops were an integral part of the Ayawiri diet.

There were several crops plants that were less ubiquitous in the Ayawiri assemblage compared to other sites dating to earlier time periods in the region. Cactus seeds were not very abundant or common in the Ayawiri assemblage. With the intensive agriculture that was taking place around the site, cactus plants may have been eliminated to make room for fields and crops, subsequently decreasing the availability of cactus fruits.

Cyperaceae also decreased in importance based on the comparatively low ubiquity of seeds. However, this is not a good measure of the incorporation of totora rhizomes into the diet. Consumed raw, there is no known direct resource use that would result in carbonized totora seeds. It is highly unlikely that the Cyperaceae seeds I found are the remains of human foodways, but this does not dismiss the possibility rhizomes were eaten. Totora may have been used for construction materials such as thatched roofing. An accidental house fire would have preserved any seeds attached to the inflorescence. If this is the case, then it was used less at Ayawiri than other sites in the region. Notably, it is a several hour walk to the nearest extant stands of totora at Lago Umayo. Due to the limited availability, perhaps Ayawiri residents were using totora less for food and construction material than residents living near littoral ecotopes, where these plants grow.

Relbunium sp., another plant with locally known economic importance as a plant dye, was also less prominent in the plant economy at Ayawiri than other sites and time periods in the region. We know textile production was carried out at Ayawiri. Numerous spindle whorls were found discarded on house floors (Arkush and Paredes 2012, 2013) indicating residents were producing fiber yarn within the residential area of the fort. If *Relbunium* sp. plants were used as a textile red dye by Ayawiri residents, then my findings indicate it was less important during the LIP than previously, where higher ubiquities have been reported. Perhaps residents substituted cochineal, a parasitic cactus beetle commonly used to produce red colors, for relbunium dye during the LIP. On the other hand, maybe weavers produced fewer luxury textiles during the LIP and focused on making un-dyed quotidian pieces.

The crop notably missing from the Ayawiri assemblage is maize. Today, a maize variety adapted to harsh environment is grown in small amounts near lakeshores, where the microclimate of the littoral ecotopes protects the lowland crop from nighttime frosts. Maize has long been valued in the *altiplano*. Logan and colleagues (2012) found microbotanical remains in ritual ceremonial contexts dating back to the Middle Formative Period (800-250 B.C.E.). Bruno (2007) identified a few morphologically non-local charred maize kernels from secure contexts at the Formative Period site Kala Uyuni on the southern shores of Lake Titicaca. During the Middle

Horizon (C.E. 500-1100) imported maize was a cornerstone of the local diet for residents at Tiwanaku, where researchers found macrobotanical corn remains to be the second most ubiquitous crop type recovered (Wright et al. 2003). These researchers argue the importance of maize at Tiwanaku could only have been achieved through importation, since maize does not readily grow there due to the climate and high elevation of the region. Maize cupules, glumes, and kernels have been found in elite, commoner, domestic, and sacred architectural spaces at Tiwanaku. Drunk as chicha beer, maize also served the function as a quotidian and ritually important beverage. Whether drunk as a beverage or consumed in soups or other recipes, maize has long been, without a doubt, an integral part of *altiplano* foodways.

Based on the long-standing, prized use of maize, I had expected to find that both its substantive and symbolical value endured during the LIP. The complete absence of maize at Ayawiri points to a transformation of its importance, and potentially a shift in sacred and profane plant use during the LIP. Perhaps, trade networks broke down due to the fear of enemy attack, eliminating access to maize. Perhaps, exotic perishable goods were no longer prized or valued during the LIP, and the absence of maize signals a transformation in culture and symbolism in the region. Or maybe the absence of maize at Ayawiri is a result of both of the aforementioned causes; trade networks broke down, causing a transformation in people's values, or values shifted causing a cessation in trade networks. This economic shift surely signals a change in trade relations and access to luxury crops produced in distant regions. Additionally, the absence of maize at Ayawiri signifies a transformation in domestic and ritual foodways, in which maize had been such an integral part of previously. Rather than valuing exotically produced crops during the LIP, based on the macrobotanical remains at Ayawiri, residents shifted their foodway values to prizing locally produced grains and tubers.

Camelid Fodder or Grazing Patterns

With my findings, I can identify ecotopes where residents grazed their camelid herds. Based on information derived from modern Andean camelid foraging studies, we know that modern alpaca and llama herds in the Andes eat a diverse and broad diet (Bryant and Farfan 1984; Flannery et al. 1989). Andean camelids can consume an array of forage plants and cultigens (Bonavia 2008). Furthermore, among Andean farmers, it is common practice to share cultivars with herd animals (Hastorf and Wright 1998).

In order to carry out this analysis, I grouped the plant taxa found in samples from Ayawiri into four categories based on the ecotopes where they are commonly found. 1) *Crop plant* remains including *Chenopodium* spp. seeds and parenchyma that are cultivated in fields. 2) *Crop companion weeds* are plants that thrive in disturbed plots of land. They grow as weeds in actively managed fields, or as succession plants in agricultural plots lying fallow. In this study, these taxa include seeds from Malvaceae, *Relbunium* sp., Rubiaceae, and *Trifolium amabile* plants. 3) *Small herbaceous* plants grow wild throughout the region around Ayawiri, but particularly in the valley bottoms. The small herbaceous plant seeds I found include Poaceae and *Plantago* sp. 4) *Wetland plants* are taxa that grow in lacustrine or riverine areas. In this study, the only taxon I found that grows solely in wetlands is Cyperaceae. Today, sedges do not grow in the nearby bofedal. Therefore, residents would have had to travel further afield to acquire this plant.

An abundance of crop and crop companion weed plant remains would indicate an intensive land use strategy where farmers grazed their herds within agricultural fields and/or shared their food with camelids, whereas the remains of wild herbaceous seeds and riverine plants that thrive in wetlands would point to an extensive herding strategy and human land use pattern. Abundant and ubiquitous crop, weed, and herbaceous macrobotanical remains would be indicative of a mixed strategy of intensive agriculture in the terraced fields and extensive grazing/foddering,

Based on the abundance of crop and companion weed plants, my findings indicate Ayawiri camelids were primarily grazed intensively in cultivated fields, probably on the terraces adjacent to site. The exceptionally large concentrations of chenopods are evidence that residents foddered camelid herds. However, residents occasionally took their herds to graze in riverine or lacustrine areas as indicated by the identification of a small amount of wetland plant remains, such as Cyperaceae. Compared to Formative Period sites in the *altiplano,* the low incidence of Cyperaceae plants and other wetland species indicates herds rarely grazed in wetlands. These data point to a very constrained grazing and land use strategy during the LIP.

Cultivated, Weedy or Wild: Chenopod Analysis

Chenopodium spp. seeds are the most abundant crop at Ayawiri. Indeed, I have identified well over one million chenopods (an extrapolated number based on weight) recovered from just about every context including kitchen floors, non-kitchen house floors, hearths, pits, and fill. This is strong evidence that chenopods were foundational to the diet of Ayawiri residents. These findings raise the question: Were Ayawiri people growing the chenopods during the LIP? Or were they gathering wild chenopods? If they were cultivating these crops, how intensively did farmers weed fields and manage specific chenopod varieties?

Identifying these behaviors depends on an in-depth analysis of the signatures of domesticated, weedy, or wild chenopods. In order to do this, it is necessary to take a multivariate approach that includes the use of a light microscope and scanning electron microscopy. This approach is based on *Chenopodium* sp. studies that were initially developed by researchers working on domestication of chenopod species in North America. These projects assess seed diameter, testa thickness, seed shape, and testa texture to identify evidence of domestication (Fritz 1986; Fritz and Smith 1988; Gremillion 1993; Smith 1985a, b; Wilson 1981). Researchers in the Andes have adapted and refined these methods in order to study specific trajectories of quinoa and kañawa domestication during the Terminal Archaic and the Formative Period throughout the south-central highlands (Bruno 2006; Bruno and Whitehead 2003; Eisentraut 1998; Langlie et al. 2011). In particular, the addition of an assessment of beak prominence (the protrusion of the radicle beyond the margin of the seed) has helped Andean researchers distinguish between distinct domesticated varieties (see Langlie et al. 2011). In North American, research has demonstrated that wild chenopods have weak beaks, whereas cultigens have prominent beaks (Gremillion 1993:497). Gordon (2006) identified a similar trend in Mesoamerican chenopods where beak prominence helps to distinguish wild chenopod varieties from domesticated ones. Notably, this study on Ayawiri chenopods is the first multi-variate analysis of its type of Late Intermediate Period chenopods in the Lake Titicaca Basin.

Diameter and Seed Coat Thickness

Under the selective pressures of cultivation throughout the Formative Period, seed size of Andean chenopods has been shown to increase (Browman 1989:143-148; Bruno 2001; Bruno 2006; Bruno and Whitehead 2003). This increase in size was the result of what Harlan (1975) has identified as seedbed competition, where the larger seeds out-compete smaller seeds. Humans then harvested and sowed the larger seeds, changing the phenotype of subsequent generations of saved seeds. During this process farmers also selected the fastest maturing plants. The first seeds to germinate in a garden are ones that have thinner testa for the radicle to quickly break through. Thus, a decrease in relative testa thickness is also an indicator of human-induced selective pressures (Smith 1989:1568).

Margin Configuration, Seed Coat Texture, and Beak Prominence

A change in seed coat texture and margin configuration has been show to accompany changes in chenopod seed diameter and testa thickness (Bruno 2006, 2008; Bruno and Whitehead 2003; Gremillion 1993; Langlie et al. 2011; Smith 1984). In cross-section thick seed coats compress the embryo and perisperm of wild and weedy chenopods, whereas thinner seed coats of domesticated chenopod varieties allow the embryo and perisperm to expand in the seed coat. This plumping results in a rounded-to-truncate margin where you can distinguish the shape of the embryo under the seed coat. In some cases, this also results in an increase in beak prominence because the embryo is no longer constricted by the thick seed coat. The complete results of these analyses are presented in Appendix G. Here, I focus on the data that point to whether the chenopods at Ayawiri were cultivated varieties, wild, or weedy.

Chenopod Analysis Results

The mean diameter of the 997 chenopods seeds measured in this study is 1.16 mm (σ =.4, Min= 0.4 mm, Max= 2.0 mm). Due to poor preservation of morphological traits, I was able to determine the margin configuration and the testa texture of only 456 chenopod seeds (see Table 6.2 and Figure 6.15). From the chenopods for which I was able to distinguish both these traits, 92% have a smooth testa texture with rounded or truncate margin configuration (n=419).

Table 6.2: Summary of the margin configurations compared to the testa texture for Ayawiri *Chenopodium* spp. seeds.

	Canaliculate	Reticulate	Smooth	No Data	Totals
Biconvex	1	1	7	2	11
Equatorially Banded	0	1	0	0	1
Rounded	6	13	280	39	338
Truncate	1	7	139	14	161
No Data	8	5	265	208	486
Totals	16	27	691	263	997

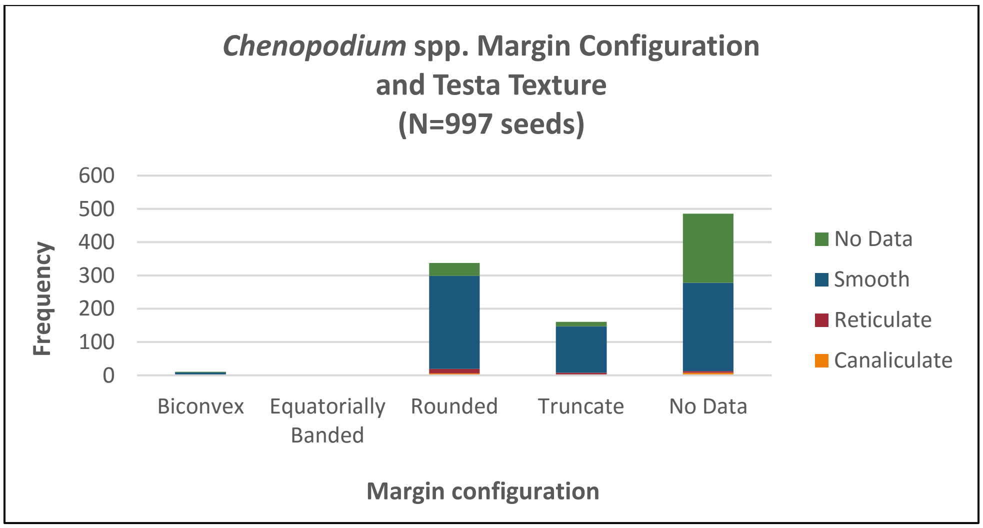


Figure 6.15: Bar graph of the margin configurations compared to testa texture for Ayawiri *Chenopodium* sp. seeds.

While seed diameter was visible on every specimen, it was not always possible to distinguish margin configuration, seed coat texture and beak prominence due to charring and other taphonomic processes. When seeds were puffed due to conditions of the fire in which they were carbonized, the margin configuration was often distorted. Seeds lacking a testa or that were poorly preserved did not have a distinguishable seed coat. Sometimes the beak was broken off specimens. It is worth noting that for the qualitative portion of this analysis, I often had a hard time distinguishing between the choices of shapes or textures. There are three reasons why I think this was difficult. First, charring and puffing distort these features to varying degrees. Second, these features are not discrete categories; rather, phenotypic change is the result of human selection over time. Third, chenopod plants are wind pollinated (Wilson 1990), so introgression between wild, weedy, and cultivated species could have an impact on seed morphology. I believe these processes are responsible for overlap in these morphological features. In other words, I think these categories should be thought of as a continuum rather than discrete categories. This makes sense since human selection occurs over time and this process results in small incremental phenotypic change.

Even when the testa was broken off of specimens, I was still able to determine how far the radicle extended past the perimeter of the seed as long as the embryo was still attached to the perisperm. I was able to determine the beak shape of 723 chenopods (Table 6.3). Of the seeds with intact beaks 58% have prominent beaks and 29% have weak beaks.

Table 6.3: Summary of the beak shape for Ayawiri *Chenopodium* spp. seeds.

Beak Shape	Very Prominent	Prominent	Weak	Very Weak	No Data	Total
	68	419	210	26	274	997

The mean testa thickness of the 73 chenopods that I examined with the SEM is 8.5 µm (σ =5.8 µm, Min= 2.2 µm, Max= 36.8 µm). Generally, I found that chenopod seeds with a larger diameter had thinner testa textures, and smaller chenopods had a slightly thicker testa texture (see Table 6.4, which I sorted in ascending order by the value of the ratio of testa thickness/seed diameter).

Table 6.4: Summary of the ratio of testa thickness/seed diameter of Ayawiri chenopods.

Specimen #	Total Testa Thickness (μm)	Log Total Testa Thickness	Seed Diameter (μm)	Log Seed Diameter	Ratio Testa/ Diameter	Testa Texture	Margin	Beak
73	4.4	0.64	1800	3.255	0.002	Smooth	Truncate	Prominent
68	4.8	0.68	1700	3.230	0.003	Smooth	Truncate	Weak
67	5.2	0.72	1800	3.255	0.003	Smooth	Rounded	Weak
42	5	0.70	1500	3.176	0.003	Smooth	Truncate	Weak
66	6	0.78	1800	3.255	0.003	Smooth	Rounded	Prominent
3	5.4	0.73	1600	3.204	0.003	Smooth	Rounded	Prominent
55	6.2	0.79	1700	3.230	0.004	Smooth	Rounded	Weak
63	6	0.78	1500	3.176	0.004	Smooth	Rounded	Weak
4	6.8	0.83	1500	3.176	0.005	Smooth	Rounded	Prominent
43	8	0.90	1700	3.230	0.005	Smooth	Truncate	Prominent
65	7.2	0.86	1500	3.176	0.005	Smooth	Truncate	Prominent
6	8.8	0.94	1800	3.255	0.005	Smooth	Rounded	Prominent
11	5	0.70	1000	3.000	0.005	Smooth	Truncate	No Data
71	8.4	0.92	1600	3.204	0.005	Smooth	Truncate	Prominent
31	7.4	0.87	1400	3.146	0.005	Smooth	Truncate	Very Prominent
8	9	0.95	1700	3.230	0.005	Smooth	Rounded	Prominent
69	9	0.95	1700	3.230	0.005	Smooth	Truncate	Prominent
39	7.6	0.88	1400	3.146	0.005	Smooth	Truncate	Prominent
36	9	0.95	1600	3.204	0.006	Smooth	Rounded	Very Prominent
61	9	0.95	1600	3.204	0.006	Smooth	Truncate	Prominent
57	10.4	1.02	1800	3.255	0.006	Smooth	Truncate	Prominent
1	9.5	0.98	1600	3.204	0.006	Smooth	Truncate	Prominent
2	10.4	1.02	1700	3.230	0.006	Smooth	Rounded	Prominent
35	10	1.00	1500	3.176	0.007	Smooth	Truncate	Prominent
54	11	1.04	1600	3.204	0.007	Smooth	Truncate	Prominent
62	12.6	1.10	1800	3.255	0.007	Smooth	Truncate	Prominent
64	11.4	1.06	1600	3.204	0.007	Smooth	Rounded	Prominent
5	11	1.04	1500	3.176	0.007	Smooth	Rounded	Prominent
70	12.4	1.09	1600	3.204	0.008	Smooth	Rounded	Prominent
58	13.6	1.13	1700	3.230	0.008	Smooth	Truncate	Prominent
34	12.2	1.09	1500	3.176	0.008	Reticulate	Truncate	Prominent
56	13.2	1.12	1600	3.204	0.008	Smooth	Truncate	Prominent
32	14	1.15	1600	3.204	0.009	Reticulate	Rounded	Prominent
37	12.4	1.09	1400	3.146	0.009	Smooth	Rounded	Very Prominent
51	8	0.90	900	2.954	0.009	Smooth	Rounded	Prominent
60	14.8	1.17	1600	3.204	0.009	Smooth	Truncate	Prominent
9	16.8	1.23	1700	3.230	0.010	Smooth	Truncate	Weak
38	17.8	1.25	1800	3.255	0.010	Smooth	Rounded	Prominent
30	16.2	1.21	1500	3.176	0.011	Reticulate	Truncate	Very Prominent
33	16.2	1.21	1500	3.176	0.011	Reticulate	Rounded	Very Prominent
59	16.6	1.22	1400	3.146	0.012	Smooth	Truncate	Prominent
19	11.2	1.05	900	2.954	0.012	Smooth	No Data	Weak
47	11.6	1.06	900	2.954	0.013	Smooth	Rounded	Weak
41	19.6	1.29	1500	3.176	0.013	Smooth	Rounded	Prominent
14	13.4	1.13	1000	3.000	0.013	Smooth	Rounded	Weak
22	15.2	1.18	1000	3.000	0.015	Smooth	Rounded	Weak

Specimen #	Total Testa Thickness (µm)	Log Total Testa Thickness	Seed Diameter (µm)	Log Seed Diameter	Ratio Testa/ Diameter	Testa Texture	Margin	Beak
72	32.2	1.51	1700	3.230	0.019	Smooth	Rounded	Very Prominent
53	15.2	1.18	800	2.903	0.019	Smooth	Rounded	Weak
13	17.6	1.25	900	2.954	0.020	Smooth	No Data	Weak
7	39	1.59	1800	3.255	0.022	Smooth	Rounded	Very Prominent
21	22.6	1.35	1000	3.000	0.023	Reticulate	Equatorially Banded	Prominent
15	22.4	1.35	900	2.954	0.025	Smooth	Rounded	Prominent
45	22.4	1.35	900	2.954	0.025	Smooth	Rounded	Prominent
29	20.2	1.31	800	2.903	0.025	Smooth	Rounded	Weak
48	20.2	1.31	800	2.903	0.025	Smooth	Rounded	Prominent
52	20.6	1.31	800	2.903	0.026	Smooth	Rounded	Prominent
28	20	1.30	700	2.845	0.029	Smooth	Rounded	Prominent
50	20	1.30	700	2.845	0.029	Smooth	No Data	Prominent
25	20.2	1.31	700	2.845	0.029	Smooth	Rounded	Prominent
27	23.8	1.38	800	2.903	0.030	Smooth	No Data	Prominent
26	29.8	1.47	1000	3.000	0.030	Smooth	Rounded	No Data
49	27	1.43	900	2.954	0.030	Smooth	No Data	Weak
46	24.2	1.38	800	2.903	0.030	Smooth	Rounded	Prominent
24	24.4	1.39	800	2.903	0.031	Smooth	Rounded	Prominent
40	46.4	1.67	1500	3.176	0.031	Smooth	Truncate	Prominent
16	25	1.40	800	2.903	0.031	Smooth	Rounded	Prominent
23	25.2	1.40	800	2.903	0.032	Smooth	Rounded	Prominent
12	29.2	1.47	800	2.903	0.037	Smooth	Rounded	Prominent
17	26	1.41	700	2.845	0.037	Smooth	Rounded	Weak
44	32.8	1.52	800	2.903	0.041	Smooth	Rounded	Prominent
20	38.8	1.59	700	2.845	0.055	Smooth	Rounded	Weak
10	43.8	1.64	700	2.845	0.063	Smooth	Rounded	Prominent
18	73.6	1.87	700	2.845	0.105	Smooth	Rounded	Prominent

[A] "Because the testa thickness is measured on only one side of [I], double the testa thickness value in order to account for the entire area represented by the testa when calculating the testa/diameter ratio (Bruno and Whitehead 2006:344)."
[B] "A log was applied to transform the values (Bruno and Whitehead 2006:344)."
[C] "To calculate the ratio, [I] divided total testa thickness (microns) by diameter (microns) (Bruno and Whitehead 2006:344)."

Another trend that I noticed is that smaller chenopods are generally rounded, whereas the larger chenopods tend to be truncate. There are no correlations between testa texture, beak prominence, and other variables. When I plot out the ratio of the testa compared to the seed diameter there are two distinct clusters. Generally, the larger seeds have a lower ratio whereas the smaller seeds have a higher ratio (Figure 6.16). Based on this information I have identified two types of chenopods at Ayawiri. The large type I refer to as Ayawiri Chenopod Type #1 and the smaller type I call Ayawiri Chenopod Type #2.

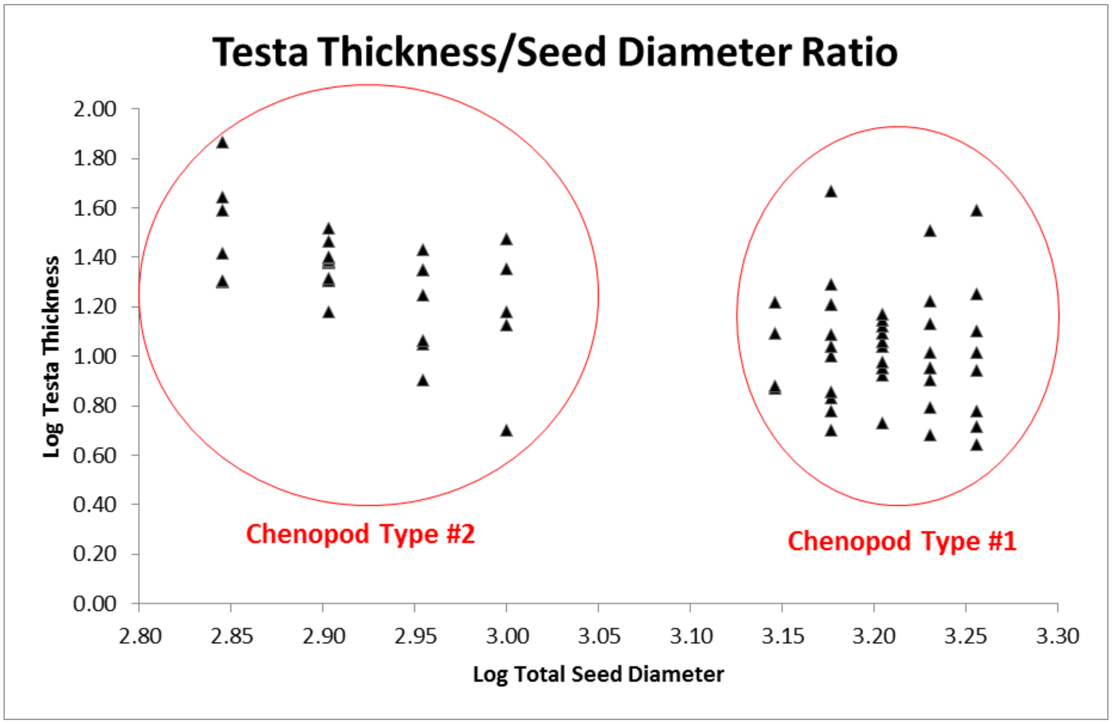


Figure 6.16: Scatterplot of log testa thickness compared to log diameter of Ayawiri chenopod seeds (n=73).

Based on this scatterplot I divided these data into two samples based on the evident discreteness of Chenopod Type #1 (n=43 seeds) and Type #2 (n=30). To evaluate whether seed diameter and testa thickness are statistically different between these two types, I twice ran two sample Welch's *t*-tests. First, I tested whether seed diameter was significantly different between the two chenopod types. Then, I tested whether testa thickness was different between the two types. Both seed diameter (t=-29.003, df=69, $p < 0.001$) and testa thickness (t=4.277, df=47, $p < 0.001$) are significantly different at the 0.05 level. These tests confirm that the measured samples Chenopod Types #1 and Type #2 are from populations that have discretely different mean seed diameters and testa thicknesses. At least for this sample, either testa thickness or seed diameter are sufficient measurements that can used to distinguish these populations from one another.

Comparing Chenopods

To shed further light on these data, I compare modern and archaeological Andean chenopods to the Ayawiri seeds. Modern quinoa has a margin configuration that is truncate (Bruno 2008:289). Both kañawa and wild Andean chenopods have round to truncate margin configurations, whereas the weed quinoa negra has a biconvex to equatorially banded margin (Bruno 2008:289). The chenopods in this study have margin configurations that are typically rounded (n=347) to truncate (n=162). These findings indicate that most Ayawiri chenopods are crops, but that a few are wild or weedy chenopods. Only 12 chenopods have a biconvex margin and one seed has an equatorially banded margin. If these morphological types represent weeds or wild chenopods, then there are very few of them in the assemblage.

The testa texture of modern quinoa is smooth, and kañawa is canaliculate (Bruno 2008:89). The testa texture of quinoa negra is reticulate, and wild species have a punctate testa texture. Almost all the seeds in this study have a smooth testa texture. This could indicate they are quinoa or another crop. As I noted, I think charring potentially distorts testa texture. I cannot rule out the possibility that I identified seeds as having a smooth testa texture, when in fact they were distorted.

Langlie et al. (2011) found that an archaeological variety of domesticated chenopod from the Oruro region has a very prominent beak. This contrasts with the archaeological and modern crop varieties described by Bruno (2008) and Bruno and Whitehead (2003). In these studies, the beaks of chenopods are prominent to weak (distinguished from photos since these researchers did not include this metric). Quinoa negra in particular appears to have a weak beak. Although this requires further research in the Andes, I think an increase in beak prominence goes hand-in-hand with other domestication syndrome features in chenopods. The Ayawiri chenopods generally have prominent beaks, providing further support they are crops.

Researchers have demonstrated that samples of modern quinoa and the weed quinoa negra overlap in diameter (Bruno and Whitehead 2003:343; Nordstrom 1990:11). Modern charred quinoa measures 1.6 to 2.2 mm; whereas, the weed quinoa negra measures 1.4 to 1.6 mm (Bruno 2008:289). This demonstrates that seed diameter alone is insufficient in the Andes to distinguish weeds from crops. Charred seeds of the crop kañawa measure 0.8 to 1.4 mm (Bruno 2008:289), and wild chenopod species measure about 0.7 to 1.2 mm (Bruno 2008:289; Browman 1989:146). The measurements of the diameter of the Ayawiri chenopods spans the entire range of wild, weedy, and cultivated species. However, the mean diameter of 1.16 mm is smaller than that of either modern quinoa or quinoa negra populations.

On the other hand, the Ayawiri chenopods are similar in diameter to other archaeological specimens that were identified as cultivated crops. Chenopod grain sizes increase through time at Chiripa. Browman (1989:145) found seed diameter, during the latest time period at Chiripa measured on average 1.0 mm (however, he may have included a type of very small *Amaranthus* sp.). He reports this increase in seed diameter through time was the result of human selection. Similarly, Bruno and Whitehead (2006:349) found archaeological quinoa and quinoa negra seeds from Formative Period Chiripa are smaller than modern specimens. Today, quinoa is under different selective pressures than it was in the past. Indeed, modern farming practices could be responsible for the seed diameter difference between ancient and modern quinoa. This means that I cannot rule out the possibility that the Ayawiri chenopods include cultivated varieties.

The testa thicknesses of modern quinoa range between 1.2 and 3.75 μm, and kañawa range from 4.25 to 7.5 μm (Bruno 2006:38-39). The testa thickness of weedy quinoa negra ranges from 22 to 51 μm and the wild species *paiko* testa thickness ranges from 11 to 14.5 μm (Bruno 2006:38-39). Of the two types of seeds that I examined from Ayawiri, Ayawiri Chenopod Type #1 seeds have a testa thickness consistent with both quinoa and kañawa. Ayawiri Chenopod Type #2 seeds have testa thickness well within the range of wild chenopods, but they do not have testa thickness as thick as the weed quinoa negra. Only one chenopod, Specimen #18, has a testa thickness within the range of quinoa negra.

Bruno and Whitehead (2003:344) found the values of the testa thickness to seed diameter ratio for quinoa are between .001 and 0.004 and ratios for quinoa negra range 0.031 to 0.068. The low value of the ratio for quinoa reflects the larger seed diameter and thinner testa. The comparatively higher value for negra reflects the thicker testa. Kañawa should be closer to testa thickness/seed diameter values of quinoa, whereas wild chenopods should be slightly less than the quinoa negra ratio range. Of the two types of chenopods I identified from the site, Ayawiri Chenopod Type #1 has a testa thickness to seed diameter ratio that is within the range of quinoa. Ayawiri Chenopod Type #2 has a ratio similar to wild chenopods and kañawa (when compared to Bruno 2008:303 Table 8.12).

Chenopods as a Proxy for Behavior

My analysis has revealed, based on multiple qualitative and quantitative measurements, that Ayawiri Chenopod Type #1 resembles quinoa. It has a rounded to truncate margin, a smooth testa texture, a prominent beak, and a low testa thickness to seed diameter ratio. Although

Ayawiri Chenopod Type #1 has a smaller seed diameter than the modern quinoa, it is well within the range of archaeological quinoa specimens.

Ayawiri Chenopod Type #2 has a testa thickness/seed diameter ratio consistent with both kañawa and wild chenopods. Notably, I did find large quantities of this chenopod type in the cache below a house floor that likely indicates it was a cache of cultivated seeds rather than indirect resource use in dung burned for fuel. Based on this contextual information, I think this is evidence that Ayawiri Chenopod Type #2 is also a cultivar.

I found chenopod seeds with morphological features of quinoa negra (thick testa, equatorially banded) in less than 1% of the samples I analyzed. At Formative Period Chiripa, Bruno and Whitehead (2003) found higher amounts of quinoa negra in early contexts and lower amounts in later contexts. They suggest this indicates that Chiripa residents meticulously weeded their fields later in time coinciding with agricultural intensification. I think the low incidence of quinoa negra type seeds in Ayawiri samples also indicates residents were carefully weeding their fields. It is also possible that camelids and/or humans may have been eating the quelites of quinoa negra before these plants went to seed.

As I have documented, there is overlap between the morphological features of the different types of archaeological chenopods in this study. There are also disparities between archaeological chenopods and modern seeds that are pronounced. Bruno and Whitehead (2008:350) note sharp distinctions between Formative Period quinoa and modern specimens. They attribute this difference to human selection over time. However, there are fewer distinctions between Late Formative Period quinoa and LIP chenopods than there are between all measured archaeological chenopods from the *altiplano* and modern specimens. Based on this, I posit human selection postdating the LIP resulted in the sharp disparities in morphological features between chenopod crops, weeds, and wild seeds. Perhaps, there was a selective pressure during the modern era, such as a colonial preference for *quinoa real,* the variety sold in grocery stores today, that caused these differences. Going forward, further research is needed on Middle Horizon Period chenopods and chenopods from other time periods in the region to clarify this trend.

Based on this analysis, I conclude that Ayawiri residents were cultivating quinoa and potentially kañawa. While both crops do not require much rainfall to thrive, kañawa requires less precipitation than quinoa. Except in the case of the cached storage pit of chenopods, it is difficult to determine whether the Ayawiri chenopods were brought to the site through direct resource use or in dung burned for fuel. Furthermore, it is not possible to differentiate whether residents were foddering their livestock on crops or grazing them in fields. I found chenopods in just about every sample I analyzed and often in abundance. I think this is evidence that Ayawiri residents were indeed consuming quinoa and kañawa and sharing their crops with their animals. The paucity of quinoa negra type chenopods indicates residents were intensively weeding and managing their fields. Even though the LIP was an arduous time period climatically and socially, famers took great care tending their quinoa fields.

Conclusions

In conclusion, Ayawiri residents relied on a plant economy that was not too different than their ancestors in the region. For their primary carbohydrates and plant proteins they ate quinoa, possibly kañawa, potatoes, and other tubers. Sometimes residents ate sweet cactus fruits, but not as much as Formative peoples or Middle Horizon city dwellers living in the southern Titicaca Basin. This rich carbohydrate and grain heavy diet was likely supplemented by chenopod quelites and perhaps even *Plantago* sp. leafy greens. Maize was not a part of the Ayawiri economy. This signals a departure from Middle Horizon foodways and focus on drinking of maize chicha. Furthermore, these data indicate a termination of exchange of staple goods with lower elevation peoples who supplied the maize. Ayawiri peoples burned camelid dung to fuel warming and cooking fires. This means that macrobotanical remains also provide insight into grazing strategies. Herds were primarily grazed within fields or foddered on chenopods. This is a departure from the dependence on wetland plants and grazing areas during the Middle Horizon and Formative. Herders rarely ventured to lacustrine or riverine ecotopes, indicating a very constrained use of the landscape.

Chapter 7. Contextual Analysis of Macrobotanical Remains from Ayawiri

In Chapter Seven I examine and compare the contexts of macrobotanical remains from Ayawiri. Drawing on this analysis, the locations where plants were used and for what purposes is identified. In addition, I assess the ecotopes where plant taxa likely grew in the area near the site to determine land use strategies employed by different groups of residents. Using this data, evidence of social diversity in foodways is determined among residential households living at Ayawiri during the LIP. I begin this chapter by briefly detailing the archaeological contexts where macrobotanical remains were recovered, focusing on five compounds. I examine macrobotanicals found in each compound to determine residents' quotidian plant use in these spaces. Then, I turn my attention to comparing macrobotanical remains between contexts including non-kitchen house structures, kitchens, hearths, patios, and middens. Lastly, I examine similarities and difference in the plant remains between household compounds to pinpoint evidence of intra-site social diversity. The goals of this analysis is to shed light on how and where residents used plants in their daily lives at Ayawiri.

In total, Proyecto Machu Llaqta archaeologists excavated approximately 200 m^2 in six residential compounds in different areas of the Ayawiri site in 2011 and 2012 (see Figure 7.1) (Arkush 2014). Generally, our team found intact LIP house floors and artifacts *in situ* within 10 to 30 cm below the surface level. We did find a few modest Formative Period contexts at the site. While I mention these in my descriptions of the excavations, these samples are excluded from this study because the data is not relevant to my research goals and the form and function of the

Formative contexts are unresolved (see Appendix H for Formative Period macrobotanical findings). Drawing on excavation reports (Arkush and Paredes 2012, 2013), I detail the findings of excavations from contexts where I analyzed macrobotanical remains.

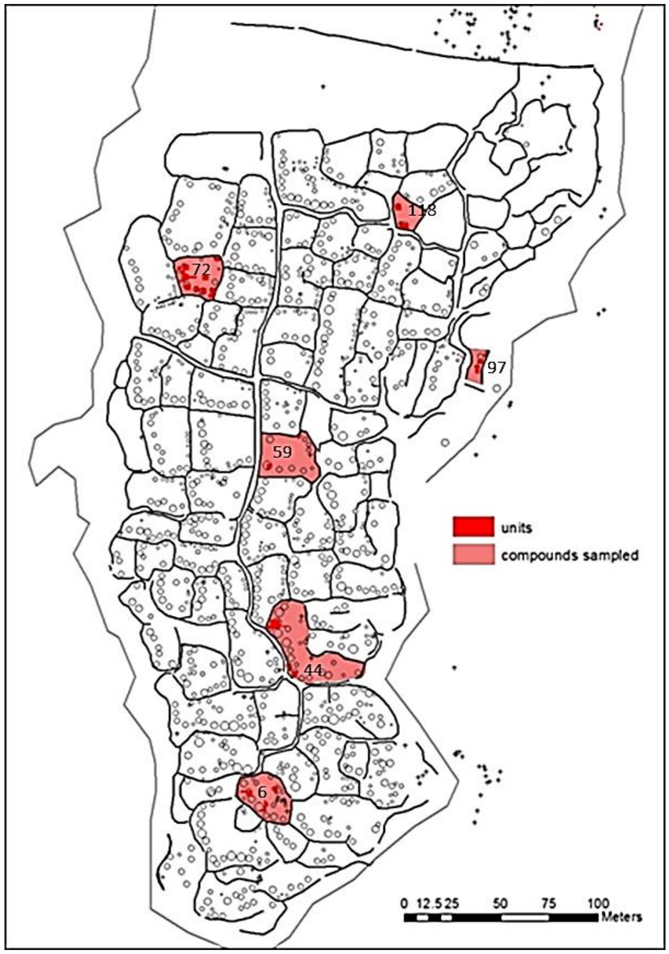


Figure 7.1: Excavations in the residential sector at Ayawiri (map rendered by E.N. Arkush).

Compound 6

Compound 6 is located in the southern sector of the site. Arkush (2015) found that this area of the site is the oldest based on lichenometry data. She also notes that the southern sector is the safest because the hillside there is too steep to climb, and it furthest from the northern approach. Additionally, there are more and bigger houses per compound in this area of the site. In Compound 6 we excavated three units. Full details of these excavations are provided by Arkush and Paredes (2012), and I draw on their manuscript to describe excavation findings. Within these units the excavation team targeted three house structures, a portion of the interior patio in the compound, and midden behind one house (see Figure 7.2).

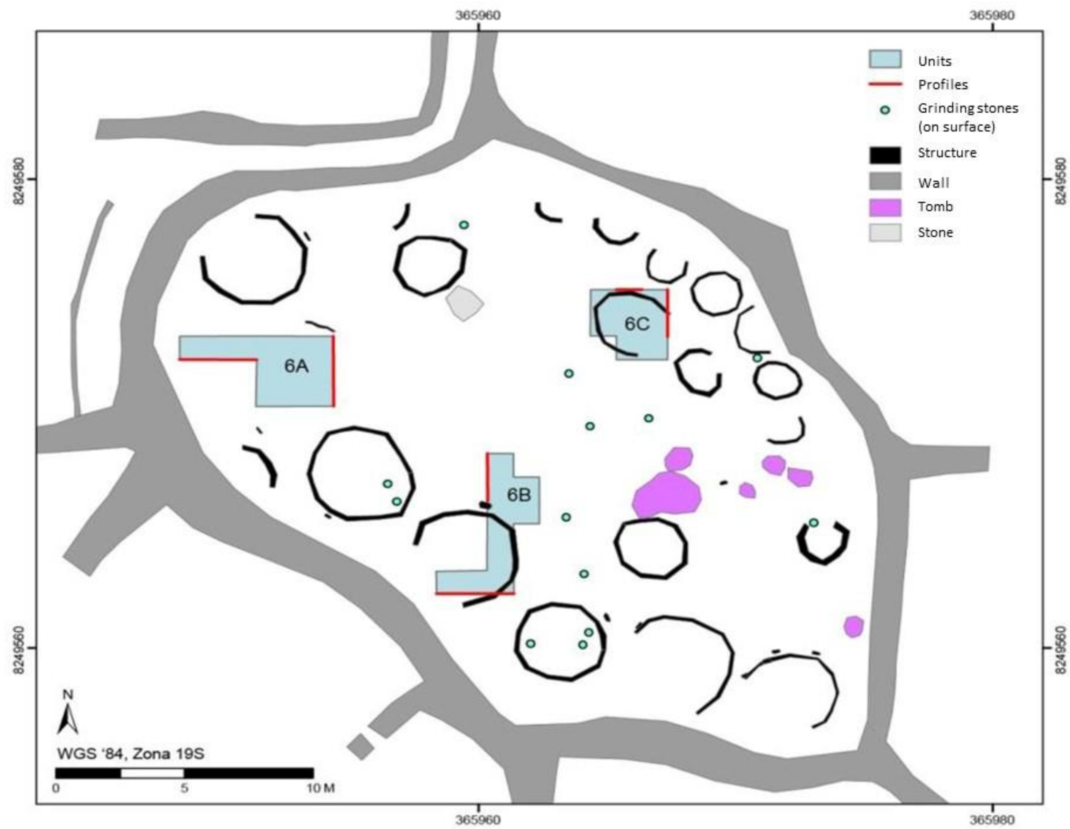


Figure 7.2: Compound 6 delineating the excavation units
(map rendered by E.N. Arkush).

Unit 6A Non-Kitchen House Structure

In Unit 6A we excavated a large non-kitchen house structure that measures approximately 3 m in diameter. The foundation of this house is composed of a ring of vertically positioned white foundation slabs made of limestone. Within the house, excavations uncovered a compact floor impressed with red and white clay inclusions. There was no hearth in this structure, but we did find a stone axe.

Unit 6A Non-Kitchen House Structure Macrobotanical Remains

I analyzed two macrobotanical samples from the LIP occupational layer of the floor of the non-kitchen house structure in Unit 6A (Table 7.1). Sample V2-2305/5 was collected from the interior of the structure just to the left of the door. This sample has a low density (5.6 seeds/liter) and a low richness (one taxon present). Sample V2-2305/23 was collected from the floor opposite the doorway near the back wall of the structure. This sample has medium density (30.2 seeds/liter) and richness (three taxa present). There is a large quantity of *Chenopodium* spp. seeds in this sample. Bone was found in both flotation samples from this context. This presence of food remains and the absence of other culinary preparation artifacts indicate that the structure was likely used for food consumption. The lower density of macrobotanical residues near the door might be evidence of regular cleaning activities, whereas the concentration near the back of the house was where unwanted materials were swept out of the way. The small amount of the crop companion weed seed Malvaceae was probably brought into this house in dung burned for fuel.

Table 7.1: Macrobotanical remains found in Unit 6A.

Locus #	V2-2305/5	V2-2305/23
Unit	**6A**	**6A**
Context	**Occupation/ Floor**	**Occupation/ Floor**
Taxa Standardized Density (Specimen/L of Soil Floated)		
CROP PLANT REMAINS		
Chenopodium spp.	5.60	29.70
CROP COMPANION WEED SEEDS		
Malvaceae	0.00	0.20
FUEL		
Wood (Ct.)	0.20	1.90
OTHER		
Uncharred Bone	1.20	0.00
Charred Bone	0.00	2.30
TOTALS		
Total Density Seeds	5.6	30.2
RICHNESS	1	3

Unit 6B Non-Kitchen House Converted into a Kitchen House

In unit 6B we excavated a non-kitchen house similar in size to 6A. This structure also has a foundation of vertically positioned white limestone slabs encircling the perimeter of the structure. Excavators found an incomplete and partially destroyed compact red clay floor in this house. There were very few artifacts associated with this floor except near the doorway, where there was a small concentration of broken ceramics. I did not analyze macrobotanical artifacts from this non-kitchen house structure. However, I did analyze macrobotanical remains from subsequent excavations below this floor. Through deeper excavations we found the non-kitchen house was built on top of an earlier LIP kitchen house, based on the identification of a hearth and associated cooking artifacts. In other words, the kitchen house was converted into a non-kitchen house later in the LIP. In this unit we also excavated a portion of the patio in front of the kitchen structure. Excavators noted fill mixed with artifacts and portions of a red clay floor.

Unit 6B Kitchen Structure Macrobotanical Remains

From Unit 6B I analyzed one macrobotanical sample collected from the floor of the kitchen structure, one from the matrix found inside the hearth, and one sample from the patio (Table 7.2). Sample V2-2329/3 was collected from the floor of the kitchen structure along the wall opposite the doorway. I found a high density of chenopods in this sample (237.13 seeds/liter), charred bone, and a few fragments of dung. Sample V2-2331/6 was collected from inside the hearth. This sample has an exceptionally high density of chenopods (6560.2 seeds/liter). There was also a small tuber and charred bone in the hearth. I found fragments of charred wood, but no small seeds indicative of dung burning in the hearth. This indicates wood, probably the shrub thola, was the primary fuel the last time residents used this hearth. Based on the comparatively high density of food remains in this structure, it was a space used for culinary purposes.

Samples V2-2340/6 was collected from the patio in front of the kitchen structure. A medium density of chenopods (between 13.9 seeds/liter) was found in this sample that are likely residues of cooking, probably from inside the kitchen structure. These residues were discarded in the patio. The presence of burned dung, Malvaceae, *Trifolium amabile*, and Cyperaceae seeds indicate dung from herds grazed in fields and wetlands was indeed used for fire fuel in this compound. Residents then cleaned out their hearths and brushed the remains out onto the patio floor.

Table 7.2: Macrobotanical results from Unit 6B kitchen house.

Locus #	**V2-2329/3**	**V2-2331/6**	**V2-2340/6**
Unit	**6B**	**6B**	**6B**
Context	**Floor**	**Hearth with artifacts associated**	**Occupation/ Floor of patio**
Taxa Standardized Density (Specimen/L of Soil Floated)			
CROP PLANT REMAINS			
Chenopodium spp.	237.13	6560.20	13.90
Tubers/Parenchyma	0.00	0.00	0.00
CROP COMPANION WEED SEEDS			
Malvaceae	0.00	0.00	0.00
Trifolium amabile	0.00	0.00	0.00
SMALL HERBACEOUS SEEDS			
Brassicaceae	0.00	0.00	0.00
WETLAND PLANT SEEDS			
Cyperaceae	0.00	0.00	0.00
FUEL			
Dung	0.13	0.00	0.00
Wood (Ct.)	0.00	1.60	0.00
OTHER			
Uncharred Bone	0.13	0.28	0.00
Charred Bone	0.00	8.50	1.70
TOTALS			
Total Density Seeds	237.125	6560.4	13.9
RICHNESS	1	3	1

Unit 6C Kitchen Structure

We excavated a kitchen structure in Unit 6C. This is the largest kitchen structure we excavated at the site, measuring approximately 3 m in diameter. In the middle of the structure there was a large concentration of artifacts abandoned *in situ* including grinding stones, lithic flakes, broken ceramic vessels, and fragments of camelid bone (Figure 7.3). Excavators also noted a low bench composed of a row of stones along the interior of the eastern wall of the structure. Just inside the doorway in the eastern portion of the structure, we found a small clay hearth that measured 10 x 20 cm. Even though there was a dense concentration of artifacts on the kitchen floor, excavators noted only a few pieces of ceramic and burned bone near the hearth.

Figure 7.3: Unit 6C is a kitchen structure (left photo) with a dense concentration of food preparation artifacts. A small clay hearth along the interior bench of 6C (right photo).

Unit 6C Kitchen Structure Macrobotanical Remains

From Unit 6C I analyzed four macrobotanical samples collected from the occupation level of the kitchen structure floor and one sample recovered from inside the hearth (Figure 7.3). All samples from this structure have low-to-medium densities of chenopods ranging from 6.9 to 23.6 seeds/liter. Parenchyma was also found in three samples. These food remains provide further evidence that cooking was indeed carried out in this house. The presence of Malvaceae and *Trifolium amabile* throughout the structure floor and the medium density of wood in the hearth (59.5 fragments/liter) indicate dung and wood were used for fire fuel. Additionally, the camelids that produced this dung were grazed primarily in fields on crop companion weeds and, possibly, chenopods.

Table 7.3: Macrobotanical results from unit 6C.

Locus #	V2-2354/27	V2-2355/29	V2-2357/21	V2-2359/1	V2-2361/1
Unit	6C	6C	6C	6C	6C
Context	Occupation/ Floor	Occupation/ Floor	Occupation/ Floor	Occupatio n/ Floor	Hearth
Taxa Standardized Density (Specimen/L of Soil Floated)					
CROP PLANT REMAINS					
Chenopodium spp.	12.30	23.60	6.40	11.20	6.00
Tubers/Parenchyma	0.00	0.10	0.10	0.10	0.00
CROP COMPANION WEED SEEDS					
Malvaceae	0.00	0.10	0.20	0.50	0.50
Trifolium amabile	0.00	0.00	0.30	0.10	0.00
FUEL					
Wood (Ct.)	0.10	0.00	0.00	1.00	59.50
OTHER					
Uncharred Bone	0.00	0.00	0.20	0.00	0.00
TOTALS					
Total Density Seeds	12.4	23.9	7.2	12.5	6.5
RICHNESS	2	3	4	5	2

Compound 44

Compound 44 is located in the south-central sector of the site along the eastern side of the elevated causeway. This compound is one of the largest at Ayawiri and contains the most structures. In Compound 44 we excavated three units that encompassed the remains of three house structures, a storage structure, patio, and midden behind one house (Figure 7.4). Full details of these excavations are provided by Arkush and Paredes (2012), and I draw on this manuscript to describe excavation findings.

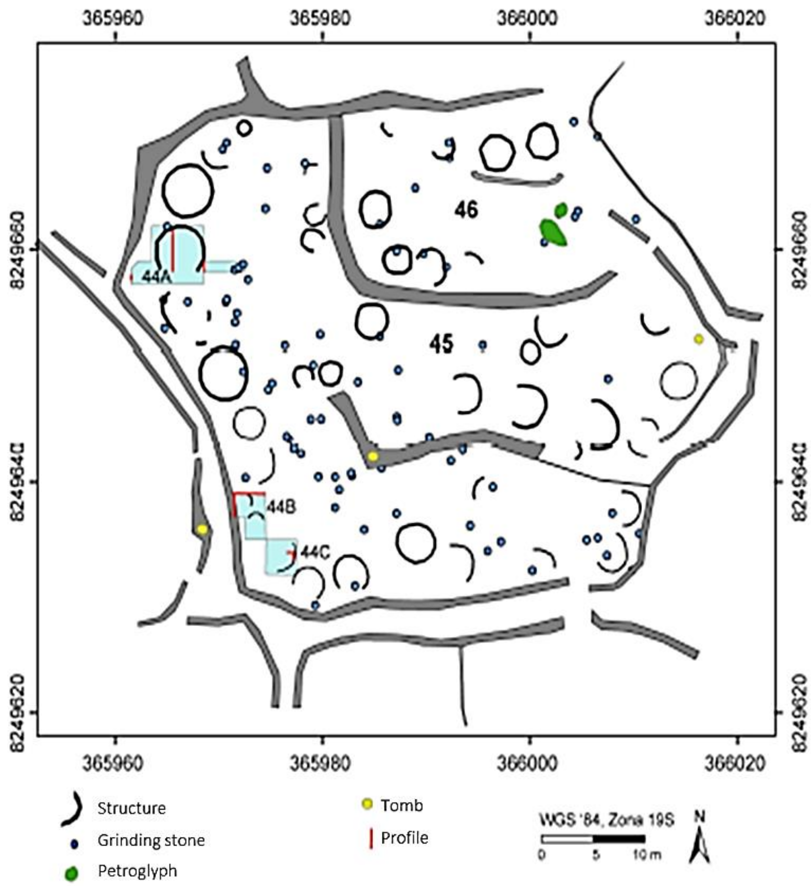


Figure 7.4: Compound 44 delineating the excavation units
(map rendered by E.N. Arkush).

Unit 44A Non-Kitchen House Structure

In Unit 44A we excavated one of the largest non-kitchen house structures at the site measuring 5 m in diameters. We also excavated a portion of the patio in front of this structure and a midden located behind the structure adjacent to the elevated causeway. The foundation of the house has a row of vertically positioned white limestone slabs encircling the foundation (Figure 7.5). The floor is composed of compact red clay and is particularly well preserved in the north and northwest portions of the structure. Excavators found a few ceramic sherds, bones, and lithics on the floor. A burned area that excavators interpreted as an informal hearth was identified in the middle of the structure. This informal hearth is composed of charred layers and looks nothing like the well-preserved formal clay cooking hearths found in kitchen structures. Excavators made no clear suggestions about what this structure was used for.

Figure 7.5: Non-kitchen house structure in Unit 44A. Note row of the foundation's vertically positioned white limestone slab stones.

Unit 44A Non-Kitchen House Structure Macrobotanical Remains

I analyzed macrobotanicals from two strata of the Unit 44A house floor. Excavators referred to the first stratum as the *use surface* because artifacts were found *in situ* (Figure 7.4). Excavators called the stratum below the use surface the *red clay floor* (Table 7.5). The use surface has a moderate density of macrobotanicals ranging from 0.6 to 45.8 seeds/liter. On the other hand, four samples from the red clay floor have high densities of chenopod seeds ranging from 148.8 to 333.6 seeds/liter. The red clay floor also has higher richness values of macrobotanical specimens. I think the macrobotanical remains in the red clay floor were compacted into this stratum during repeated use, whereas the use surface stratum represents residues that were not cleaned from the final occupation of the house and soil that accumulated there after abandonment. In both the use surface stratum and the red clay floor macrobotanical samples with higher densities were recovered from the perimeter of the structure, whereas lower density samples were collected from the center of the structure. I think these data reflect cleaning activities, where debris was swept to the perimeter against the structure walls.

What was this non-kitchen house used for? Based on the intensity of deposition of food remains including chenopod seeds and parenchyma/tubers I think communal eating activities, or perhaps even feasting events, were carried out in this enclosed space. The house is large enough to host more than one family. Perhaps, the small informal hearth was used as a warming fire.

Table 7.4: Macrobotanical remains from the use surface of the non-kitchen house structure in Unit 44A.

Locus #	**V2-1033/7**	**V2-1035/5**	**V2-1035/12**	**V2-1035/20**	**V2-1038/7**	**V2-1038/9**	**V2-1038/12**	**V2-1038/22**	**V2-1038/23**	**V2- 1038/31**
Unit	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**
Context	**Use surface in house**	**Use surface in house**	**Use surface in house**	**Use surface in house**	**Use surface in house**	**Use surface in house**	**Use surface in house**	**Use surface in house**	**Use surface in house**	**Use surface in house**
Taxa Standardized Density Specimen/L Soil Floated										
CROP PLANT REMAINS										
Chenopodium spp.	39.60	39.40	45.30	27.10	3.30	4.10	1.20	6.60	0.60	1.80
Tubers/Parenchyma	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
CROP COMPANION WEED SEEDS										
Malvaceae	0.20	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Trifolium amabile	0.40	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SMALL HERBACEOUS SEEDS										
Unknown Seeds	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.10	0.00	0.10
WETLAND PLANT SEEDS										
Cyperaceae	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FUEL										
Wood (Ct.)	0.40	1.30	1.30	0.70	0.00	0.40	0.00	0.10	0.10	0.30
OTHER										
Uncharred Bone	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTALS										
Total Density Seeds	40.8	39.5	45.8	27.2	3.7	4.1	1.2	6.8	0.6	1.9
RICHNESS	5	2	2	2	3	1	1	3	1	2

Table 7.5: Macrobotanical remains from the red clay floor of the non-kitchen house strcture in Unit 44A.

Locus #	V2-1041/14	V2-1041/15	V2-1041/16	V2-1043/7	V2-1043/10	V2-1043/25	V2-1044/8	V2-1046/7	V2-1046/8	V2-1046/9	V2-1046/11	V2-1046/12	V2-1046/21	V2-1046/22
Unit	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**
Context	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**	**Red clay floor**
	Taxa Standardized Density Specimen/L Soil Floated													
CROP PLANT REMAINS														
Chenopodium spp.	17.90	179.70	181.60	0.00	2.80	37.40	2.40	3.20	22.80	6.80	16.60	19.00	148.50	38.60
Tubers/Parenchyma	1.40	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.30
CROP COMPANION WEEDS SEEDS														
Trifolium amabile	0.50	0.00	0.00	0.00	0.00	0.20	0.00	0.20	0.00	0.00	0.10	0.00	0.00	0.00
Relbunium sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Malvaceae	0.00	0.10	0.20	0.00	0.00	0.10	0.00	0.00	0.00	0.10	0.00	0.00	0.20	0.00
SMALL HERBACEOUS SEEDS														
Unknown Seeds	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WETLAND PLANT SEEDS														
Cyperaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Potamogenton sp.	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DYE PLANT SEEDS														
Verbena sp.	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
FUEL														
Dung	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wood (Ct.)	1.10	3.10	3.20	0.10	0.00	8.30	0.80	0.01	4.10	0.00	0.30	8.60	1.10	0.50
OTHER														
Uncharred Bone	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Charred Bone	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.10	12.80	0.50	1.2
TOTALS														
Total Density Seeds	21.4	183.5	181.8	0.1	2.9	38.6	2.5	3.4	23	7.2	16.8	19	148.8	39.1
RICHNESS	4	3	2	1	2	6	2	2	2	4	3	1	3	3

Unit 44A Midden

West of the structure in Unit 44A, excavators noted there was a stratum of wall collapse. Stacked stones from the elevated causeway tumbled into this area. Below the wall collapse, they found evidence of a trash midden consisting of lithic debris, ceramics sherds, and animal bone. Excavators interpreted these findings as the product of residents or passerbys traveling along the elevated causeway periodically discarding their trash behind the house. To the east of the non-kitchen house, excavators dug a trench from the doorway extending into the center of the patio, where they found the remains of a compact, reddish clay floor indicating the interior of the house floor extended into the patio. Excavators noted animal bones, obsidian debitage, and ceramic fragments on the patio floor. These data indicate domestic activities were carried out in the patio of 44.

Unit 44A Midden Macrobotanical Remains

I analyzed five macrobotanical samples from the midden behind the non-kitchen house and two samples from the patio in front of the structure in Unit 44A. I found there is a low-to-medium density of macrobotanical specimens deposited in the samples from the midden behind the structure ranging between 0.5 and 22.7 seeds per liter (Table 7.6). The density of crop plant remains from this area is equally low. These macrobotanicals, along with the discarded broken ceramics and animal bone, are evidence of the disposal of eating activities. This further affirms that the non-kitchen house structure in Unit 44A was used for eating, probably communal meals, rather than food preparation. The low amounts of small herbaceous seeds that were discarded in the midden and the wood indicate both dung and woody plants were used for fire fuel by residents living in this compound. The camelids that produced the dung burned for fuel were primarily grazed in fields and only rarely visited wetland ecotopes. Samples V2-1128/5 and 1128/6 were recovered from the patio in front of the structure. These samples contained a low density of seeds ranging from 0.6 to 3.6 specimens per liter. Residents were not regularly throwing out charred cooking residues or emptying out the contents of cooking hearths in this area. Or if they were, they subsequently cleaned the patio and swept rubbish behind their houses along the perimeter of the compound.

Table 7.6: Macrobotanical remains from Unit 44A midden.

Locus #	**V2-1002/4**	**V2-1003/2**	**V2-1007/4**	**V2-1008/7**	**V2-1009/4**	**V2-1128/5**	**V2-1128/6**
Unit	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**	**44A**
Context	**Midden**	**Midden dark soil lens**	**Midden**	**Midden**	**Midden**	**Patio**	**Patio**
Taxa Standardized Density							
(Specimen/L Soil Floated)							
CROP PLANT REMAINS							
Chenopodium spp.	0.40	2.20	2.80	3.20	13.70	3.60	0.60
Tubers/Parenchyma	0.00	0.00	0.00	0.10	0.00	0.00	0.00
CROP COMPANION WEED SEEDS							
Malvaceae	0.00	0.00	0.20	0.00	0.60	0.00	0.00
Trifolium amabile	0.00	0.00	0.00	0.10	0.00	0.00	0.00
SMALL HERBACEOUS SEEDS							
Brassicaceae	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WETLAND PLANT SEEDS							
Cyperaceae	0.00	0.00	0.00	0.00	0.30	0.00	0.00
FUEL							
Wood (Ct.)	0.00	0.40	0.80	2.50	0.60	0.20	0.80
OTHER							
Uncharred Bone	0.00	0.00	0.00	0.00	0.40	0.00	0.00
Charred Bone	0.00	0.40	0.10	0.00	0.00	0.00	0.00
TOTALS							
Total Density Seeds	0.5	2.6	3.6	3.8	22.7	3.6	0.6
RICHNESS	2	2	3	3	4	1	1

Unit 44B Superimposed Storage Structure and Non-Kitchen House Structure

Unit 44B and 44C are adjacent to one another in the southwestern area of the compound. In Unit 44B we found several structures and events superimposed over the top of one another. Structure C is a small storage structure that measures about 1.6 m in diameter. This structure is composed of a layer of compacted stones surrounded by a circular stone foundation. Structure C was built on top of an earlier house structure, Structure B. Based on the stratigraphy of these two structure, the excavators determined the western wall of Structure B was reused to form a small portion of the foundation wall of Structure C (see Figure 7.6).

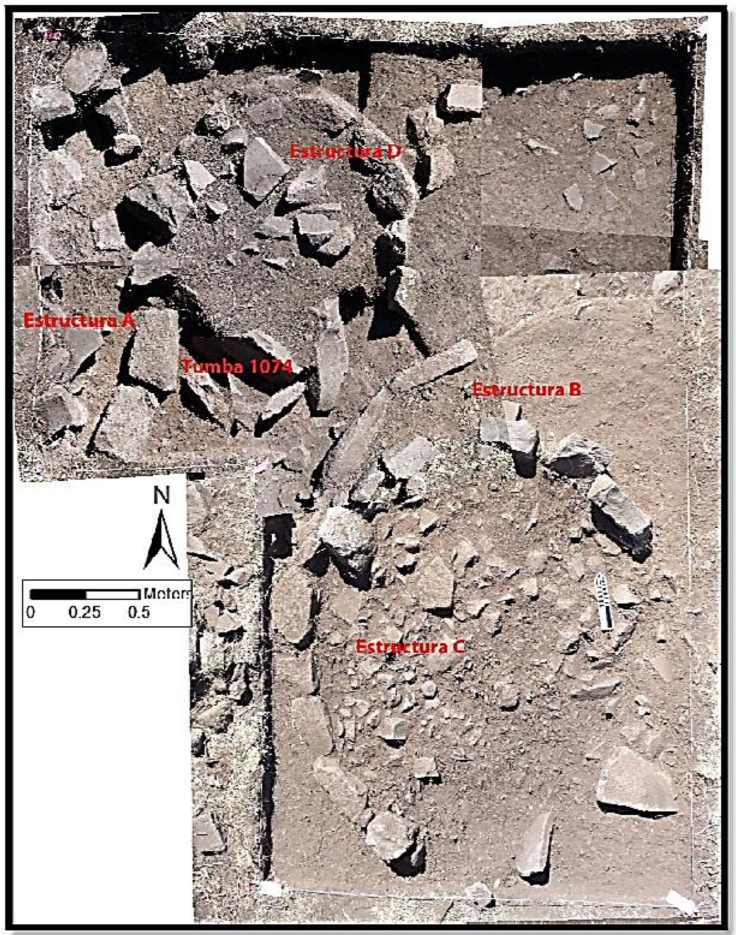


Figure 7.6: Structures in Unit 44B.

Unit 44B Storage Structure and House Structure Macrobotanical Remains

I analyzed four samples from the house structure that was later reused as a storage structure in 44B (Table 7.7). These samples were discretely collected from the fill and the use surface of the floor of Structure B, the house structure. I found a low-to-medium density of chenopods in the house, ranging between 7.7 and 13.7 seeds/liter. I found fragments of tuber and parenchyma in these samples and very few small herbaceous seeds. Similar amounts of wood were recovered from all loci associated with this context. The density of crop remains from the house structure floor may indicate that it was used as a kitchen structure. Without having excavated the eastern portion of this structure, where we would expect to find a hearth, the use of this space is unclear.

Table 7.7: Macrobotanical remains from Storage Structure and House Structure in Unit 44B.

Locus #	**V2-1114/4**	**V2-1114/14**	**V2-1116/13**	**V2-1116/14**
Unit	**44B**	**44B**	**44B**	**44B**
Context	**Fill and floor of Structure B**	**Fill and floor of Structure B**	**Use surface, structure B**	**Use surface, structure B**
Taxa Standardized Density (Specimen/L Soil Floated)				
CROP PLANT REMAINS				
Chenopodium spp.	13.60	8.40	13.70	7.70
Tubers/Parenchyma	0.00	0.00	0.10	0.40
CROP COMPANION WEED SEEDS				
Malvaceae	0.00	0.20	0.10	0.00
cf. *Solanum* sp.	0.20	0.00	0.00	0.00
FUEL				
Wood (Ct.)	2.50	0.40	1.20	0.60
OTHER				
Charred Bone	0.20	0.00	0.00	0.00
TOTALS				
Total Density Seeds	14.2	9.5	14.5	8
RICHNESS	3	3	3	2

Unit 44B Midden and Tomb

Structure D is another storage structure located in the northern part of the unit. This storage structure is similar in construction to Structure C; however, it measures only 0.9 m in diameter. Below the Structure D there was an ash pit with deer antlers that was interpreted as a ritual offering. This structure was partially built adjacent to a small slab cist tomb (Figure 7.7). This tomb is lined in stone slabs, contains two vessels, and at the bottom excavators found the broken cranium of an infant placed under an overturned bowl. According to the excavation report, it is unclear whether Structure C and D are contemporaneous; however, based on the stratigraphic superimposition, it is clear that the tomb predates the storage structures and that the storage structures were placed so that they did not disturb the tomb. In the area excavated around these structures, high densities of artifacts indicate the space was used as a midden.

Figure 7.7: An offering of deer antlers found below Structure D (left photo) located next to a small cist tomb containing an infant cranium placed under an overturned bowl (right photo) in unit 44B.

Unit 44B Midden and Tomb Macrobotanical Remains

I analyzed four macrobotanical samples from the midden surrounding Structures C and D, three samples from the area that was interpreted as a ritual offering and area of ash with deer antlers below Structure D, and three samples from inside the tomb (Table 7.8). The four flotation samples from the midden contained varying amounts of crop remains and very few small herbaceous seeds. I found fragments of dung and wood in these samples. This mixed assemblage could be the residues of cooking lending further evidence to the interpretation the excavators made in the field that this area was used as a midden. Excavators interpreted the ash pit below Structure D as a ritual offering. I found a low-to-medium density of chenopods (5.3-19.6 seeds/liter) and fragments of tuber/parenchyma. There is also charred bone in this sample. These plant residues were likely an offering of food laid on top of the tomb and burned after the tomb was sealed shut. There were macrobotanical remains in the soil matrix inside the tomb. These could have been mixed into this soil from the offering on top, or perhaps soil that covered the burial was gathered from the nearby midden.

Table 7.8: Macrobotanical remains from Unit 44B.

Locus #	V2-1060/5	V2-1061/5	V2-1066/5	V2-1070/4	V2-1071/4	V2-1072/1	V2-1073/4	V2-1074/8	V2-1074/22
Unit	**44B**	**44B**	**44B**	**44B**	**44B**	**44B**	**44B**	**44B**	**44B**
Context	**Midden**	**Midden**	**Midden**	**Ash pit, ritual offering**	**Midden**	**Ash pit, ritual offering**	**Ash pit, ritual offering**	**Tomb**	**Tomb**
Taxa Standardized Density Specimen/L Soil Floated									
FOOD									
Chenopodium spp.	3.00	1.20	9.40	19.60	13.50	16.60	5.30	8.70	1.80
cf. *Solanum* sp.	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Tubers/Parenchyma	4.02	4.00	0.30	0.00	0.10	1.50	0.50	0.30	0.00
CROP COMPANION WEED SEEDS									
Malvaceae	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.30	0.00
Relbunium sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
SMALL HERBACEOUS SEEDS									
Brassicaceae	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.10
Unknown Seeds	0.10	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
WETLAND PLANT SEEDS									
Cyperaceae	0.20	0.00	0.00	0.00	0.00	0.10	0.00	0.10	0.00
DYE PLANT SEEDS									
Verbena sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FUEL									
Dung	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.80	0.00
Wood (Ct.)	0.50	0.00	0.20	2.30	1.30	2.20	1.30	1.20	0.00
OTHER									
Uncharred Bone	0.00	0.00	0.80	0.00	0.00	0.30	0.00	0.30	0.00
Charred Bone	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00
TOTALS									
Total Density Seeds	3.5	1.4	9.7	20.2	14	17.6	5.6	9.9	2.5
RICHNESS	5	2	3	5	2	5	2	5	3

Unit 44C Kitchen Structure

In Unit 44C excavators found a kitchen structure measuring a little less than 3 m meters in diameter. This structure contained a small clay hearth sitting on an intact occupation layer dense in domestic artifacts (Figure 7.8). In this occupation layer we found a stack of stone hoes (locally referred to as *chaquitallcas*), grinding stones, mortars and pestles, stone knives, spindle whorls, sling stones, camelid bones, and numerous broken utilitarian cooking pots. There is also a flattened platform of rocks that measures 70 cm in diameter adjacent to the west side of the hearth that appeared to have served as a food preparation area. This dense concentration of artifacts sat on top of a red clay floor that was particularly evident near the doorway located on the eastern side of the structure.

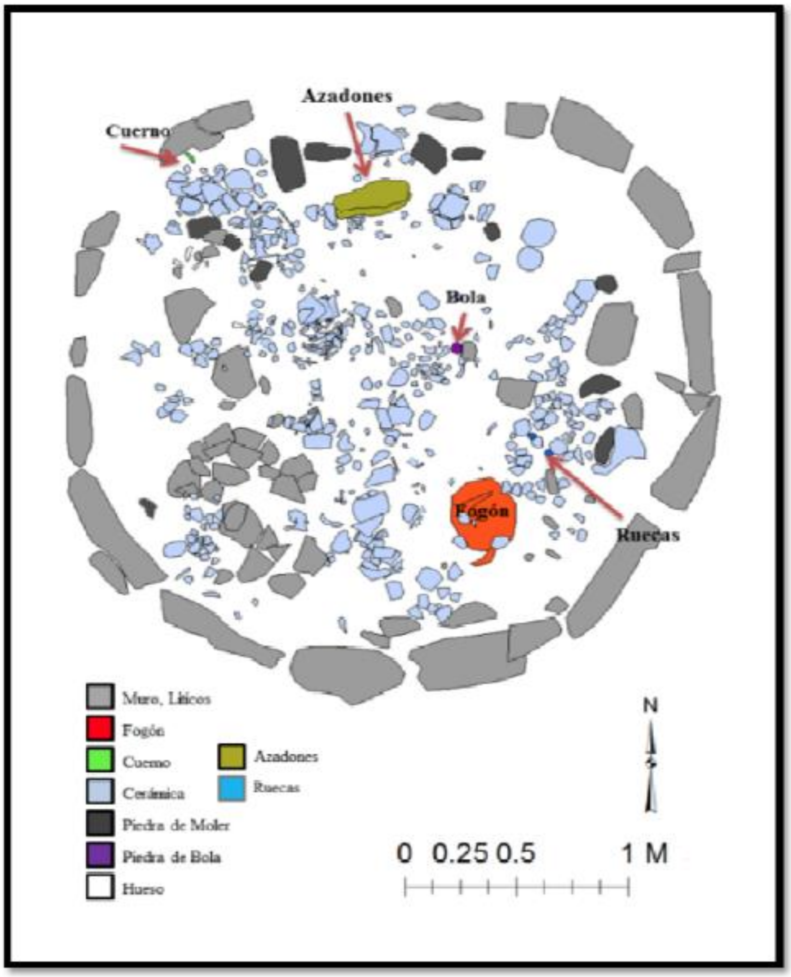


Figure 7.8: Distribution of artifacts found in the kitchen structure of Unit 44C (map rendered by E.N. Arkush).

Unit 44C Kitchen Structure Macrobotanical Remains

I analyzed six macrobotanical samples from the use surface of the kitchen structure (Table 7.9). This stratum represents what was left sitting on the floor of the structure during abandonment. Excavators gathered these flotation samples from the stratum with the high density of artifacts mapped in Figure 7.8. Samples V2-1124/21 and 1124/26 were collected from the eastern side of the structure near the doorway. These samples each have only one chenopod seed in them. Sample V2-1142/15 was collected from the northern side around the stack of hoes. Sample V2-1142/15 was collected from the northern side of the structure, and samples V2-1144/2 and V2-1147/9 were collected from the center of the structure. These samples have a moderate density of chenopods with low densities of wood. Sample V2-1146/2 was collected from the western side of the structure opposite the doorway and contains a high density of chenopods (116.3 seed/liter) and a few fragments of charred bone. This distribution of macrobotanical remains reveals cleaning behaviors inside this kitchen structure. The floor was kept clean in front of the doorway, and the burned cooking residues were swept to the back of the structure. The near absence of small herbaceous seeds and higher densities of wood indicate residents of 44C primarily used woody shrubs to fuel their fires.

Table 7.9: Macrobotanical remains from Unit 44C.

Locus #	**V2-1124/21**	**V2-1124/26**	**V2-1142/15**	**V2-1144/2**	**V2-1146/2**	**V2-1147/9**
Unit	**44C**	**44C**	**44C**	**44C**	**44C**	**44C**
Context	**Use surface**	**Use surface**	**Use surface**	**Use surface**	**Use surface**	**Use surface**
Taxa Standardized Density (Specimen/L Soil Floated)						
CROP PLANT REMAINS						
Chenopodium spp.	0.10	0.10	12.20	5.60	116.30	17.00
SMALL HERBACEOUS SEEDS						
Unknown Seeds	0.00	0.00	0.00	0.00	0.20	0.00
FUEL						
Wood (Ct.)	0.00	0.00	0.40	0.50	0.30	0.60
OTHER						
Uncharred Bone	0.00	0.00	0.00	0.00	0.60	0.00
Charred Bone	0.00	0.00	0.30	0.00	0.00	0.00
TOTALS						
Total Density Seeds	0.1	0.1	12.3	5.7	120.5	17.2
RICHNESS	1	1	2	2	4	1

I analyzed six macrobotanical samples collected from the compact clay floor of the kitchen structure, one from the fill of the flat platform of rocks, and one from inside the hearth in Unit 44C (Table 7.10). The samples collected from the clay floor would have been compacted into the floor over the use life of the structure. Samples V2-1150/2 and V2-1306/2 were collected from around the hearth. These two samples have higher densities of chenopod seeds than samples collected elsewhere in the structure. Generally, there was a low density of crop companion weed seeds and even fewer small herbaceous seeds in the floor samples. There were also a few fragments of wood charcoal in these samples. These data indicate that as food remains were accidentally burned and dropped around the hearth they were compacted into the floor around the hearth over time. Sample V2-1309/1 collected from inside the hearth contained only a few chenopods and a fragment of parenchyma. This indicates the hearth was cleaned out before abandonment of the structure, or the fire inside burned so hot that even the fuel incinerated into ash.

Table 7.10: Macrobotanical remains from the kitchen structure in Unit 44C.

Locus #	V2-1149/5	V2-1150/2	V2-1150/4	V2-1303/5	V2-1303/11	V2-1306/2	V2-1258/1
Unit	**44C**	**44C**	**44C**	**44C**	**44C**	**44C**	**44C**
Context	**Floor**	**Floor**	**Floor**	**Floor**	**Floor**	**Floor**	**Circular arrangement of stones**
Taxa Standardized Density (Specimen/L Soil Floated)							
CROP PLANT REMAINS							
Chenopodium spp.	18.90	29.20	7.70	1.70	9.33	34.70	9.00
Tubers/Parenchyma	0.00	0.00	0.00	0.00	1.00	0.00	0.00
CROP COMPANION WEED SEEDS							
Malvaceae	0.40	0.00	0.10	0.00	0.17	0.30	0.17
Relbunium sp.	0.00	0.10	0.00	0.10	0.00	0.00	0.00
Trifolium amabile	0.10	0.10	0.00	0.00	0.00	0.00	0.17
SMALL HERBACEOUS SEEDS							
Unknown Seeds	0.00	0.20	0.00	0.00	0.00	0.00	0.00
FUEL							
Wood (Ct.)	0.30	0.90	1.00	0.00	0.83	0.30	0.17
OTHER							
Uncharred Bone	0.50	0.00	0.20	0.00	0.00	0.60	0.00
Charred Bone	0.00	0.20	0.00	0.00	0.00	0.00	0.00
TOTALS							
Total Density Seeds	20	29.9	7.8	1.80	9.83	35.20	9.83
RICHNESS	4	5	2	2	3	3	4

Compound 59

Compound 59 is located in the central sector of the site along the eastern side of the elevated causeway. This compound is average in size and contains an average number of structures compared to other compounds at Ayawiri. There are a couple unusually large houses in this compound that have a foundation composed of a row of vertically positioned white limestone slabs. In Compound 59 we excavated two units that contained a house structure that has a foundation of white vertically positioned limestone slabs, a portion of the patio in front of this structure, and a storage structure (Figure 7.9). Full details of these excavations are provided by Arkush and Paredes (2013), and I draw on their manuscript to describe excavation findings. I only analyzed macrobotanical remains from the kitchen structure, so I focus on describing this context.

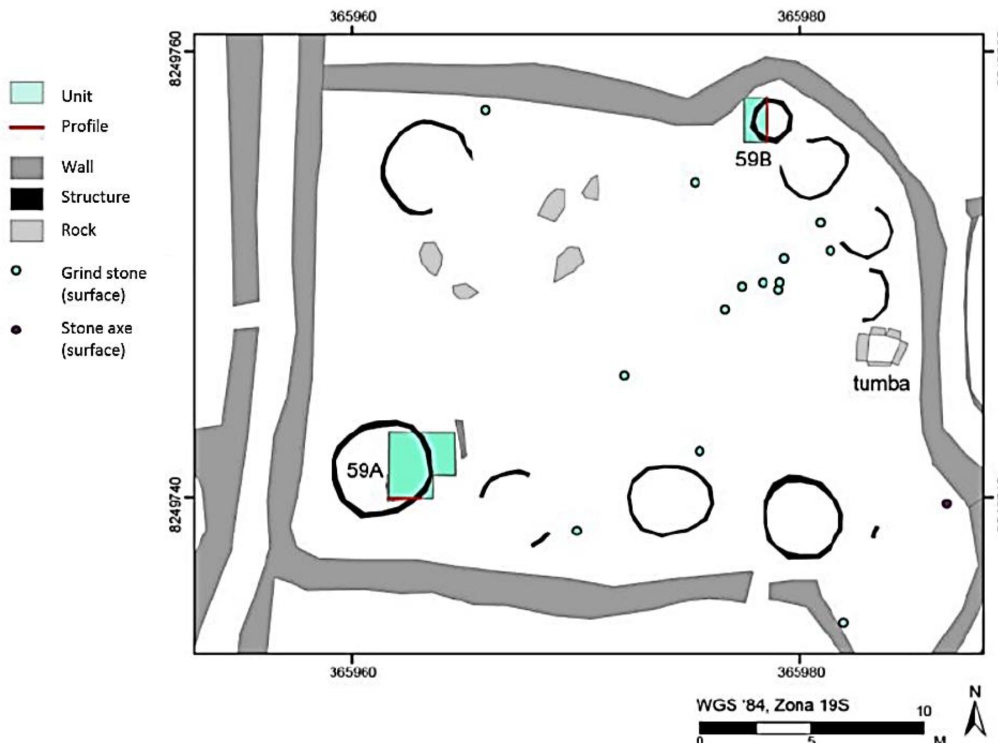


Figure 7.9: Compound 59 delineating excavations units (map rendered by E.N. Arkush).

Unit 59A House Structure

In Unit 59A a portion of a large house structure was located in the southwest area of the compound. The foundation of this house is ringed by a row of vertically situated white limestone slabs and measures about 3 m in diameter. The excavation team found a small concentration of ceramic sherds and animal bones in one corner of the house, but the floor was relatively clean and devoid of artifacts compared to other excavated structures. There were remnants of a red clay floor, but it did not extend through the entire house. While the whole house was not excavated, no hearth was identified in the excavation unit in the locations adjacent to the threshold of the door where hearths had been found in other structures. Based on the presumed absence of a hearth and other culinary artifacts, it is likely that this structure is a large house structure. Additionally, the clay floor and white vertical slab stones are characteristic of house structures in other compounds. In the southeast corner of the unit excavators found a pit that extended below the floor that contained loose, organic dark soil and a large quantity of the burned remains of potatoes and quinoa. Twenty-eight carbonized potatoes (weighing 17.11 g) were hand collected and the rest of the soil from this context was floated. Excavators noted this feature looks nothing like a clay hearth found on top of floors in kitchen houses. The contents of this pit were incredibly well carbonized indicating the fire the was low and slow preserving morphological features of the potatoes and chenopod seeds. This indicates that the fire was set intentionally rather than accidentally, which supports the interpretation that the feature is likely a sub-floor offering. Since the floor did not extend over this part of the structure it is not possible to determine whether the cache predates the construction of the structure or if it was cut into the floor during occupation. Notably, there was no evidence that the entire structure was burned. Excavators found carbon only in the part of the structure where the cache was found.

Unit 59A Cache inside House Structure Macrobotanical Remains

I analyzed one macrobotanical sample from Unit 59A. This sample was collected from the burned pit. This sample has a high density of chenopods and fragments of tubers (Table 7.11). There is also a high density of wood and charred bone in this sample. These findings indicate that this pit did indeed contain a cache of food remains. This quantity of chenopods alone would have fed a nuclear family for at least two meals. The charred potatoes are remarkably well preserved. Therefore, I think the charred potatoes were stored in their freeze-dried form as chuño. Quinoa, chuño, and chunks of camelid meat would have made a hearty stew for residents living in Compound 59.

Table 7.11: Macrobotanical remains from Unit 59A.

Locus #	**2506/4**
Unit	**59A**
Context	**Pit with burnt material**
Taxa Standardized Density (Specimen/L of Soil Floated)	
CROP PLANT REMAINS	
Chenopodium spp.	94865.2*
Tubers/Parenchyma	20.48
FUEL	
Wood (Ct.)	47.80
OTHER	
Charred Bone	68.28
TOTALS	
Total Density Seeds	94865.2
RICHNESS	1

** Estimated compuation based on weight*

Compound 72

Compound 72 is located in the northern sector of the site along the western side of the elevated causeway. This compound is medium-sized and contains an average number of structures compared to other compounds at Ayawiri. Arkush and Paredes (2013:23) note none of the structures in this compound are particularly large. In Compound 72 five units were excavated in 2011 that encompassed midden, several house structures and kitchens that contained numerous hearths located in the western, southern, and southeastern part of the compound, a central part of the patio, and a storage structure in the northeastern part of the compound (Figure 7.4). Full details of these excavations are provided by Arkush and Paredes (2012). Six units were excavated in 2012 in Compound 72, including three more structures, part of the patio, and areas of midden adjacent to structures. Full details of these excavations are provided by Arkush and Paredes (2013), and I draw on this manuscript to describe excavation findings. I focus on describing excavations and architecture from contexts where I analyzed macrobotanical remains.

Figure 7.10: Compound 72 delineating excavation units (map rendered by E.N. Arkush).

Unit 72A Two Kitchen Structures

In Unit 72A, located in the southeastern area of the compound we found two kitchen structures that each had small clayed hearths (Figure 7.11). The northern kitchen structure, referred to as Structure A, measures approximately 2.5 m in diameter and the southern kitchen structure, referred to as Structure B, measures less than 2 m in diameter. In Structure A, there was a concentration of ceramic sherds and a grinding stone next to the hearth. The clay of the hearth itself was not as hardened as other hearths (Figure 7.12). Excavators suggested this might indicate it was not used for very long. There was a complete ceramic vessel sitting in or on top of this hearth, possibly indicating residents rapidly abandoned this structure. This hearth was also surrounded by a small circle of rocks. Structure B was not evident from the surface before excavation began because it was covered in rocks that had fallen from the compound walls. Below these rocks excavators found a dense concentration of quotidian artifacts including grinding stones, ceramics, and even a small, stone pendant carved into a human figure (Figure 7.12). The hearth in Structure B is composed of fire-hardened clay typical of the other hearths we found at Ayawiri; however, it was partially destroyed. According to excavators there was no evidence of ash inside the hearth, indicating it was cleaned out before it was abandoned. In the area excavated around the exterior of these structures, excavators noted they found grinding stones and small amounts of trash such as broken ceramic and animal bones.

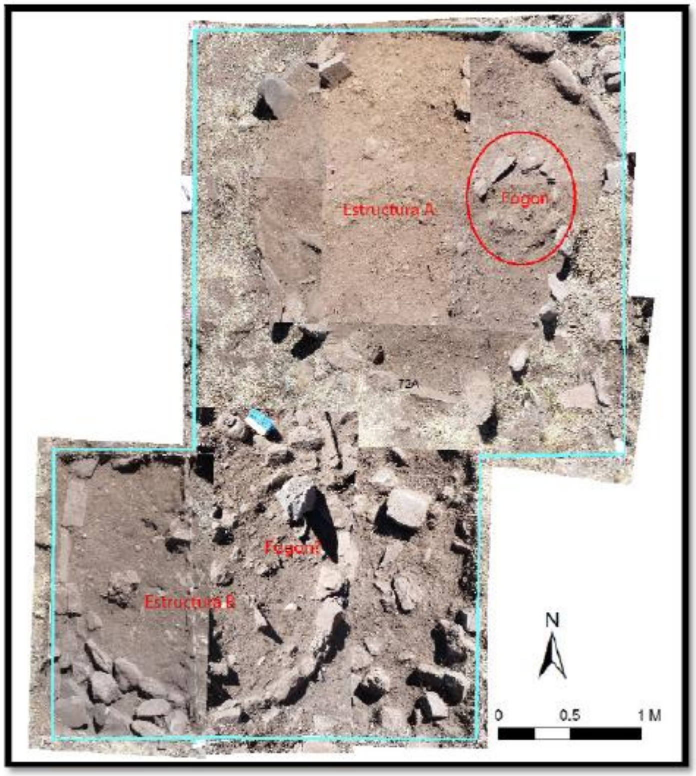


Figure 7.11: Two kitchen structures referred to as Structure A and Structure B with small clay hearths in Unit 72 A.

Figure 7.12: Partially fire-hardened hearth in Unit 72A Structure A (left photo). Stone pendant in the shape of a human figure (right photo).

Unit 72A Two Kitchen Structures Macrobotanical Remains

I analyzed four macrobotanical samples from Unit 72A (Figure 7.12). Two samples were collected from the hearth in Structure A, one sample was collected from the floor of Structure B, and one sample was recovered from the hearth in Structure B. The only crop food remains found in samples from these structures are chenopods. Even from the hearths, I only found a low density of chenopods ranging between 4.33 and 4.9 seeds/liter. I found Malvaceae seeds and wood fragments in both hearths. The presence of only crop companion weeds seeds indicates dung burned for fuel in these structures was gathered from camelids who were grazed in fields. The similarity in the densities of macrobotanical remains and taxa present in the hearths might indicate inhabitants were fueling the hearths with the same fuel, and perhaps they used these structures for the same amount of time.

Table 7.12: Macrobotanical remains from Structure A and B in Unit 72A.

Locus #	V2-1453/2	V2-1454/6	V2-1463/7	V2-1469/1
Unit	72A	72A	72A	72A
Context	Hearth, Structure A	Hearth, structure A	Use surface/floor, Structure B	Hearth/floor Structure B
Taxa Standardized Density (Specimen/L of Soil Floated)				
FOOD				
Chenopodium spp.	0.20	4.90	0.30	4.33
SMALL HERBACEOUS SEEDS				
Malvaceae	0.00	0.10	0.00	1.67
Trifolium amabile	0.00	0.10	0.00	0.00
FUEL				
Wood (Ct.)	0.20	1.30	0.20	0.67
TOTALS				
Total Seeds	0.3	5.2	0.3	6
RICHNESS	2	4	1	2

Unit 72B Kitchen Structure and Non-Kitchen House Structure

In Unit 72B located in the western part of the compound, excavators found a kitchen structure adjacent to the northwest corner of a non-kitchen house structure (Figure 7.13). The kitchen structure, referred to as Structure A, measures about 2 m in diameter and has two oval slab stones placed vertically inside the threshold. These stones probably formed the frame of the doorway. Inside the structure, excavators found a dense concentration of artifacts adjacent to a small clay hearth just to the left side of the doorway including a few broken ceramic vessels, lithics, a canine of a camelid, and a copper or bronze knife that may have been a tumi (the handle was broken off). While there is nothing exceptional about this cooking structure, the last use of the oven was anomalous: antler was shoved in oven vent, and burned camelid bones and teeth were put inside the oven. Perhaps the last meal prepared in this space was for a special occasion or served for a ritual. Or maybe these items were placed there to ritually terminate the life of the hearth. The fire hardened clay hearth measured 20 x 35 cm and, unlike other hearths at the site, was still filled with burned materials. The floor of the structure was composed of a layer of compact soil.

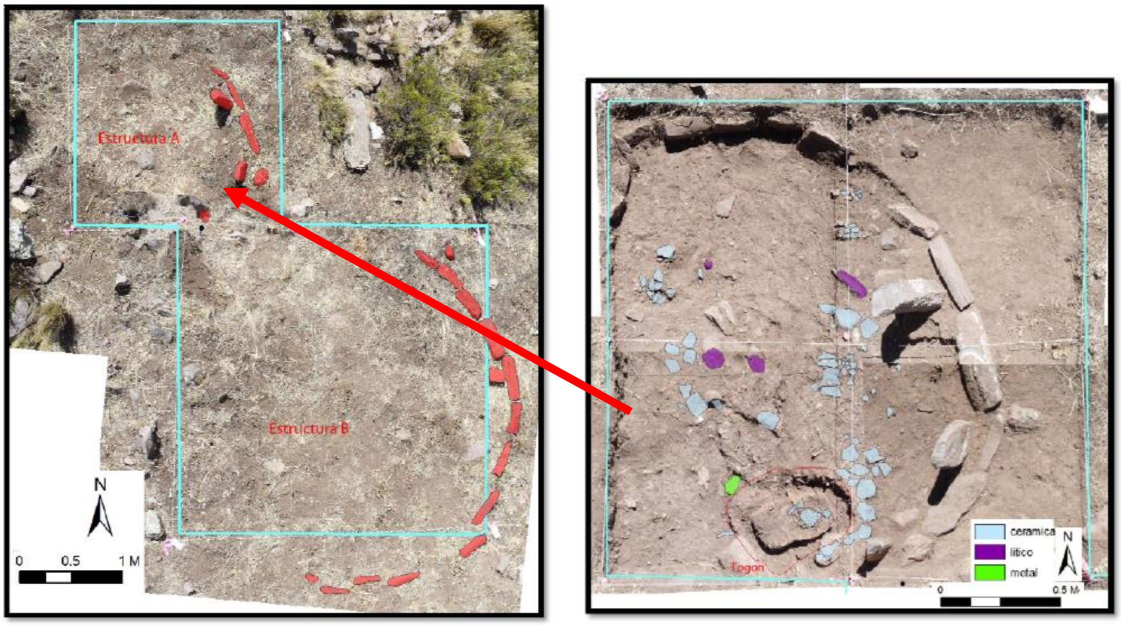


Figure 7.13: A kitchen structure referred to as Structure A located north of a non-kitchen house structure referred to as Structure B in Unit 72B (left photo). The hearth and associated artifacts in Structure A (right photo).

Structure B is the largest structure in Compound 72 measuring over 4 m in diameter (Figure 7.14). In the northern part of this structure excavators found several complete ceramic vessels. In the western part of Structure B, excavators found a lithic axe, a large copper chisel, fragments of deer antler, and the articulated leg of a camelid. The remnants of a red clay floor were noted in a few parts of Structure B.

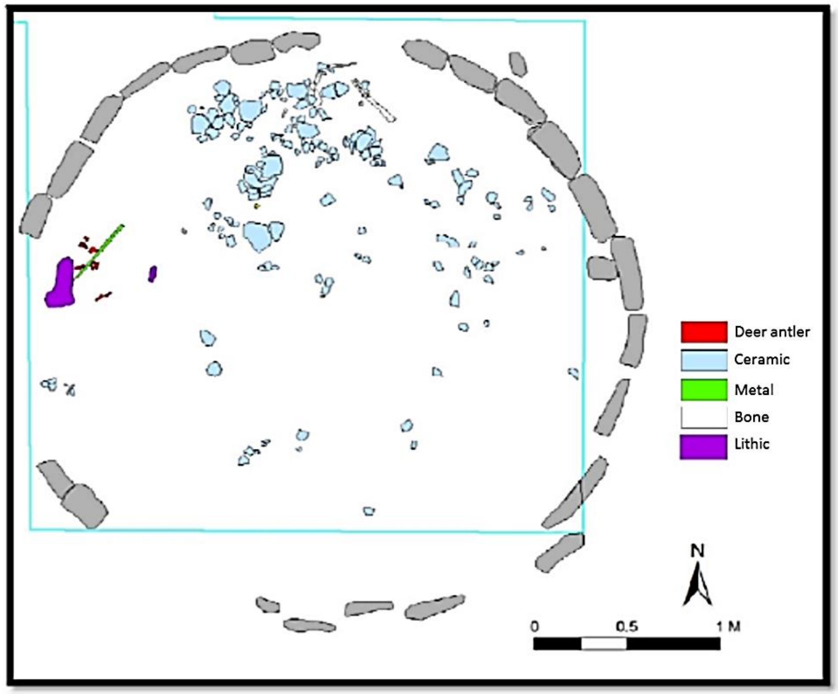


Figure 7.14: Artifacts found in situ on the floor of Unit 72B Structure B (map rendered by E.N. Arkush).

Unit 72B Kitchen Structure and Non-Kitchen House Structure Macrobotanical Remains

I analyzed three macrobotanical samples from the floor of Structure A, one from the hearth, and five from the floor of Structure B (Figure 7.13). Samples from the floor of Structure A have a low density of crop remains (3.6-5.2 chenopod seeds/liter) and barely any small herbaceous seeds, fuel, or bone fragments. Sample V2-1360/5 from the hearth in Structure A has a medium, density of chenopods (67.0 seeds/liter). There is also parenchyma and charred bone in this sample. Compared to the floor, there is also a higher density of wood (12.2 fragments/liter) and small herbaceous seeds in the hearth. Based on the artifacts found in this structure and crop remains in the hearth, this structure was no doubt used for food preparation. The high density of plant remains in the hearth indicate it was not cleaned out before abandonment.

All five samples from the floor of Structure B contain chenopods, mostly in low densities of 2.5 to 8.4 seeds/liter. Sample V2-1402/4 contains medium density of chenopods (21.0 seeds/liter). Very few tubers or small herbaceous seeds were recovered from this structure. Charred bone was found in a few samples in Structure B, whereas only uncharred bone was found in Structure A. These data indicate that food preparation and cooking were carried out in Structure A. After it was cooked, it was consumed in Structure B and inhabitants may have accidentally or intentionally discarded the burned bone and charred bits of plant foods on the floor.

Table 7.13: Macrobotanical remains from Unit 72B.

Locus #	V2-1356/16	V2-1358/21	V2-1358/22	V2-1360/5	V2-1402/1	V2-1402/3	V2-1402/4	V2-1402/11	V2-1403/1
Unit	**72B**	**72B**	**72B**	**72B**	**72B**	**72B**	**72B**	**72B**	**72B**
Context	**Use surface/ floor, Structure A**	**Use surface/ floor, Structure A**	**Use surface/ floor, Structure A**	**Hearth, structure A**	**Use surface/ floor, Structure B**	**Use surface/ floor, Structure B**	**Use surface/ floor, Structure B**	**Use surface/ floor, Structure B**	**Use surface/ floor, Structure B**
Taxa Standardized Density (Specimen/L of Soil Floated)									
FOOD									
Chenopodium spp.	5.20	3.60	4.00	67.00	3.80	2.50	21.00	6.30	8.40
Tubers/Parenchyma	0.20	0.00	0.00	0.30	0.20	0.10	0.00	0.00	0.00
SMALL HERBACEOUS SEEDS									
Brassicaceae	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Malvaceae	0.00	0.00	0.10	2.00	0.00	0.10	0.10	0.20	0.00
Relbunium sp.	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00
Trifolium amabile	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Unknown Seeds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
FUEL									
Wood (Ct.)	0.10	0.00	0.10	12.20	1.20	0.20	0.10	2.20	1.40
OTHER									
Uncharred Bone	0.00	0.00	0.90	26.40	0.00	0.00	0.00	0.00	0.00
Charred Bone	0.30	0.00	0.00	0.00	0.60	0.30	0.00	10.10	0.10
TOTALS									
Total Seeds	5.2	3.6	4.5	72.5	3.9	2.6	21.2	6.5	8.6
RICHNESS	1	1	4	6	2	2	3	2	3

Unit 72C Kitchen Structure

In Unit 72C located in the southwestern area of the compound, excavators found another kitchen structure that measures about 3 m in diameter. This structure was deemed a kitchen structure because excavators found two small, fire-hardened clay hearths located just to the left of the doorway, in the southeastern part of the structure (Figure 7.16). This structure is much larger than other kitchen structures, and the identification of two hearths, instead of one, is anomalous. Excavators noted the hearth to the west, referred to as Hearth 1, is squared off on one end and the elevation is slightly lower than Hearth 2. There are no artifacts associated with Hearth 1, whereas broken ceramics were found in and around Hearth 2. Additionally, Hearth 2 is rounded and similar in form to other hearths at the site. Unfortunately, excavators found that Hearth 2 was partly destroyed. Based on the superimposition of the stratigraphy, Hearth 1 appears to be older than Hearth 2. In the northern area of this structure, excavators found a dense concentration of utilitarian ceramic vessels, animal bones, mortars, pestles, and grinding stones below the floor (Figure 7.15). This concentration of artifacts is interpreted as a sub-floor offering.

Figure 7.15: Artifacts from a sub-floor offering of the kitchen structure in Unit 72C.

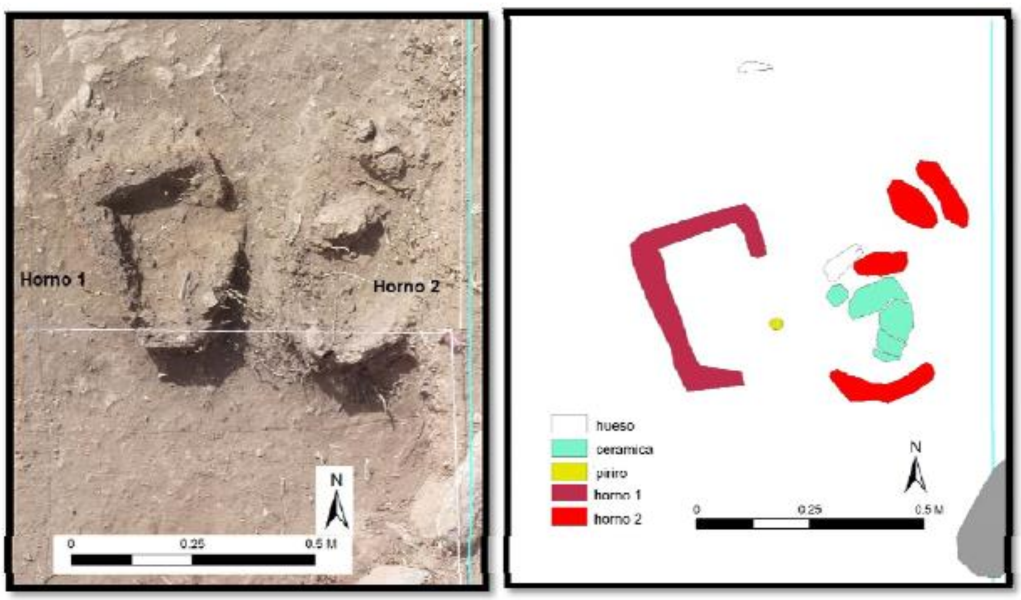


Figure 7.16: Photo (left) and corresponding map (right) of two hearths found in Unit 72 C.

Unit 72C Kitchen Structure Macrobotanical Remains

I analyzed six samples from Unit 72C (Table 7.14). Three samples were collected from the floor, one sample was collected from the sub-floor artifact offering, and two from the hearths. I found a low density of crop remains samples and a very low density of small herbaceous seeds, wood, and charred bone in the structure floor samples and the sub-floor offering. Both hearths contained low densities of chenopods (0.5-0.9 seeds/liter). The hearths also contained very little herbaceous seeds or wood. Perhaps, the hearths were cleaned out regularly. Alternatively, the hearths may not have been used very much or for very long before abandonment.

Table 7.14 : Macrobotanical remains from Unit 72C.

Locus #	**V2-1407/4**	**V2-1407/12**	**V2-1407/13**	**V2-1408/3**	**V2-1408/5**	**V2-1409/11**
Unit	**72C**	**72C**	**72C**	**72C**	**72C**	**72C**
Context	**Use surface**	**Use surface/ floor**	**Use surface/ floor**	**Hearth**	**Hearth**	**Sub-floor artifact offering**
Taxa Standardized Density (Specimen/L of Soil Floated)						
FOOD						
Chenopodium spp.	0.30	4.70	4.10	0.90	0.50	4.30
cf. *Solanum* sp.	0.00	0.00	0.00	0.00	0.00	0.10
Tubers/Parenchyma	0.00	0.00	0.10	0.00	0.00	0.20
SMALL HERBACEOUS SEEDS						
Malvaceae	0.00	0.00	0.20	0.00	0.00	0.40
Relbunium sp.	0.00	0.00	0.00	0.10	0.00	0.00
Trifolium amabile	0.00	0.10	0.00	0.00	0.00	0.00
Unknown Seeds	0.00	0.00	0.10	0.00	0.00	0.00
FUEL						
Wood (Ct.)	0.30	0.10	0.60	0.10	0.00	0.50
OTHER						
Charred Bone	0.00	0.00	0.00	0.30	0.00	0.10
TOTALS						
Total Seeds	0.3	4.8	4.6	1	0.6	4.9
RICHNESS	1	2	4	2	2	4

Unit 72D Central Patio

In Unit 72 D, located in the central patio of the compound, excavators noted did not find many artifacts. They did find a couple of grinding stones on the occupation level and lithic debitage, indicating crop processing and food preparation were carried out in this area. Additionally, there was a large stone in the middle of the compound that was placed vertically. This stone looked like an uncarved monolith, leading excavators to speculate it had a ritual or special use; however, no use was determined and very few artifacts were found that would elucidate the purpose of this stone.

Unit 72D Central Patio Macrobotanical Remains

I analyzed one macrobotanical sample from Unit 72D (Table 7.15). This sample was collected from the occupation level of the central patio of Compound 72. I only found one burned chenopod seed in this sample. Cooking or food consumption clearly did not take place in the central patio. Additionally, this area was kept quite clean of rubbish.

Table 7.15: Macrobotanical remains from Unit 72D.

Locus #	**V2-1364/4**
Unit	**72D**
Context	**Context of light use??**
Taxa Standardized Density (Specimen/L of Soil Floated)	
FOOD	
Chenopodium spp.	0.10
TOTALS	
Total Seeds	0.1
RICHNESS	1

Unit 72E Storage Structure and Fill

In Unit 72E located in the northeastern corner of the compound, excavators found a small storage structure measuring approximately 1 m in diameter (Figure 7.17). Excavators note that the structure is similar in form to the storage structure in 44B. It has a circular stone foundation and a layer of flattened rocks that would provide airflow and drainage for stored goods. A few ceramic fragments were found in the fill of this structure, but no other artifacts were found that would shed light on its intended use.

Figure 7.17: Photo of stone rubble lining the storage structure in Unit 72E.

Unit 72E Storage Structure and Fill Macrobotanical Remains

I analyzed two samples from Unit 72E (Table 7.16). One sample was collected from the stone rubble that composed the base of the storage structure and the other was recovered from the fill around the structure. Sample V2-1476/4 from the stone rubble base of the storage structure contained only four chenopod seeds, one Malvaceae seed, and a fragment of wood. This low density of plant remains is not surprising. Food would have been stored in a raw state, and if any crops were left in the structure they would have decomposed. Cooking, other burning activities, or refuse disposal were clearly not carried out in this location. Excavators identified sample V2-1480/4 as collected from midden around the storage structure. Very few macrobotanical remains were found in this sample, indicating either uncharred perishables were discarded in this location, or the stratum just contained fill.

Table 7.16: Macrobotanical remains from Unit 72E.

Locus #	**V2-1476/4**	**V2-1480/4**
Unit	**72E**	**72E**
Context	**Stone covering, structure**	**Fill/midden**
Taxa Standardized Density (Specimen/L of Soil Floated)		
FOOD		
Chenopodium spp	0.40	1.70
SMALL HERBACEOUS SEEDS		
Malvaceae	0.10	0.00
Unknown Seeds	0.00	0.10
FUEL		
Wood (Ct.)	0.10	1.20
OTHER		
Uncharred Bone	0.00	0.10
TOTALS		
Total Seeds	0.5	2
RICHNESS	2	3

Unit 72F Midden

In Unit 72F, located in the northwest area of the compound, excavators found a midden. It is located between the western compound wall and behind the structures in Units 72B and

72G. Excavators found grinding stones, broken ceramics, and bones strewn throughout the matrix of this unit.

Unit 72F Midden Macrobotanical Remains

I analyzed one macrobotanical sample from Unit 72F (Table 7.17) containing a low density of chenopod seeds (3.8 seeds/liter) and a single Malvaceae seed. These remains provide weak but complementary evidence that this part of the compound was used as a midden.

Table 7.17: Macrobotanical remains from Unit 72F.

Locus #	**V2-2112/1**
Unit	**72F**
Context	**Midden**
Taxa Standardized Density (Specimen/L of Soil Floated)	
FOOD	
Chenopodium spp.	3.80
SMALL HERBACEOUS SEEDS	
Malvaceae	0.10
TOTALS	
Total Seeds	4.1
RICHNESS	3

Unit 72G Non-Kitchen House Structure

In Unit 72G, located in the northwest area of the compound, excavators found a 3 m wide house structure that did not have a hearth. I did not analyze any macrobotanical samples from this structure.

Unit 72H Patio in front of Non-Kitchen House Structure

Unit 72H is located in the western part of the compound and extends into the patio in front of the house structure of Unit 72B. Excavators found a compact surface and a few small artifacts laying on this surface.

Unit 72H Patio in front of a Non-Kitchen House Structure Macrobotanical Remains

I analyzed one sample from Unit 72H (Table 7.18). This sample was collected from the patio in front of the house structure in Unit 72B. I only found a few charred chenopod seeds in this sample (1.67 seeds/liter). These seeds likely ended up in this location through seed rain or refuse disposal.

Table 7.18: Macrobotanical remains from Unit 72H Patio.

Locus #	**V2-2154/2**
Unit	**72H**
Context	**Use surface/floor**
Taxa Standardized Density (Specimen/L of Soil Floated)	
FOOD	
Chenopodium spp.	1.67
TOTALS	
Total Seeds	1.67
RICHNESS	1

Unit 72J Non-Kitchen House Structure

Unit 72J is a non-kitchen house structure that measures almost 4 m in diameter located along the southern perimeter of the compound adjacent to the kitchen structures found in Unit 72A. This structure does not have a hearth or a row of white vertically situated limestone slabs encircling its foundation. Excavators noted that there was not a hearth in this structure, and they found a concentration of rocks in the middle of the floor (Figure 7.18). Arkush (personal communication, 2016) notes that it is still unclear why these rocks were found in the middle of the structure or what they were used for. She suggests that perhaps these rocks were put there to intentionally terminate the use-life of the structure. They do not look like roof collapse. Additionally, excavators commented that they found small obsidian lithic fragments in just about every locus from the house floor. However, analysis revealed that the obsidian density for this structure is close to the average for house floors and not especially high. There is no significant evidence that cooking was carried out in this house.

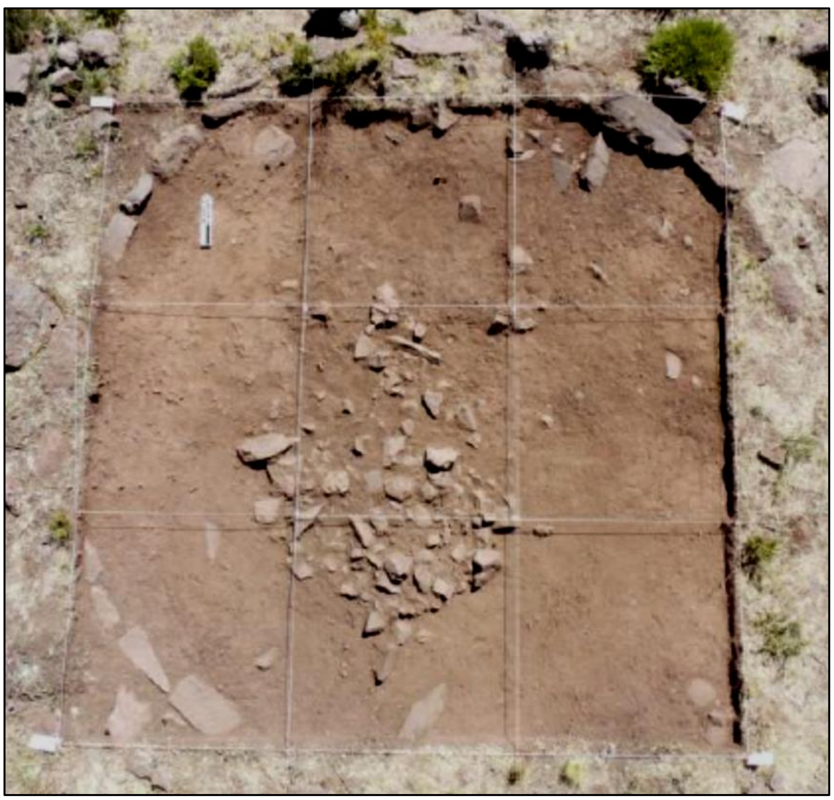


Figure 7.18: House structure in Unit 72J showing concentration of rocks in the center of the floor.

Unit 72J Non-Kitchen House Structure Macrobotanical Remains

I analyzed one sample from this structure (Table 7.19). There was only a single fragment of charred wood from this context. This is a lower density of macrobotanical remains than in samples from fill or midden in Compound 72. While a single sample is insufficient to draw any conclusions, this low density of plant remains points to very little cooking activities or even consumption in this structure. At the same time, these findings rule out the possibility food processing took place in this location.

Table 7.19: Macrobotanical remains from Unit 72J.

Locus #	**V2-2054/6**
Unit	**72J**
Context	**Use surface/floor**
Taxa Standarized Density (Specimen/L of Soil Floated)	
FUEL	
Wood (Ct.)	0.10

Unit 72K Kitchen House Structure

In Unit 72K, located along the southcentral perimeter of the compound adjacent to the western side of Unit 72J, excavators found another kitchen house. Within this structure they found one of the largest hearths at the site measuring 40 x 30 cm. The hearth is oblong-shaped and made of fire-hardened clay, similar in form to the other hearths at the site (Figure 7.19). Additionally, the hearth is surrounded by a circle of stones similar to the hearth in Unit 72A Structure A. Burned matrix containing wood charcoal was found inside the hearth. They also found a broken tupu and sling stones in the structure. There was concentration of utilitarian cooking vessels, spindle whorls, and animal bones found *in situ*, particularly around the hearth. These artifacts are all associated with domestic and cooking activities indicating the structure was indeed used as a kitchen. The floor of this structure was composed of compact clay. Below the clay floor in the northwest part of the structure adjacent to the doorway, excavators found a concentration of burned material including charred bone and wood that could be a sub-floor offering.

Figure 7.19: Unit 72K hearth in kitchen structure.

Unit 72K Kitchen Structure Macrobotanical Remains

I analyzed two macrobotanical samples from Unit 72K (Table 7.20). One sample was collected from inside and around the hearth and the other from the burned feature below the floor. Sample V2-2007/5 from the hearth contained a low density of chenopods (7.88 seeds/liter). There were no other small herbaceous seeds in this sample even though there were fragments of dung. This indicates the charred chenopods in the hearth were probably from dung from camelids foddered on crops. I also found wood. This indicates that dung and wood, probably woody shrubs, were also used to fuel the hearth. Sample V2-2008/1 was collected from the burned feature below the floor. This feature has a very high density of chenopods (116.8/liter), a few Malvaceae seeds, fragments of wood charcoal, and medium density of charred bone (33.4

fragments/liter). While there is no parenchyma or tuber in this sample, the location and appearance of this feature is quite similar to the burned feature below the floor in Unit 59A. While the feature in 72K is not as dense as the one in Unit 59A, it still contains a high density of chenopods and burned bone. These data are strong evidence that this feature is a burned storage feature or an offering below the structure.

Table 7.20: Macrobotanical remains from Unit 72K.

Locus #	**V2-2007/5**	**V2-2008/1**
Unit	**72K**	**72K**
Context	**Hearth and associated artifacts**	**Burnt area below floor**
Taxa Standarized Density (Specimen/L of Soil Floated)		
FOOD		
Chenopodium spp.	7.88	116.80
SMALL HERBACEOUS SEEDS		
Malvaceae	0.00	0.40
FUEL		
Dung	0.25	0.00
Wood (Ct.)	0.50	6.20
OTHER		
Charred Bone	0.00	33.40
TOTALS		
Total Seeds	8.625	117.8
RICHNESS	3	3

Compound 118

Located in the northeastern area of the residential sector at Ayawiri, Compound 118 is relatively small and contains only three visible structures. In Compound 118, three units were excavated that contained a three kitchen structures (Figure 7.20). Full details of these excavations are provided by Arkush and Paredes (2013), and I draw on this manuscript to describe excavation findings.

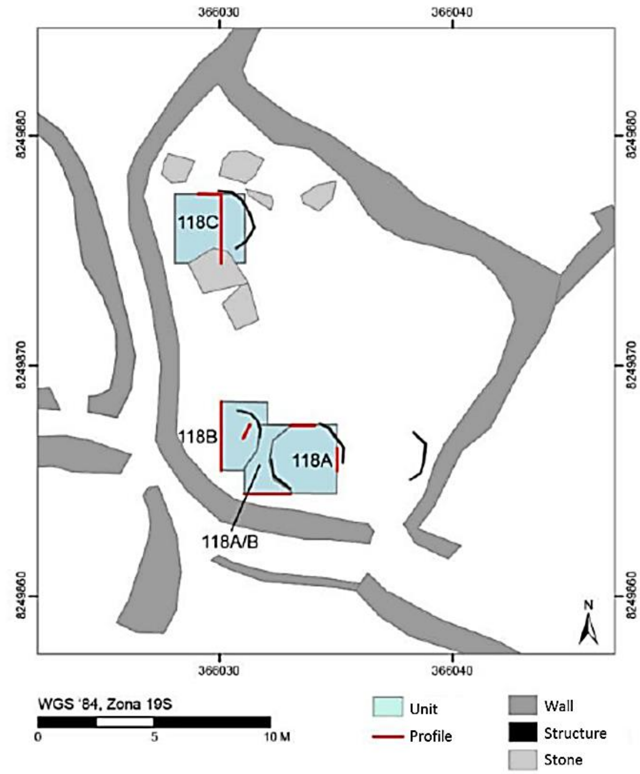


Figure 7.20: Compound 118 delineation excavation units (map rendered by E.N. Arkush).

Unit 118A Kitchen Structure

In Unit 118A, located along the southern perimeter of the compound, excavators found a large kitchen structure that measures about 3 m in diameter (Figure 7.21). A small, fire-hardened clay hearth was found in the eastern part of the structure. This hearth is similar in form to other hearths found at the site. The hearth was partly destroyed and pieces of burned clay were found strewn across the clay floor of the structure. Excavators speculated that this hearth may have been kicked or knocked over. Ceramic fragments, spindle whorls, and camelid bone were found around the hearth. A concentration of lithics was found on the western side of the structure. These artifacts indicate food preparation and cooking were clearly carried out in this structure. Below the floor of this structure, excavators found a small Late Formative Period context containing ash, ceramics, and lithics. There was no architecture encapsulating this deposit. Based on this, excavators noted the purpose or use of this feature was unclear and was perhaps a secondary deposit or a midden.

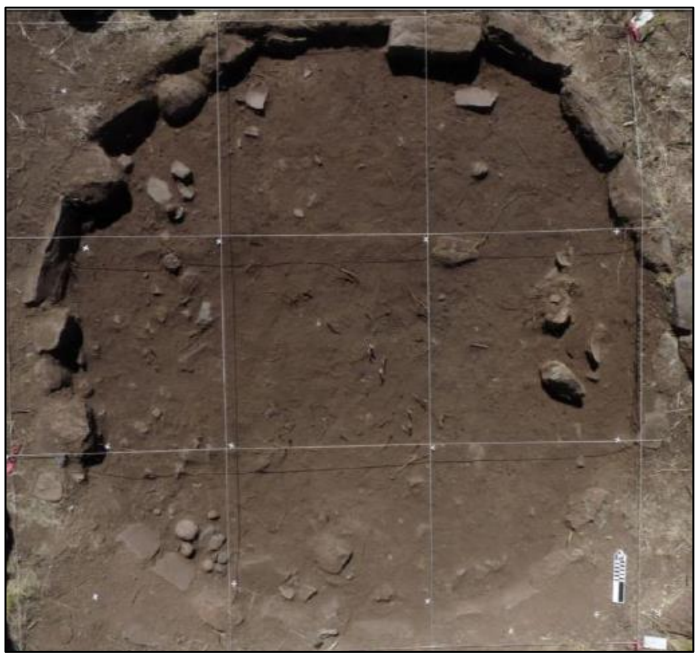


Figure 7.21: Kitchen Structure in Unit 118A. Note the hearth on the eastern side of the structure and a concentration of lithics on the western side.

Unit 118A Kitchen Structure Macrobotanical Remains

I analyzed three macrobotanical samples from Unit 118A (Table 7.21). Two of these samples were collected from the floor of the kitchen structure and one was recovered from inside and around the hearth. All three samples have comparatively low densities of plant remains measuring between 1.3 and 6.2 seeds/liter. At the same time, two samples have higher richness values between five and six taxa. Small amounts of crop companion weeds were found in all three samples, indicating the dung burned for fuel in this structure was collected from camelids grazed in agricultural fields. The low density of seeds in these samples, particularly samples collected from the floor, are evidence this kitchen was not occupied for very long or it was kept very clean.

Table 7.21: Macrobotanical remains from Unit 118A.

Locus #	**V2-2203/10**	**V2-2203/29**	**V2-2204/4**
Unit	**118A**	**118A**	**118A**
Context	**Use surface/ floor**	**Use surface/ floor**	**Hearth and associated artifacts**
Taxa Standardized Density (Specimens/L of Foil Floated)			
CROP PLANT REMAINS			
Chenopodium spp.	1.70	1.20	5.40
CROP COMPANION WEED SEEDS			
Malvaceae	0.10	0.00	0.30
Relbunium sp.	0.10	0.00	0.00
Trifolium amabile	0.20	0.10	0.20
SMALL HERBACEOUS SEEDS			
Unknown Seeds	0.10	0.00	0.00
WETLAND PLANT SEEDS			
Cyperaceae	0.00	0.00	0.10
FUEL			
Wood (Ct.)	2.40	1.40	0.40
TOTALS			
Total Seeds	2.6	1.3	6.2
RICHNESS	6	2	5

Unit 118B Kitchen Structure

In Unit 118B, located along the southwest perimeter of the compound, excavators found another kitchen structure measuring less than 3 m in diameter. This kitchen structure was covered by a layer of large stones that appeared to have collapsed from the wall and causeway running along the south and west perimeter of the compound (Figure 7.22). Inside this structure excavators found a fire-hardened clay hearth sitting on top of charred rocks with a broken cooking pot inside of it. They also found several complete or almost complete utilitarian ceramic cooking vessels, camelid bones, spindle whorls, small lithic grinding stones, and small obsidian tools. Additionally, a small ring made out of copper or bronze was found that was shaped like a butterfly. There was no evidence of a clay or compact floor in this structure.

Figure 7.22: Kitchen structure in Unit 188B. Note the stone collapse laying on top of the level of occupation.

Unit 118B Macrobotanical Remains from Kitchen Structure

I analyzed one macrobotanical sample from the hearth in Unit 118B (Table 7.22). This sample contains a low density of chenopods. Perhaps the hearth was regularly cleaned out, or the structure was not occupied for very long, resulting in a low intensity of deposition.

Table 7.22: Macrobotanical remains from Unit 118B hearth.

Locus #	**2230/V2-2**
Unit	**118B**
Context	**Hearth and associated artifacts**
Taxa Standardized Density (Specimens/L of Soil Floated)	
CROP PLANT REMAINS	
Chenopodium spp.	0.90
TOTALS	
Total Seeds	0.9
RICHNESS	1

Unit 118C Kitchen Structure

In Unit 118C located on an elevated area along the northwestern perimeter of the compound excavators found a third kitchen structure in the compound measuring almost 3 m in diameter and partly sitting on top of a large boulder (Figure 7.23). This boulder forms the floor of part of this structure. In the excavation notes it was hypothesized that this location was somehow special in this compound. However, the artifacts that the excavators found were typical utilitarian objects.

Figure 7.23: Kitchen structure in Unit 118C. Note the structure sits on a large boulder discernible in the southern portion of the photo.

The floor of the kitchen structure in Unit 118C is composed of compacted soil. In the southeastern part of the structure excavators found a hearth made of fire-hardened clay (Figure 7.24). Excavators note that part of the hearth was rebuilt using a ceramic fragment. Ceramic cooking pots and vessels were found around the hearth, along with animal bones. Fragmented lithics were found sitting on the floor throughout the structure.

Figure 7.24: Clay hearth found in Unit 118C.

Unit 118C Kitchen Structure Macrobotanical Remains

I analyzed three macrobotanical samples from the kitchen structure in Unit 118C (Table 7.23). Two samples were collected from the hearth and one sample was collected from the floor in the center of the structure. Sample V2-2255/8 was collected from the ash lens above the hearth has a low density of seeds (6.0 seeds/L) and sample V2-2259/5 from inside the hearth has a moderate density of seeds (25.3 seeds/L). There were also a couple fragments of parenchyma in the hearth. These data indicate that the hearth was used for cooking and/or it contained dung burned for fuel from camelids foddered on crops, and is was not cleaned out after it was used. Sample V2-2256/11 collected from the floor in the center of the structure also has a low density of seeds (6.5 seeds/liter). These materials were probably deposited there as the result of someone regularly cleaning out the hearth, or debris from cooking accidents. Even though this structure was located on a prominent large boulder elevated above the rest of the compound, I did not find any evidence of special use among the macrobotanical remains. I think residents used this structure as a quotidian cooking space.

Table 7.23: Macrobotanical remains recovered from Unit 118C.

Locus #	**V2-2255/8**	**V2-2259/5**	**V2-2256/11**
Unit	**118C**	**118C**	**118C**
Context	**Dark lens above hearth**	**Hearth**	**Structure floor**
Taxa Standardized Density (Specimen/L of Soil Floated)			
CROP PLANT REMAINS			
Chenopodium spp.	5.67	24.00	5.60
Tubers/Parenchyma	0.00	0.20	0.00
CROP COMPANION WEED SEEDS			
Malvaceae	0.17	0.60	0.30
Trifolium amabile	0.00	0.30	0.40
FUEL			
Wood (Ct.)	1.83	7.50	0.20
OTHER			
Uncharred Bone	0.00	0.00	0.20
Charred Bone	0.00	0.40	0.00
TOTALS			
Total Seeds	6	25.3	6.5
RICHNESS	3	4	5

Comparing Macrobotanical Remains across Contexts

In this section, I compare macrobotanical remains from similar contexts. In particular, I focus on comparing hearths to identify how they were used by Ayawiri residents. Then an assessment is made of plant remains from kitchen houses and non-kitchen house structures to determine the activities that were carried out in these spaces.

Hearths

I analyzed macrobotanical remains from the soil of nine hearths (Table 7.24). Houses with hearths were clearly spaces for food preparation, and as I noted, excavators often found artifacts associated with food preparation on the floors of these structures such as small lithics and grinding stones. Every hearth contained chenopod seeds, whereas only three of the hearths contained fragments of carbonized tubers. Additionally, I found a tuber in one of the hearths. These remains indicate the hearths were clearly used for cooking food. The differences in the standardized densities of macrobotanical remains between hearths is likely due to cleaning activities. The small size and shallow depth of the hearths means a single fire would have resulted in charcoal and ash building up very quickly. Residents probably had to clean out the hearths after every meal or at least every other meal in order to keep reusing them. The hearths with higher densities of plant remains were probably not cleaned out before abandonment.

Table 7.24: Standardized density of macrobotanical remains from hearths.

Unit #	**Context**	***Chenopodium* spp.**	**Parenchyma/tubers**
		Count/liter	
44C	Hearth	1.2	0.1
72B	Hearth, structure A	67	0.3
72C	Hearth 2	0.9	0
72C	Hearth 1	0.5	0
72A	Hearth, structure A	2.55	0
72K	Hearth	31.5	0
118C	Hearth	14	0.1
6B	Hearth	6560.2	0
6C	Hearth	6	0

Comparing Plants from Different Contexts

If structures with hearths are cooking spaces at the site, then we would expect these areas to have comparatively higher densities of macrobotanicals from food processing, cooking accidents, snacks, meals, and quotidian activity. Thus, the data found in these areas provide a baseline for comparison and understanding activities carried out in other areas of the site.

Arkush (personal communication, 2016) notes house structures with a row of vertically positioned white limestone slabs encircling the perimeter of structures may have had a special purpose because they are larger than houses without white slabs, they are not found in every compound, and they are not evenly distributed across the site. Many houses, including kitchen house have rows of vertically positioned slab stones, but large house structures with limestone foundations seemed to be exceptional. Could these structures be used for special purposes? By comparing macrobotanical remains between cooking structures and the floors of nearby house structures with white vertically positioned limestone slab foundations and those without, it is possible to gain insight of the use of these spaces. The differences in the density of macrobotanical remains between nearby structures in a compounds are more likely to be the product families carrying out different activities in difference spaces rather than the total length of time the space has been occupied. Since different areas of the site were occupied for different lengths of time, it is particularly important to compare cooking structures to nearby house structures in the same compound to control for intensity of deposition associated with length of occupancy of any single compound.

Structures found in Units 6A and 44A are both non-kitchen house structures with a row of vertically positioned white limestone slabs encircling the foundation. Excavations did not find artifacts that indicated the use of these structures, or evidence these spaces were used for activities that were particularly exceptional. These structures also have red clay floors.

Unit 72B structure B is a large structure without a hearth that lacks white vertical slab stones around the perimeter of the foundation, but it does have remnants of a red clay floor similar to the ones found in Units 6A and 44A. Through excavations, nearby kitchen structures were found in both Compounds 6 and 44 and adjacent to the house structure referred to as Unit 72 structure B. Here, I compare macrobotanical food remains from these house and kitchen structures.

I found a higher density of food remains on the floor of the non-kitchen house in Unit 6A than 6C, a nearby kitchen structure (Table 7.25). The floor of the structure in Unit 44A has the highest standardized density of food remains from any structure floor at the site. Additionally, this unit contained twice as many chenopod seeds per liter of soil as the floor of the structure in Unit 44C, a nearby kitchen structure that contained a high density of cooking artifacts found *in situ.* This indicates that activities taking place in 6A and 44A involved at the very least, the incorporation of crop remains into the floors. Based on the higher density of crop remains in house structures with vertically positioned white limestone slab foundations than kitchen structures in the same compound and absence of cooking related artifacts, I suggest these non-kitchen houses were used as enclosed communal eating areas.

While I only analyzed one sample from the house structure in Unit 59A, the macrobotanical remains recovered from this context further support the idea that large house structures were areas where communal eating were carried out. Like non-kitchen houses in Unit 6A and 44A, the foundation of the house in Unit 59A was also ringed by a row of vertically situated white limestone slabs and the floor was lined in red clay. No hearth was found in the excavation unit indicating it was likely not used as a kitchen structure (see comments about the determination of this earlier in this chapter). Nonetheless, a cache of burt chenopods, potatoes, and tubers was found below the floor of this structure. In the cache I found about 95,000 chenopod seeds/L and 20 tuber fragments/L of soil. In addition, I identified numerous fragments of charred animal bone in this sample. These remains could be evidence of communal feasting that was commonly carried out in large structures with foundations composed of vertical white limestone slabs. Or perhaps a food offering was placed below the floor to consecrate the feasting activities regularly carried out in the structure.

Even though Unit 72B did not have a foundation composed of vertically oriented white limestone slabs, it is one of the largest structures in Compound 72 and has a kitchen adjacent to it. Furthermore, it had a red clay floor similar to house structures foundations composed of white limestone slabs. The house structure in Unit 72B contained lower standardized densities of food remains than the adjacent kitchen structure. Nonetheless, the house structure still contained a medium density of chenopods and parenchyma, even though no hearth was found in this structure. Perhaps the purpose of the house structure in Unit 72B was for communal eating, but these events were smaller scale and less formal than feasting carried out in structures with vertically positioned white limestone slab stone foundations. Only further excavations of houses and adjacent kitchens at Ayawiri can clarify this pattern.

Table 7.25: A comparison of the standardized density of macrobotanical remains from non-kitchen houses and kitchen houses.

Unit #	Context	White Slab Foundation	N=	Standardized Density (Specimens/L of soil floated): ***Chenopodium* spp.**	**Parenchyma/tuber**
44A	House Structure	Yes	26	46.3	0.13
44C	Kitchen Structure	No	13	20.5	0.05
6A	House Structure	Yes	2	17.65	0
6C	Kitchen Structure	No	5	13.02	0.07
72B	House Structure	No	5	8.4	0.08
72B	Kitchen Structure	No	4	19.95	0.13

The location of the structures in Unit 6A, 44A, 59A, and the house structure in Unit 72B within normal compounds indicate they were owned by households, rather than the broader community. While they may have been used as a quotidian dining space for the households that resided in each compound, the macrobotanical residues incorporated into the floors, particularly in comparison to kitchen structures, is exceptional. Perhaps structures with white limestone slab foundations were used as spaces where community leaders congregated to hash out community relations over feasts of large amounts of quinoa and tubers, or local crops. Since there are other similar structures in size and layout in other compounds, small-scale communal meals between households may have rotated from one compound to another. Households would have been responsible for facilitating these small and manageable meals, and doing so would have required reciprocal relationship among residents at the site. However, large white limestone slab foundation structures are not found in every compound. This indicates several extended family groups may have gathered in these spaces.

During earlier times in the region, components of feasts and large communal meals included exotic crops such as maize that were important symbolic and substantive foods. With the termination of access to exotic crops at Ayawiri during the LIP, I suggest there was a transformation in the components of feasts. Instead of an abundance of maize, the high quantity of chenopod remains found in both structures in Units 6A and 44A are the distinguishing characteristics of feasting activities. According to my findings, during the LIP at Ayawiri, locally grown quinoa, kañawa, potatoes, and other tubers were cooked in kitchen structures and transformed into a cuisine worthy of communal consumption. These foods were eaten in separate non-kitchen house structures. Often these house structures were marked by a ring of white vertically positioned limestone slabs around the foundation (some kitchen structures also have this architectural feature), red clay floors, and the interior of these spaces was large enough to host extended families and, perhaps, participants from outside the hosting household.

Comparing Chenopods from Different Contexts

Drawing on the multi-variate analysis I conducted on Ayawiri chenopods, I compared seeds found in hearths, kitchen houses, and non-kitchen houses (Table 7.26). This analysis determines whether different chenopod seed morphological types are more common in certain contexts and less common in others. Any differences may point to different uses of specific chenopod types.

Table 7.26: Chenopod measurements sorted by context.

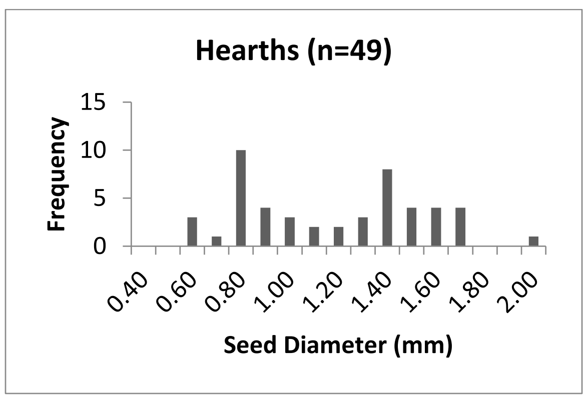
Context		Hearths	6A Non-Kitchen House	6C Kitchen House	44A Non-Kitchen House	44C Kitchen House
Chenopods measured (n=)		49	21	40	226	132
Mean Seed Diameter (mm)		1.18	1.2	1.1	1.2	1.2
Standard Deviation		0.36	0.4	0.4	0.4	0.37
Beak Prominence	Very Weak	0	0	0	7	0
% Frequency	Weak	20	42	23	24	37
	Prominent	77	58	73	55	52
	Very Prominent	3	0	4	14	11
Margin Configuration	Biconvex	4	0	14	2	3
% Frequency	Rounded	68	17	50	63	68
	Truncate	28	83	36	36	30
Testa Texture	Canaliculate	0	0	16	0	3
% Frequency	Reticulate	12	0	3	2	3
	Smooth	88	100	81	98	94

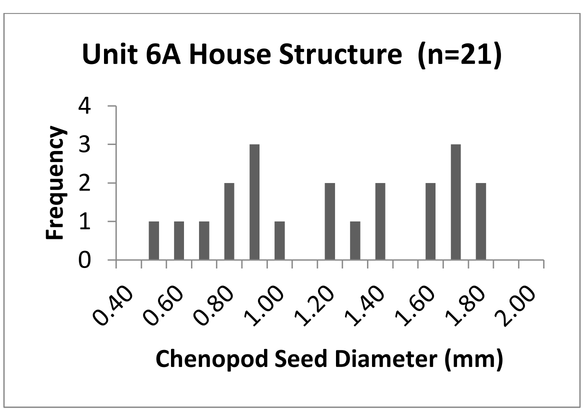
There is very little difference in the mean diameter or standard deviation of chenopod seeds from hearths, kitchen houses, and non-kitchen houses. The beak prominence of chenopod seeds from all contexts is generally weak or prominent. There are more truncate seeds (83%) than rounded seed (17%) in Unit 6A non-kitchen house. Whereas in the other structures and the hearths there are generally less truncate seeds than rounded seeds. Over 88% of all chenopods seeds from these contexts have smooth testa textures. Notably, 100% of the seeds from Unit 6A non-kitchen house have a smooth seed coat.

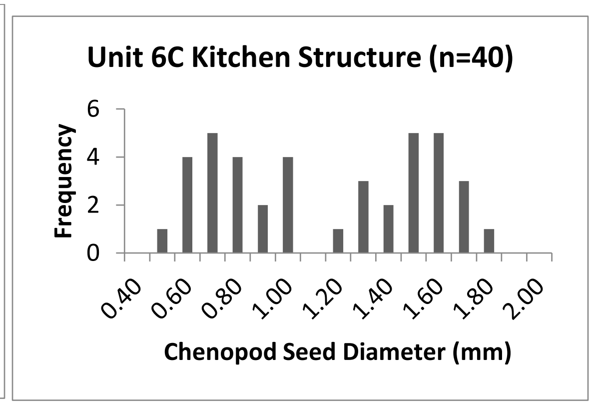
These data indicate that the chenopods found in all five contexts at Ayawiri are generally similar. Chenopod seeds from Unit 6A house structure are the most morphological homogenous indicating they are, perhaps, the same variety.

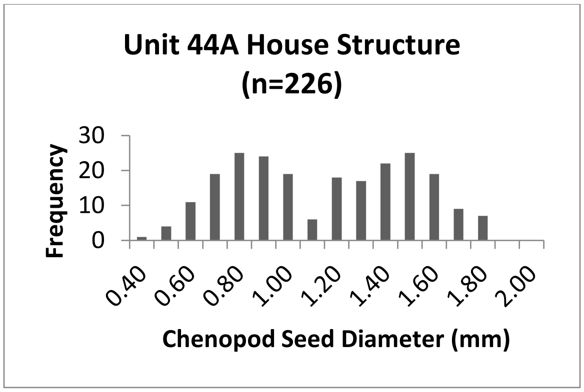
When I compared seed diameter to testa thickness in Chapter Six I determined there are two distinct chenopod types in the Ayawiri assemblage. Therefore, it is predictable the distribution of the mean should be bimodal if both types are found every context. The mean and standard deviation are insufficient to detect the presence of these two populations, so I plotted the seed diameter in histograms to further discern chenopods morpho-types between contexts (Table 7.27).

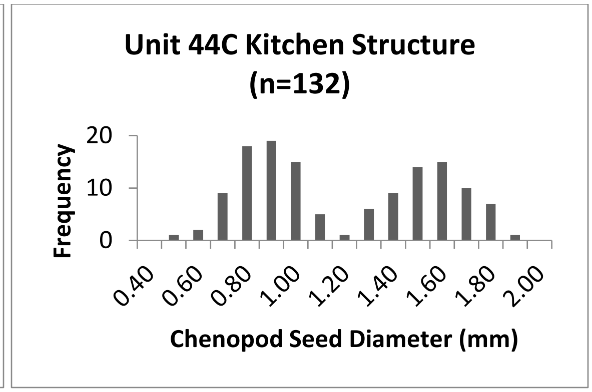
Table 7.27: Histograms comparing chenopod seed diameter between contexts.











These histograms depict a bimodal distribution of chenopod seed diameter in all five contexts. These data indicate that the same chenopods varieties, Chenopod Type #1 and Type #2 in particular, were used and discarded in hearths, kitchen structuers, and on the floors of houses. If camelids ate only kañawa, and quinoa was reserved for human consumption, then we would expect there to be differences between the residues found in hearths where dung was burned and the chenopod seeds in non-kitchen houses where I have determined humans were partaking in meals. However, there is no difference between these contexts. These data provide further support that Ayawiri residents were sharing their crops with their herds. These data also indicate chenopod varieites in compound 44 and 6 are similar. Residents in both compounds used quinoa and kañawa. To shed further light on social diversity evident in plant use at the site, it is necessary to analyze all plant taxa found in different compounds.

Social Diversity and Plant Remains

Since extended family kin groups resided in discrete compounds, a comparison of food crops and other plant remains between compounds elucidates differences between families living at the site. These data are another piece of evidence in the puzzle regarding the nature of social diversity and status among residents at Ayawiri, and more generally among groups during the LIP.

Household Compounds: Similarities in Crops

Generally, I found chenopods and parenchyma/tubers to be the primary crops in each compound. *Chenopodium* spp. seeds compose 99% of the total assemblage of identified macrobotanical remains. A comparison between compounds reveals chenopods were no less than 86% of the total identified plant remains within any compound. I found parenchyma/tubers in samples in every compound. The amount of parenchyma found is highly dependent on taphonomic processes. Therefore, I do not think it effective to compare differences in frequency or density between compounds. My findings indicate there is no clear evidence that any one of the analyzed compounds at the site had a different staple crop economy. There is no evidence that any of the five compounds from which I analyzed macrobotanical samples had access to different types or amounts of crops. Clearly quinoa and tubers were essential crops for each household, and each family group had access to large amounts of this crop. These data lead me to conclude that households from across the site had a generally standardized plant diet. While further and supplementary data are needed, including the results form bioarchaeological and zooarchaeological analysis, based on my findings, there was a fairly generalized food economy at Ayawiri pointing to egalitarian access between households. These findings parallel analyses including architectural and other artifact classes at the site that point to a fairly even distribution of status, prestige, and power among household groups (Arkush 2015).

Rare and Ritually Important Plants

I did not find any plant remains that possess sacred or ritual importance. I fully sorted all but two flotation samples with the intention of finding rarely used ritual plant remains. I did not find any tobacco seeds, coca, maize, or evidence of hallucinogenic plant use documented in earlier time periods in the region. I did find a few *Relbunium* sp. seeds in samples from the red clay floor of the non-kitchen house structure in Unite 44A and the floor of the kitchen structure in Unit 44C. While these seeds were likely burned in camelid dung, it is possible they are the evidence that the plant was used for dye. If this is the case, then not every compound at the site used or had access to this plant. Based on the numerous spindle whorls we found in almost every kitchen structure, there is substantial evidence that textile production was a common activity that took place in every compound at Ayawiri. While very tenuous, the presence of *Relbunium* sp. seeds in only a few compound point to the possibility that red dyed textiles were rarely produced at the site and only by a limited number of families.

Household Compounds: A Difference in Dung Composition

In addition to studying the crops in each compound, analysis of macrobotanical remains allows for an assessment of where herds were grazed. These data show residents in different compounds burned dung for fuel from herds that were grazed in different ecotopes. In order to do this, I compared the percent frequency between compounds of wetland plant remains (Cyperaceae) to crop companion weed seeds (*Trifolium amabile, Relbunium* sp., *Verbena* sp. and cf. *Solanum* sp.) to small herbaceous seeds (Brassicaceae, Cactaceae, *Plantago* sp., and Poaceae) (Figure 7.25).

Before these data are presented, it is important to mention chenopods were found in large quantities in every compound at Ayawiri and sometimes in the absence of artifacts and other direct evidence for cooking. Indeed, I found more chenopods than all other taxa combined in each compound. To me, this shows that camelids also consumed chenopods. The signatures of dung burning throughout the site indicate that herds were either grazed in chenopod fields, or residents foddered their llama herds on crops.

Macrobotanical samples from all compounds contained comparatively low frequencies of wetland plant seeds: between zero and ten percent. This indicates the camelids that produced the dung burned throughout the site were rarely taken to lacustrine or riverine locations for grazing. Compound 118, located in the northeastern sector of the site, contained the highest percent frequency of weedy plant remains and an equivalent frequency of small herbaceous seeds. This indicates the dung burned in this compound was collected from herds that were grazed in both fields and valleys. Compounds 72, 44, and 6 contained a burned dung signature of herds that were grazed primarily in valleys and less frequently in fields.

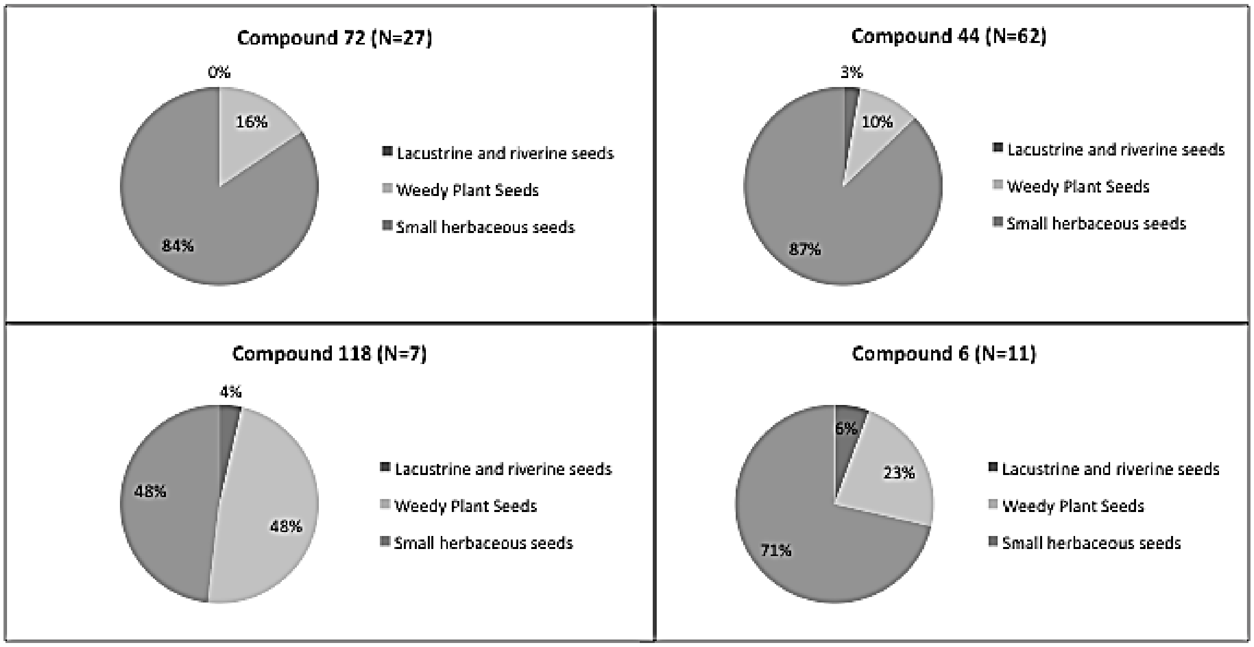


Figure 7.25: Percent frequency comparison between compounds of lacustrine/riverine seeds to small herbaceous seeds.

Conclusions

In sum, contextual analysis of macrobotanical remains sheds light on Ayawiri foodways, use of space, social diversity, and grazing strategies. Based on the food crop remains in structures with hearths, I determined these spaces were indeed used for cooking. In a few cases, there were high concentrations of charred remains concentrated right around the hearths. Doorways of kitchen structures were generally swept clean, whereas areas near the back wall of structures were not. Macrobotanical remains from hearths indicate that at least four were cleaned before abandonment, while the other five contained the charred residues of fuel, including both dung and wood.

Macrobotanical remains support the interpretations made by excavators that spaces behind houses were locations where garbage were discarded. Patios on the other hand were kept quite clean. Macrobotanical remains were sparse in front of structures and in the central part of compounds.

Macrobotanical analysis is the key dataset that sheds light on the use of the large non-kitchen structures at Ayawiri. While these structures lack many artifacts or features related to the activities carried out inside these structures, based on the high density of charred chenopods I determined eating took places in these spaces. The high density of chenopods recovered from non-kitchen house floors indicates communal meals consisting of locally produced foods was the standard plant food in meals. The size of these feasts was constrained by the number of people that could fit into 4 to 5 m wide structures. These meals were hosted in residential space among extended family kin groups.

Macrobotanical remains provide further evidence that there was very little difference in social differentiation among extended families residing at the site, at least as far as food stuffs were concerned. Compounds in the southern, central, and northern part of the site contained similar kinds of crop remains. There was no evidence of non-local crops or ritual plant use among the samples I analyzed. Chenopods and tubers provided the foundation of foodstuffs for all families at the site. The plant portion of the Ayawiri diet was focused on locally produced crops.

The very few plant taxa identified in samples from Ayawiri is exceptional. Often archaeobotanists working in the region find two to three times more taxa. The low diversity cannot be attributed to sampling error since I fully sorted 106 of 108 LIP samples in order to detect rare taxa. A low diversity of plant taxa indicate Ayawiri residents had a constrained use of plants available to them and potentially a restricted a diet compared to earlier populations residing in the Titicaca Basin.

Macrobotanical data also indicate camelid herds had a constrained diet compared to earlier time periods and the modern era. Camelids were primarily grazed or foddered on crops. Additionally, they were grazed in fields and in valleys based on the identification of macrobotanical remains that usually grow in these ecotopes. Herds were rarely brought to lacustrine or riverine based on the low incidence of wetland crops. These data are strong evidence that Ayawiri farmers and herders rarely ventured far from the fortress. Rather, they remained close to safe confines of the site.

Chapter 8. Terraces: Design, Layout, and Labor

In Chapter Eight I provide background information on agricultural terraces. Then, I assess the layout of the terraces at Ayawiri using aerial images and information gathered while I was in the field. Through this analysis an assessment is made of the basic design features and sociopolitical organization of the farmers who constructed and maintained the terrace complex at Ayawiri.

Agricultural Terrace Design

Most terraces are constructed by embanking soil against an earthen ridge or stacked-stone retaining wall (also referred to as a terrace riser). In doing so, farmers reduce the gradient of the hillside, transforming land otherwise unsuitable for agricultural production into arable plots. Leveled platforms are easily tilled and planted with crops. When farmers modify hillsides into agricultural terraces, they are, foremost, increasing the productive capacity of the landscape. This aspect of terrace design is what deems it a form of agricultural intensification (following Boserup 1965).

Agricultural terraces are considered one of the oldest agricultural earthworks methods that preserve water and prevent soil degradation (Dorren and Rey 2004). Prehistoric farmers independently invented this landscape engineering strategy in several locations around the world, including Ethiopia (Watson 2009), the Philippines (Acabado 2010), southeast China (Conklin 1980; Hallsworth 1987), the North American Southwest (Donkin 1979; McGuire and Villapando

2015), Mesoamerica (Rodriguez 2006), and the Andes (Cook 1916, 1925). Many research projects from various branches of agrarian sciences have focused on studying the sustainable and productive capacity of terrace farming in the past, present, and even future projections (ie. Dorren and Rey 2004; FAO 2000; Goodman-Elgar 2008). In fact, agrarian researchers are still championing agricultural terraces as a best management strategy for conserving soil quality and managing water for growing crops in arid environments (Wheaton and Monke 2001).

Beyond their agricultural value, terraces represent significant inputs of human labor in initial construction and maintenance. While a large labor force is required to construct riser walls and mound the earth to level growing area, very few tools or technologies are required to construct or farm terrace fields. Digging sticks and shovels are sometimes used to build terraces but are not required. Terraces can be built simply by means of human hands stacking stones and moving earth.

In addition to providing land to grow crops, terraces are locations where various daily activities take place. As a result, the artifacts found in terraces are evidence of the palimpsest of the social and historical circumstances under which they were constructed and maintained. While archaeologists most often target residential spaces and quotidian areas for information regarding ancient lifeways, it is possible to study the broader anthropological value of landscape modification, agricultural production, and the human use of the land through time by conducting archaeological investigations of agricultural terraces.

Maintenance

As agricultural terraces require a large amount of human labor to build, they also require ongoing maintenance. Terrace riser walls must be strong enough to withstand gravity, heavy sediments, regular intervals of anthropogenic activities, and weather. The combination of these forces often causes risers to swell, degrade, slump, and collapse (Inbar and Llerena 2000:77). Additionally, large plants and vegetation with deep penetrating roots growing on terrace riser walls can threaten the integrity of terraces (Tarolli et al. 2014:20). Wild plants growing on terraces need to be constantly trimmed back because pulling them out can actually loosen soil and encourage erosion.

Farmers need to constantly maintain riser walls to ensure long-term viability. A constant labor force is required for terrace maintenance; a labor shortage often leads to riser collapse, terrace degradation, and landslides (Inbar and Llerena 2000; Vogel 1988).

Types

Numerous agricultural terrace classification systems have been developed to analyze the wide variety of field systems around the world (for examples see FAO 2000; Morgan 2005; Niles 1982). For example, in the Cuzco Valley in Peru terraces have been categorized into three types based on masonry and apparent function (Niles 1982). However, the Ayawiri terraces lack these stylistic characteristics. This leads me to focus on the terrace classification most commonly cited and relevant to this study, specifically those developed in the Andes. Spencer and Hale (1961:10) define two types of terraces: bench terraces and broadfield terraces (also referred to as broad-based, common, or normal terraces).

Constructed on slopes that are steeper than a 20% gradient (FAO 2000), bench terracing involves constructing vertical stacked-stone riser walls parallel to the declivity of hillsides and manually embanking soil behind and atop risers (Spencer and Hale 1961). This process creates leveled flat land tracts that are congenial for crops.

Broadfield terraces, on the other hand, are plowed areas on natural breaks of shallow hills. These field systems are built on slopes with gradients less than 20% (FAO 2000). To create a broadfield terrace, farmers construct short embankments of mounded earth, rocks, or small stacked-stone walls parallel to the hillside gradient. Through time, agricultural activities such as tilling, planting, harvesting, and other erosive processes result in soil naturally mounding against constructed riser walls. With minimal effort farmers capitalize on gravity and erosion to construct broad flattened agricultural plots.

Enhancing the Agricultural Landscape

By design, terraces increase the fertility and agricultural sustainability of the natural landscape in three ways. First, terraces guards against erosion, resulting in the maintenance of soil fertility. Second, terraces capture rainwater runoff and ensure soils are sufficiently moistened. And third, the design of terraces creates convective action that increases the soil temperature enabling crops to germinate sooner each season and guarding against nighttime frost damage (Cook 1925; Dick et al. 1994; Inbar and Llerena 2000; Treacy 1989). Using terraces as a location to graze livestock increases the fertility through dung amendment.

Particularly in the mountains where thin topsoil is susceptible to gravitational erosion (mass wasting) and aeolian processes, transforming hillsides into agricultural terraces stabilizes vulnerable soils (Goodman-Elgar 2008:3072). Micromorphological research on terrace soil indicates, like any agricultural soil, the sustainability of terrace soil fertility is susceptible to overuse (Goodman-Elgar 2008:3085). Farmers must implement soil management strategies to capitalize on terrace fertility by managing fallow periods. Resting the soil for a year or several years between planting cycles ensures minimal loss and rejuvenation of important soil nutrients essential to crops, including nitrogen, phosphorus, and potassium.

Agricultural terrace systems also help keep the soil moistened for crops. Instead of rainwater freely flowing down hillsides, the leveled surfaces of terraces force precipitation to infiltrate the soils (Dorren and Rey 2004:98). This design ensures that rain water penetrates to the roots of crop plants, while simultaneously preventing rainwater from causing topsoil runoff.

Environmental Implications of Abandoned Terraces

Terracing hillsides for agriculture greatly impacts local ecosystems. One study found that past agricultural activities leave distinguishable micromorphological signatures centuries later in terrace sediments including higher concentrations of phosphorous, organic carbon, and nitrogen as compared to the surrounding unaltered landscape (Sandor and Eash 1995). Chemical changes of this nature affect long-term floral and faunal changes.

Environmental changes are precisely what farmers intend to happen when they engineer hillsides. The process of terracing transforms locations otherwise unsuitable for farming into viable agricultural plots. Indeed, terrace agricultural can be considered a form of niche construction where humans consciously or not make the environment more amenable for their species (Smith 2011). As such, terraces should be considered an important part of the legacy of past cultures that needs to be protected and preserved.

On the other hand, when farmers cease to farm and maintain terraces, the environmental results are often negative, impacting entire local ecosystems. For example, Treacy (1989) found that abandoned terraces in the Colca Valley of Peru have higher rates of soil erosion and sediment yield values than cultivated terraces. Other researchers point out that abandoned terraces cause increased soil erosion, slumping, collapse of terrace walls, and even landslides (Inbar and Llerena 2000; Lasanta et al. 2001). Tarolli et al. (2014) found that when terraces are abandoned eroding hillsides can also change hydrological dynamics over a large region.

In addition to environmental effects, abandonment of terraces has far reaching social implications. In particular, landslides caused by eroding abandoned terraces are a particular problem for populations living below. In Italy, there is a concern that eroding abandoned terraces threaten the lives of residents living in many cities (Tarolli et al. 2014).

Terraces in the Andes

First researched by Cook (1916), agricultural terraces compose a large percentage of the viable farmland throughout the Andean cordillera. To date, there is no accurate measurement of the amount of terraced land in the Andes. Nonetheless, a few researchers have calculated estimates of the land coverage of Andean terraces. For example, CEPAL (1989) suggests that there are approximately two million hectares of terraced agricultural lands in Peru, whereas Erickson (1992a:287) estimates there are roughly 10,000 km^2 (or one million hectares) of modified hillsides in the country. Almost all Andean agricultural terraces were constructed in prehistory. Unfortunately, 50 to 75% of the terraces have fallen into disuse since the Spanish conquest (Denevan 1988). This can be partly attributed to violent colonial encounters and the changing sociopolitics of the Andes over the past few centuries. Terraces also have fallen into disuse because modern agricultural methods are not amenable to this type of farming. Bench terraces in particular are not accessible to plows drawn by draft animals or tractors. As the modern era progresses and new farming technology is introduced into the Andes, it is predictable that terrace agriculture will decrease that will have widespread impacts on the environment and human groups residing there. Currently, terrace agriculture continues to be an environmentally sustainable agricultural method particularly suited to the *altiplano*.

Ayawiri Terraces

In this section, I present a description synthesizing the layout of the Ayawiri terraces based on satellite imagery and limited survey conducted during excavations. I describe previous research on the layout of raised field systems to provide a comparative local framework for assessing the layout of the terraces. Additionally, I assess the sociopolitics imprinted in the layout and construction manner of the terraces.

The layout of terraces reflects the social, economic, and political circumstances under which they were constructed and used. Initial planning of terrace construction required cooperation among families and within the community. Annual cropping and fallow regimes needed to be constantly negotiated between farmers. The foods produced on terraces needed to be distributed amongst the community. If farmed long-term, erosion necessitated the need for ongoing maintenance and stabilization. These activities are all imprinted in the land and embedded in the soils of the terrace complex surrounding Ayawiri.

The terraces at Ayawiri are mostly bench terraces that follow the natural contours of the hillside (Figure 8.1). Niles (1982) argues that this terrace form increases stability of terraces, because terraces that are built along the contours of a hillside preserves natural hydrology, whereas heavily modified hillsides with equal sized bench terraces in straight lines loosen soil and disturb the hydrology of an area threatening the integrity of slopes.

The Ayawiri bench terraces are composed of stacked stone retaining walls and earth mounded behind these walls. The tallest retaining wall measured was over 5 m tall, while the smallest wall measured was only 0.5 m. Terraces adjacent to one another were quite variable in height. Similarly, the orientation of the terraces follows the curves and undulations of the hillside. This feature of the terrace complex is particularly noticeable on the southern hillside.

Figure 8.1: Bench terraces that follow the natural contours of the hillslope at Ayawiri.

At the base of the terrace complex abutting the valley bottom, there are a few rows of broadfield terraces. These terraces have significantly shorter stacked stone risers and broader tracts of arable land than the bench terraces. The broadfield terraces are adjacent to camelid corrals and residential compounds of several families that live in Chila today.

Since we were excavating the terraces during the Andean winter (July through August), fields were not in full bloom. However, the remains of dried plants from previous agricultural seasons shed light on the cropping regime of the modern era. It was apparent that not all terraces were farmed the previous year. Based on the abundance of overgrown weedy plants, many terraces were left fallow. The locations of the terraces that were farmed the previous year were quite variable. For example, one farmer that I talked to had cultivated a handful of fields at the bottom of the terrace complex, several in the middle, and a few high up on the hillside near the fortified residential area at Ayawiri. However, very few of the terraces cultivated in 2012 were located next to one another.

Several stacked stone walls run perpendicular to the declivity of the hillside extending from the top of the mesa to the valley bottom. These walls are visible from the ground and in satellite images. There is no earth mounded up against these walls, so they are not load-bearing. Initially, I suspected these were used to help demarcate fallowing cycles; however, based on the random location of fields farmed in 2012, these walls are not used that way today. The farmers from Chila suggested the walls demarcated property, and they were able to tell me who owned which vertical section of terraces. So, a single extended family group farmed several terraces at the base, middle, and atop their section of the complex, while numerous terraces lay fallow within in their landholdings.

The Ayawiri terraces rely primary on precipitation for water; I only encountered one crude irrigation channel located on the southern escarpment while surveying the terraces. The irrigation channel was composed of a few large flat stones lined up with a small dirt ditch between them that directs rainwater runoff. Local farmers confirmed the lack of irrigation throughout the terrace complex. There are two natural springs located about midway up the terrace complex (Arkush 2011); one is located on the eastern slopes, and the other is located on the western slopes. These springs only produce a very small amount of water, and they are often completely dry during the winter. Along with other members of Proyecto Machu Llaqta, I measured the amount of water the eastern spring produced in June 2012 and found it put out about one to two liters of water per hour. We attempted to carry out this same measurement with the western spring, but it was completely dry during the winter months while we were there. While the springs likely fed crops growing on the terraces right next to these sources, there were no detectable irrigation channels directing the flow of the running water that would indicate these sources were significant to past or present farmers working the terraces.

Due to the lack of irrigation networks and steep slope of the hillside, Ayawiri terraces are particularly susceptible to degradation and riser collapse. The seasonality of precipitation and extreme daily temperature fluctuations loosen the sediments, increasing the risk of sediment runoff and riser collapse. Furthermore, sparse vegetation has been linked to higher rates of erosion in the Andes (Inbar and Llerena 2000:78). The sparse weedy vegetation found on fields left in fallow at Ayawiri points to how vulnerable this particular terrace system is to erosion and collapse of retaining walls.

While surveying the terraces I identified many instances of riser wall conservation and stabilization. Local farmers informed me that natural erosional processes often compromise the integrity of riser walls, resulting in a collapse. Farmers then rebuild the walls and re-mound the earthen planting platform. These processes of reconstruction are quite apparent. Lichens on the rocks of retaining walls were particularly useful indicators of recent reconstruction events. On many ancient risers, lichens covered almost the entire exposure of rock faces, whereas on recently reconstructed terraces the rock surface with lichens was irregular, disturbed, and, sometimes, buried. Evidence of these maintenance and reconstruction efforts suggest long-term cultivation and use of the terrace complex.

Sociopolitics Mapped on Field Systems

Several sound models have been developed to assess the sociopolitical organization of the labor required to build raised field systems in the Titicaca Basin (Bandy 2005; Erickson 1993; Kolata 1993). This type of research has not been conducted on terraces in the region, or other field systems for that matter. Thus, I draw on models developed to assess sociopolitics mapped onto raised fields to provide local, analogous frameworks for studying societal organization that underpinned agriculture in the Lake Titicaca Basin. These data shed light on the broader sociopolitical organization of intra-community relations in the region and the motivations for agricultural intensification through time.

Generally, interpretations of the sociopolitical organization of the construction of raised fields and general agricultural production fall into two models that are largely contradictory to one another: 1) a top-down model and 2) a bottom-up model (Janusek and Kolata 2004). The top-down model asserts that elites mandated construction and oversaw production and maintenance of raised fields. On the other hand, in the bottom-up model local farmers cooperatively built raised fields and oversaw production. These models of raised field production hinge on three lines of data: 1) layout; 2) surface features; and 3) time period of construction. Raised field researchers in the Titicaca Basin have particularly focused on the analysis and interpretations of the layout and surface features to provide insight into the administration of agricultural production. Timing of the construction and abandonment of raised fields has been tied to culture histories. Specifically, researchers have tied agriculture chronology to the historical rise of centralized authorities and elites. Notably, both those who subscribed to the top-down and the bottom-up model agree that local power structures embedded in kin groups were essential to the organization of raised field agriculture.

In the top-down model, it is contended that political elites directed labor required to build and farm raised fields in the Titicaca basin. Kolata (1986) was the first to argue that Tiwanaku elites owned raised fields and oversaw their production. By 1996 Kolata and Ortloff suggest that elites collaborated with local leaders to oversee construction and management of raised fields. Similarly, Stanish (1994) argues that before the rise of the Tiwanaku state, local elites oversaw raised field agriculture. Later during the Middle Horizon, Stanish believes Tiwanaku elites took on the role of managing raised fields and extracting surplus. Bandy (2005) links the top-down model to a staggered production cycle model. Raised field systems created convection patterns of air movement that resulted in warmer microenvironments that allowed crops to be planted earlier than in other agricultural fields. Elites could centrally mandate early season labor, and then the surplus harvests from the raised fields without interrupting or straining normal local dryland subsistence farming strategies. In other words, farmers could work for the government on raised fields for a duration, then they could go home and oversee their own farms all in the same season. Bandy argues the top-down model best fits the ecology and seasonality of the Titicaca basin.

Alternatively, Erickson (1992b, 1993, 1999) argues state mandated organization of labor was unnecessary to construct the raised fields in the Titicaca Basin. Rather, he favors the bottom-up model, in which communities and kin-based social groups possessed social control over labor, and local farmers possessed the skills to organize raised field construction efforts. Particularly in the Huatta region of the Titicaca basin where Erickson (1993) asserts raised fields were constructed before the rise of Tiwanaku, he notes the raised fields are laid out in segments indicating they were constructed in an incremental fashion. Additionally, he argues farming raised fields persisted long after the Middle Horizon. Based on this timing, he asserts the invention of raised fields preceded the development of a centralized authority, and farming these fields persisted long after sociopolitical collapse and decentralization of authority. According to this chronology, Erickson concludes that a bottom-up model of raised field production is the only viable model.

Kolata and his colleagues (Kolata 1991; Kolata and Ortloff 1989, 1996) argue that regional features linking raised field systems were built so that elites could oversee production. Particularly in the Koani Pampa region, causeways, dikes, and canals that linked field systems were indicative of powerful elite control over production. Furthermore, artificial canalization of the Katari River and control of water resources could only have been accomplished by a considerable and centralized organization of labor that saturated the ground of hundreds of hectares of raised fields.

Erickson (1993) stresses that the variable layout and character of raised fields provide data about the decentralized political authority that oversaw construction and production. Generally, in the circum-Titicaca region the reticulated platforms of raised fields are arranged in two distinct patterns oriented on the landscape: a checkerboard pattern, or irregular polygons. The checkerboard pattern consists of a group of five to seven parallel platforms that have been called bundles. Bundles alternate direction and orientation (Erickson 1993:390). The irregular polygon pattern of raised fields is quite variable in form. Most commonly, canals radiate out from a central location (Erickson 1993:391). Based on these layouts, raised field construction was mandated by local power structures, and maintenance was carried out under the direction of locally organized farm labor, likely amongst kin groups. Variability in size and orientation of raised fields indicates that there was not a common blueprint, and, therefore, local groups likely oversaw construction. Additionally, Erickson concludes that rocks located between raised fields delineated property boundaries of certain groups. He attributes variability in these marker rocks to stylistic signatures of certain groups, probably kin affiliations.

Regardless whether researchers subscribe to a top-down or bottom-up model, all researchers studying raised fields have speculated that kin groups were essential to organizing raised field production. The debate lies in whether kin groups were sufficient to manage labor, or whether elites intervened. At the heart of this debate is the well documented kin-based social organization termed the *ayllu*, which still exists in the region today. Formally in the Andes, an *ayllu* is a named clan group that commensally and reciprocally socializes, shares landholdings, sponsors festivals, and performs public labor projects (Urton 1993:230). *Ayllus* are composed of ten to hundreds of individuals; these group communally owns land (Kolata 1993:215). In Urton's (1993) ethnography of modern *ayllus* in the central highlands of Peru, he found that the kin groups are responsible for organizing communal labor required to farm cash crops, and they negotiated between groups the cycles of fallowing potato fields.

Kolata (1993:215-221) asserts *ayllu* groups were responsible for innovating raised field agriculture in the Titicaca Basin. In his model, a single *ayllu* worked together to move earth and construct platforms and canals, and, with the rise of the Tiwanaku state during the first millennium A.D., lords and elites garnered increasing control over planning and production of raised fields. This model is based on excavations on the Bolivian side of the lake that revealed limited evidence of habitation structures adjacent to massive networks of raised fields (Kolata 1993:219). These findings are viewed as evidence that the state was concerned with procuring large quantities of agricultural surplus, rather than a village growing crops for local consumption.

Erickson, on the other hand, argues the *ayllus* maintained control over raised field construction and production throughout the first millennium A.D. (Erickson 1993:388-399). He argues that variability in raised field layout represent local *ayllu*-level planning that might also symbolize “ethnicity and style” (Kolata 1993:391). Erickson directly refutes the top-down model by arguing that if Tiwanaku authorities planned and scheduled construction of raised fields, there would be less variability (Kolata 1993:391).

Erickson and Kolata initiated raised field rehabilitation projects in Peru and Bolivia respectively (Erickson 1988; Kolata 1993). To oversee these projects, teams of kin-groups that resembled *ayllu* organization were employed to farm the land. Working with these local social groups surely informed political and economic models for prehistoric raised field construction. The major distinction between the integration of the *ayllu* model in Kolata’s and Erickson’s models is that Kolata perceives the *ayllu* as a system that the state eventually exploited for labor, whereas Erickson believes that the *ayllu* is a social system that ensured that the state did not intervene in agricultural production. I believe the *ayllu* system could have been a necessary organizing principle in the construction of the Ayawiri terraces. The question remains: How was labor organized to construct the Ayawiri terraces?

Assessing the Layout of the Ayawiri Terraces

The basis of analysis of the sociopolitical organization of raised field production can be applied to the study of terraces. Based on the layout and architectural features of the Ayawiri terraces, the nature of these interpersonal and community-level political relations can be inferred.

Ayawiri terraces are so expansive that they can easily be identified in satellite imagery (Figure 8.2), rendering analysis of the layout straightforward. The sheer amount of earth that was moved to build the terraces constitutes communal construction projects carried out by a large community. The maintenance and cultivation of terraces required the establishment of a social organization that scheduled labor and distributed responsibilities among residents.

While there is a cemetery at Ayawiri, there is no other formal communal space or civic architecture. The open areas between the three northern defensive walls and a few of the compounds in the northern residential sector may have been places where residents congregated. However, residents did not invest in creating architecture to facilitate these types of meetings such as a plaza or court. The raised causeways that intersect the site would have surely been a space where community members interacted as they passed one another while exiting and entering the site, but these spaces are not large enough for gathering of more than a few people. The terraces may have been used during the LIP as space where interpersonal and civic engagement took place among residents. As farmers and families spent time tending to their crops, they would have regularly passed one another traveling to their terraced fields. Many of the terraces are large enough to have hosted larger gatherings of many families.

Figure 8.2: Google Earth image of the terraces that flank the fortress at Ayawiri.

If constructing the terraces at Ayawiri were an activity sponsored by a central authority we would expect forethought and planning to result in rigid uniformity; whereas, decentralized labor and lack of civic planning often result in irregular field design (Donkin 1979; Erickson 1988; Kolata 1993; Rodriguez 2006). For example, the discernible linearity, remarkable masonry, and dimensions of high prestige Inca terraces reflect a centralized planning authority (Niles 1982:165-167). However, there is a high degree in variability in height and size of the terraces at Ayawiri. Like raised fields, this indicates there was no common blueprint to which terrace builders adhered. At Ayawiri there does not seem to be the rigid uniformity in the layout or architecture indicative of centrally organized labor. The irregularity in terrace spacing, architecture, and size indicates long-term and small-scale incremental labor investments. This patchwork design represents a decentralized labor organization that, as Erickson (1988, 1994) argues, results from localized negotiations between kin groups.

The stones used to build riser walls at Ayawiri are uncut and crudely stacked (Figure 8.3). There is uniformity in orientation of the riser stones and I did not observe any evidence that clay or mortar was used to consolidate the walls. These data provide further evidence that the terraces were constructed through a decentralized system of labor organization where planning and oversight of construction was minimal.

Figure 8.3: Photos of stacked stone riser wall. Note the unworked stone that are irregularly stacked in various orientations.

The walls that run from the fortress to the valley, perpendicular to the declivity of the terrace slopes are used today to demarcate familial property ownership (visible in Figure 8.2). Marking possession of agricultural landholdings in the Andes seems to be a long-held cultural feature, also documented in raised field systems. Perhaps the perpendicular walls that vertically transected the terraces were constructed to delineate kin group ownership of tracts of terraces at Ayawiri. The marker walls that transect the terraces are similar in architectural style and form to the division of space within the fortified residential sector of Ayawiri. Both consist of uncut filed stones stacked upon one another in no particular pattern. Houses at Ayawiri appear to be organized into family and extended family compound groups demarcated by stacked stoned walls (Arkush 2011:120). The walls that transect the terraces further reinforce the notion that political authority and labor organization were coordinated amongst kin groups on the terraces. These findings indicate farm labor and the goods produced on the terraces was likely organized amongst extended family groups.

Notably, the walls that transect the terraces may have served other functions. For example, they may reduce wind that makes working on the terraces miserable for both humans and herds. Alternatively, the walls may provide drainage. Without further research on these walls, speculations can only be made.

Today, to walk from the valley to the highest terraces and even the fortified residential sector located atop the mesa at Ayawiri, you must take one of a few trails. Although these trails are not well marked, the design of the switchbacks makes the hike relatively easy; deviating from the trails results in a very difficult climb often straight up precarious terrace risers. Following the trails is logistically necessary to travel the steep slopes. Notably, the pathways transect the vertical marker walls that run from the fortress to the valley. Thus, residents regularly traversed neighboring kin-groups' terraced fields, and in fact, this still occurs today.

It has been argued that causeways linking raised fields were indicative of elite administration of agricultural production (Kolata 1991; Kolata and Ortloff 1989, 1996). However, I interpret the pathways as evidence of functionally significant cooperation between neighbors. The pathways were also locations of interaction between kin groups. Working in their fields and traveling across their neighbors' lands, terrace farmers at Ayawiri worked side-by-side on the hillsides. Terraces served the purpose of a public area where neighbors could socialize.

Conclusions

In sum, the Ayawiri terraces are mostly bench terraces, with a few broadfield terraces located at the bottom of the complex. The terraces follow the natural contours of the hillside and there is no evidence of large-scale irrigation networks that would require cooperation between groups living at the site in order to distribute water. Riser walls are composed of unworked stacked stones and there is no evidence of clay or mortar used to construct the walls. There is no conformity in the orientation of the stacked stones. These data indicate no centralized planning authority oversaw construction of the terraces. Small-scale and long-term labor investment organized among kin groups oversaw construction and maintenance of the Ayawiri terraces. However, cooperation amongst the community was necessary to build and regulate access to the terrace complex. Farmers had to follow meandering trails that cut across various sectors of the terraces that probably belong to their neighbors. These trails likely served as de facto public space where neighbors regularly socialized.

Chapter 9. Terrace Excavation Results and Findings

In Chapter Nine I describe the results from the 2013 field season at Ayawiri, where I oversaw excavations of four terraces located on the eastern escarpment below the fortified residential area of the site. The primary goal of these excavations was to determine when the terraces were constructed. First, I describe the location of each excavated terrace with respect to the *pukara*. Then, the appearance and layout of each excavated terrace is presented. I also describe data from excavations including the soil type, color, and texture. Then I summarize the identified soil strata and note significant cultural material recovered from each stratum. Lastly, I provide an interpretation of the past use of each terrace based on the excavation findings.

Selecting Terraces

All four of the excavated terraces were located on the slopes east of Ayawiri on lands owned by persons living in Chila. I targeted excavations of terraces located on the eastern hillside primarily because Chila residents were more amenable to archaeological collaboration than the community living to the west of the site. I hired numerous members of the Chila community to assist in excavations. I selected four agricultural terraces to excavate: TZ3, TZ-4, TZ-5, and TZ-6 (Figure 9.1). Two of the excavated terraces were located near the site, one was located approximately half way between the valley bottom and eastern approach to the perimeter walls of the *pukara*, and the fourth excavated terrace was located along the valley bottom near an Inca Period chulpa (burial tower). There was a second similar chulpa located near the valley that was destroyed in the 20th century by local residents who needed cut stone. Within each of the four excavated terraces, we dug one excavation unit. Each of the excavated terraces was a different shape and height, consequently we adjusted the layout of each unit to account for these differences. In total we excavated 23 m^2.

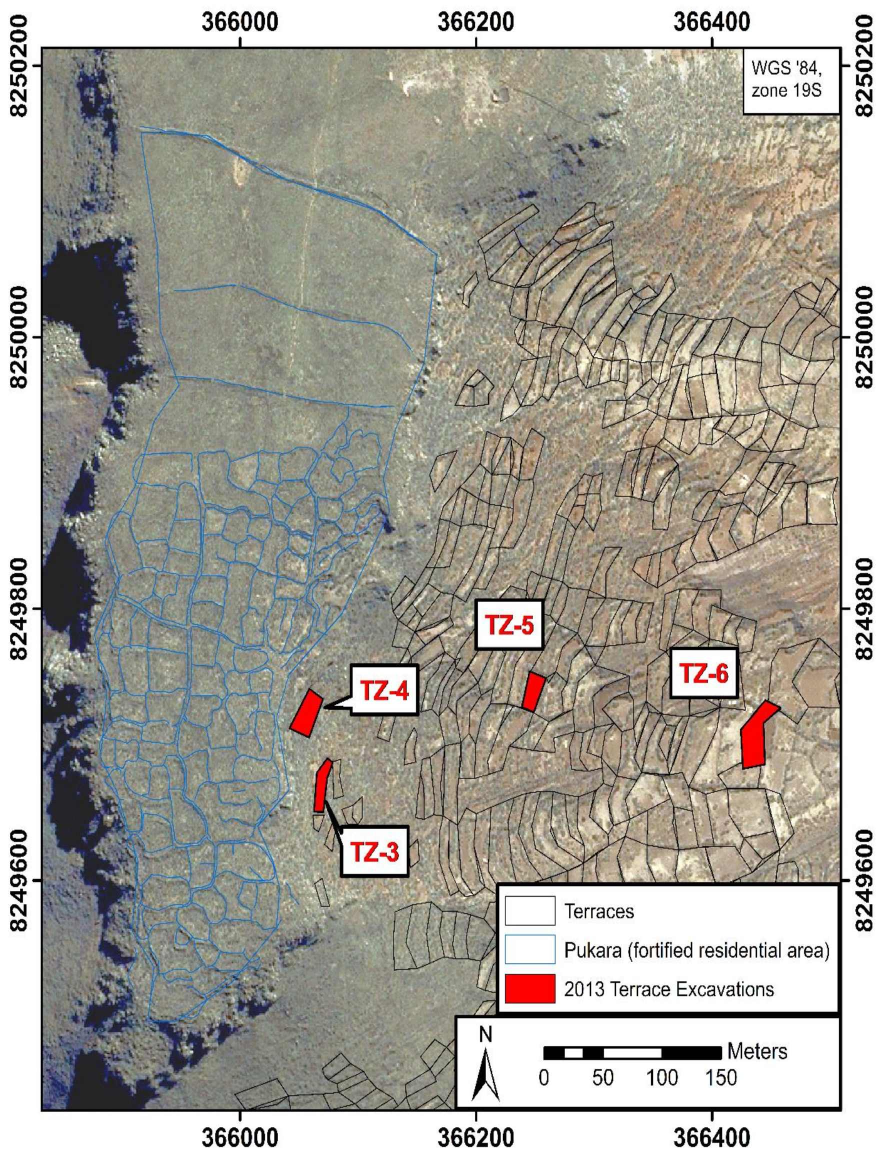


Figure 9.1: Aerial map depicting location of excavated terraces at Ayawiri in relation to the fortified residential sector.

Terrace-4

Terrace-4 (TZ-4) is located high on the hillside near the northeast part of the residential area of the fortress (see Figure 9.1). This terrace is relatively shallow compared to nearby terraces, vertically measuring about 1 m (Figure 9.2). Modern furrows and the remains of dried crop plants were apparent, indicating this area was cultivated the previous season. The local landowner confirmed TZ-4 is still regularly being used to produce crops such as potatoes, oca, and other tubers. Before we began excavations we cleaned and removed the remaining stems of last year's crops including those of wheat and potatoes.

Figure 9.2: Photo of TZ-4 riser wall.

The excavation unit on TZ-4 was a 1 x 6 m trench that was oriented perpendicular to and intersecting the terrace riser. The trench was oriented this way to expose the natural downward sloping paleo-A horizon and bedrock of the hillside buried below the terrace, and to understand how the terrace wall was constructed. We positioned the northeast corner of the unit at UTM 19S 336058E 8249765S (WGS84), and the elevation of the modern surface of this terrace is approximately 4,101 masl. Within the excavation unit, the terrace riser measures 80 cm tall. The terrace wall has two levels: the upper and the lower (Figure 9.3). The upper level is located 40 cm west or upslope from the lower level.

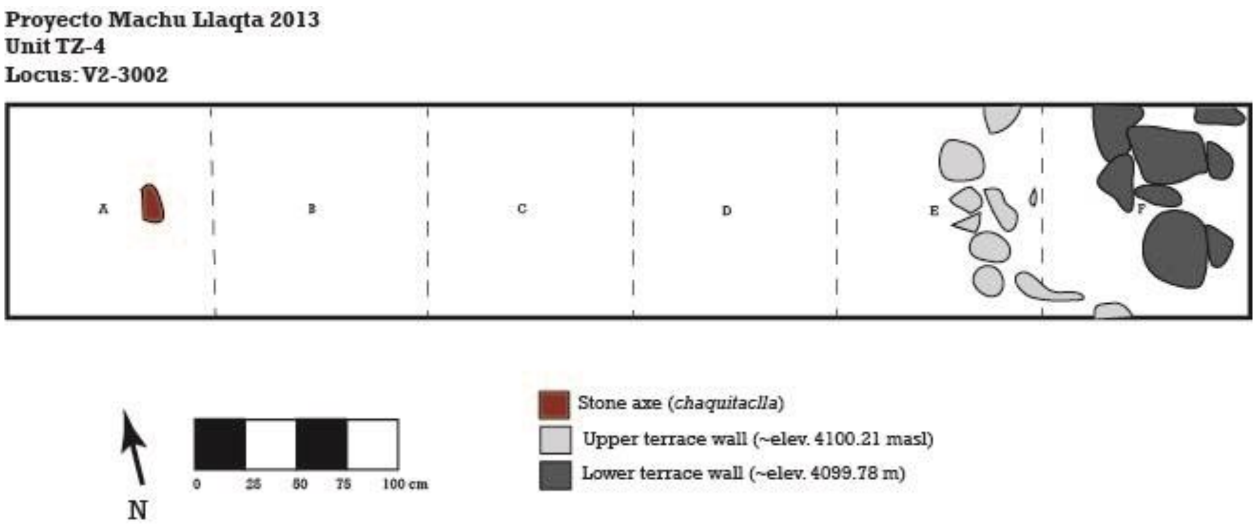


Figure 9.3: Map of the modern surface of TZ-4.

During excavations we identified five distinct strata that were grouped into depositional events including the modern surface (Event 1), agricultural fill (Event 2), two distinct portions of the wall (Event 3 and 4), and bedrock (Event 5). Based on the shallow depth of this terrace, tilling likely penetrated to bedrock, completely overturning the soil matrix and superimposing any *in-situ* artifacts. The full inventory of artifacts recovered from TZ-4 is presented in Appendix I.

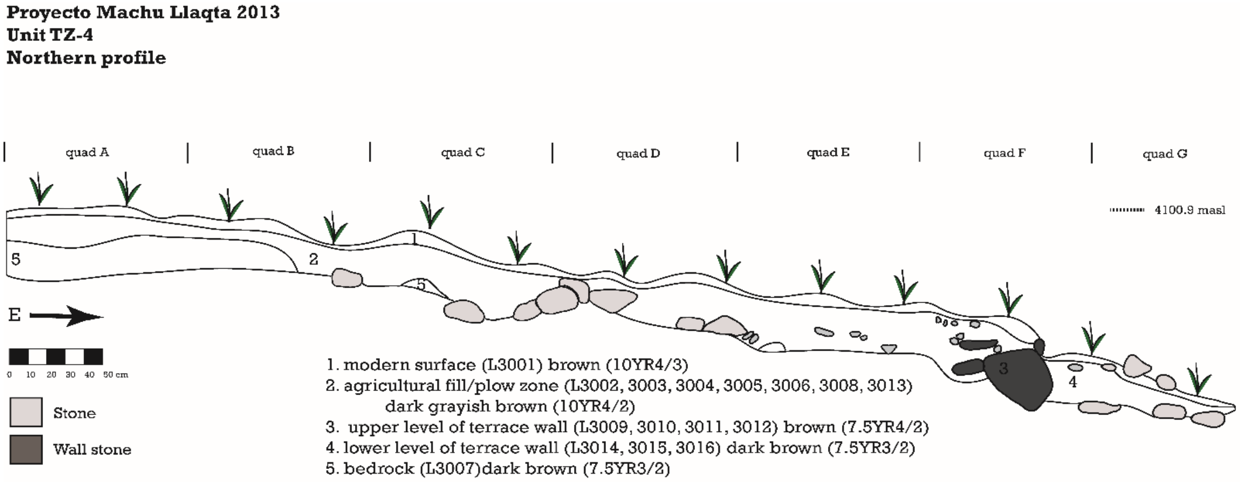


Figure 9.4 : Northern profile of TZ-4.

Event 1 (Loci V2-3001) Modern Surface

In this level we identified a semi-compact modern surface stratum of brown (10YR4/3) silty loam soil mixed with dried stems and roots of modern crop plants. During excavations I noted a low density of small stone inclusions, measuring 5 to10 cm in diameter, mixed throughout the matrix. I found a traditional stone hoe (a *chaquitallca*) protruding through the modern surface in quadrant A (Figure 9.5) that was used in antiquity to prepare agricultural beds for crops.

Figure 9.5: Traditional stone hoe, locally referred to as a *chaquitaclla* found embedded in TZ-4.

Event 2 (Loci V2-3002, 3003, 3004, 3005, 3006, 3008, and 3013) Agricultural Fill/Plow Zone

Located below the modern surface, this level was composed of compacted dark grayish brown (10YR4/2) silty loam soil. This level was still within the modern plow zone based on the identification of modern roots and furrows extending throughout the trench. A low density of medium rocks, measuring 10 to 20 cm in diameter, was dispersed throughout the fill. During excavations a high density of ceramic fragments and a moderate density of lithic artifacts was noted in this level. I collected Soil Core #6 from locus V2-3013 and submitted it for OSL analysis. This sample dates to 105 ± 15 B.P. (Table 9.1).

Event 3 (Loci V2-3009, 3010, 3011, and 3012) Upper Level of Terrace Wall

This level was composed primarily of large stacked stones that measured 20 to 40 cm in diameter and brown (7.5YR4/2) compact silty loam soil fill in-between the rocks. These stacked stones form the upper portion of the riser wall. A broken grinding stone was found in quadrant E. Additionally, a low density of ceramic fragments and lithic artifacts were recovered from the soil matrix between the riser stones. I collected Soil Core #3 from locus V2-3010 and submitted it for OSL analysis. This sample dates to 155 ± 15 B.P. (Table 9.1).

Event 4 (Loci V2-3014, 3015, and 3016) Lower Level of Terrace Wall

Forty centimeters east of and below the upper level of the terrace riser, we identified a distinct lower portion of the retaining wall. This level was also composed of primarily large wall rocks that measured 20 to 40 cm in diameter and dark brown (7.5YR3/2) compact silty loam matrix. During excavations I noted a low density of ceramic fragments and lithic artifacts in the matrix fill embedded between the wall rocks.

Event 5 (Locus V2-3007) Bedrock

This level was composed of very compact dark brown (7.5YR3/2) rock, and was sterile of cultural artifacts or natural inclusions. We only dug into this level in quadrants A and B to confirm that we had indeed, reached sterile bedrock that appeared to extend beneath the entire trench sloping downhill to the east.

Table 9.1: Results of OSL dates from TZ-4.

Sample #	Locus #	Laboratory #	OSL age (yr)[f]
Core 3	V2-3010	BG3980	155 ± 15
Core 6	V2-3013	BG3984	105 ± 15

Diagnostic Ceramics from TZ-4

Analysis of ceramics found in TZ-4 indicates that 95% date to the Late Intermediate Period. Three ceramic sherds were found in the agricultural fill/plow zone that date to earlier time periods of the Middle Horizon and Late Formative (Table 9.2). These sherds likely eroded or tumbled down the hillside and were mixed into this stratum either during construction of the terrace or subsequent agricultural tilling. The diagnostic ceramics found in the first terrace wall all date to the LIP, or early part of the Late Horizon, suggesting that the terrace was constructed during these time periods or later.

Table 9.2: Summary table of diagnostic ceramic sherds recovered from TZ-4.

Event #	Event Name	*Terminus Post Quem*	# Identifiable Sherds (n=)	Pukara n=	Tiwanaku n=	Pucarani n=	Sillustani n=	Collao n=	? N=
1	Modern surface	LIP/LH	6	1	0	1	3	0	1
2	Agricultural fill/plow zone	LIP/LH	37	2	1	20	13	1	0
3	Upper level of terrace wall	LIP/LH	11	0	0	8	2	1	0
4	Lower level of terrace wall	LIP/LH	11	0	0	3	4	3	1
5	Bedrock	-	0	0	0	0	0	0	0

Interpretation of TZ-4

I found that TZ-4 consists of a short riser and soil naturally eroded and mounded behind the wall. This terrace is unique because it is a broadfield terrace located high up on the hillside near the fortified residential area of the site. Most of the terraces around it are bench terraces, whereas the broadfield terraces are mostly found at the bottom of the terrace complex along the fringes of the valley.

The stratigraphy and construction sequence of TZ-4 was straightforward. First, the terrace retaining wall was constructed right on top of bedrock. Then, the terrace was loaded with soil, probably originating from uphill. Then, a second wall was constructed slightly up hill and vertically above the first wall. Based on the steep slope of the modern surface, I suspect the second wall was constructed specifically to halt soil erosion. Soil was mounding up over the top of the second wall and would likely erode over the top of these stones in heavy rain. The *chaquitallca* is evidence of past agricultural activities in this location. The broken grinding stone, and early ceramic sherds found in the agricultural fill of TZ-4 probably were discarded as rubbish from the fort and tumbled downhill. These artifacts were then mixed into the fill during tilling. Based on the diagnostic ceramics embedded in the wall of TZ-4, it was constructed no earlier than the LIP. The two OSL dates obtained from this terrace indicate it was disturbed, stabilized, or constructed one or two centuries ago.

Terrace-5

Terrace-5 (TZ-5) is located on the hillside east of the fortress residential area about half-way between the eastern fortification walls and the valley bottom (see Figure 9.1). The height of this terrace riser is average as compared to those nearby, vertically measuring approximately 1.5 m. Before we began excavations, TZ-5 was covered in modern weedy and wild plants, indicating that it was not planted with crops the previous year. No artifacts were apparent on the modern surface.

We chose to position our excavation unit on the eastern edge of the terrace. This excavation unit was a 1 x 4.6 m trench oriented perpendicular to and intersecting the terrace wall. The trench was positioned in this location because there was less vegetation there. Within the excavation unit, the terrace wall vertically measures 1.38 m and was composed of stacked, unworked stones that measured between 20 and 60 cm in diameter (Figure 9.6).

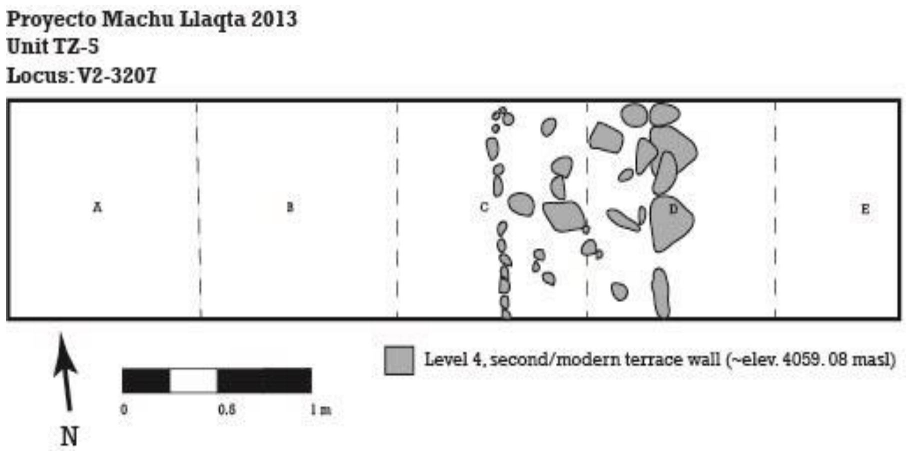


Table 9.3: Map of the surface of the modern/second wall of TZ-5.

Figure 9.6: Photo of TZ-5 retaining wall.

During excavations we identified six distinct events including the modern surface (Event 1), the modern terrace wall (Event 4, second terrace wall), another buried, earlier retaining wall built behind the modern terrace wall (Event 2, first terrace wall), plow zones/agricultural fill associated with each wall (Events 3 and 5), and agricultural fill associated with the modern terrace wall (Event 6) (Figure 9.7). The full inventory of artifacts recovered from TZ-5 is presented in Appendix I.

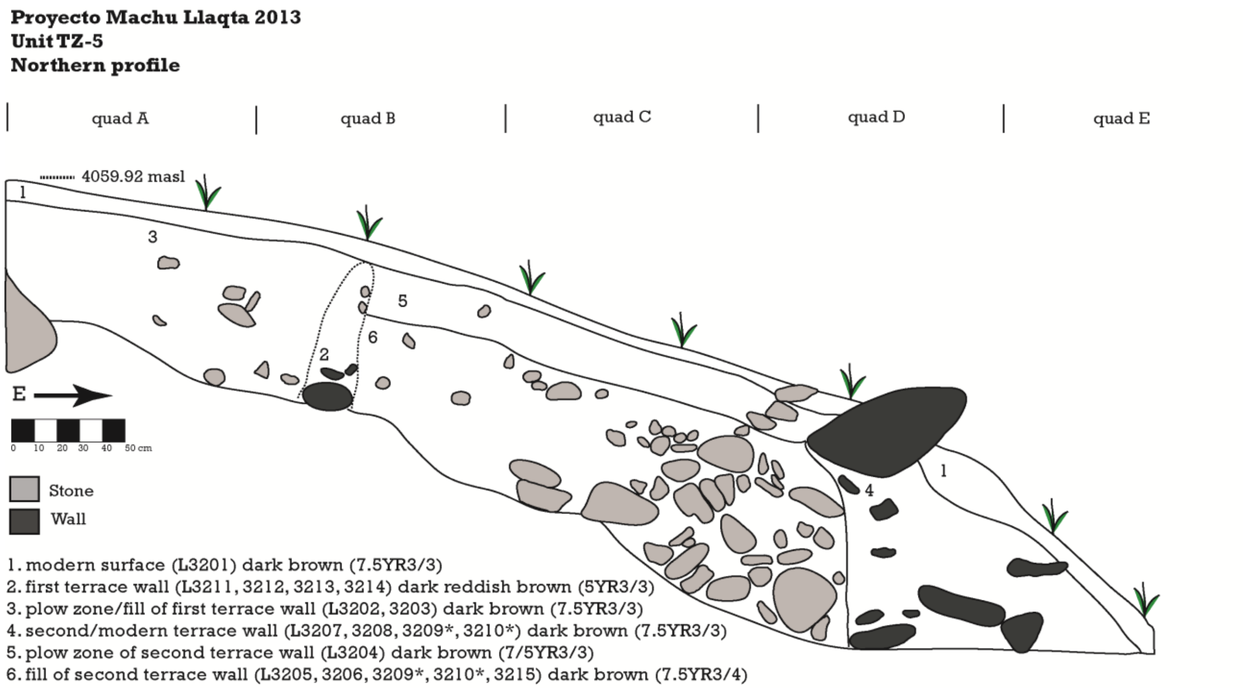


Figure 9.7 : Northern profile of TZ-5.

Event 1 (Locus V2-3201) Modern Surface

This modern surface level was composed of semi-compact dark brown (7.5YR3/3) silty loam. Before we began excavations, we identified predominantly weedy and wild vegetation growing on the surface. The roots from this vegetation penetrated through the stratum.

Event 2 (Loci V2-3211, 3212, 3213, and 3214) First Terrace Wall

This wall was located west or uphill of the second/modern terrace wall and was not visible until we excavated through the modern surface level (Figure 9.8). I first identified it based on a row of stones that bisected the trench. Based on the location behind the modern wall, and the stratigraphy of the soil, the first terrace wall likely predates the second modern wall. This wall was composed of stacked stones that measured between 20 and 60 cm in diameter. There was compact dark reddish brown (5YR3/3) clay loam embedded between the rocks. I collected Soil Core #20 from locus V2-3212 that penetrated below the wall and submitted it for OSL analysis. This sample dates to 2105 B.P. ± 200 (Table 9.4).

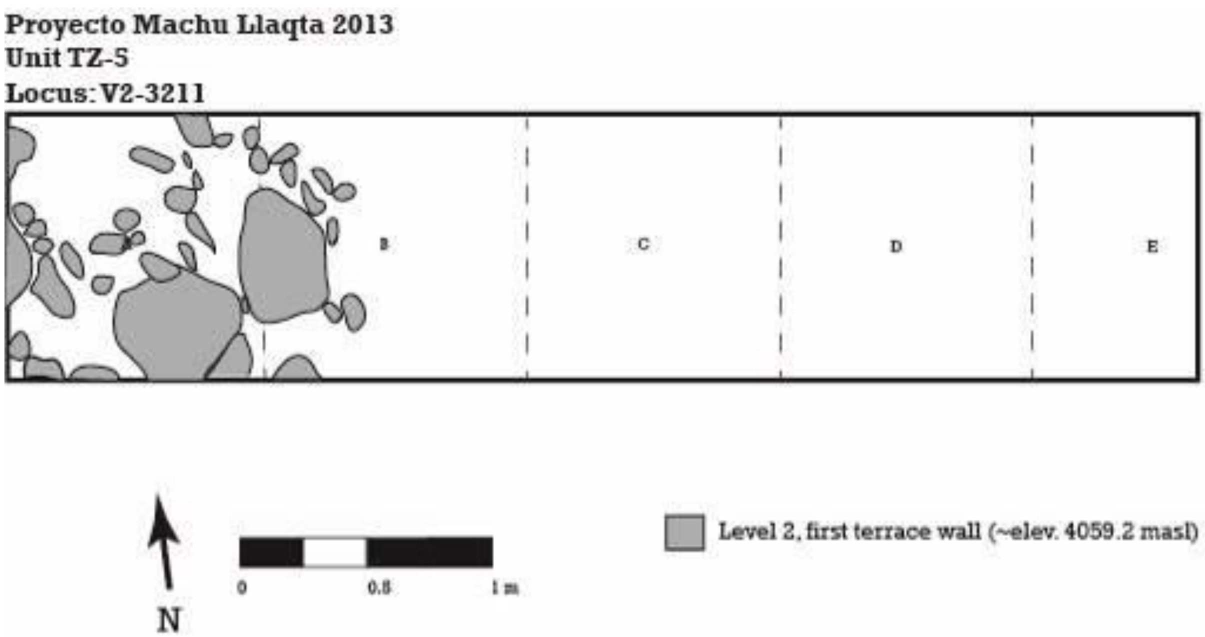


Figure 9.8 : Map of the first wall of TZ-5.

Event 3 (Loci V2-3202, and 3203) Plow Zone of First Terrace Wall

Located below the modern surface level and west of first terrace wall, we found a level was found composed of semi-compact dark brown (7.5YR3/3) silty loam soil with inclusions smaller than 5 cm in diameter. Based on the soil color and the penetration of modern roots in this level, I identified this stratum as plow zone. A low density of ceramic fragments and lithic artifacts was noted throughout this level.

Event 41 (Loci V2-3207, 3208, 3209, and 3210) Second/Modern Terrace Wall

This level was composed primarily of large stacked stone that measured 20 to 50 cm in diameter and semi-compact dark brown (7.5YR3/3) silty loam embedded between the riser stones. During excavations a low density of artifacts in the matrix was noted, including ceramic fragments, lithic artifacts, and a few uncharred animal bones. I also found two sling stones embedded between rocks that formed the riser wall (Figure 9.9). These sling stones measured between 3.5 cm and 5 cm in diameter. I collected Soil Core #29 from locus V2-3209 from the matrix of the wall and submitted it for OSL analysis. This sample dates to 490 ± 45 B.P. (Table 9.4).

Table 9.4: Results of OSL ages for TZ-5.

Sample #	**Locus #**	**Laboratory number**	**OSL age (yr)**
Core 20	V2-3212	BG3982	2105 ± 200
Core 29	V2-32z09	BG3985	490 ± 45

1 *Both loci V2-3209 and V2-3210 were excavated from Event 4, the second/modern terrace wall and Event 6, the agricultural fill. While the wall was likely constructed at the same time the agricultural fill was deposited in the terrace, I chose to separate these events for analytical purposes because Event 6 was likely subjected to annual agricultural processes resulting in further mixing of the soil.*

Figure 9.9: Photo of a large sling stone found in TZ-5. Scale in centimeters.

Event 5 (Locus V2-3204) Plow Zone of Second/Modern Terrace Wall

Located below the modern surface stratum and east of the first terrace wall, this level was composed of semi-compact dark brown (7.5YR3/3) silty loam and a low density of fill rocks that measured 10 to 20 cm in diameter. I identified this level as plow zone based on the modern roots penetrating throughout this level and the overturned appearance of the matrix. During excavations I noted a low density of ceramic and lithic artifacts in this level.

Event 6 (Loci V2-3205, 3206, 3209, 3210*, and 3215) Agricultural Fill associated with Second Terrace Wall*

Located below the plow zone of the second terrace wall and east of the first terrace wall, this level was composed of semi-compact dark brown (7.5YR3/4) silty loam soil with small pebble inclusions that measured 5 to 10 cm in diameter. I noted a low density of artifacts dispersed throughout this level including fragments of ceramics, lithic artifacts, and a few fragments of uncharred animal bone. Additionally, I found another sling stone and a fossilized invertebrate in this stratum (Figure 9.10). Arkush (personal communication, 2016) noted that similar fossils were found at Ayawiri and other sites in the region, and people probably collected them.

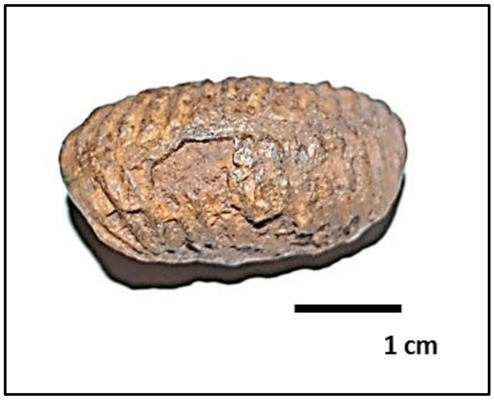


Figure 9.10: Fossil invertebrate found in TZ-5 Event 6.

Diagnostic Ceramics from TZ-5

Analysis of ceramics found in TZ-5 revealed that 100% of the diagnostic sherds date to the Late Intermediate Period or the end of the LIP and the early part of the Late Horizon (

Table 9.5). The ceramic sherds in the agricultural fill, including the Late Horizon ones, were likely mixed due to tilling and could have been deposited there well after the LIP. The ceramic sherds embedded in first terrace wall all date to the LIP, whereas the ceramics in the second wall date to the latter part of the LIP and/or the Late Horizon.

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Table 9.5 : Summary table of diagnostic ceramics recovered from TZ-5.

Event #	Event Name	*Terminus Post Quem*	# Identifiable Sherds (n=)	Pukara n=	Tiwanaku n=	Pucarani n=	Sillustani n=	Collao n=	? N=
1	Modern surface	LIP	2	0	0	2	0	0	0
2	First terrace wall	LIP	6	0	0	6	0	0	0
3	Plow zone of first terrace wall	LIP/LH	8	0	0	7	0	1	0
4 &6*	Second/modern terrace wall and associatedagricultural fill	LIP/LH	11	0	0	7	3	1	0
5	Plow zone of second/modern terrace wall	LIP	3	0	0	1	2	0	0

**These events were combined for analytical purposes because one loci contained materials from both events.*

Interpretations of TZ-5

TZ-5 is an unstable bench terrace with two construction phases. First, a stacked stone terrace retaining wall was built, and soil was mounded into a small flat platform suitable for planting. However, this retaining wall was weak and eventually collapsed. In order to halt erosive processes, a second wall was constructed downslope to stabilize the terrace. While initially, soil was mounded behind this second riser wall, erosion continued. At the time of excavations, the second/modern wall appeared to be slumping and partly collapsed. I think, in a heavy rain, the structural integrity of the wall will be compromised.

While an OSL sample from below the first riser wall dates to the Late Formative Period over 2,000 years ago, I believe it was constructed during the LIP. The OSL core penetrated too deep and the OSL date measures a natural buried paleosol. Based on the diagnostic ceramics found in the terraces walls, TZ-5 was constructed at the very earliest during the LIP. Ceramics found in the first terrace wall all date securely to the LIP, whereas the ceramics embedded in the second/modern terrace wall date to later part of the LIP and early part of the Late Horizon. The ceramics support the interpretation that first wall was constructed before the second wall. Furthermore, ongoing stabilization of TZ-5 also took place during the LIP or later. Indeed, the OSL date from this wall indicates there was work on this wall during the 16th century.

The sling stones found embedded in TZ-5 are quite large. Today, farmers at Ayawiri use small pebbles for sling stones to herd their animals by throwing them at those who stray from the pack. However, the large sling stones found in TZ-5 would have rendered anyone or any animal unconscious. The sling stones could have been hurled from atop the fortress as defense, or they could have been used by farmers to protect their fields.

Terrace-6

Terrace-6 (TZ-6) is located on the hillside east of the *pukara* about halfway between the eastern fortification walls and the valley (see Figure 9.1). TZ-6 is near an Inca Period burial tower, or *chulpa*. The height of this terrace riser wall vertically measures between 1 and 2 m. I noted there were agricultural furrows and remnants of crops plants on the surface of TZ-6. Further discussions with local farmers confirm this field is still used for agricultural production, and it was used to grow potatoes and oca in 2013.

Table 9.6: Inca burial tower or *chulpa* located near the base
of the terrace complex (photo by E.N. Arkush).

In the location where we initially planned to excavate, the terrace riser wall did not have lichen growing on it and the soil appeared loose. A discussion with local farmers confirmed my suspicions that this part of the terrace was reconstructed and reinforced in the past decade. Thus, the excavation unit was moved to the northern end of terrace where the modern riser appeared undisturbed.

We excavated a 1 x 5 m unit trench that was oriented perpendicular to and intersecting the terrace wall (Figure 9.11). Within the unit of excavation, the modern terrace wall was composed of stacked stones that measured between 20 and 60 cm in diameter. In the excavation unit, the modern terrace riser measured 1.05 m in height to the top of the stacked stones, but the soil is mounded up over the wall to 1.53 m.

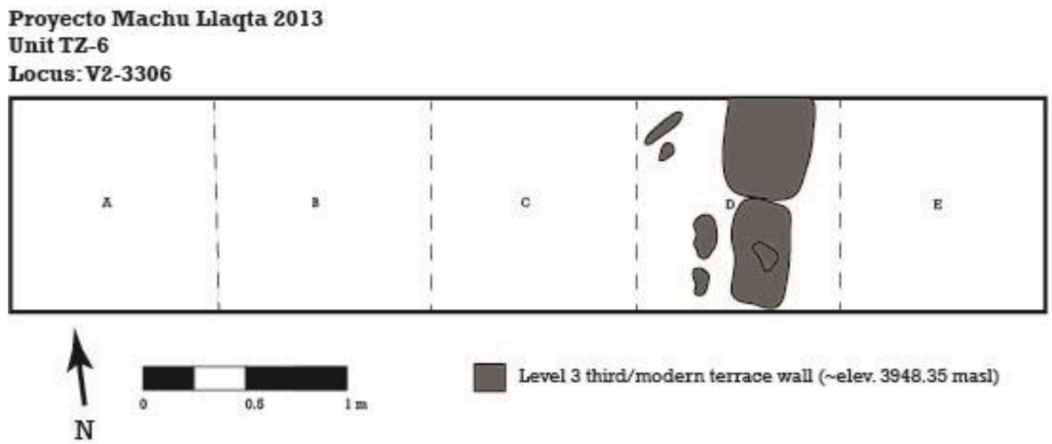

Figure 9.11: Map of the surface of the modern/third wall of TZ-6.

Figure 9.12 : Photo of TZ-6 retaining wall.

During excavations seven distinct events were identified including the modern surface (Event 1), plow zone (Event 2), the modern/third terrace wall (Event 3), two earlier walls (first and second terrace wall) (Events 5 and 7 respectively), and agricultural fill behind each wall

(Events 4 and 6) (Figure 9.13). The full lists of artifacts recovered from TZ-6 is presented in Appendix I.

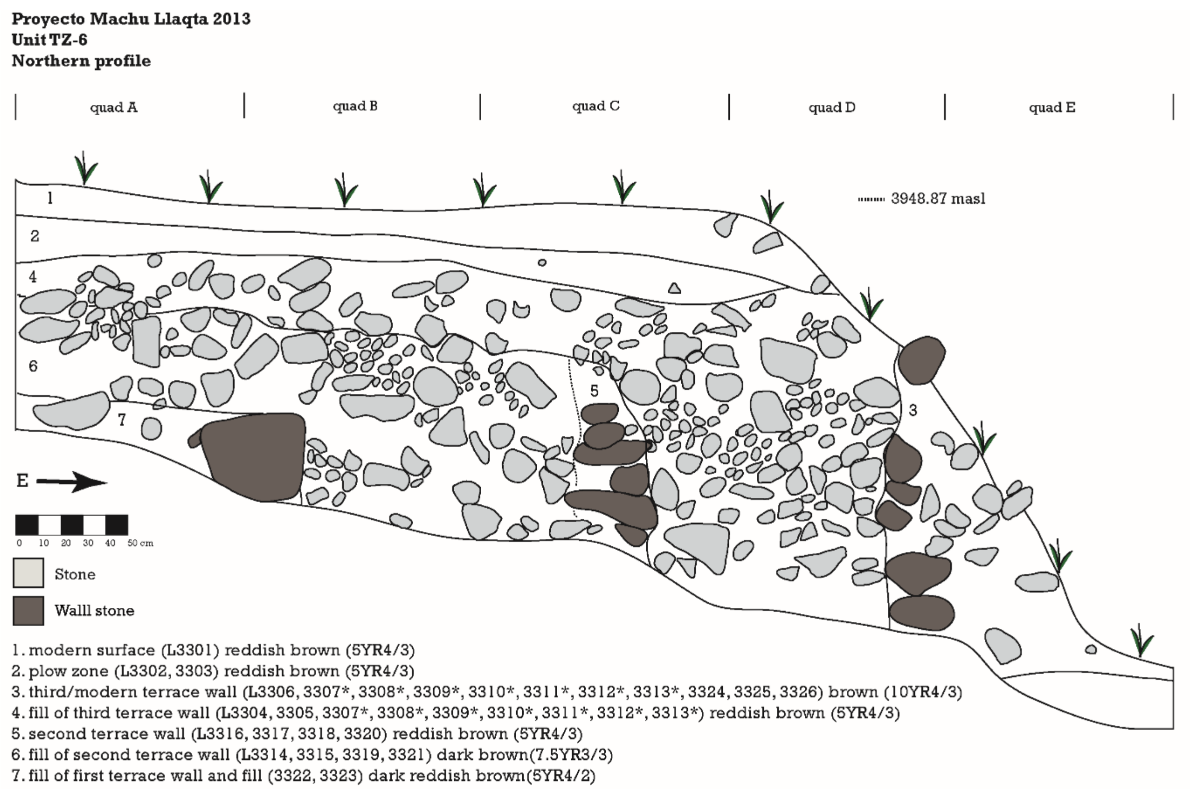

Figure 9.13: Northern profile of TZ-6.

Event 1 (Locus V2-3301) Modern Surface

The modern surface stratum was semi-compact reddish brown (5YR4/3) silty loam soil with the remains dried crop plants and furrows. A few fragments of ceramic sherds were recovered from this level.

Event 2 (Loci V2-3302, and 3303) Plow Zone

Located below the modern surface, this level was composed of semi-compact reddish brown (5YR4/3) silty loam with small pebbles that measured 1 to 5 cm in diameter. A low density of ceramic sherds, lithics, and animal bone fragments was noted from this stratum.

Event 32 (V2-Loci 3304, 3306, 3307, 3308, 3309, 3310, 3311, 3312, 3313, 3324, 3325, and 3326) Third/Modern Terrace Wall

This level was composed primarily of stacked stones that measure 20 to 60 cm in diameter (Figure 9.11). There was semi-compact brown (10YR4/3) silty loam between the rocks. A low density of ceramic sherds, lithic artifacts, and animal bone fragments from matrix of the riser wall were recovered from excavations. I collected Soil Core #31 from locus V2-3309 located in the middle of the wall and Soil Core #40 from locus V2-3325 from the matrix underneath the wall. These samples were submitted for OSL analysis and date to 21,875 ± 620 B.P. and 920 ± 70 B.P. respectively (Table 9.8).

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2 *Loci V2-3307, 3308, 3309, 3310, and 3311 were excavated from both Event 3, the third/modern terrace wall and Event 4, the agricultural fill. While the wall was likely constructed at the same time the agricultural fill was deposited in the terrace, Event 4 was likely subjected to annual agricultural tilling, planting, and other disturbances resulting in further mixing of the soil.*

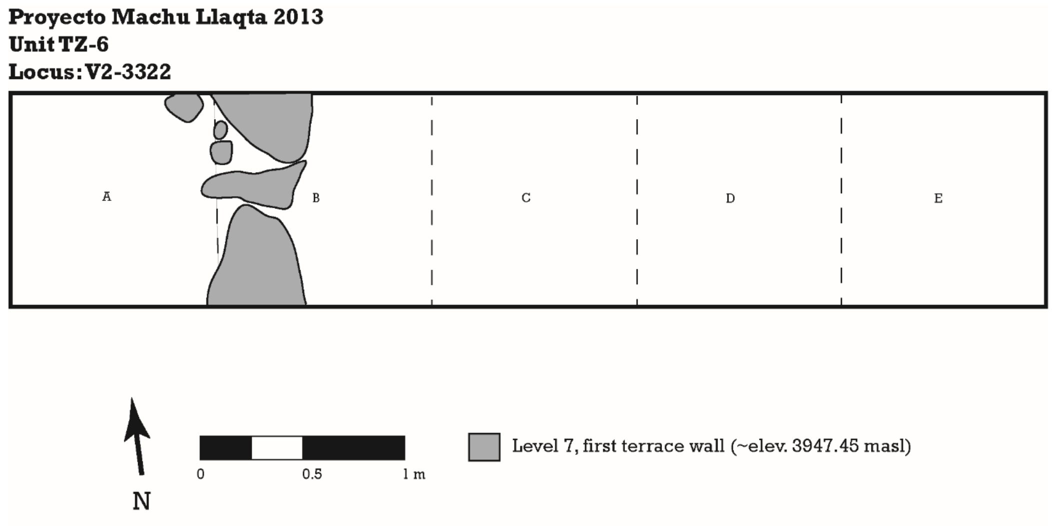

Figure 9.14: Map of the first terrace wall of TZ-6.

Event 4 (Loci V2-3305, 3307, 3308, 3309, 3310, 3311, 3312, and 3313) Agricultural Fill associated with Third/Modern Terrace Wall

Located west of and uphill of the third/modern terrace wall and east of the second modern terrace wall, this level was composed of semi-compact reddish brown (5YR4/3) silty loam. During excavations, I noted a medium density of randomly dispersed fill rocks that measured 10 to 30 cm in diameter.

Event 5 (Loci V2-3316, 3317, 3318, and 3320) Second Terrace Wall

Located below the modern surface and plow zone and west or uphill of the third/modern wall, this level was composed primarily of stacked stones that measure 20 to 50 cm in diameter. There was reddish brown (5YR4/3) silty loam between the rocks. A low density of ceramic sherds, and fragmented animal bones from this level was noted during excavations. I collected two wood charcoal samples that were securely embedded in different parts of the matrix of the riser. AMS analysis of the first sample of wood charcoal dates to A.D. 1223-1285 (p=95.4%), and the second sample is roughly contemporaneous, dating to A.D. 1226-1232 (p=1.1%), 1244-1299 (p=93.6%), or 1373-1377 (p=0.6%) (calibrated at 2σ using the program OxCal 4.2 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer et al. 2013) (Table 9.7).

Table 9.7: AMS radiocarbon dates from second terrace wall samples V2-3320/1 and V2-3317/1.

Laboratory Number	Locus #	Material	^{14}C ± δ Yrs B.P. $\delta^{13}C$-Corrected	$\delta^{13}C$ per mil	Cal. A.D. Yrs ± 2σ
D-AMS 013418	V2-3320/1	Wood charcoal	751 ±25	-36	1223-1285 (p=95.4%)
D-AMS 013417	V2-3317/1	Wood charcoal	727 ±28	-31.8	1226-1232 (p=1.1%), 1244-1299 (p=93.6%), 1373-1377 (p=0.6%)

**Radiocarbon dates were calibrated using the program OxCal 4.2 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer 2013)* .

Event 6 (Loci V2-3314, 3315, 3319, and 3321) Agricultural Fill Associated with Second Terrace Wall

Located to the west or uphill of the second terrace wall and below the plow zone, this level was composed mostly of rocks that measured 10 to 30 cm in diameter and dark brown (7.5YR3/3) silty loam between the rocks. Only a low density of ceramic sherds, animal bone fragments, and a few pieces of carbon from this level was noted during excavations. I collected Soil Core #34 from locus V2-3219 that penetrated through the bottom fill of this stratum down to bedrock and submitted it for OSL analysis. This sample dates to 5985 ± 450 B.P. (Table 9.8).

Event 7 (Loci V2-3322, and 3323) First Terrace Wall and Fill

Located to the west of the second terrace wall and below the plow zone, this level was composed primarily of wall rocks and compact dark reddish gray (5YR4/2) clay loam fill between the rocks. Only a few fragments of ceramic sherds and animal bones were noted in this level during excavations. I collected Soil Core #37 from locus V2-3322 that passed through soil between two stones in the lowest course of the wall down to bedrock and submitted it for OSL analysis. This sample dates to 5050 ± 200 B.P. (Table 9.8).

Table 9.8: Results of OSL ages for TZ-6.

Sample #	Locus #	Laboratory #	OSL age (yr B.P.)
Core 31	V2-3309	BG3986	21,875 ± 620
Core 34	V2-3319	BG3983	5985 ± 450
Core 37	V2-3322	BG3910	5050 ± 450
Core 40	V2-3325	BG3909	920 ± 70

Diagnostic Ceramics from TZ-6

Analysis of ceramics found in TZ-6 indicate that 100% date to the Late Intermediate Period or the end of the LIP and the early part of the Late Horizon (Table 9.9). The ceramic sherds in the agricultural fill were likely mixed due to tilling and planting, and could have been redeposited there well after the LIP. While no ceramics were found in the first terrace wall, sherds embedded in second and third/modern terrace wall all date to the LIP or the latter part of the LIP and/or the Late Horizon.

Table 9.9: Diagnostic ceramics recovered from TZ-6.

Event #	Event Name	*Terminus Post Quem*	# Identifiable Sherds (N=)	Pukara n=	Tiwanaku n=	Pucarani n=	Sillustani n=	Collao n=	? n=	Modern n=
1	Modern surface	Modern	6	0	0	5	0	0	0	1
2	Plow zone	LIP/LH	15	0	0	11	3	1	0	0
3 & 4*	Third/modern terrace wall and asscoiated agricultural fill	LIP/LH	22	0	0	16	4	0	2	0
5	Second terrace wall	LIP/LH	6	0	0	5	0	0	1	0
6	Agricultural fill associated with second terrace wall	LIP/LH	7	0	0	6	1	0	0	0
7	First terrace wall and fill	-	0	0	0	0	0	0	0	0

*These events were combined because one loci contained materials from both events.

Interpretation of TZ-6

TZ-6 is a deeply stratified bench terrace. Excavations revealed there were three phases of construction. First, a wall consisting of a single layer of large stones stacked next to one another was built directly on bedrock. Soil was mounded up behind this wall. Then, as soil eroded down the hillside, it appears that this short riser was no longer stable. A second retaining wall was built to halt erosion. Soil was then mounded into a flat arable platform. Over time, the second retaining wall was also compromised by soil eroding down the mounting. To halt this process, a third wall was constructed. While the modern/third wall was covered in sloping eroding soil, the flatness of the modern surface of the terrace indicates TZ-6 is fairly stable today.

During excavations a large amount of unworked stones were found in the fill of this terrace, discernible in Figure 9.13. These stones may have been intentionally placed in this deeply stratified terrace to encourage drainage of rainwater runoff down to other terraces. On the other hand, they might be the result of regular erosional processes of heavy stones naturally found on the hillside.

The four OSL dates obtained from this terrace shed light on the soil formation, geological history, and anthropogenic history of the terraces. Core #31, recovered from terrace fill, dates to the Pleistocene 21,875 ± 620 B.P. This core was collected from a stratum above Core #40 that dates to 920 ± 70 B.P. This stratigraphic superimposition was the result of the creation of the terraces where soil fill was mounded without being fully exposed to light. I believe Core #40, securely collected from below a terrace riser, reflects the date the terrace was actually constructed. Cores #34 and #37 date to approximately 6,000 B.P. These dates reflect soil formation processes rather than anthropogenic activities.

Based on the diagnostic ceramics found in the terraces walls, TZ-6 was constructed at the very earliest during the LIP. Based on the ceramics identified in the second and third/modern terrace wall, reconstruction and stabilization happened during the LIP or later. Two AMS dates on wood charcoal from securely within the terrace wall affirm construction and stabilization was carried out on the terrace complex during the latter half of the LIP.

Terrace-3

Terrace-3 is located near the east walls of the *pukara* high up on the hillside (see Figure 9.1). The terrace measures between 2.5 and 3.5m in height. The surface of this terrace was covered in modern agricultural furrows, and dried remnants of crops plants. I spoke with the landowner, who confirmed that he grew potatoes on TZ-3 in 2013. We noticed fragments of LIP ceramics strewn across the modern surface of the terrace. Notably, there were three concentrations of carbon on the modern surface that local informants attributed to cooking pits, locally referred to as *huatyas*, used during last year's harvest. However, we decided not to dig in these areas to avoid contamination by recent cooking activities.

The excavation unit on TZ-3 was located on the eastern edge of the terrace, intersecting the central portion of the retaining wall. We excavated a 2 x 4 m unit trench that was oriented perpendicular to and intersecting the terrace riser wall of TZ-3. Within the excavation unit, the modern terrace wall was composed of stacked stones that measured between 20 and 80 cm in diameter. The modern terrace wall measured 3.05 mm in height to the top of the stacked stones (Figure 9.15 and Figure 9.16).

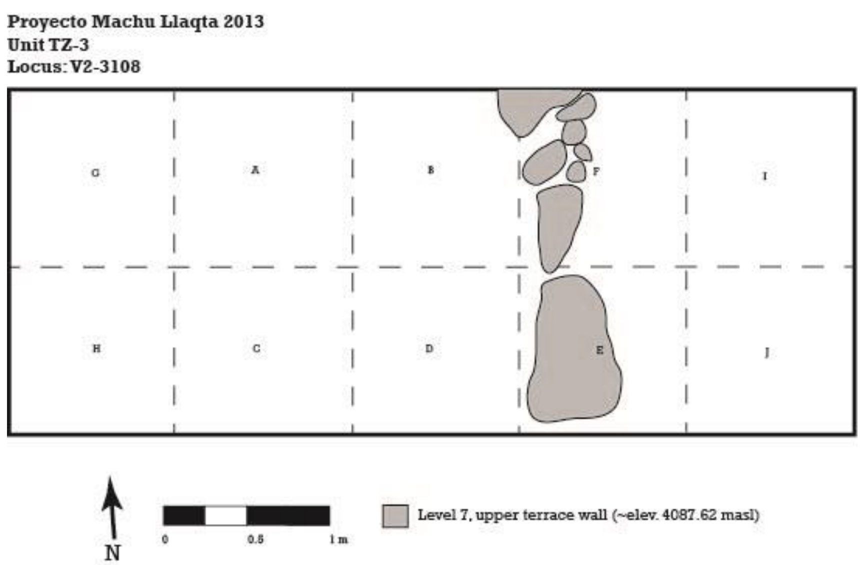

Figure 9.15: Map of the surface of the upper part of the modern wall of TZ-3.

Figure 9.16 : Photo of TZ-3 retaining wall.

During excavations nine distinct events were identified including the modern surface (Event 1), plow zone (Event 2), two types of agricultural fill (Events 3 and 4), a sub-adult burial (Event 5), a level containing am arrangement of stones of unknown purpose or use (Event 6), two distinct levels of the terrace wall (Events 7 and 8), and a reddish-color soil that comprised the terrace riser foundation (Event 9) (Figure 9.17). The full inventory of artifacts recovered from TZ-6 is presented in Appendix I.

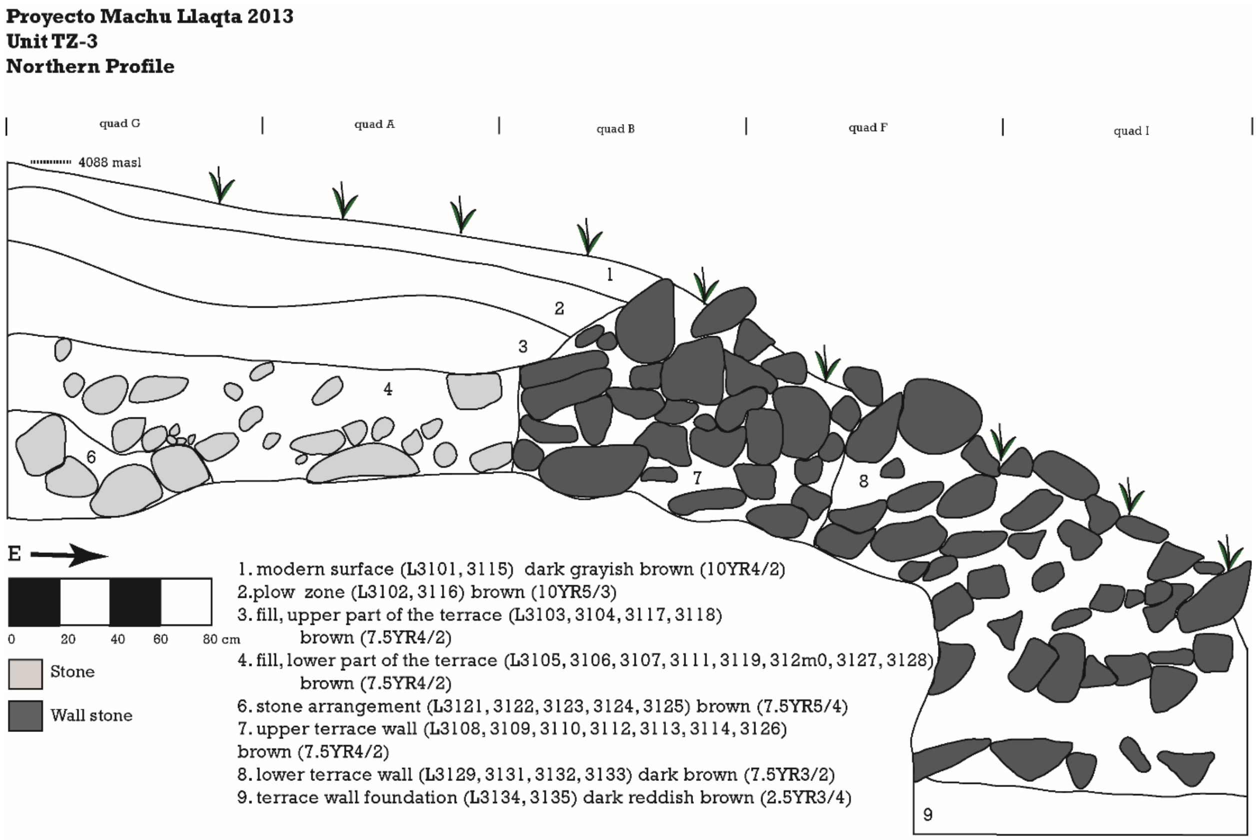

Figure 9.17: Northern profile of TZ-3. Note Event 5, a sub-adult burial found near the southern profile, is not visible in this profile.

Event 1 (Loci V2-3101, and 3115) Modern Surface

The modern surface level was a loose dark grayish brown (10YR4/2) silty loam soil with the remains of dried crop plants atop visible agricultural furrows. The roots of these dried crop plants penetrated through this level. There was a moderate density of ceramic sherds, and a low density of lithic artifacts and fragmented animal bones from the surface level.

Event 2 (Loci V2-3102, and 3116) Plow Zone

Located west of the terrace wall, the plow zone was composed of semi-compact brown (10YR5/3) silty loam and small pebbles that measured 1 to 3 cm in diameter. In this level there was a high density of ceramic sherds, and a moderate density of lithic artifacts.

Event 3 (Loci V2-3103, 3104, 3117, and 3118) Fill of the Upper of the Terrace

Located below the plow zone, this level was semi-compact brown (7.5YR4/2) silty loam with small inclusions measuring less than 5 cm in diameter. During excavations I identified three concentrations of darker soil that I refer to as soil stains in this level; however, no artifacts were recovered from these areas. The first soil stain was identified between quadrants A, B, C, and D, measured 20 x 13 cm in diameter, and penetrated 2 cm deep into this level. The second soil stain was brown (7.5YR4/3), it was found between quadrants A and C, measured 9 x 7 cm in diameter, and penetrated 2 cm deep into this level. The third soil stain was located between quadrants C and D, measured 25 x 12 cm in diameter, and extended 2 cm deep into this level. Around these soil stains I found a high density of ceramic sherds and lithic artifacts, but based on their orientation, none looked to be in a primary context.

Event 4 (Loci V2-3105, 3106, 3107, 3111, 3119, 3120, 3127, and 3128) Fill of the Lower Terrace

Located directly below the fill of the upper part of the terrace event, this level consisted of semi-compact brown (7.5YR4/2) silty loam with some clay, and a low density of rocks that measured between 10 and 80 cm in diameter. I noted a high density of ceramic fragments, animal bones, and lithic artifacts dispersed throughout this level. Additionally, we found a concentration of charcoal in the southwest corner of quadrant C (Loci V2-3107 and 3108) that was the remains of an earthen oven on the terrace surface. Since the terraces at Ayawiri are still actively cultivated, and the proximity of the carbon to the surface, I suspect this *huatya* is modern.

Event 5 (Locus V2-3130) Burial

Near the southern profile of the excavation unit, below the fill of the lower part of the terrace I found a small circle of rocks that contained the remains of a sub-adult human (Figure 9.18). The circle measured approximately 20 cm in diameter. The soil was semi-compact very dark gray (7.5YR3/1) silty loam. I found a fragmented base of a ceramic bowl that stylistically dates to the Late Intermediate Period overturned on top of the long bones. I also found several other ceramic fragments mixed within the matrix of the burial. The placement of the fragmented ceramic bowl indicates that it was intentionally placed over the burial in an inverted position. I only found a few long bones, teeth and part of the mandible of the sub-adult. The position of the bowl and the bones is quite similar to the burial found in Unit 44B in the residential sector of the site. Arkush (personal communication, 2016) notes that there are a couple of other cases of overturned bowls in offerings at Ayawiri, and these data may mean that this was appropriate for signaling ending or completion, or at least "retiring" the bowl from service. Additionally, the pattern in tombs at Ayawiri is secondary burial and selective retention and placement of crania and long bones, so we would not expect to see an intact articulated skeleton. Nonetheless, the fragmentation of the bowl and the other ceramics found in the matrix around the burial indicates that the burial was disturbed, possibly by agricultural activity or erosional processes. A sample of wood charcoal was collected from the fill next to this burial. AMS analysis indicates this sample dates to A.D. 1678-1765 (p=34.8%), A.D. 1800-1892 (p=45.3%), or A.D. 1908-1940 (p=15.4%) (calibrated at 2σ using the program OxCal 4.2 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer et al. 2013) (Table 9.10). This affirms my suspicions during excavations that the burial was indeed disturbed during the last few centuries.

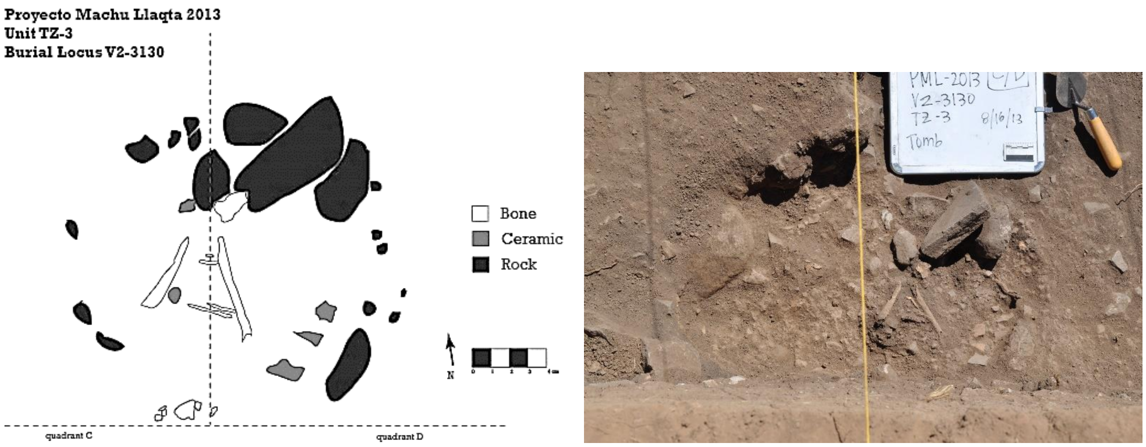

Figure 9.18: Map (left) and photo (right) of a sub-adult burial found in TZ-3 locus V2-3130.

Table 9.10: AMS radiocarbon date from burial found in TZ-3 V2-3130.

Laboratory Number	**Locus #**	**Material**	**^{14}C ± δ Yrs B.P. δ^{13}C-Corrected**	**δ^{13}C per mil**	**Cal. A.D. Yrs ± 2σ**
D-AMS 013416	V2-3130/5	Wood charcoal	131 ±21	-24.7	1678-1765 (*p*=34.8%), 1800-1892 (*p*=45.3%), 1908-1940 (*p*=15.4%)

**Radiocarbon dates were calibrated using the program OxCal 4.2 (Bronk Ramsey 2009) and the IntCal13 calibration curve (Reimer 2013) .*

Event 6 (Loci V2-3121, 3122, 3123, 3124, and 3125) Stone Arrangements

Located below the lower terrace fill, the stone arrangements are features composed of two distinct concentrations of slab stones in quadrants G and H. The soil inside and around these features is composed of loose brown (7.5YR5/4) silty loam and a couple of the rocks were burned. Additionally, I found a concentration of carbon, ceramic fragments, and charred camelid bone inside and adjacent to this rock feature. In the northwest corner of quadrant H, I found another circle of rocks. The rocks measured 20 to 40 cm in diameter and were arranged in a circle that extended into the northwest unit wall. In this feature, I noted a high density of ceramic fragments and camelid bones and a low density of lithics. These two rock features appear to be roasting pits. Below these features there was bedrock.

Event 7 (Loci V2-3108, 3109, 3110, 3112, 3113, 3114, and 3126) Upper Terrace Wall

Located below the modern surface stratum and east of the terrace fill event, the upper terrace wall was composed of primarily large stacked stones that measured between 20 and 70 cm in diameter. There was brown (7.5YR4/2) silty loam compacted between the wall rocks. During excavations a moderate concentration of ceramic fragments and a low density of lithics and animal bones was noted in the wall matrix.

Event 8 (Loci 3129, 3131, 3132, 3133) Lower Terrace Wall

Located underneath and about 50 cm to the east or downslope of the upper terrace wall, the lower terrace wall is composed of large stacked stones that measure 20 to 60 cm in diameter, small fill rocks that measured 5 to 20 cm in diameter, and dark brown (7.5YR3/2) silty loam packed between these wall rocks (Figure 9.19). A high density of ceramic sherds, a moderate density of lithics, and a low density of animal bones was embedded in the wall. I collected Soil Box #1 from locus V2-3135 from the western profile of the transition between Event 8 and 9 below the lower terrace wall and submitted it for OSL analysis. This sample dates to 39,120 ± 2970 B.P. (Table 9.11).

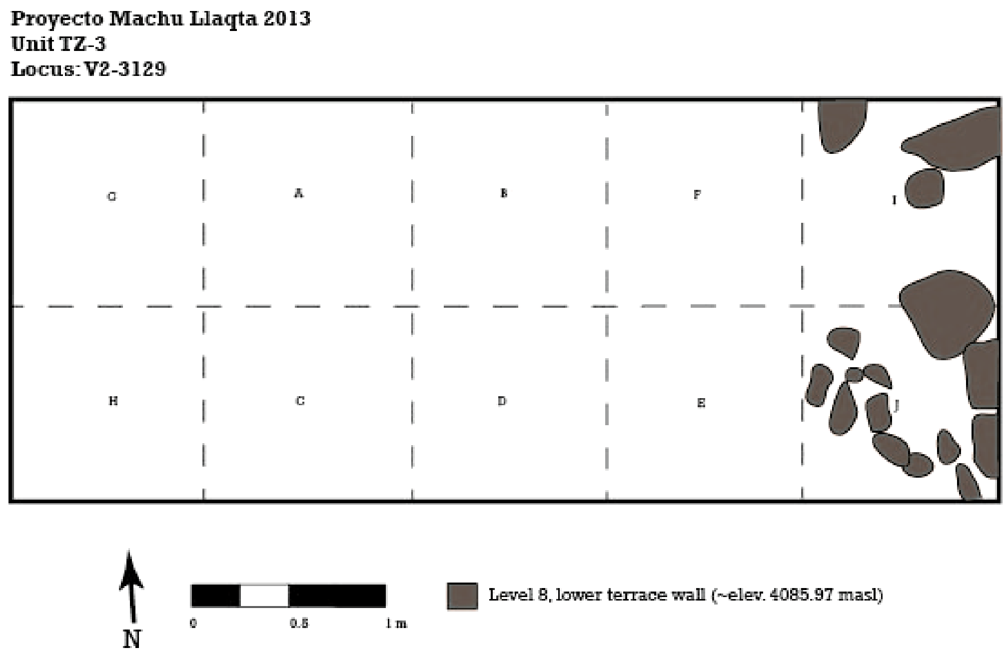

Figure 9.19: Map of the lower wall of TZ-3.

Event 9 (Loci V2-3134, and 3135) Terrace Wall Foundation

Located below the lowest course of stacked stones of the riser, this level composed the foundation of the terrace riser wall. This level was dark reddish brown (2.5YR3/4) compact clay loam. There was a moderate density of stone inclusions that measured 0.5 to10 cm in diameter throughout this level. There was also a low density of ceramic sherds, lithic artifacts, and animal bones in this level. I collected Soil Core #11 from locus V2-3133 through the same soil color change between Event 8 and 9 below the lower terrace wall and submitted it for OSL analysis. This sample dates to 9565 ± 780 B.P. (Table 9.1).

Table 9.11: Results of OSL ages for TZ-3.

Sample #	Locus #	Laboratory #	OSL age (yr)
Box 1	V2-3135	BG3987	39,120 ± 2970
Core 11	V2-3133	BG3981	9565 ± 780

Diagnostic Ceramics from TZ-3

Analysis of ceramics found in TZ-3 indicates that of the 367 diagnostic ceramic sherds found, 86% date to the LIP or the LIP/Late Horizon. Only 3% date to the Formative and 5% date to the Middle Horizon. Of the 57 sherds embedded in the terrace wall, only one sherd predates the LIP. Based on the abundance of LIP sherds and the *terminus post quem date*, the terrace was constructed at the very earliest during the LIP (

Table 9.12). Most of the ceramic sherds that predate the LIP were found mixed into fill. Although a diagnostically Middle Horizon Tiwanaku sherd was found in relation to the disturbed sub-adult buried in TZ-3, the overturned painted bowl that covered the bones is characteristic of the LIP. This indicates the burial dated to the LIP or later.

Table 9.12: Summary table of diagnostic ceramics recovered from TZ-3.

Event #	Event Name	*Terminus Post Quem*	# Identifiable Sherds (n=)	Pukara n=	Tiwanaku n=	Pucarani n=	Sillustani n=	Collao n=	? N=
1	Modern Surface	LIP/LH	8	0	1	4	1	1	1
2	Plow Zone	LIP/LH	15	0	2	5	3	2	3
3	Fill of the upper part of the upper part of the terrace	LIP/LH	40	4	0	18	10	5	3
4	Fill of the lower part of the terrace	LIP/LH	140	2	11	79	25	12	11
5	Burial	LIP/LH	8	0	1	5	2	0	0
6	Stone arrangements	LIP/LH	60	3	2	38	13	6	1
7	Upper terrace wall	LIP/LH	32	0	0	21	7	1	3
8	Lower terrace wall	LIP/LH	30	0	1	20	3	2	2
9	Terrace wall foundation	LIP	3	0	0	3	0	0	0

Interpretation of TZ-3

TZ-3 is a deeply stratified bench terrace. Excavations uncovered ceramic sherds and other debris that likely eroded downhill from the residential area at Ayawiri. However, this terrace also contained the material remains of agricultural activities and everyday lifeways that took place in this location. Analysis of the stratigraphy of this terrace revealed a retaining wall was initially constructed, and soil mounded into a platform behind this wall. Thereafter, a sub-adult was buried in the fill of this terrace. This burial appeared to be disturbed and overturned, perhaps by agricultural tilling and planting, or by erosion a couple centuries later.

The concentrations of carbon, stone arrangements, and camelid bones found in TZ-3 look to be *in situ* evidence of a roasting pit and larger-scale activities that took place on the terrace. Perhaps these material remains are the evidence of midday meals farmers prepared for themselves in their fields. Or maybe TZ-3 was used as an area for larger scale preparation of food that was then carried up to be consumed within the fortified residential area at Ayawiri.

Eventually, erosional processes compromised the integrity of the retaining wall of TZ-3. To halt this process, the wall was reinforced and repurposed. Based on the stratigraphy of the terrace, stones were stacked vertically atop the earlier part of the wall slightly uphill. Then agricultural fill was mounded behind this part of the riser increasing the depth of the terrace.

OSL ages from this terrace dating to the Pleistocene and early Holocene are too early to measure anthropogenic activity. Rather, they date soil formation and the geological history in the region.

While some of the artifacts found in TZ-3 are evidence of activities that took place there, many of the ceramic sherds probably tumbled and wash down the hillside from the hilltop residential area. A few ceramic sherds found in the fill of the terrace date to the Late Formative and the Middle Horizon. Beside these sherds I found no evidence of a Late Formative or Middle Horizon occupation on the terraces. However, there was a Late Formative period occupation atop the mesa and a few Middle Horizon ceramic sherds were also found there. Since there is no clear evidence of the context of these earlier occupations on the terraces, it is most likely that LIP and Middle Horizon sherds were either intentionally discarded on the terraces after their use-life expired from atop the mesa or they tumbled down the hillside due to natural erosional processes. Most sherds found in the fill date to the LIP. Ceramics embedded in both the lower and upper part of the wall, particularly the lowest stratum, indicate this terrace was constructed at the very earliest during the LIP. Stabilization of the upper part of the terrace retaining wall also dates to the LIP or later based on diagnostic ceramics found embedded in the wall. Nonetheless, OSL dates and an AMS date affirm stratigraphic interpretations that the sub-adult buried in the upper part of the terrace was disturbed at some point in the last few centuries. This disturbance was likely the product of normal soil turning and tilling associated with the annual agricultural cycle.

Synthesizing Evidence from the Terrace Excavations

The goals of excavating the terraces adjacent to Ayawiri were primarily to identify when the fields were constructed and when agriculture intensified on the hillsides near the fortress. While ceramic data shed light on the earliest time periods the terraces could have been constructed, findings from excavations provide information about much more. I pinpointed how erosional processes affected the stratigraphy of terraces. I identified how the fields were constructed, stabilized, and maintained over time. Finally, artifacts found embedded in the matrix of the terraces shed light on quotidian activities and events that residents carried out in these locations.

Farmers who built and farmed the terraces were constantly trying to grapple with and counteract erosional process. Evidence from excavations indicate the steep slope of the hillside, combined with gravity and seasonal rainfall, caused soil, stones, and other artifacts to tumble downslope. Apparent in the profiles of TZ-4, TZ-5, and TZ-6 the stones and soil matrix of the modern retaining walls are slumping downslope. The retaining walls of TZ-3 and TZ-4 were both reinforced at least once by adding another level of stacked stones slightly uphill the initial wall. However, these efforts to stabilize the terraces were not always sufficient. Evidence from TZ-5 and TZ-6 indicates that sometimes walls could not be stabilized and entire new walls were constructed down slope. I found two of these earlier unstable walls embedded inside TZ-6, and one buried wall in TZ-5. Local farmers that still cultivate these terraces informed me that building another wall downslope of a compromised retaining wall is how they stabilize and halt erosional processes. The labor that was required to build the terraces was substantial. The stabilization events that were only evident through excavations indicate that maintaining the terrace complex was even greater than initial construction. Buried inside some terraces are one or two more riser walls. Therefore, it is nearly impossible to estimate the labor hours that went into building the Ayawiri terrace complex. Nonetheless, stabilization efforts would have taken place over generations and centuries.

Material remains were also susceptible to the same erosional processes as the terrace risers. The impacts of erosional processes are documented in the abundance of ceramic sherds found throughout the matrix of all four terraces. Furthermore, sherds dating to the Late Formative, Middle Horizon, LIP, and later are all mixed together in the agricultural fill of TZ-3 and TZ-4. This mixing occurred as sherds washed down the hillside and were incorporated into the matrix of each terrace during construction. The soil containing these sherds was turned over during tilling and planting, further mixing the deposition of artifacts.

Only a small percentage of the ceramics found in the terraces predate the LIP, and these are mixed in strata containing LIP ceramics. Additionally, Middle Horizon and Late Formative ceramics were only found in the agricultural fill of the terraces indicating they ended up there as a result of secondary deposition, rather than during construction of the risers in the lowest strata. Ceramic evidence also indicates all four excavated terraces were constructed during the LIP or later. The *terminus post quem* dates of sherds found in the walls of all four terraces correlates to the LIP or the cusp of the LIP and the Late Horizon Periods. These data indicate ancient farmers constructed the terraces to grow food to sustain the population that lived within the fortified habitation area of the site.

AMS dates confirm the terraces were built during the LIP and continuously maintained into the modern era. OSL dates on the other hand, elucidate the geological history, dates of terrace construction, and maintenance. These dating methods provide complementary data to ceramic *terminus post quem* dates from secure stratigraphic events.

The traditional stone hoe found in TZ-4 is evidence of past agricultural activities carried out there. In addition to being used for crop production, the density and type of artifacts indicate the terraces were used for other purposes. Ceramic fragments, animal bones, and lithics reveal that cooking and domestic activity took place on the terraces. Particularly on TZ-3, the terraces were used as a space for roasting meat based on the identification of the circles of stone containing layers of carbon and burnt camelid bone. The sub-adult buried in TZ-3 indicates that the terraces also functioned as a place to occasionally inter the dead.

Ayawiri Terraces as a Tactic of Warfare

With the understanding that the terraces at Ayawiri were constructed during the LIP, a consideration can be made of how intensification and this built landscape impacted life for residents living at the fort. Analysis of the landscape can also be used to identify how past people used the land (both naturally and constructed) to facilitate warfare strategies for residents living at Ayawiri. Here, I draw on previous research on warfare in the region and my own experiences traversing this landscape to shed light on how the terraces also served to provide protection to the fortified community.

Excavation data indicate the terraces also served a defensive function. I found several sling stones buried in the terraces and the terrace walls. I propose these sling stones could have been slung there from the fringes of fortified residential area atop the mesa, using force and gravity to ward off aggressors. Alternatively, farmers could have kept stores of sling stone in their fields to have them at the ready in case an enemy suddenly attacked. Hurling sling stones down the hillside would have protected residents and quite literally, the fruits of their labor. While personal security and safety would have been a primary concern for Ayawiri residents, being able to defend crops growing on the terraces would have ensured sustenance and long-term survival.

Previously, Arkush (2011) used viewshed analysis in a GIS to identify that there are networks of inter-visibility between hillforts in the Andes. If LIP people could see neighboring forts, then the terrace complexes would have been even more apparent. Generally, the terraces surrounding these settlements are more expansive than the hilltop habitation areas. The high visibility of terraces to an encroaching enemy and their representation of the labor force of the people who resided there indicate that the modified landscape served as a signal to neighboring populations and, perhaps, it dissuaded aggressive enemies.

Terraces were easily discernible from great distances due to the geology and ecology of the *altiplano.* This flat and treeless landscape allows people to see an encroaching enemy long before their arrival at the site (Figure 9.20). This would have given Ayawiri residents sufficient time, if they saw an enemy coming, to retreat to defensive positions. The visibility of the modified hillside at Ayawiri conspicuously signals economic security. Particularly within the context of warfare and political unrest, terraces were an important and intimidating symbol of the physical force of the people residing at the site and the community to mobilize farming labor, and even personnel for battle. LIP people who chose to live nestled in the fortress atop the terraces were not trying to hide; rather they lived in perhaps the most conspicuous location on the landscape. The terraces overtly signaled precisely where large groups of people resided.

Figure 9.20: Photo of the surrounding landscape taken from the fortified residential area.

Terraces may have simultaneously worked against the security of Ayawiri residents. As conflict escalated between warring factions during the latter half of the LIP (Arkush and Tung 2013), an encroaching enemy could identify exactly where to attack. The modified landscape revealed the location of residents, compromising their security in the face of a concerted force. Furthermore, to an enemy, the terraces would have been enticing to raid or even seize the already improved agricultural land if they were fighting over resources.

Security logistics are also apparent in the terrace layout. At Ayawiri, in order to get from the base of the terrace complex to the edge of the fortified residential sector you must walk up for at least 30 minutes across the modified hillside, following meandering trails that may not be apparent without prior knowledge or experience. Because of the pitch, it is almost impossible to climb straight up the terraces, as you would a hillside. Instead, you must follow a series of switchbacks that exposed hikers from above. The inaccessibility created by the terraces increases security for fortress residents. The time required to travel up the hillside and the exposure afforded fortress residents sufficient time to retreat to the *pukara* to defend themselves.

Notably, the western slope below the fortress is not cultivated today, yet it was terraced anyway. According to farmers from Chila living below the eastern slopes of the site, the western slopes do not receive enough sun to regularly melt nighttime *altiplano* frost, which they believe makes cultivating this particular area nearly impossible. Today the western terraces are owned by pastoralists belonging to the Teracumilla Ranch, and they seem to have no interest in cultivating this landscape.

Nonetheless, it is possible the western terraces were farmed in antiquity. The western terraces are certainly colder than the eastern terraces and could have been the first to be abandoned during the colonial era. If these fields were less desirable than the eastern slopes, then why was the western hillside area terraced? It is possible that this area was terraced in order to increase production for the large population living at the site. Additionally, risers may have been constructed to impede access from the western approach, further increasing security for Ayawiri residents. Modifying the western slopes would have increased the visibility of the site from the western approach, again, serving as a visual deterrent to encroaching enemies. Regardless of whether these western fields were productive, Ayawiri residents were well protected living atop their terraced defenses provided by the modified landscape. Further archaeological research on the western slopes is needed to clarify when the western terraces constructed, and agronomic research will be necessary to determine if it is even possible to grow crops there.

Conclusion

Findings from excavations of the terraces at Ayawiri indicate they were constructed during the LIP, a period of warfare and decentralized political authority. These findings stand in contrast to traditional assumptions that the construction of large-scale field systems require a centralize political authority to mobilize and direct labor and manage production. Furthermore, these data expand our knowledge of the various ways in which terraces were used during this time. Terraces were an important part of the LIP landscape, first and foremost for their value as agriculturally productive lands; Ayawiri terraces were also used for quotidian activity. They were considered as a place important enough to inter a sub-adult. Finally, the terraces were logistically beneficial during war times. Residents could defend themselves and their crops by hurling sling stones down the terrace complex.

Chapter 10. Discussion and Concluding Remarks

In Chapter Ten I present a discussion of the findings of my dissertation research. First, I return to the questions that provided the framework for my research and discuss how my findings answered these questions. Then, an assessment is made of the effectiveness of dating methods employed in terrace excavations. Suggestions are provided for future research that arose from results of this dissertation. I conclude with a discussion regarding how this research contributes to a broader understanding of both climate history and culture history in the south-central Andes.

Results from the analysis of macrobotanical remains collected from domestic contexts at Ayawiri pinpoint the crops that farmers grew, the plants that residents used, and the locations on the landscape that herders grazed their camelids during the Late Intermediate Period. Additionally, I analyzed an array of qualitative and quantitative features of archaeological *Chenopodium* spp. seeds. This study is the first paleoethnobotanical study of LIP plant use and chenopod morphology in the Lake Titicaca Basin. Since very little research has been conducted on the LIP in the *altiplano,* these data fill in a gap in our understanding of prehistoric plant use in the Andes. Also my excavations within the terrace complex flanking the hillside below the fort shed light on when the terraces were constructed and how the landscape was used and modified in prehistoric times. This research is novel because I applied three dating techniques in tandem, including optically stimulated luminescence dating, to identify when a field complex was built and cultivated. With these data, I return to the questions that provided the framework for my dissertation research.

Research Questions

1) What crops were grown during the LIP?

The most significant crops in terms of quantity recovered in the Ayawiri assemblage are chenopods. Based on multivariate analysis, I have determined that residents grew and consumed both quinoa and kañawa. Chenopods were found in all but three flotation samples from the site, often in large quantities. This indicates chenopod cultivars were essential to the diet of the entire community living at Ayawiri. Chenopod grains provided residents a stable food source, rich in protein and amino acids.

Chenopods in the diet were complemented by potatoes and possibly other tubers. Although parenchyma fragments were less common than chenopods in analyzed samples, this does not indicate that tubers were any less important in the Ayawiri diet. The high water content of tubers means they are less likely to preserve than seed crops. Future analysis of starch grains that I collected from grinding stones might shed light on the diversity of tubers crops grown during the LIP, although currently our ability to identify diversity in tuber taxa from starch grains is limited (see Rumold 2011). Charred potato specimens like those that I found in caches are a rare occurrence in the archaeological record. They were likely stored freeze dried potatoes, or *chuño*, that burned *in situ* as an offering. The traditional highland practice of freeze-drying potatoes would have made it easier for specimens to carbonize in a fire.

Chenopods and tubers provided Ayawiri residents with a hearty and stable food source. These crops can be locally grown, are more or less tolerant to the low precipitation typical in the region and can be stored for multiple years. Two caches containing large quantities of chenopods and potatoes were found found below structure floors. The discovery of these caches below a house floor and their burned condition indicates they were possibly offerings. Based on the stratigraphy encountered during excavations it is unclear whether the caches predate the occupation of the structures and were put there before the houses were built, or whether residents dug out pits in their structures and placed the offerings there during the occupation of the houses. Regardless, the inclusion of these local foodstuffs in sub-floor house offerings indicate that quiona and potatoes held ritual importance during the LIP.

This diet was surely supplemented by leafy greens. Chenopod plants are quelites that have spicy edible leaves. *Plantago* sp. was found and remains of this plant could be evidence that its tender greens were eaten raw or added to stews.

I also found Cactaceae and *Opuntia* sp. seeds in a few samples. Cactus fruits would have provided Ayawiri residents a sweet seasonal treat that broke up the bland flavors of chenopods and tubers. If humans consumed cactus, they did so rarely, or residents did not discard the seeds in ways that would have resulted in them being carbonized and preserved like people did at other sites in the region during earlier time periods.

2) *Where on the landscape did Ayawiri residents graze their herds?*

Small fragments of charred dung and small quantities of herbaceous seeds indicate that camelid dung was used to fuel fires at Ayawiri. As a result, analysis of macrobotanical remains also sheds light on camelid grazing behaviors. Based on the large quantities of chenopods, Ayawiri residents both consumed these crops and grazed their herds in chenopod fields. Lacustrine and riverine plant remains were nearly absent in flotation samples, whereas crop companion weeds and even small herbaceous seeds were ubiquitous. These data indicate that herds were rarely grazed in wetland areas. Instead, grazing most commonly occurred in fallowed fields.

3) *When was the terrace complex adjacent to Ayawiri constructed?*

Before excavations, I hypothesized that the terraces surrounding Ayawiri could have been built during the Late Formative, Middle Horizon, LIP, or the Late Horizon. I found the terraces were built during the Late Intermediate Period. These field systems are rain fed, and there is only one small irrigation network throughout the entire field complex. Ceramic types, AMS dating, and OSL dating indicate the terraces have been used in an ongoing basis since the LIP. Additionally, terrace riser walls buried inside a few terraces indicate that farmers have long been stabilizing and reconstructing dilapidated terrace walls to ensure their continued viability.

4) *How did warfare and drought impact agriculture and lifeways for Ayawiri residents?*

My findings indicate that Ayawiri residents gave stronger consideration to the threat of warfare than the LIP drought in the design of their agricultural strategies. Compared to earlier time periods in the region, Ayawiri residents depended on only a limited array of locally grown crops. I found no evidence of foreign produced plants at Ayawiri. Maize, coca, and other plants grown in lower elevations and imported to the Titicaca Basin were integral to ritual and domestic life in earlier time periods in the region. Trade relations had long ensured that if one region had a lean agricultural year, residents could rely on friends and relatives in other regions to supplement their food stores where crop yields were sufficient. This was not the case at Ayawiri. The absence of foreign produce goods indicates that trade networks broke down probably over the fear of enemy attack. As a result, Ayawiri residents relied on locally produced goods. While it is impossible to determine whether Ayawiri was a wholly self-reliant community, my findings indicate that any food not produced by fortress residents was produced locally in nearby ecozones.

I found no evidence that Ayawiri residents were intensively cultivating or exploiting wetland environments. In earlier time periods totora (Cyperaceae), a managed wetland plant that is locally used as food and for construction material, is common in archaeological assemblages. In contrast, I found very few totora seeds. This indicates Ayawiri residents chose not to farm or exploit wetland ecotopes that would have buffered against crop loss during dry years. Additionally, based on the absence of lacustrine or riverine plants, residents rarely took their herds to graze in wetland ecotopes. Extensively grazing herds on wild plant stands rather than foddering them would have ensured sufficient crop stores for humans in case a drought caused crop failure. Instead, Ayawiri herds were grazed intensively in fallowed fields and on crops. These data indicate that residents were more concerned about keeping their herds near the safety and protection of the fort than about the risks of overgrazing and crop failure due to drought.

The LIP construction of the terraces on the eastern slopes of Ayawiri demonstrates that residents were intensifying crop production near their homes. A field scattering strategy in which an array of crops was grown in different microenvironments would have also buffered against crop loss due to inter-annual climate variation in the Titicaca Basin; however, Ayawiri residents chose to build and cultivate their fields near their homes. By growing crops and grazing herds near their homes, Ayawiri residents ensured that humans, plants, and animals alike were not exposed to the threat of raids or enemy attack.

Further research is needed to clarify when the terraces on the western slopes of Ayawiri were constructed and how they were used by farmers of the past. Due to the lack of sun necessary to warm the soil and melt nighttime frosts, farmers from Chila believe the western slopes are unproductive and less desirable than the eastern slopes. Yet the area was terraced in prehistory anyway. Foremost, terracing the western slopes would have increased arable land. Furthermore, terracing the western slopes adjacent to the hillfort during the LIP would have increased defensible fields near the fort, thereby increasing the carrying capacity of environment near the site. Additionally, terracing in this location may have increased nearby grazing grounds for camelids, allowing herds to stay closer to the safety of the fort. Logistically, terracing may have increased security of the hilltop fort because the modified hillside would have made it more difficult to climb that side of the hill. Future research on the western terrace complex has the potential to elucidate when the hillside was modified, what quotidian activities were carried out there, and perhaps, why it was terraced in the first place. Future agronomic research is necessary to shed light on the productive potential of the western slopes in comparison to the eastern slopes.

Based on my findings that the eastern terraces were built during the LIP, I believe that Ayawiri residents farming the terraces were able to protect both their food stores and their herds from enemy raids. Not only did terraces bolster food security, they also increased the protection of residents in the fort. The modified hillside was more difficult to climb up than an unaltered hill. Lack of knowledge of the switchbacks and trails would have slowed down approaching aggressors. Furthermore, sling stones found in the terraces indicate that Ayawiri residents were prepared to defend their fort and fields. While terraces are primarily an agricultural strategy, for Ayawiri residents, they also functioned as a strategic form of defense in a time of warfare.

Discussion of Terrace Dating Methods

The three methods used to date the agricultural terraces are central to understanding how the landscape was constructed and used at Ayawiri. Here, I provide a brief assessment of the utility of each method.

I found *terminus post quem* dates from ceramic styles particularly valuable to determining the antiquity of deeply stratified terraces where modern tilling would not penetrate to the lowest levels. While ceramics found on the surface and in fill are susceptible to post-depositional mixing, ceramics at the base of tall terraces likely date to the time period the terraces were constructed.

Although I thought I had identified the paleo-A horizon of the natural hillside buried below many terraces, OSL dating instead returned a wide range of dates beginning in the Pleistocene. As a result, my application of OSL sheds light on both the anthropogenic and the geological history of the terraces. Optically stimulated luminescence dating may still be useful to date agricultural fields in combination with other dating methods and a rigorous geoarchaeological methodology for assessing terrace stratigraphy. I view my application of OSL as a pilot study that, with refinement, can be applied in the future to study both the geological and anthropogenic history of agricultural fields.

Accelerator mass spectrometry dating of ^{14}C decay was quite valuable in this study. However, only carbon with a clear provenience and secure stratigraphic context was submitted for dating. Carbon within modern or ancient plow zones was eschewed. Unfortunately, due to the small quantity of carbon found in clear and undisturbed contexts during excavations, this method has its limitations. Because each method used to date terraces has weaknesses, I think a multi-proxy approach to dating agricultural fields should be employed whenever possible.

Discussion of the Broader Implications

This research contributes to a broader understanding of farming practices, sociopolitics, and lifeways during the LIP in the Lake Titicaca Basin. While a few studies have focused on documenting early morphological changes in chenopod seeds during the Formative Period, this study examines an assemblage of fully domesticated pre-Colonial chenopods. I found two distinct morphological types that appear to be ancestral to modern quinoa and kañawa. Even though these seeds date to three millennia after initial domestication, they are quite small. Nonetheless, they exhibit similar morphological features to modern varieties including testa texture, margin configuration, beak prominence, and ratios comparing testa thickness to seed diameter. These findings lead to me conclude that quinoa grown and sold today is markedly larger and more homogenous in morphology than that grown in pre-Colonial times. Further research is needed on chenopod morphology during the Middle Horizon and LIP to document the diversity of pre-Colonial chenopods over time and region, and during the Late Horizon and Colonial Period to identify how seed morphology was impacted by the political subjugation of the region.

Compared to the Middle Horizon and Formative Periods, crop diversity and the number of plant taxa used sharply decreased during the LIP at Ayawiri. Archaeologists studying warfare in different geographic locations have documented a similar trend (Kuckelman 2016; Kurin

2016; Milner 1999, 2007; VanDerwarker and Wilson 2016). Several of these researches have also documented a decrease in overall human health corresponding to increasing violence (Kuckelman 2016; Kurin 2016; Tung et al. 2016) and declining nutrition (Kuckelman 2016; Kurin 2016). A decrease in the diversity of dietary plants should not necessarily correlate with a decline in general human health. Supplemented by camelid meat, a diet of potatoes and quinoa is very nutritious, even if rather bland. This means that Ayawiri residents were potentially quite healthy. Importantly, quinoa is one of the only crops in the world that provides all essential amino acids and it is exceptionally high in protein for a grain (Repo-Carrasco et al. 2003; Vega-Gálvez et al. 2010). Potatoes contain high amounts of carbohydrates required for day-to-day energy expenditure and important minerals such as iron, Vitamin B, and Vitamin C (Kolasa 1993:376-378). Based on this nutritional profile, there is no expectation that health would necessarily decrease. Bioarchaeological findings from skeletal remains found at Ayawiri will hopefully shed light on this issue.

The foodways I identified through studying the contexts of plant remains from Ayawiri point to a transformation in sociopolitical interactions from the Middle Horizon to the Late Intermediate Period. The location of house structures in compounds indicate that social structures and perhaps even farm labor were organized by extended family kin groups. Furthermore, communal eating of locally produced crops was carried out within this familial context. While patio spaces in compounds would have facilitated the congregation of larger groups of people for meals or feasts, I found no evidence in the macrobotanical data that any cooking or consumption took place in these locations. Patios were kept quite clean of debris. Rather, cooking was carried out in the confines of kitchen structures and meals were eaten in house structures. The number of people attending communal meals was limited to the dozen or so persons that could comfortably fit inside these non-kitchen houses. Additionally, the small number of participants in meals that consisted of only locally produced crops stand in contrast to the elaborate and ostentatious public feasting on local and exotic foods documented during both the Formative Period and the Middle Horizon Period in the Lake Titicaca Basin.

Prestige goods, collective space, or markers of wealth that are common and discernible in the archaeological record of early hierarchically-organized eras in the *altiplano* are nearly absent at Ayawiri. The layout of compounds and location of activity areas indicate that households were responsible for managing their own food storage, processing, and consumption. Kitchen hearths were only large enough to cook a meal sufficient for a nuclear or extended family. I found that crop stores and residues of crops were present in the living spaces of households in the northern, central and southern parts of the *pukara.* Additionally, my analysis of the organization of of space of the terraces flanking the site points to a household organization of labor and agricultural production. These actions enforced relative economic autonomy and equality among residents.

My finding that the construction of the Ayawiri terrace complex occurred during the LIP sheds new light on the chronology and motivations behind field construction in the *altiplano.* Generally, it is believed that a centralized political authority is needed to organize, mobilize, and manage the labor required to build terraces and large field systems and oversee production. In accordance with this theory, other researchers working the region have found that raised fields, sunken gardens, and even a terrace complex were built during the Formative and Middle Horizon when political power was coalescing so that a central authority could oversee the construction, maintenance, and production of corporate farming systems. The Ayawiri terrace complex, however, was constructed through household labor and during a period of political fragmentation. The construction of terraces was motivated, in part, by fears of warfare, the need to produce food for sustenance, and to create pasture near the fortress to protect llama herds from raids. Further research throughout the region is needed to elucidate if the chronology of terrace construction at Ayawiri fits a pattern of LIP agricultural intensification. Additionally, research is needed on other terrace complexes adjacent to Formative, Middle Horizon, and Late Horizon sites in the region to determine when and why they were built.

Ayawiri residents seem to have been primarily concerned with the threat of warfare. Based on paleoenvironmental data, researchers working throughout the Andes have proposed that drought and subsequent agricultural crises precipitated warfare during the LIP (Nielsen 2002; Nielsen 2001; Seltzer and Hastorf 1990; Torres-Rouff and Costa Junqueira 2006). While ice cores and lake cores provide valuable information about the past climate, they do not predict or show causal relationships of how farmers and communities responded to climate changes. In order to measure how farmers responded to these risks, it is necessary to evaluate the residues of their actions. Even though a drought occurred during the LIP, Ayawiri residents prioritized implementing farming strategies to cope with warfare. The community chose farming and grazing strategies that increase physical safety and community security rather than extensive strategies that would have buffered against crop loss due to drought. Perhaps there were crop failures and food shortages during the early part of the LIP, but by the later part of the LIP when conflict intensified and Ayawiri was fully populated, families of this farming community were able to employ intensive agropastoral strategies, rely on rainfed field systems to produce abundant stores of chenopod and tuber crops.

During the Late Horizon, after the Colla were conquered in battle and incorporated into the Pan-Andean empire trade networks throughout the Lake Titicaca Basin were reopened by the Inca. Populations in the region resettled in valley bottoms and farmers were required to provision the Inca Empire and their army with surplus foods (Murra 1986:52). Even though Ayawiri was abandoned during the Late Horizon, terrace farming and the terrace complex at the site was not necessarily abandoned. Two chulpas, or burial towers located at the base of the terrace complex symbolize Late Horizon economic interests in the area (note one of these chulpas was destroyed and mined for cut stone by local residents in the 20th century). These chulpas were likely built by a local lord in emulation of Inca style chulpas. By burying their dead in a conspicuous structure, Late Horizon political authorities marked their claims to the agricultural landscape and perhaps even crop surpluses produced in this location. In this manner, the ancestors of the new Late Horizon political regime watched over the management of terrace farming from the vantage of the chulpas Currently, there have been no studies conducted in the northern Lake Titicaca Basin on Late Horizon archaeobotanical remains, so we do not know the extent of changes in local farming strategies or foodways following the LIP. Further research is needed to clarify the dynamic changes in farming and ecosystem management that occurred when the Inca conquered the region.

Avenues for Future Research

This dissertation provides new data about Late Intermediate Period farming strategies in in the Lake Titicaca Basin. At the same time, this research was limited by time constraints, funding, and scope. Here, I suggest avenues for potential future research spurred by these findings.

During excavations in the residential sector of the LIP fort, Proyecto Machu Llaqta archaeologists found a few Late Formative contexts including a potential domestic hearth.

Several archaeobotanical studies have been carried out on Formative ritual and ceremonial sites in the southern Lake Titicaca basin particularly on the Taraco Peninsula (Browman 1989; Bruno 2006, 2008, 2011, 2014; Langlie et al. 2011; Whitehead 2007). Future research on Ayawiri Late Formative samples has the potential to provide complementary data to these studies on domestic foodways and a more regional understanding of farming strategies as practiced during this pivotal time period of the initial coalescence of sociopolitical authority and rise of Tiwanaku. However, this analysis is currently constrained by an unresolved understanding of the Formative occupation at the site.

This dissertation research examined the farming and foodways of a single LIP community. Further analysis of archaeobotanical samples from other LIP sites is essential to understanding regional farming strategies and foodways during this tumultuous time period. In order to capture the diversity of farming strategies employed during the LIP, it would be useful to analyze macrobotanical remains and field systems of LIP communities living in different microenvironments, such as near lakes and wetlands. Perhaps these communities relied more on lacustrine resources. Additionally, it is important to consider scale; Ayawiri is one of the largest hillforts in the region. Perhaps smaller hillfort communities practiced different farming strategies. The size and the strength of the labor force at smaller forts would have surely resulted in different land use strategies.

This brings me to the importance of studying field systems throughout the region. Research on terrace agriculture has been largely overshadowed by studies on raised fields and even sunken gardens. Raised fields are a curiosity in the region since they are so expansive, and their prehistoric abandonment has far reaching implications. However, terraces are one of the primary indigenous field systems still used by farmers. The food produced on terraces still supports communities living throughout the region. The food security that terraces provided in prehistory to communities in the Lake Titicaca Basin surely underpinned socioeconomic development as much as raised fields. With this in mind, more research is needed to understand when, where, why, and how terraces were constructed.

While terraces remain a sustainable and productive agricultural strategy in the Andes, it is estimated that 50-75% of terraced fields have fallen into disuse since the Spanish conquest (Denevan 1988; Denevan et al. 1987; Donkin 1979; Erickson 1994). This abandonment can be attributed to a variety of political and economic reasons, including forced resettlement of populations by the Inca, then the Spanish, then encroaching industrialization throughout the modern era, and recently by younger generations moving to the cities for more employment opportunities.

More broadly, this research documents food security strategies during a period of warfare and climate uncertainty. In a recent report released by the U.S. Department of Defense, Secretary of Defense Chuck Hagel refers to climate change as a “threat multiplier” that will intensify the challenges of global instability, hunger, poverty, and conflict (U.S. Department of Defense 2014:2). Human societies need to calculate ways to respond to the global changes prompted by the imminent 1 to 4^{O}C increase in annual temperature predicted in the next 100 years. How our species responds to these risks will determine our success or demise. Political ecologists and ethnobotanists stress the importance of a response that considers locally developed indigenous strategies (e.g. Salick and Byg 2007). These strategies have “a fundamental importance in the management of local resources, in the husbanding of the world’s biodiversity, and in providing locally valid models for sustainable living” (Turner et al. 2000:1275). Local models, such as the one documented in this dissertation, are socially sensitive, agriculturally sustainable and will be essential to prevent food insecurity (while at the same time grappling with violent conflict) in the long-term.

Concluding Remarks

While others have pointed out that an agropastoral lifeway is flexible and resilient to inter-annual weather variability (ie. Browman 1987; Marston 2011), my findings show that it is also a durable subsistence strategy during times of warfare. Titicaca Basin residents were able to adapt their cropping schemes, herding strategies, and field systems to survive a period of martial conflict. These strategies and even these field systems have survived millennia. Indeed, the terraces around Ayawiri are still being sown with quinoa and potatoes today.

During times of crisis, vulnerabilities in food systems are quickly revealed, sometimes overnight (Endres and Endres 2009:410). The Late Intermediate Period was an era of political, social, and environmental crisis. When a community's survival depends on procuring its own food, its members make strategic choices that ensure their survival. My dissertation findings pinpoint the resilient agricultural choices the people who resided at Ayawiri made during the LIP.

Development agencies have emphasized the need for policy and agricultural reform to ensure food security in the current era, with specific focus on climate change risk management strategies in arid regions (Howden et al. 2007; Rosengrant 2011). Today, research teams and NGO's are working to preserve the myriad indigenous varieties of potatoes in Peru (Olson 2013). They see these cultivars as an important part of cultural heritage, and curating this genetic diversity may hold the key to grappling with future agrarian issues such as climate change, disease, or pestilence. I argue terraces are also part of this legacy and could provide solutions to some of the challenges of climate change. The microclimates that terraces provide ensured past farmers could produce crops at various altitudes and an array of climatic and sociopolitical conditions, as I have demonstrated in this dissertation. Terraces are part of the cultural and ecological legacy left by ancient farmers. Abandoning terraces results in their rapid degradation, landslides, and loss of this agrarian legacy that past generations left to us.

In the Andean highlands, while both terrace complexes and the martial conflict of the LIP have been until recently, overlooked by researchers, both have left their impact on the modern day landscape. Farmers continue to use traditional methods to cultivate the terraced hillside adjacent to Ayawiri. Property negotiations are still primarily organized locally, and labor is largely organized amongst kin groups. Potato and quinoa farming on terraces is still a major part of life in the local community, as can be seen in the trench profiles and notes from the terrace excavations. Ayawiri farmers imprinted their history by modifying the landscape surrounding their villages, they left genetic diversity in quinoa, potatoes, and other crops that they selected and grew each year, and they passed on the knowledge necessary to survive in this harsh environment to their offspring and their successors still farming the region today.

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Appendix A. Results of Ceramic Analysis

Results of ceramic analysis from TZ-3

	Event #	Event Name	Locus #	*Terminus Post Quem*	# Identifiable Sherds (n=)	Total Sherds (N=)	Pukara n=	Tiwanaku n=	Pucarani n=	Sillustani n=	Collao n=	? n=
	1	**Modern Surface**										
			V2-3101	LIP/LH	1	36	0	0	1	0	0	
			V2-3115	LIP/LH	7	18		1	3	1	1	1
Totals					**8**	**54**	**0**	**1**	**4**	**1**	**1**	**1**
	2	**Plow Zone**										
			V2-3102	LIP/LH	4	34	0	2	2	0	0	0
			V2-3116	LIP/LH	11	36	0	0	3	3	2	3
Totals					**15**	**70**	**0**	**2**	**5**	**3**	**2**	**3**
	3	**Fill of the upper part of the upper part of the terrace**										
			V2-3103	LIP/LH	6	38	4	0	0	1	0	1
			V2-3104	LIP	6	35	0	0	3	3	0	0
			V2-3117	LIP/LH	16	74	0	0	9	3	2	2
			V2-3118	LIP/LH	12	58	0	0	6	3	3	0
Totals					**40**	**205**	**4**	**0**	**18**	**10**	**5**	**3**
	4	**Fill of the lower part of the terrace**										
			V2-3105	LIP/LH	8	62	0	1	2	2	2	1
			V2-3106	LIP/LH	15	36	0	3	6	2	2	2
			V2-3107	LIP/LH	13	72	0	1	10	1	0	1
			V2-3111	LIP/LH	24	163	0	0	9	4	4	7
			V2-3119	LIP/LH	10	56	0	0	8	1	1	0
			V2-3120	LIP/LH	7	17	0	1	4	1	1	0
			V2-3127	LIP/LH	34	232	1	3	24	5	1	0
			V2-3128	LIP/LH	29	131	1	2	16	9	1	0
Totals					**140**	**769**	**2**	**11**	**79**	**25**	**12**	**11**
	5	**Burial**										
			V2-3130	LIP/LH	8	54	0	1	5	2	0	0
Totals					**8**	**54**	**0**	**1**	**5**	**2**	**0**	**0**
	6	**Stone arrangemen ts**										
			V2-3121	LIP/LH	10	3	0	0	10	3	0	0
			V2-3122	LIP/LH	8	3	0	0	3	4	0	1
			V2-3123	LIP/LH	29	109	2	2	14	5	6	0
			V2-3124	LIP/LH	3	11	0	0	3	0	0	0
			V2-3125	LIP/LH	10	49	1	0	8	1	0	0
Totals					**60**	**175**	**3**	**2**	**38**	**13**	**6**	**1**

	Event #	Event Name	Locus #	*Terminus Post Quem*	# Identifiable Sherds (n=)	Total Sherds (N=)	Pukara n=	Tiwanaku n=	Pucarani n=	Sillustani n=	Collao n=	? n=
	7	**Upper terrace wall**										
			V2-3108	LIP	1	14	0	0	1	0	0	0
			V2-3109	LIP/LH	1	5	0	0	0	0	0	1
			V2-3110	LIP/LH	7	26	0	0	5	2	0	0
			V2-3112	LIP/LH	2	13	0	0	1	1	0	0
			V2-3113	LIP/LH	11	38	0	0	6	2	1	2
			V2-3114	LIP/LH	9	27	0	0	8	1	0	0
			V2-3126	LIP/LH	1	9	0	0	0	1	0	0
Totals					**32**	**132**	**0**	**0**	**21**	**7**	**1**	**3**
	8	**Lower terrace wall**										
			V2-3129	LIP/LH	2	9	0	0	0	0	2	0
			V2-3131	LIP/LH	6	95	0	0	3	1	0	0
			V2-3132	LIP/LH	19	109	0	1	14	2	0	2
			V2-3133	LIP	3	23	0	0	3	0	0	0
Totals					**30**	**236**	**0**	**1**	**20**	**3**	**2**	**2**
	9	**Terrace wall foundation**										
			V2-3134	LIP	3	3	0	0	3	0	0	0
Totals					**3**	**3**	**0**	**0**	**3**	**0**	**0**	**0**

Results of ceramic analysis from TZ-4

	Event #	Event Name	Locus #	*Terminus Post Quem*	# Identifiable Sherds (n=)	Total Sherds (N=)	Pukara n=	Tiwanaku n=	Pucarani n=	Sillustani n=	Collao n=	? N=
	1	**Modern surface**										
			V2-3001	LIP/LH	6	65	1	0	1	3	0	1
Totals					**6**	**65**	**1**	**0**	**1**	**3**	**0**	**1**
	2	**Agricultural fill/plow zone**										
			V2-3002	LIP/LH	14	90	2	0	6	5	1	0
			V2-3003	LIP/LH	3	16	0	0	2	1	0	0
			V2-3004	LIP/LH	6	7	0	0	4	2	0	0
			V2-3005	LIP	2	18	0	0	2	0	0	0
			V2-3006	LIP/LH	1	9	0	0	1	0	0	0
			V2-3008	LIP/LH	10	83	0	1	4	5	0	0
			V2-3013	LIP/LH	1	27	0	0	1	0	0	0
Totals					**37**	**250**	**2**	**1**	**20**	**13**	**1**	**0**
	3	**Upper level of terrace wall**										
			V2-3009	LIP	1	49	0	0	1	0	0	0
			V2-3010	LIP/LH	1	36	0	0	0	1	0	0
			V2-3011	LIP/LH	7	75	0	0	6	1	0	0
			V2-3012	LIP/LH	2	38	0	0	1	0	1	0
Totals					**11**	**198**	**0**	**0**	**8**	**2**	**1**	**0**
	4	**Lower level of terrace wall**										
			V2-3014	LIP/LH	1	26	0	0	0	0	1	0
			V2-3015	LIP/LH	9	42	0	0	2	4	2	1
			V2-3016	LIP	1	3	0	0	1	0	0	0
Totals					**11**	**71**	**0**	**0**	**3**	**4**	**3**	**1**
	5	**Bedrock**										
			V2-3007	N/A	0	0	0	0	0	0	0	0

Results of ceramic analysis from TZ-5

	Event #	Event Name	Locus #	*Terminus Post Quem*	# Identifiable Sherds (n=)	Total Sherds (N=)	Pukara n=	Tiwanaku n=	Pucarani n=	Sillustani n=	Collao n=	? n=
	1	**Modern surface**										
			V2-3201	LIP	2	2	0	0	2	0	0	0
Totals					**2**	**2**	**0**	**0**	**2**	**0**	**0**	**0**
	2	**First terrace wall**										
			V2-3212	LIP	2	2	0	0	2	0	0	0
			V2-3213	LIP	1	1	0	0	1	0	0	0
			V2-3214	LIP	3	3	0	0	3	0	0	0
Totals					**6**	**6**	**0**	**0**	**6**	**0**	**0**	**0**
	3	**Plow zone of first terrace wall**										
			V2-3202	LIP	4	4	0	0	4	0	0	0
			V2-3203	LIP/LH	4	4	0	0	3	0	1	0
Totals					**8**	**8**	**0**	**0**	**7**	**0**	**1**	**0**
	4	**Second/modern terrace wall**										
	6	**Agricultural fill associated with second terrace wall**										
			V2-3207	LIP/LH	1	3	0	0	0	0	1	0
			V2-3208	LIP	2	3	0	0	2	0	0	0
			V2-3209*	LIP	3	3	0	0	3	0	0	0
			V2-3215*	LIP	5	5	0	0	2	3	0	0
Totals					**11**	**14**	**0**	**0**	**7**	**3**	**1**	**0**
	5	**Plow zone of second/modern terrace wall**										
			V2-3204	LIP	3	5	0	0	1	2	0	0
Totals					**3**	**5**	**0**	**0**	**1**	**2**	**0**	**0**

Results of ceramic analysis from TZ-6

	Event #	Event Name	Locus #	*Terminus Post Quem*	# Identifiable Sherds (n=)	Total Sherds (N=)	Pukara n=	Tiwanaku n=	Pucarani n=	Sillustani n=	Collao n=	? n=	Modern n=
	1	**Modern surface**											
			V2-3301	Modern	6	6	0	0	5	0	0	0	1
Totals					**6**	**6**	**0**	**0**	**5**	**0**	**0**	**0**	**1**
	2	**Plow zone**											
			V2-3302	LIP/LH	14		0	0	11	2	1	0	0
			V2-3303	LIP/LH	1		0	0	0	1	0	0	0
Totals					**15**		**0**	**0**	**11**	**3**	**1**	**0**	**0**
	3	**Third/modern terrace wall**											
	4	**Agricultural fill associated with third/modern terrace wall**											
			V2-3304*	LIP	1	6	0	0	1	0	0	0	0
			V2-3305*	LIP	2	2	0	0	2	0	0	0	0
			V2-3306	LIP/LH	1	1	0	0	1	0	0	0	0
			V2-3307*	LIP/LH	2	2	0	0	1	1	0	0	0
			V2-3308*	LIP/LH	7	8	0	0	6	0	0	1	0
			V2-3309*	LIP/LH	2	5	0	0	2	0	0	0	0
			V2-3310*	LIP/LH	1	4	0	0	1	0	0	0	0
			V2-3311*	LIP/LH	3	3	0	0	2	1	0	0	0
			V2-3325	LIP/LH	3	9	0	0	0	2	0	1	0
Totals					**22**	**40**	**0**	**0**	**16**	**4**	**0**	**2**	**0**
	5	**Second terrace wall**											
			V2-3317	LIP	1	1	0	0	1	0	0	0	0
			V2-3318	LIP/LH	1	1	0	0	0	0	0	1	0
			V2-3320	LIP/LH	4	6	0	0	4	0	0	0	0
Totals					**6**	**8**	**0**	**0**	**5**	**0**	**0**	**1**	**0**
	6	**Agricultural fill associated with second terrace wall**											
			V2-3319	LIP/LH	4	12	0	0	3	1	0	0	0
			V2-3321	LIP/LH	3	3	0	0	3	0	0	0	0
Totals					**7**	**15**	**0**	**0**	**6**	**1**	**0**	**0**	**0**

Appendix B. Detailed Results of OSL Analysis

Reported by Dr. Steve Forman

Sample #	Locus #	Laboratory number	Aliquots	Grain size (microns)	Equivalent dose (gray)[a]	Over-dispersion (%)[b]	U (ppm)[c]	Th (ppm)[c]	K (%)[c]	Cosmic dose (m/Gray/yr)[d]	Dose rate (mGray/yr)[e]	OSL age (yr)[f]
Box 1	TZ-3 base	BG3987	28/30	250-150	115.78 ± 5.56	20 ± 3	2.01 ± 0.01	10.20 ± 0.01	1.88 ± 0.01	0.28 ± 0.03	2.96 ± 0.15	39, 120 ± 2970
Core 3	V2-3010	BG3980	32/34	250-150	0.54 ± 0.05	62 ± 8	2.11 ± 0.01	9.56 ± 0.01	2.30 ± 0.01	0.40 ± 0.04	3.39 ± 0.16	155 ± 15
Core 6	V2-3013	BG3984	32/35	150-100	0.32 ± 0.04	86 ± 11	1.92 ± 0.01	8.98 ± 0.01	1.78 ± 0.01	0.40 ± 0.04	2.92 ± 0.15	105 ± 15
Core 11	V2-3133	BG3981	33/38	150-100	22.38 ± 1.16	28 ± 4	1.24 ± 0.01	5.18 ± 0.01	1.70 ± 0.01	0.29 ± 0.03	2.34 ± 0.13	9565 ± 780
Core 20	V2-3212	BG3982	30/35	250-150	6.67 ± 0.49	36 ± 5	1.97 ± 0.01	8.21 ± 0.01	2.22 ± 0.01	0.35 ± 0.04	3.16 ± 0.15	2105 ± 200
Core 29	V2-3209	BG3985	30/33	150-100	1.52 ± 0.11	38 ± 5	1.78 ± 0.01	6.86 ± 0.01	2.22 ± 0.01	0.38 ± 0.04	3.10 ± 0.15	490 ± 45
Core 31	V2-3309	BG3986	25/28	63-100	61.85 ± 2.95	20 ± 3	1.49 ± 0.01	7.59 ± 0.01	1.93 ± 0.01	0.27 ± 0.03	2.83 ± 0.14	21,875 ± 620
Core 34	V2-3319	BG3983	40/40	150-100	11.67 ± 0.98	43 ± 5	1.24 ± 0.01	5.18 ± 0.01	1.25 ± 0.01	0.28 ± 0.03	1.95 ± 0.11	5985 ± 450
Core 37	V2-3322	BG3910	25/30	100-63	15.93 ± 0.76	24 ± 3	1.89 ± 0.01	7.20 ± 0.01	2.15 ± 0.01	0.34 ± 0.03	3.15 ± 0.16	5050 ± 450
Core 40	V2-3325	BG3909	34/40	150-100	2.12 ± 0.09	44 ± 5	1.40 ± 0.01	5.17 ± 0.01	1.54 ± 0.01	0.34 ± 0.03	2.29 ± 0.13	920 ± 70

[a] *Equivalent dose analyzed under blue-light excitation (470 ± 20 nm) by single aliquot regeneration protocols (Murray and Wintle, 2006).*

[b] *Values reflect precision beyond instrumental errors; values of ≤ 25% (at 1 sigma errors) indicate low spread in equivalent dose values with an unimodal distribution. Elevated values of >25% indicate a mixture of grain ages and/or insufficient solar resetting with deposition.*

[c] *U, Th and K2O content analyzed by inductively coupled plasma-mass spectrometry at ALS Laboratories, Reno, NV, USA; U content includes equivalent of Rb content.*

[d] *From Presott and Hutton (1994).*

[e] *Includes an estimated moisture content of 10 ± 3%.*

[f] *Ages calculated using the Central Age Model or Finite Mixture Model with overdispersion values of 25% (at two sigma), respectively. All errors are at 1 sigma, calculated in a quadrature with the reference year AD 2010.*

Appendix C. Raw results of Macrobotanical Analysis

Locus # V2-	Unit	Volume (liters)	Cactaceae seeds	*Opuntia* sp. seeds	*Chenopodium* sp. seeds	Poaceae type #1 seeds	Poaceae type #2 seeds	Poaceae type #3 seeds	Poaceae type #4 seeds	Poaceae type #5 seeds	>0.5 mm Poaceae type #6	Poaceae Unknown seed type	*Piptochaetium* sp. Seeds	Malvaceae seed type #1	Malvaceae unknown seed type	Cyperaceae seed type #1	Cyperaceae seed type #2	*Trifolium amabile* seeds	*Relbunium* sp. seeds	Brassica seed type #2	*Plantago* sp. seeds	*Verbena* sp. seeds	cf. Solanaceae seeds	Unknown Seeds	Unidentifiable Seeds	Total Seeds
1002/4	44A	10			4						1															5
1003/2	44A	10			22	1	3																			26
1007/4	44A	10			28	2	2	1	1						2											36
1008/7	44A	10			32	3	1		1									1								38
1009/4	44A	10			137	31	7					43		6		2	1									227
1033/7	44A	5			198	2								1		1		2								204
1035/5	44A	10			394													1								395
1035/12	44A	10			453		1					4														458
1035/20	44A	10			271										1											272
1038/7	44A	10			33	1	2																	1		37
1038/9	44A	10			41																					41
1038/12	44A	10			12																					12
1038/18	44A	10			176		1																			177
1038/22	44A	10			66	1																		1		68
1038/23	44A	10			6																					6
1038/31	44A	10			18																			1		19
1041/14	44A	10			179	1				1		26						5				2			5	219
1041/15	44A	10			1797	12	21			4					1											1835
1041/16	44A	10			1816									2												1818
1043/7	44A	10			0															1						1
1043/10	44A	10			28		1																			29
1043/25	44A	10			374	1	5				1				1			2						1	1	386

Locus # V2-	Unit	Volume (liters)	Cactaceae seeds	*Opuntia* sp. seeds	*Chenopodium* sp. seeds	Poaceae type #1 seeds	Poaceae type #2 seeds	Poaceae type #3 seeds	Poaceae type #4 seeds	Poaceae type #5 seeds	>0.5 mm Poaceae type #6	Poaceae Unknown seed type	*Piptochaetium* sp. Seeds	Malvaceae seed type #1	Malvaceae unknown seed type	Cyperaceae seed type #1	Cyperaceae seed type #2	*Trifolium amabile* seeds	*Relbunium* sp. seeds	Brassica seed type #2	*Plantago* sp. seeds	*Verbena* sp. seeds	cf. Solanaceae seeds	Unknown Seeds	Unidentifiable Seeds	Total Seeds
1044/8	44A	10			24		1																			25
1045/13	44A	10			3366					1				5				2	1		1				1	3377
1046/7	44A	10			32													2								34
1046/8	44A	10			228						2															230
1046/9	44A	10			68		1				1			1								1				72
1046/11	44A	10			166		1											1								168
1046/12	44A	10			190																					190
1046/21	44A	10			1485		1							2												1488
1046/22	44A	10			386		3					1														390
1060/5	44B	10			30	1										2		1						1	1	36
1061/5	44B	10			12									2												14
1066/5	44B	10			94					1								2								97
1070/4	44B	10			196	1	1					1						1					1	1		202
1071/4	44B	10			135				4			1														140
1072/1	44B	10			166		4		1							1		3		1						176
1073/4	44B	10			53	1	2																			56
1074/5	44B	10			24									1												25
1074/8	44B	10			87		1	2				4		3			1		1							99
1074/22	44B	10			18	1						5								1						25
1083/2	UT-1A-15	10	3		18																					21
1088/13	UT-1A-134	10			0																					0
1092/18	UT-1A-125	0.2			11									1						1					1	14
1114/4	44B	10			136		4																2			142

Locus # V2-	Unit	Volume (liters)	Cactaceae seeds	*Opuntia* sp. seeds	*Chenopodium* sp. seeds	Poaceae type #1 seeds	Poaceae type #2 seeds	Poaceae type #3 seeds	Poaceae type #4 seeds	Poaceae type #5 seeds	>0.5 mm Poaceae type #6	Poaceae Unknown seed type	*Piptochaetium* sp. Seeds	Malvaceae seed type #1	Malvaceae unknown seed type	Cyperaceae seed type #1	Cyperaceae seed type #2	*Trifolium amabile* seeds	*Relbunium* sp. seeds	Brassica seed type #2	*Plantago* sp. seeds	*Verbena* sp. seeds	cf. Solanaceae seeds	Unknown Seeds	Unidentifiable Seeds	Total Seeds
1114/14	44B	10			84		7					2		2											1	96
1116/13	44B	10			137							7		1												145
1116/14	44B	10			77		2					1														80
1124/21	44C	10			1																					1
1124/26	44C	10			1																					1
1128/5	44A	10			36																					36
1128/6	44A	10			6																					6
1142/15	44C	10			122		1																			123
1144/2	44B	10			56		1																			57
1146/2	44C	10	24		1163	1	5					10												2	2	1207
1147/9	44C	10			170		2																			172
1149/5	44C	10			189	3						3		4				1								200
1150/2	44C	10			292							3						1	1					2	2	301
1150/4	44C	10			77									1												78
1258/1	44C	6			54		3							1				1								59
1303/5	44C	10			17														1							18
1303/11	44C	6			56		2							1												59
1306/2	44C	10			347		1					1			3											352
1309/1	44C	10			12									1												13
1356/16	72B	10			52																					52
1358/21	72B	10			36																					36
1358/22	72B	10			40		2				1			1					1							45
1360/5	72B	10			670	3	7					22		19	1			1	1	1						725
1364/4	72D	10			1																					1
1402/1	72B	10			38							1														39
1402/3	72B	10			25									1												26

Locus # V2-	Unit	Volume (liters)	Cactaceae seeds	*Opuntia* sp. seeds	*Chenopodium* sp. seeds	Poaceae type #1 seeds	Poaceae type #2 seeds	Poaceae type #3 seeds	Poaceae type #4 seeds	Poaceae type #5 seeds	>0.5 mm Poaceae type #6	Poaceae Unknown seed type	*Piptochaetium* sp. Seeds	Malvaceae seed type #1	Malvaceae unknown seed type	Cyperaceae seed type #1	Cyperaceae seed type #2	*Trifolium amabile* seeds	*Relbunium* sp. seeds	Brassica seed type #2	*Plantago* sp. seeds	*Verbena* sp. seeds	cf. Solanaceae seeds	Unknown Seeds	Unidentifiable Seeds	Total Seeds
1402/4	72B	10			210							1		1												212
1402/11	72B	10			63									2												65
1407/4	72C	10			3																					3
1407/12	72C	10			47													1								48
1407/13	72C	10			41	2								2										1	1	47
1408/3	72C	10			9														1							10
1408/5	72C	10			5							1														6
1409/11	72C	10			43							1		4									1			49
1453/2	72A	10			2							1														3
1454/6	72A	10			49								1	1				1								52
1463/7	72A	10			3																					3
1469/1	72A	3			13									2	3											18
1476/4	72E	10			4									1												5
1480/4	72E	10			17					2														1		20
2007/5	72K	8			63							2						4								69
2008/1	72K	5			584	3								1	1											589
2054/6	72J	10			0																					0
2112/1	72F	10			38	1						1		1											4	45
2154/2	72H	6			10																					10
2203/10	118A	10			17	4								1				2	1					1	13	39
2203/29	118A	10			12													1								13
2204/4	118A	10			54	1						1		3		1		2								62

Locus # V2-	Unit	Volume (liters)	Cactaceae seeds	*Opuntia* sp. seeds	*Chenopodium* sp. seeds	Poaceae type #1 seeds	Poaceae type #2 seeds	Poaceae type #3 seeds	Poaceae type #4 seeds	Poaceae type #5 seeds	>0.5 mm Poaceae type #6	Poaceae Unknown seed type	*Piptochaetium* sp. Seeds	Malvaceae seed type #1	Malvaceae unknown seed type	Cyperaceae seed type #1	Cyperaceae seed type #2	*Trifolium amabile* seeds	*Relbunium* sp. seeds	Brassica seed type #2	*Plantago* sp. seeds	*Verbena* sp. seeds	cf. Solanaceae seeds	Unknown Seeds	Unidentifiable Seeds	Total Seeds
2230/2	118B	10	1		9																					10
2255/8	118C	6			34							1		1												36
2256/11	118C	10			56		1							2	1			4						1		65
2259/5	118C	10			240	2						2		4	2			3								253
2305/5	6A	10			56																					56
2305/23	6A	10			297		3							2												302
2329/3	6B	8			1897																					1897
2331/6	6B	10			65602					1																65603
2340/6	6B	10			139																					139
2354/27	6C	10			123							1														124
2355/29	6C	10			236							2		1											3	242
2357/21	6C	10			64		2					1		2				3								72
2359/1	6C	10		1	112	1			5					5				1								125
2361/1	6C	2			12									1												13
2506/4	59A	10			948652																					948652
Total		**1025.2**	**28**	**1**	**1035585**	**80**	**102**	**3**	**12**	**10**	**6**	**150**	**1**	**93**	**16**	**7**	**2**	**49**	**8**	**5**	**1**	**3**	**4**	**14**	**35**	**1036215**

Locus # V2-	Unit	Volume (liters)	>2 mm Parenchyma Ct.	>2 mm Parenchyma Wt. (g)	Tubers Hand Collected Ct.	Tubers Hand Collected Wt. (g)	>2 mm Wood Ct.	>2 mm Wood Wt. (g)	> 2.0 mm Dung	Burned Bone	Uncharred Bone
1002/4	44A	10									
1003/2	44A	10					4	0.02		4	
1007/4	44A	10					8	0.05		1	
1008/7	44A	10	1	0.11			25	0.13			
1009/4	44A	10					6	0.07			4
1033/7	44A	5					2	0.01			
1035/5	44A	10					13				
1035/12	44A	10					13	0.21			1
1035/20	44A	10					7	0.05			
1038/7	44A	10									
1038/9	44A	10					4	0.05			
1038/12	44A	10									
1038/18	44A	10					7	0.03		1	
1038/22	44A	10					1	0.01			
1038/23	44A	10	1	0.01			1	0.01			
1038/31	44A	10					3	0.01			
1041/14	44A	10	14	0.22			11	0.04			2
1041/15	44A	10					31				
1041/16	44A	10					32	0.2		8	
1043/7	44A	10	15				1				
1043/10	44A	10									
1043/25	44A	10					83	0.78			
1044/8	44A	10					8	0.11			
1045/13	44A	10					36	0.42	2		
1046/7	44A	10					5	0.01			
1046/8	44A	10					41	0.2		1	
1046/9	44A	10					1	0			
1046/11	44A	10	2	0.01			3	0		1	
1046/12	44A	10					86	1.7		128	
1046/21	44A	10					11	0.2		5	
1046/22	44A	10	3	0.01			5	0.06		12	
1060/5	44B	10	40.23				5	0.06			
1061/5	44B	10	40	0.72							
1066/5	44B	10	3	0.02			2	0.01	2		8

Locus # V2-	Unit	Volume (liters)	>2 mm Parenchyma Ct.	>2 mm Parenchyma Wt. (g)	Tubers Hand Collected Ct.	Tubers Hand Collected Wt. (g)	>2 mm Wood Ct.	>2 mm Wood Wt. (g)	> 2.0 mm Dung	Burned Bone	Uncharred Bone
1070/4	44B	10					23	0.15			
1071/4	44B	10	1	0.01			13	0.2			
1072/1	44B	10	15	0.09			22	0.13			3
1073/4	44B	10	5	0.11			13	0.28		5	
1074/5	44B	10						2			
1074/8	44B	10	3	0.02			12	0.17	8		3
1074/22	44B	10									
1083/2	UT-1A-15	10					2	0.01			
1088/13	UT-1A-134	10									
1092/18	UT-1A-125	0.2					1			1	
1114/4	44B	10					25	0.4		2	
1114/14	44B	10					4	0.04			
1116/13	44B	10	1	0.04			12	0.09			
1116/14	44B	10	4	0.02			6	0.16			
1124/21	44C	10									
1124/26	44C	10									
1128/5	44A	10					2	0.01			
1128/6	44A	10					8	0.2			
1142/15	44C	10					4	0.04		3	
1144/2	44B	10					5	0.05			
1146/2	44C	10					3	0.02			6
1147/9	44C	10					6	0.05			
1149/5	44C	10					3	0.02			5
1150/2	44C	10					9	0.07		2	
1150/4	44C	10					10	0.11			2
1258/1	44C	6					1	0.01			
1303/5	44C	10									
1303/11	44C	6	6	0.05			5	0.06			
1306/2	44C	10					3	0.01			6
1309/1	44C	10	1	0.01							
1356/16	72B	10	2	0.03			1	0.04		3	
1358/21	72B	10									

Locus # V2-	Unit	Volume (liters)	>2 mm Parenchyma Ct.	>2 mm Parenchyma Wt. (g)	Tubers Hand Collected Ct.	Tubers Hand Collected Wt. (g)	>2 mm Wood Ct.	>2 mm Wood Wt. (g)	> 2.0 mm Dung	Burned Bone	Uncharred Bone
1358/22	72B	10					1	0.01			9
1360/5	72B	10	3	0.08			122	1.53			264
1364/4	72D	10									
1402/1	72B	10	2	0.11			12	0.28		6	
1402/3	72B	10	1	0.04			2	0.01		3	
1402/4	72B	10					1	0.12			
1402/11	72B	10					22	0.2		101	
1407/4	72C	10					3	0.01			
1407/12	72C	10					1	0.01			
1407/13	72C	10	1	0.01			6	0.08			
1408/3	72C	10					1	0.01		3	
1408/5	72C	10									
1409/11	72C	10	2	0.01			5	0.04		1	
1453/2	72A	10					2	0.01			
1454/6	72A	10					13				
1463/7	72A	10					2	0.02			
1469/1	72A	3					2	0.01			
1476/4	72E	10					1	0.01			
1480/4	72E	10					12	0.06			1
2007/5	72K	8					4	0.03	2		
2008/1	72K	5					31	0.47		167	
2054/6	72J	10					1	0.01			
2112/1	72F	10									
2154/2	72H	6									
2203/10	118A	10					24	0.19			
2203/29	118A	10					14	0.06			
2204/4	118A	10					4	0.04			
2230/2	118B	10									
2255/8	118C	6					11	0.09			
2256/11	118C	10					2	0.04			2
2259/5	118C	10	2	0.01			75	0.45		4	
2305/5	6A	10					2	0.01			12

Locus # V2-	Unit	Volume (liters)	>2 mm Parenchyma Ct.	>2 mm Parenchyma Wt. (g)	Tubers Hand Collected Ct.	Tubers Hand Collected Wt. (g)	>2 mm Wood Ct.	>2 mm Wood Wt. (g)	> 2.0 mm Dung	Burned Bone	Uncharred Bone
2305/23	6A	10					19	0.14		23	
2329/3	6B	8							1		1
2331/6	6B	10	1	0.02			16	0.13		85	2.84
2340/6	6B	10								17	
2354/27	6C	10					1	0.01			
2355/29	6C	10	1	0.01							
2357/21	6C	10	1	0.01							2
2359/1	6C	10	1				10	0.09			
2361/1	6C	2					119	1.67			
2506/4	59A	10	204.84	22.3	28	17.11	477.96	7.51		682.8	
Total		**1025.2**	**375**	**24.07**	**28**	**17.11**	**1667**	**20**	**15**	**1270**	**334**

Raw Results of Macrobotanical Remains from Unresolved or Non-LIP Contexts

Locus # V2-	Unit	Time period	Volume (liters)	Cactaceae seeds	*Opuntia* sp. seeds	*Chenopodium* sp. seeds	Poaceae type #1 seeds	Poaceae type #2 seeds	Poaceae type #3 seeds	Poaceae type #4 seeds	Poaceae type #5 seeds	>0.5 mm Poaceae type #6	Poaceae Unknown seed type	*Piptochaetium* sp. Seeds	Malvaceae seed type #1	Malvaceae seed type #2	Malvaceae unknown seed type	Cyperaceae seed type #1	Cyperaceae seed type #2	*Trifolium amabile* seeds	*Relbunium* sp. seeds	Brassica seed type #2	*Plantago* sp. seeds	*Verbena* sp. seeds	cf. Solanaceae seeds	Unknown Seeds	Unidentifiable Seeds	Total Seeds
1075/4	44B	LIP/Late Horizon	0																									0
1075/5	44B	LIP/Late Horizon	5			48	1		1				1			2				6							10	69
1101/5	44B	Formative/LIP	10			80		2						2			2			1								87
1307/2	44C	Mixed	10			50						1			6		3											60
2210/6	118A	Mixed	10	1		71		2						2	2					2				2			4	86
2213/4	118A	Mixed, Formative	10			134		5					7	5	11			2		#	2			1		1		184
2257/3	118C	Mixed	10			29						5								1								35
2260/18	118C	Mixed	10			28																						28
2316/9	6A	Formative	10			29									2													31
2318/1	6A	Formative	8			4																						4
2344/5	6B	Mixed	8			116					3		5		14				2	4							46	190
1403/1	72B	LIP	10			84							1													1		86

Locus # V2-	Unit	Time period	Volume (liters)	>2 mm Parenchyma Ct.	>2 mm Parenchyma Wt. (g)	>2 mm Wood Ct.	>2 mm Wood Wt. (g)	> 2.0 mm Dung	Burned Bone	Uncharred Bone
1075/4	44B	LIP/Late Horizon	0			1	0.01		17	7.27
1075/5	44B	LIP/Late Horizon	5	69	2.68	8	0.13			
1101/5	44B	Formative/LIP	10	39	0.68	13	0.09			
1307/2	44C	Mixed	10			4	0.06			
2210/6	118A	Mixed	10			6	0.03			
2213/4	118A	Mixed, Formative	10							
2257/3	118C	Mixed	10			38	0.23			
2260/18	118C	Mixed	10			15	0.21			
2316/9	6A	Formative	10							
2318/1	6A	Formative	8							
2344/5	6B	Mixed	8	46	0.23	54	0.4	20		
1403/1	72B	LIP	10			14	0.1			

Appendix D. Measurements of Cyperaceae Seeds

Locus #	Cyperaceae Seed Type	Height	Width	Surface Treatment	Shape
V2-1072/1	1	1.4	0.9	Reticulate	2 sided
V2-1060/5	1	1.7	1	Reticulate	2 sided
V2-1060/5	1	1.5	1	Reticulate	2 sided
V2-1114/14	1	1.4	0.9	Grotty	2 sided
V2-2213/4	1	1.3	0.8	Reticulate	2 sided
V2-2213/4	1	1.3	1	Reticulate	2 sided
V2-1009/4	1	1.2	0.9	Reticulate	2 sided
V2-1009/4	1	1.1	0.8	Grotty	2 sided
V2-1046/22	2	2	1	Reticulate	4 sided
V2-1360/5	2	1.1	0.6	Reticulate	4 sided
V2-2344/5	2	1	0.7	Reticulate	4 sided
V2-1074/8	2	0.9	0.6	Grotty	4 sided
V2-1041/14	2	1.4	0.9	Reticulate	4 sided
V2-1009/4	2	0.9	0.6	Grotty	4 sided

Appendix E. Measurements of Malvaceae Seeds

Locus #	Malvaceae Seed Type	Height (mm)	Width (mm)	Surface Treatment
V2-1007/4	3	1.4	1.1	grotty
V2-1007/4	3	0.8	0.8	grotty
V2-1035/20	1	1.2	1.4	smooth
V2-1041/16	3	1.3	1.1	grotty
V2-1041/16	1	1.1	0.8	smooth
V2-1041/15	3	1.2	8	grotty
V2-1043/25	3	1	0.9	grotty
V2-1046/9	1	1.4	0.9	smooth
V2-1075/1	2	1	1	reticulate
V2-1075/5	2	1	0.9	reticulate
V22-1046/21	1	1	0.9	smooth
V22-1046/21	1	1.2	1	smooth
V2-1101/5	3	1.3	1	grotty
V2-1101/5	3	1.2	1	grotty
V2-1114/14	1	1.3	1	smooth
V2-1114/14	1	1.1	0.7	smooth
V2-1116/13	1	1.1	0.9	smooth
V2-1146/2	1	1	0.8	smooth
V2-1146/2	1	1.2	1	smooth
V2-1146/2	1	1	1	smooth
V2-1146/2	1	1.2	1	smooth
V2-1146/2	1	1.3	1	smooth
V2-1150/2	1	1	0.9	smooth
V2-1150/4	1	1.2	1.2	smooth
V2-1258/1	1	1	0.8	smooth
V2-1303/11	1	1.4	1	smooth
V2-1306/2	3	1.2	1	grotty
V2-1306/2	3	-	0.9	grotty
V2-1306/2	3	1.4	1	grotty
V2-1307/2	1	1.1	0.8	smooth
V2-1307/2	1	1	0.7	smooth
V2-1307/2	1	1.1	1	smooth
V2-1307/2	1	1	0.7	smooth
V2-1307/2	1	1.1	1	smooth
V2-1307/2	3	1.2	0.9	grotty
V2-1307/2	3	1.1	1	grotty
V2-1307/2	1	1.3	1	smooth
V2-1307/2	3	1.2	1	grotty
V2-1360/5	1	1.3	0.9	smooth
V2-1360/5	1	1.3	1.1	smooth
V2-1360/5	3	1	0.7	grotty
V2-1360/5	1	1.1	0.9	smooth

Locus #	Malvaceae Seed Type	Height (mm)	Width (mm)	Surface Treatment
V2-1360/5	1	0.9	0.7	smooth
V2-1360/5	1	0.9	0.4	smooth
V2-1360/5	1	1	0.8	smooth
V2-1360/5	1	0.9	0.9	smooth
V2-1360/5	1	1	1	smooth
V2-1360/5	1	1.2	1	smooth
V2-1360/5	1	1.3	1.2	smooth
V2-1360/5	1	1.5	1	smooth
V2-1360/5	1	1.2	0.9	smooth
V2-1360/5	1	1.2	0.9	smooth
V2-1360/5	1	1.2	0.9	smooth
V2-1360/5	1	1	0.9	smooth
V2-1360/5	1	1.1	1	smooth
V2-1360/5	1	1.1	1	smooth
V2-1360/5	1	1.2	1	smooth
V2-1402/3	1	1.1	0.9	smooth
V2-1402/4	1	1.2	1	smooth
V2-1402/11	1	1.1	0.7	smooth
V2-1402/11	1	1.1	0.9	smooth
V2-1407/13	1	1	0.9	smooth
V2-1407/13	1	1.2	1	smooth
V2-1454/6	1	1.2	0.9	smooth
V2-1469/1	3	1.3	1.1	grotty
V2-1469/1	1	1.3	0.9	smooth
V2-1469/1	1	1.1	1	smooth
V2-1469/1	3	1.2	1	grotty
V2-1469/1	3	1.2	1	grotty
V2-2008/1	1	1.2	0.9	smooth
V2-2008/1	3	1.2	1	grotty
V2-2112/2	1	1.3	1.4	smooth
V2-2112/2	1	1.1	0.9	smooth
V2-2203/10	1	1	0.8	smooth
V2-2204/4	1	1.3	1	smooth
V2-2204/4	1	1	0.8	smooth
V2-2204/4	1	1	0.8	smooth
V2-2210/6	1	1.3	1.1	smooth
V2-2210/6	1	1.1	1	smooth
V2-2213/4	1	1.3	1	smooth
V2-2213/4	1	1.2	0.9	smooth
V2-2213/4	1	1.1	0.7	smooth
V2-2213/4	1	1	0.8	smooth
V2-2213/4	1	1.1	0.9	smooth
V2-2213/4	1	1	0.6	smooth
V2-2213/4	1	1.2	1.1	smooth
V2-2213/4	1	1.1	0.9	smooth
V2-2213/4	1	1.2	1	smooth

Locus #	Malvaceae Seed Type	Height (mm)	Width (mm)	Surface Treatment
V2-2213/4	1	1	1	smooth
V2-2213/4	1	1.2	0.9	smooth
V2-2255/8	1	1.2	1	smooth
V2-2256/11	3	1.2	1.1	grotty
V2-2256/11	1	1	0.9	smooth
V2-2256/11	1	1	0.9	smooth
V2-2259/5	3	0.9	0.7	grotty
V2-2259/5	1	1.2	1	smooth
V2-2259/5	1	0.9	0.7	smooth
V2-2259/5	3	1	0.8	grotty
V2-2259/5	1	0.8	0.6	smooth
V2-2259/5	1	1.4	1.2	smooth
V2-2305/23	1	1.2	0.8	smooth
V2-2305/23	1	1	0.9	smooth
V2-2316/9	1	1	0.8	smooth
V2-2316/9	1	1.2	1	smooth
V2-2344/5	1	1	0.9	smooth
V2-2344/5	1	1.1	0.8	smooth
V2-2344/5	1	1.3	0.9	smooth
V2-2344/5	1	1.2	1	smooth
V2-2344/5	1	0.9	0.6	smooth
V2-2344/5	1	1.2	0.9	smooth
V2-2344/5	1	1	0.9	smooth
V2-2344/5	1	1.2	1	smooth
V2-2344/5	1	1.4	1	smooth
V2-2344/5	1	1.2	0.6	smooth
V2-2344/5	1	1	0.7	smooth
V2-2344/5	1	1	0.8	smooth
V2-2344/5	1	1.1	1.1	smooth
V2-2344/5	1	1.5	1.3	smooth
V2-2355/29	1	1.5	1	smooth
V2-2357/21	1	1.2	0.8	smooth
V2-2357/21	1	0.9	0.7	smooth
V2-2359/1	1	0.8	0.7	smooth
V2-2359/1	1	1	0.8	smooth
V2-2359/1	1	1	0.9	smooth
V2-2359/1	1	1.5	1	smooth
V2-2359/1	1	1	1.1	smooth
V2-2361/1	1	1.2	0.9	smooth
V2-1476/4	1	1.3	1	smooth
V2-1045/13	1	1.4	0.9	smooth
V2-1045/13	1	1	0.6	smooth
V2-1045/13	1	1	0.7	smooth
V2-1045/13	1	1.4	0.9	smooth
V2-1045/13	1	1.2	0.9	smooth
V2-1074/8	1	1.2	1	smooth

Locus #	Malvaceae Seed Type	Height (mm)	Width (mm)	Surface Treatment
V2-1074/8	1	1.3	1	smooth
V2-1074/8	1	1.2	1	smooth
V2-1359/22	1	0.9	0.9	smooth
V2-1061/5	1	1	0.8	smooth
V2-1061/5	1	1.1	0.8	smooth
V2-1309/1	1	1.1	0.9	smooth
V2-1074/5	1	0.8	0.6	smooth
V2-1098/12	1	1.4	1	smooth
V2-1033/7	1	1.1	0.9	smooth
V2-1409/11	1	1	0.8	smooth
V2-1409/11	1	1.1	1	smooth
V2-1409/11	1	1	1	smooth
V2-1409/11	1	1.2	0.9	smooth
V2-1149/5	1	1.2	0.9	smooth
V2-1149/5	1	0.9	0.7	smooth
V2-1149/5	1	1	0.8	smooth
V2-1149/5	1	1	0.8	smooth
V2-1009/4	1	1	0.9	smooth
V2-1009/4	1	1	0.8	smooth
V2-1009/4	1	1	0.8	smooth
V2-1009/4	1	1	0.9	smooth
V2-1009/4	1	1.1	0.9	smooth
V2-1009/4	1	1	0.8	smooth

Appendix F. Measurements of Poaceae Seeds

Locus #	Poaceae Type	Height (mm)	Width (mm)
V2-1002/4	6	1.5	0.5
V2-1003/2	2	1.5	0.4
V2-1003/2	2	1.1	0.5
V2-1003/2	2	1.3	0.5
V2-1003/2	1	1.2	0.5
V2-1007/4	4	2	0.5
V2-1007/4	5	5	1.4
V2-1007/4	5	4	1.1
V2-1007/4	2	1.2	0.5
V2-1007/4	2	1.4	0.6
V2-1007/4	4	1.6	0.5
V2-1008/7	1	1.6	0.4
V2-1008/7	1	1.4	0.4
V2-1008/7	2	1.1	0.5
V2-1008/7	4	2	0.7
V2-1038/7	1	1.6	0.3
V2-1038/7	2	1.5	0.4
V2-1038/7	2	1.3	0.4
V2-1038/18	2	1.1	0.4
V2-1038/22	1	1.6	0.4
V2-1043/10	2	1.1	0.4
V2-1041/15	2	1	0.4
V2-1041/15	2	1	0.3
V2-1041/15	2	1	0.4
V2-1041/15	2	0.9	0.4
V2-1041/15	2	0.9	0.3
V2-1041/15	1	1.2	0.2
V2-1041/15	1	1.5	0.4
V2-1041/15	1	1.1	0.3
V2-1041/15	1	1.5	0.3
V2-1041/15	1	1.4	0.3
V2-1043/25	6	2	0.8
V2-1043/25	1	1.3	0.2
V2-1043/25	2	1	0.4
V2-1043/25	2	1.1	0.5
V2-1043/25	2	0.9	0.4
V2-1043/25	2	1.2	0.3
V2-1043/25	2	1	0.4
V2-1044/8	2	1	0.5
V2-1046/8	1	1.6	0.3
V2-1056/9	2	1.5	0.6
V2-1046/11	2	1.6	0.5
V2-1075/5	1	1.7	0.3

Locus #	Poaceae Type	Height (mm)	Width (mm)
V2-1075/5	2	2	0.5
V2-1075/5	1	1.5	0.3
V2-1073/4	2	1.5	0.4
V2-1073/4	2	1.5	0.3
V2-1073/4	2	1.6	0.4
V2-1073/4	1	1.5	0.3
V2-1072/1	2	1.4	0.5
V2-1072/1	2	1.4	0.4
V2-1072/1	2	1.6	0.6
V2-1072/1	2	1.4	0.4
V2-1071/4	5	2.5	0.8
V2-1071/4	5	3	0.9
V2-1070/4	1	1.2	0.3
V2-1070/4	2	1.1	0.4
V2-1066/5	5	2.4	0.8
V2-1046/22	2	1.3	0.5
V2-1046/22	2	1.5	0.5
V2-1046/22	2	1.1	0.3
V2-1046/21	2	1.2	0.5
V2-1101/5	2	1.1	0.4
V2-1101/5	2	1	0.4
V2-1114/4	2	1.2	0.5
V2-1114/4	2	1.3	0.4
V2-1114/4	2	1.1	0.4
V2-1114/4	2	1	0.3
V2-1114/14	2	1.1	0.5
V2-1114/14	2	1.3	0.5
V2-1114/14	2	1.1	0.5
V2-1114/14	2	1	0.3
V2-1114/14	2	1.2	0.4
V2-1116/14	2	1.2	0.4
V2-1116/14	2	1.1	0.5
V2-1142/15	2	1.2	0.4
V2-1144/2	2	1.3	0.5
V2-1146/2	1	1.4	0.3
V2-1147/9	2	1.2	0.4
V2-1147/9	2	1.5	0.5
V2-1258/1	2	1.2	0.5
V2-1258/1	2	1.1	0.5
V2-1258/1	2	1.4	0.4
V2-1303/11	2	1.1	0.5
V2-1303/11	2	1.1	0.5
V2-1306/2	2	1.3	0.5
V2-1360/5	1	1.5	0.4
V2-1360/5	1	1.6	0.3
V2-1360/5	1	1.4	0.3

Locus #	Poaceae Type	Height (mm)	Width (mm)
V2-1360/5	2	1.2	0.4
V2-1360/5	2	1.5	0.5
V2-1360/5	2	1.4	0.4
V2-1360/5	2	1.3	0.4
V2-1360/5	2	1.2	0.4
V2-1360/5	2	1.2	0.4
V2-1360/5	2	1	0.3
V2-1407/13	1	1.5	0.3
V2-1407/13	1	1.4	0.3
V2-1454/6	Piptochaetium	1.4	0.7
V2-2008/1	1	1.6	0.4
V2-2008/1	1	1.5	0.4
V2-2008/1	1	1.8	0.3
V2-2112/2	1	1.5	0.3
V2-2203/10	2	1.2	0.6
V2-2203/10	2	1.1	0.5
V2-2203/10	2	1	0.5
V2-2203/10	2	1	0.5
V2-2204/4	2	1.2	0.5
V2-2210/6	2	1.2	0.5
V2-2210/6	2	1.5	0.5
V2-2213/4	2	1.3	0.5
V2-2213/4	2	1.3	0.5
V2-2213/4	2	1.4	0.5
V2-2213/4	2	1.1	0.5
V2-2213/4	2	1.5	0.5
V2-2213/4	5	1.6	0.5
V2-2213/4	5	1.8	0.5
V2-2256/11	2	1.4	0.6
V2-2259/5	1	1.3	0.3
V2-2259/5	1	1.5	0.4
V2-2305/23	2	1.4	0.4
V2-2305/23	2	1.2	0.4
V2-2305/23	2	1.2	0.5
V2-2344/5	5	2.6	0.9
V2-2344/5	5	2.1	0.8
V2-2344/5	5	2.1	0.7
V2-2357/21	2	1.3	0.5
V2-2357/21	2	1.4	0.5
V2-2359/1	1	1.5	0.3
V2-1074/8	1	1.5	0.3
V2-1358/22	1	1.4	0.4
V2-1358/22	1	1.1	0.5
V2-1033/7	1	1.5	0.2
V2-1074/22	1	1.4	0.2
V2-1149/5	1	1.5	0.2

Locus #	Poaceae Type	Height (mm)	Width (mm)
V2-1149/5	1	1.5	0.2
V2-1149/5	1	1.5	0.3
V2-1041/14	5	2.4	0.7
V2-1041/14	1	1.3	0.3
V2-1009/4	2	1.1	0.3
V2-1009/4	2	1.1	0.3
V2-1009/4	2	1	0.4
V2-1009/4	2	1	0.3
V2-1009/4	2	1.3	0.4
V2-1009/4	2	1.1	0.4
V2-1009/4	2	1.4	0.5
V2-1009/4	1	1.8	0.2
V2-1009/4	1	1.2	0.3
V2-1009/4	1	1.4	0.2
V2-1009/4	1	1.5	0.3
V2-1009/4	1	1.1	0.3
V2-1009/4	1	1.5	0.3
V2-1009/4	1	1.4	0.3
V2-1009/4	1	1.2	0.4
V2-1009/4	1	1.4	0.3
V2-1009/4	1	1.4	0.3

Appendix G. Measurements of *Chenopodium* spp. Seeds

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (µm)
V2-1002/4	1.5	Rounded	Smooth	
V2-1002/4	1.3			
V2-1002/4	1.4			
V2-1002/4	0.75			
V2-1003/2	0.8	Rounded	Smooth	
V2-1003/2	0.8			
V2-1003/2	0.5	Rounded	Smooth	
V2-1003/2	0.9			
V2-1003/2	0.9			
V2-1003/2	1.8	Rounded		
V2-1003/2	1.6	Rounded		
V2-1003/2	1.5			
V2-1003/2	1.2			
V2-1003/2	1.4	Rounded	Smooth	
V2-1007/4	1.3			
V2-1007/4	1.1			
V2-1007/4	1.2			
V2-1007/4	1.4			
V2-1007/4	1.7			
V2-1007/4	1.1			
V2-1007/4	1	Truncate		
V2-1007/4	0.8	Rounded		
V2-1007/4	0.8	Rounded		
V2-1007/4	0.7	Rounded		
V2-1007/4	0.9	Rounded		
V2-1008/7	1.4	Rounded	Smooth	
V2-1008/7	1.2			
V2-1008/7	1.1			
V2-1008/7	1.2			
V2-1008/7	1.1			
V2-1008/7	0.5	Rounded	Smooth	
V2-1008/7	1.1		Smooth	
V2-1008/7	0.8		Smooth	
V2-1008/7	0.8		Smooth	
V2-1008/7	0.8	Rounded	Smooth	
V2-1009/4	1.6	Rounded	Reticulate	
V2-1009/4	1.7	Truncate	Smooth	
V2-1009/4	1.4		Reticulate	
V2-1009/4	1.3	Rounded	Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1009/4	1.2			
V2-1009/4	1	Rounded	Smooth	
V2-1009/4	0.7			
V2-1009/4	0.6		Smooth	
V2-1009/4	0.6			
V2-1009/4	0.7		Smooth	
V2-1033/7	1.7	Truncate	Smooth	
V2-1033/7	1.3	Rounded	Smooth	
V2-1033/7	1.5	Rounded	Smooth	
V2-1033/7	1.5		Reticulate	
V2-1033/7	1.6			
V2-1033/7	0.9		Smooth	
V2-1033/7	0.7		Smooth	
V2-1033/7	0.6		Smooth	
V2-1033/7	0.8		Smooth	
V2-1033/7	0.5			
V2-1035/12	1	Rounded	Smooth	
V2-1035/12	0.9		Smooth	
V2-1035/12	0.9		Smooth	
V2-1035/12	0.6		Smooth	
V2-1035/12	0.8		Smooth	
V2-1035/12	1.4		Smooth	
V2-1035/12	1.8	Rounded		
V2-1035/12	1.5	Truncate	Smooth	
V2-1035/12	1.4			
V2-1035/12	1.7	Rounded	Smooth	
v2-1035/20	1		Smooth	
v2-1035/20	0.9		Smooth	
v2-1035/20	0.7			
V2-1035/20	0.9		Smooth	
V2-1035/20	0.8		Smooth	
V2-1035/20	1.8	Truncate	Smooth	
V2-1035/20	1.7	Rounded	Reticulate	
V2-1035/20	1.4	Rounded	Smooth	
V2-1035/20	1.5	Truncate	Smooth	
V2-1035/20	1.7	Rounded	Smooth	
V2-1038/7	1.3	Rounded	Smooth	
V2-1038/7	0.7		Smooth	
V2-1038/7	1		Smooth	
V2-1038/7	1			
V2-1038/7	0.9		Smooth	
V2-1038/7	1.2	Truncate	Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (µm)
V2-1038/7	1.5		Smooth	
V2-1038/7	1.7			
V2-1038/7	1.4	Rounded	Smooth	
V2-1038/7	1.3	Truncate	Smooth	
V2-1038/9	1.4	Rounded	Smooth	
V2-1038/9	1.3			
V2-1038/9	1.3	Rounded		
V2-1038/9	1.4		Smooth	
V2-1038/9	1.6	Truncate	Smooth	
V2-1038/9	0.9	Rounded		
V2-1038/9	0.9		Smooth	
V2-1038/9	1.2			
V2-1038/9	0.8		Smooth	
V2-1038/9	0.8			
V2-1038/12	1.4	Truncate		
V2-1038/12	1.6	Rounded	Smooth	
V2-1038/12	1.3			
V2-1038/12	1.3		Smooth	
V2-1038/12	1.2			
V2-1038/12	0.8	Rounded	Smooth	
V2-1038/12	0.8		Smooth	
V2-1038/12	0.7		Smooth	
V2-1038/12	1	Truncate	Smooth	
V2-1038/12	0.9	Rounded		
V2-1038/18	1.3	Rounded	Smooth	
V2-1038/18	1.6	Rounded	Smooth	
V2-1038/18	1.5			
V2-1038/18	1.3		Smooth	
V2-1038/18	1.5	Rounded		
V2-1038/18	1.6		Smooth	
V2-1038/18	1.2			
V2-1038/18	1.2			
V2-1038/18	1.2			
V2-1038/18	1			
V2-1038/22	1.6	Rounded	Smooth	
V2-1038/22	1.4		Smooth	
V2-1038/22	1.1		Smooth	
V2-1038/22	1.2			
V2-1038/22	1.1		Smooth	
V2-1038/22	0.7	Truncate		
V2-1038/22	0.6		Smooth	
V2-1038/22	0.7		Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1038/22	0.6		Smooth	
V2-1038/22	0.5			
V2-1038/23	1.4			
V2-1038/23	1.4			
V2-1038/23	1.5			
V2-1038/23	1.1			
V2-1038/23	1			
V2-1038/23	0.7		Smooth	
V2-1038/31	1.6	Rounded	Smooth	
V2-1038/31	1.2	Rounded	Smooth	
V2-1038/31	1.2			
V2-1038/31	1.3			
V2-1038/31	1.2		Smooth	
V2-1038/31	1			
V2-1038/31	1			
V2-1038/31	0.9		Smooth	
V2-1038/31	1.2	Rounded	Smooth	
V2-1038/31	0.5	Rounded	Smooth	
V2-1041/14	0.7		Smooth	
V2-1041/14	0.8		Smooth	
V2-1041/14	0.8	Truncate	Smooth	
V2-1041/14	0.9	Rounded	Smooth	
V2-1041/14	0.6		Smooth	
V2-1041/14	1.8	Rounded	Smooth	
V2-1041/14	1.6	Rounded	Smooth	
V2-1041/14	1.4	Rounded	Smooth	
V2-1041/14	1.5		Smooth	
V2-1041/14	1.4		Smooth	
V2-1041/15	1.1	Rounded	Smooth	
V2-1041/15	1.3	Rounded	Smooth	
V2-1041/15	1.2	Rounded	Smooth	
V2-1041/15	1.5	Rounded	Smooth	
V2-1041/15	1.4	Truncate	Smooth	
V2-1041/15	0.9		Smooth	
V2-1041/15	0.8		Smooth	
V2-1041/15	0.9		Smooth	
V2-1041/15	0.7	Rounded	Smooth	
V2-1041/15	0.8	Rounded	Smooth	
V2-1041/16	1.4	Rounded	Smooth	
V2-1041/16	1.2			
V2-1041/16	1.5	Rounded	Smooth	
V2-1041/16	1.7	Rounded	Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (µm)
V2-1041/16	1.5	Truncate	Smooth	
V2-1041/16	0.9	Rounded	Smooth	
V2-1041/16	1			
V2-1041/16	0.8	Rounded	Smooth	
V2-1041/16	0.7		Smooth	
V2-1041/16	0.8	Truncate	Smooth	
V2-1041/16	1	Truncate	Smooth	
V2-1043/10	1.4	Rounded	Smooth	
V2-1043/10	1.5	Truncate	Smooth	
V2-1043/10	1.1	Rounded	Smooth	
V2-1043/10	1.2			
V2-1043/10	1.7	Truncate	Smooth	
V2-1043/10	0.5		Smooth	
V2-1043/10	0.9			
V2-1043/10	0.6		Smooth	
V2-1043/10	0.9		Smooth	
V2-1043/10	0.4			
V2-1043/25	1.5	Rounded	Smooth	
V2-1043/25	1.3	Rounded	Smooth	
V2-1043/25	1.5	Rounded		
V2-1043/25	1.2	Rounded	Smooth	
V2-1043/25	1.6	Truncate	Smooth	
V2-1043/25	1	Rounded	Smooth	
V2-1043/25	1.2	Truncate	Smooth	
V2-1043/25	0.7		Smooth	
V2-1043/25	0.9		Smooth	
V2-1043/25	0.7	Rounded	Smooth	
V2-1044/8	1.3		Smooth	
V2-1044/8	1.5	Truncate	Reticulate	
V2-1044/8	1.4	Truncate	Smooth	
V2-1044/8	1.4		Smooth	
V2-1044/8	1.3	Rounded	Smooth	
V2-1044/8	0.8	Rounded		
V2-1044/8	1	Rounded	Smooth	
V2-1044/8	0.6			
V2-1044/8	0.8			
V2-1045/13	1.5	Truncate	Smooth	
V2-1045/13	1.8		Smooth	
V2-1045/13	1.7	Truncate	Smooth	
V2-1045/13	1.8	Rounded	Smooth	
V2-1045/13	1.4	Truncate	Smooth	
V2-1045/13	0.9		Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1045/13	1			
V2-1045/13	0.6		Smooth	
V2-1045/13	0.7		Smooth	
V2-1045/13	0.8			
V2-1046/7	1.6	Rounded	Reticulate	
V2-1046/7	1.3	Rounded	Smooth	
V2-1046/7	1.6	Truncate	Smooth	
V2-1046/7	1.2		Smooth	
V2-1046/7	1.2		Smooth	
V2-1046/7	1	Rounded	Smooth	
V2-1046/7	0.8	Biconvex	Smooth	
V2-1046/7	0.9		Smooth	
V2-1046/7	0.9		Smooth	
V2-1046/7	0.8	Rounded	Smooth	
V2-1046/8	1.4	Truncate	Smooth	
V2-1046/8	1.5	Truncate	Smooth	
V2-1046/8	1.6	Truncate	Smooth	
V2-1046/8	1.5	Rounded	Smooth	
V2-1046/8	1.4			
V2-1046/8	0.8	Truncate	Smooth	
V2-1046/8	0.6	Rounded	Smooth	
V2-1046/8	0.7		Smooth	
V2-1046/8	0.8	Rounded	Smooth	
V2-1046/8	0.9	Rounded	Smooth	
V2-1046/9	1.8	Rounded	Smooth	
V2-1046/9	1.6	Truncate	Smooth	
V2-1046/9	1.6	Rounded	Smooth	
V2-1046/9	1.5	Truncate	Smooth	
V2-1046/9	1.7			
V2-1046/9	1	Rounded	Smooth	
V2-1046/9	0.7		Smooth	
V2-1046/9	1.1	Rounded	Smooth	
V2-1046/9	0.6		Smooth	
V2-1046/9	0.7		Smooth	
V2-1046/12	1.6	Rounded	Smooth	
V2-1046/12	1.4	Rounded	Smooth	
V2-1046/12	1.6	Truncate	Smooth	
V2-1046/12	1.5	Truncate	Smooth	
V2-1046/12	1.6	Truncate	Smooth	
V2-1046/12	1	Truncate	Smooth	
V2-1046/12	0.9		Smooth	
V2-1046/12	1	Rounded		

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1046/12	0.9			
V2-1046/12	0.7			
V2-1046/21	1.5	Truncate	Smooth	
V2-1046/21	1.8	Rounded	Smooth	
V2-1046/21	1.6	Rounded	Smooth	
V2-1046/21	1.3		Smooth	
V2-1046/21	1.5	Truncate	Smooth	
V2-1046/21	1	Rounded	Smooth	
V2-1046/21	0.8	Rounded	Smooth	
V2-1046/21	0.8		Smooth	
V2-1046/21	0.8		Smooth	
V2-1046/21	0.9		Smooth	
V2-1046/22	1.3	Rounded	Smooth	
V2-1046/22	1.4	Truncate	Smooth	
V2-1046/22	1.5	Truncate	Smooth	
V2-1046/22	1.6	Truncate	Smooth	
V2-1046/22	1.5	Truncate	Smooth	
V2-1046/22	0.6		Smooth	
V2-1046/22	0.7	Rounded	Smooth	
V2-1046/22	0.8	Biconvex	Smooth	
V2-1046/22	0.8			
V2-1046/22	0.7		Smooth	
V2-1060/5	1.7		Smooth	
V2-1060/5	1.5		Smooth	
V2-1060/5	1.5	Truncate	Smooth	
V2-1060/5	1.5	Truncate	Smooth	
V2-1060/5	1.3			
V2-1060/5	1	Rounded	Smooth	
V2-1060/5	0.9		Smooth	
V2-1060/5	0.9	Rounded	Smooth	
V2-1060/5	0.9	Biconvex	Smooth	
V2-1060/5	0.9		Smooth	
V2-1060/5	0.7	Rounded		
V2-1061/5	1.4			
V2-1061/5	0.9		Smooth	
V2-1061/5	0.8			
V2-1061/5	0.8			
V2-1061/5	0.9			
V2-1061/5	0.9			
V2-1061/5	0.9			
V2-1066/5	1.6	Truncate	Smooth	
V2-1066/5	1.3	Rounded	Reticulate	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1066/5	1.6	Rounded	Smooth	
V2-1066/5	1.7	Rounded	Reticulate	
V2-1066/5	1.7	Truncate	Smooth	
V2-1066/5	0.8	Rounded	Smooth	
V2-1066/5	1	Rounded	Smooth	
V2-1066/5	0.9		Smooth	
V2-1066/5	0.8	Rounded		
V2-1066/5	0.8			
V2-1070/4	1.4	Rounded	Smooth	
V2-1070/4	1.4	Truncate	Smooth	
V2-1070/4	1.6	Rounded	Smooth	
V2-1070/4	1.4		Smooth	
V2-1070/4	1.7	Truncate	Smooth	
V2-1070/4	0.7	Rounded	Smooth	
V2-1070/4	0.8		Smooth	
V2-1070/4	0.8	Rounded	Smooth	
V2-1070/4	0.9		Smooth	
V2-1070/4	1		Smooth	
V2-1071/4	1.7	Rounded	Smooth	
V2-1071/4	1.4	Truncate	Smooth	
V2-1071/4	1.4	Rounded	Smooth	
V2-1071/4	1.3	Rounded	Smooth	
V2-1071/4	1.3			
V2-1071/4	1	Truncate		
V2-1071/4	0.7	Rounded	Smooth	
V2-1071/4	0.6	Rounded	Smooth	
V2-1071/4	0.8	Rounded		
V2-1071/4	0.6	Rounded	Smooth	
V2-1072/1	1.6	Rounded	Smooth	
V2-1072/1	1.3		Smooth	
V2-1072/1	1.4	Rounded	Smooth	
V2-1072/1	1.4	Rounded	Smooth	
V2-1072/1	1.5	Truncate	Reticulate	
V2-1072/1	1.2	Rounded	Smooth	
V2-1072/1	0.8	Rounded	Smooth	
V2-1072/1	0.9	Truncate	Reticulate	
V2-1072/1	1	Rounded	Smooth	
V2-1072/1	0.8	Rounded	Smooth	
V2-1073/4	1.6			
V2-1073/4	1.2	Rounded		
V2-1073/4	1.4	Rounded	Smooth	
V2-1073/4	1.4		Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1073/4	1.5	Truncate	Smooth	
V2-1073/4	1	Rounded	Smooth	
V2-1073/4	0.9	Rounded		
V2-1073/4	1		Smooth	
V2-1073/4	0.7	Rounded	Smooth	
V2-1073/4	0.9	Rounded	Smooth	
V2-1074/5	1.7	Truncate	Smooth	
V2-1074/5	1.3	Rounded	Smooth	
V2-1074/5	1.2			
V2-1074/5	1.5			
V2-1074/5	1.6			
V2-1074/5	0.7		Smooth	
V2-1074/5	0.8			
V2-1074/5	0.6			
V2-1074/5	0.9			
V2-1074/5	0.7		Smooth	
V2-1074/8	1.5	Rounded		
V2-1074/8	1.7	Rounded	Smooth	
V2-1074/8	1.4	Rounded		
V2-1074/8	1.2		Smooth	
V2-1074/8	1.5	Rounded	Smooth	
V2-1074/8	1	Rounded	Smooth	
V2-1074/8	1	Rounded	Smooth	
V2-1074/8	0.6		Smooth	
V2-1074/8	0.7	Biconvex	Smooth	
V2-1074/8	0.9	Rounded	Smooth	
V2-1074/22	1.4		Smooth	
V2-1074/22	1.3		Smooth	
V2-1074/22	1.6			
V2-1074/22	1.3			
V2-1074/22	1		Smooth	
V2-1074/22	0.9			
V2-1074/22	1		Canaliculate	
V2-1083/2	1.1			
V2-1083/2	1.4			
V2-1083/2	1.2			
V2-1083/2	1.3			
V2-1083/2	1.4			
V2-1083/2	1			
V2-1083/2	1.7		Smooth	
V2-1083/2	0.8			
V2-1083/2	0.9			

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1083/2	1			
V2-1114/4	1.5	Truncate	Smooth	
V2-1114/4	1.7	Truncate	Smooth	
V2-1114/4	1.4	Rounded	Smooth	
V2-1114/4	1.5	Rounded	Smooth	
V2-1114/4	1.5		Smooth	
V2-1114/4	0.9			
V2-1114/4	0.8		Smooth	
V2-1114/4	0.6	Rounded	Smooth	
V2-1114/4	0.7		Smooth	
V2-1114/4	0.9	Rounded	Smooth	
V2-1114/14	1.5	Rounded	Smooth	
V2-1114/14	1.3		Smooth	
V2-1114/14	1.2	Rounded	Smooth	
V2-1114/14	1.5	Rounded	Smooth	
V2-1114/14	2	Truncate		
V2-1114/14	0.7		Smooth	
V2-1114/14	1	Rounded	Smooth	
V2-1114/14	1		Smooth	
V2-1114/14	0.5			
V2-1114/14	0.9	Rounded	Smooth	
V2-1116/13	1.4	Rounded	Smooth	
V2-1116/13	1.3	Truncate	Smooth	
V2-1116/13	1.3	Rounded	Reticulate	
V2-1116/13	1.5	Truncate	Smooth	
V2-1116/13	1.1		Smooth	
V2-1116/13	0.5	Rounded	Smooth	
V2-1116/13	1		Smooth	
V2-1116/13	0.9	Rounded	Smooth	
V2-1116/13	0.9		Smooth	
V2-1116/13	1	Rounded	Smooth	
V2-1116/14	1.8	Truncate	Smooth	
V2-1116/14	1.5		Smooth	
V2-1116/14	1.5	Rounded	Smooth	
V2-1116/14	2	Rounded	Smooth	
V2-1116/14	1.6	Truncate		
V2-1116/14	1.1	Truncate	Canaliculate	
V2-1116/14	0.9	Rounded	Smooth	
V2-1116/14	0.9		Smooth	
V2-1116/14	0.6	Rounded	Smooth	
V2-1116/14	0.7		Smooth	
V2-1124/21	1.7	Rounded	Canaliculate	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1124/26	1		Smooth	
V2-1128/5	1.8	Truncate	Smooth	
V2-1128/5	1.2	Rounded	Smooth	
V2-1128/5	1.8	Rounded	Smooth	
V2-1128/5	1.5	Rounded		
V2-1128/5	1.8	Truncate	Reticulate	
V2-1128/5	0.9	Rounded	Canaliculate	
V2-1128/5	0.8		Smooth	
V2-1128/5	1	Rounded	Smooth	
V2-1128/5	0.8		Smooth	
V2-1128/5	1	Rounded	Smooth	
V2-1128/6	1.2		Smooth	
V2-1128/6	1.4		Smooth	
V2-1128/6	1.2			
V2-1128/6	1.3			
V2-1128/6	1.5		Smooth	
V2-1128/6	1.5			
V2-1142/15	1.8	Truncate	Smooth	
V2-1142/15	1.8	Rounded	Reticulate	
V2-1142/15	1.5	Truncate	Smooth	
V2-1142/15	1.4	Rounded	Smooth	
V2-1142/15	1.9	Rounded	Smooth	
V2-1142/15	0.9	Rounded	Canaliculate	
V2-1142/15	1.1	Rounded	Smooth	
V2-1142/15	1	Rounded	Smooth	
V2-1142/15	0.9		Smooth	
V2-1142/15	0.8		Smooth	
V2-1144/2	1.8	Rounded	Smooth	
V2-1144/2	1.3		Smooth	
V2-1144/2	1.7	Truncate	Smooth	
V2-1144/2	1.2		Smooth	
V2-1144/2	1.7	Rounded	Smooth	
V2-1144/2	0.9	Rounded	Smooth	
V2-1144/2	0.7		Smooth	
V2-1144/2	0.7		Smooth	
V2-1144/2	0.8		Smooth	
V2-1144/2	0.7		Canaliculate	
V2-1124/26	1		Smooth	
V2-1146/2	1.6	Rounded	Smooth	
V2-1146/2	1.6	Truncate	Smooth	
V2-1146/2	1.5		Smooth	
V2-1146/2	1.6	Truncate		

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1146/2	1.5	Truncate	Reticulate	
V2-1146/2	0.9	Rounded	Smooth	
V2-1146/2	1		Smooth	
V2-1146/2	0.7		Smooth	
V2-1146/2	0.8		Smooth	
V2-1146/2	1.1		Smooth	
V2-1146/2	1.6	Truncate	Smooth	4.75
V2-1146/2	1.7	Rounded	Smooth	5.2
V2-1146/2	1.6	Rounded	Smooth	2.7
V2-1146/2	1.5	Rounded	Smooth	3.4
V2-1146/2	1.5	Rounded	Smooth	5.5
V2-1146/2	1.8	Rounded	Smooth	4.4
V2-1146/2	1.8	Rounded	Smooth	19.5
V2-1146/2	1.7	Rounded	Smooth	4.5
V2-1146/2	1.7	Truncate	Smooth	
V2-1146/2	1.7	Truncate	Smooth	8.4
V2-1146/2	0.7	Rounded	Smooth	21.9
V2-1146/2	1	Truncate	Smooth	2.5
V2-1146/2	0.8	Rounded	Smooth	14.6
V2-1146/2	0.9		Smooth	8.8
V2-1146/2	1	Rounded	Smooth	6.7
V2-1146/2	0.9	Rounded	Smooth	11.2
V2-1146/2	0.8	Rounded	Smooth	12.5
V2-1146/2	0.7	Rounded	Smooth	13
V2-1146/2	0.7	Rounded	Smooth	36.8
V2-1146/2	0.9		Smooth	5.6
V2-1147/9	1.7	Truncate	Smooth	
V2-1147/9	1.8	Rounded	Smooth	
V2-1147/9	1.8	Rounded	Smooth	
V2-1147/9	1.3	Rounded	Smooth	
V2-1147/9	1.3		Smooth	
V2-1147/9	0.9		Smooth	
V2-1147/9	0.8	Rounded	Smooth	
V2-1147/9	0.9		Smooth	
V2-1147/9	0.9		Smooth	
V2-1147/9	1			
V2-1149/5	1.6	Truncate	Smooth	
V2-1149/5	1.7	Truncate		
V2-1149/5	1.5	Truncate	Smooth	
V2-1149/5	1.3			
V2-1149/5	1.6	Rounded	Smooth	
V2-1149/5	0.8		Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (µm)
V2-1149/5	1	Rounded	Smooth	
V2-1149/5	0.7			
V2-1149/5	0.7		Smooth	
V2-1149/5	0.8		Smooth	
V2-1150/2	1.5	Truncate	Smooth	
V2-1150/2	1.6	Rounded	Reticulate	
V2-1150/2	1.6	Rounded	Smooth	
V2-1150/2	1.5	Rounded	Smooth	
V2-1150/2	1.8	Truncate	Smooth	
V2-1150/2	0.8		Smooth	
V2-1150/2	0.9		Smooth	
V2-1150/2	1	Rounded	Smooth	
V2-1150/2	0.9		Smooth	
V2-1150/2	0.8			
V2-1150/4	1.5	Truncate	Smooth	
V2-1150/4	1.6	Truncate	Smooth	
V2-1150/4	1.4	Rounded	Smooth	
V2-1150/4	1.5	Rounded	Smooth	
V2-1150/4	1.7	Rounded		
V2-1150/4	1	Truncate	Smooth	
V2-1150/4	1	Rounded	Smooth	
V2-1150/4	0.9		Smooth	
V2-1150/4	1	Rounded	Smooth	
V2-1150/4	0.8		Smooth	
V2-1258/1	1.2	Rounded	Smooth	
V2-1258/1	1.4		Canaliculate	
V2-1258/1	1.6		Smooth	
V2-1258/1	1.4		Smooth	
V2-1258/1	1.3			
V2-1258/1	0.8	Truncate	Smooth	
V2-1258/1	0.9		Smooth	
V2-1258/1	0.8	Rounded	Smooth	
V2-1258/1	0.6		Smooth	
V2-1258/1	0.8		Smooth	
V2-1503/5	1.7	Truncate	Smooth	
V2-1503/5	1.5	Biconvex		
V2-1503/5	1.1			
V2-1503/5	1.6	Rounded	Smooth	
V2-1503/5	1.5		Smooth	
V2-1503/5	0.8		Smooth	
V2-1503/5	0.9			
V2-1503/5	0.5	Biconvex		

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1503/5	0.8			
V2-1503/5	0.9			
V2-1303/11	1.6	Rounded	Smooth	
V2-1303/11	1.5	Rounded	Smooth	
V2-1303/11	1.6	Rounded	Smooth	
V2-1303/11	1.4	Rounded	Smooth	
V2-1303/11	1.7		Smooth	
V2-1303/11	1	Truncate	Smooth	
V2-1303/11	1	Truncate	Smooth	
V2-1303/11	0.9	Rounded	Smooth	
V2-1303/11	0.7	Rounded	Smooth	
V2-1303/11	0.9			
V2-1306/2	1.4	Rounded		
V2-1306/2	1.5	Rounded	Smooth	
V2-1306/2	1.6	Truncate	Smooth	
V2-1306/2	1.3		Smooth	
V2-1306/2	1.4	Truncate	Smooth	
V2-1306/2	0.9	Rounded	Smooth	
V2-1306/2	1	Rounded	Smooth	
V2-1306/2	0.7		Smooth	
V2-1306/2	0.7	Rounded	Smooth	
V2-1306/2	0.6			
V2-1309/1	1.1			
V2-1309/1	1.4			
V2-1309/1	1.3			
V2-1309/1	1.4			
V2-1309/1	0.8			
V2-1309/1	0.9	Rounded	Smooth	
V2-1309/1	1.1	Rounded	Smooth	
V2-1309/1	1			
V2-1309/1	0.8			
V2-1309/1	0.8			
V2-1356/16	1.5	Rounded	Smooth	
V2-1356/16	1.5	Rounded	Smooth	
V2-1356/16	1.3			
V2-1356/16	1.6		Smooth	
V2-1356/16	1.5			
V2-1356/16	0.9		Canaliculate	
V2-1356/16	1	Rounded	Smooth	
V2-1356/16	1.1		Smooth	
V2-1356/16	1		Smooth	
V2-1356/16	0.9			

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1358/21	1.2	Truncate	Smooth	
V2-1358/21	1.5	Truncate	Smooth	
V2-1358/21	1.7	Rounded	Smooth	
V2-1358/21	1.4			
V2-1358/21	1.5	Rounded	Smooth	
V2-1358/21	1	Rounded	Smooth	
V2-1358/21	1	Rounded	Smooth	
V2-1358/21	0.8		Smooth	
V2-1358/21	0.7		Smooth	
V2-1358/21	0.8			
V2-1358/22	1.7	Rounded		
V2-1358/22	1.6	Rounded	Smooth	
V2-1358/22	1.6	Rounded	Smooth	
V2-1358/22	1.4		Smooth	
V2-1358/22	1.6	Rounded	Smooth	
V2-1358/22	0.8		Smooth	
V2-1358/22	0.9		Smooth	
V2-1358/22	0.8			
V2-1358/22	0.9			
V2-1358/22	0.6		Smooth	
V2-1360/5	1.4	Truncate	Smooth	
V2-1360/5	1.6	Truncate	Smooth	
V2-1360/5	1.6	Truncate	Smooth	
V2-1360/5	1.5	Rounded	Smooth	
V2-1360/5	1.7	Rounded	Smooth	
V2-1360/5	2	Rounded	Smooth	
V2-1360/5	0.9	Rounded	Smooth	
V2-1360/5	0.8	Rounded	Smooth	
V2-1360/5	0.6	Rounded	Smooth	
V2-1360/5	0.9		Smooth	
V2-1364/4	1.2	Rounded	Smooth	
V2-1402/1	1.3	Rounded		
V2-1402/1	1.6	Rounded	Smooth	
V2-1402/1	1.6	Truncate	Smooth	
V2-1402/1	1.7	Rounded		
V2-1402/1	1.3	Rounded		
V2-1402/1	0.9		Smooth	
V2-1402/1	0.6			
V2-1402/1	1	Rounded	Smooth	
V2-1402/1	0.8	Rounded		
V2-1402/1	1.1	Rounded	Smooth	
V2-1402/3	1.5	Rounded	Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-1402/3	1.5		Smooth	
V2-1402/3	1.5	Rounded	Smooth	
V2-1402/3	1.4		Smooth	
V2-1402/3	1.1		Smooth	
V2-1402/3	0.8			
V2-1402/3	0.8		Smooth	
V2-1402/3	0.8	Rounded	Smooth	
V2-1402/3	0.7			
V2-1402/3	0.8		Smooth	
V2-1402/4	1.5	Rounded	Smooth	
V2-1402/4	1.4	Rounded	Smooth	
V2-1402/4	1.7	Truncate	Smooth	
V2-1402/4	1			
V2-1402/4	1	Rounded	Smooth	
V2-1402/4	1.8		Smooth	
V2-1402/4	0.9		Smooth	
V2-1402/4	0.6		Smooth	
V2-1402/4	1	Rounded		
V2-1402/4	0.8			
V2-1402/11	1.5		Smooth	
V2-1402/11	1.4	Truncate		
V2-1402/11	1.6		Smooth	
V2-1402/11	1.2			
V2-1402/11	1.4		Smooth	
V2-1402/11	1	Rounded	Smooth	
V2-1402/11	1	Rounded	Smooth	
V2-1402/11	0.9		Smooth	
V2-1402/11	1	Rounded	Smooth	
V2-1402/11	0.8	Rounded	Smooth	
V2-1407/4	1	Rounded	Smooth	
V2-1407/4	0.8			
V2-1407/4	0.7			
V2-1407/12	1.3	Truncate	Smooth	
V2-1407/12	1	Rounded		
V2-1407/12	1	Rounded		
V2-1407/12	1.1	Truncate		
V2-1407/12	0.6		Smooth	
V2-1407/12	0.7	Rounded	Smooth	
V2-1407/12	0.5		Smooth	
V2-1407/12	0.5		Smooth	
V2-1407/12	0.4			
V2-1407/12	0.5		Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (µm)
V2-1407/13	1.6	Rounded	Smooth	
V2-1407/13	1.5	Truncate	Smooth	
V2-1407/13	1.6		Smooth	
V2-1407/13	1.4		Smooth	
V2-1407/13	1.9		Reticulate	
V2-1407/13	0.7		Smooth	
V2-1407/13	0.6	Rounded	Smooth	
V2-1407/13	1	Rounded	Smooth	
V2-1407/13	1		Smooth	
V2-1407/13	0.8		Smooth	
V2-1408/3	1.4	Biconvex	Reticulate	
V2-1408/3	1.5		Smooth	
V2-1408/3	1.4			
V2-1408/3	1.4			
V2-1408/3	1.4			
V2-1408/3	0.8		Smooth	
V2-1408/5	0.7			
V2-1408/5	0.6		Smooth	
V2-1408/5	0.8			
V2-1408/5	0.6			
V2-1408/5	1	Rounded	Smooth	
V2-1409/11	1.5	Rounded	Smooth	
V2-1409/11	1.4	Rounded	Smooth	
V2-1409/11	1.2			
V2-1409/11	1.4			
V2-1409/11	1.6			
V2-1409/11	1		Smooth	
V2-1409/11	0.7			
V2-1409/11	1		Smooth	
V2-1409/11	0.9			
V2-1409/11	0.9			
V2-1453/2	1			
V2-1453/2	0.8		Smooth	
V2-1454/6	1.2	Rounded	Smooth	
V2-1454/6	1.1	Rounded	Smooth	
V2-1454/6	1.9	Rounded	Smooth	
V2-1454/6	1.6	Truncate	Smooth	
V2-1454/6	1.5			
V2-1454/6	0.9	Rounded	Smooth	
V2-1454/6	0.9	Biconvex	Smooth	
V2-1454/6	0.7	Rounded	Smooth	
V2-1454/6	0.9		Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (µm)
V2-1454/6	0.6			
V2-1463/7	1.5	Rounded	Smooth	
V2-1463/7	1.2	Rounded		
V2-1463/7	1.4	Rounded	Smooth	
V2-1469/1	1.1	Rounded		
V2-1469/1	1.8		Smooth	
V2-1469/1	1.2			
V2-1469/1	1.4			
V2-1469/1	1.4			
V2-1469/1	0.6		Smooth	
V2-1469/1	1	Rounded	Smooth	
V2-1469/1	0.7	Truncate	Smooth	
V2-1469/1	0.9	Rounded	Smooth	
V2-1469/1	1	Rounded	Smooth	
V2-1476/4	1.2			
V2-1476/4	1.5			
V2-1476/4	1.2			
V2-1476/4	0.9		Smooth	
V2-1480/4	1.4			
V2-1480/4	1.5			
V2-1480/4	1.2			
V2-1480/4	1.5			
V2-1480/4	1.2			
V2-1480/4	1		Smooth	
V2-1480/4	0.8		Smooth	
V2-1480/4	0.9		Smooth	
V2-1480/4	0.7			
V2-1480/4	0.5			
V2-2007/5	1.5	Truncate	Smooth	
V2-2007/5	1.7	Rounded	Smooth	
V2-2007/5	1.7	Truncate	Smooth	
V2-2007/5	1.2		Smooth	
V2-2007/5	1	Rounded	Smooth	
V2-2007/5	0.9	Rounded	Smooth	
V2-2007/5	0.8	Rounded	Smooth	
V2-2007/5	0.8	Rounded	Smooth	
V2-2007/5	0.8		Smooth	
V2-2007/5	0.8		Smooth	
V2-2008/1	1.5	Truncate	Smooth	
V2-2008/1	1.5	Truncate	Smooth	
V2-2008/1	1.6	Rounded	Smooth	
V2-2008/1	1.4	Truncate	Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-2008/1	1.6		Smooth	
V2-2008/1	0.7	Rounded	Smooth	
V2-2008/1	0.8	Rounded	Smooth	
V2-2008/1	0.6			
V2-2008/1	0.9	Truncate	Smooth	
V2-2008/1	0.8	Rounded	Smooth	
V2-2154/2	1.4			
V2-2154/2	1.1			
V2-2154/2	0.9			
V2-2154/2	0.6			
V2-2154/2	0.7		Smooth	
V2-2154/2	0.7			
V2-2154/2	0.7			
V2-2154/2	0.7			
V2-2203/10	1.5		Smooth	
V2-2203/10	1.5		Smooth	
V2-2203/10	1.1			
V2-2203/10	1.3			
V2-2203/10	1.5	Rounded		
V2-2203/10	0.8		Smooth	
V2-2203/10	1			
V2-2203/10	0.8		Smooth	
V2-2203/10	0.8		Smooth	
V2-2203/10	0.8		Smooth	
V2-2203/29	1.7		Smooth	
V2-2203/29	1.8		Smooth	
V2-2203/29	1			
V2-2203/29	1.1			
V2-2203/29	0.7		Smooth	
V2-2203/29	0.6			
V2-2203/29	0.8			
V2-2203/29	0.6			
V2-2203/29	0.9		Smooth	
V2-2203/29	0.7			
V2-2204/4	1.7	Truncate	Smooth	
V2-2204/4	1.1		Smooth	
V2-2204/4	1.4	Rounded		
V2-2204/4	1.1			
V2-2204/4	1.5			
V2-2204/4	1	Rounded	Smooth	
V2-2204/4	0.9		Smooth	
V2-2204/4	0.9	Truncate	Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (µm)
V2-2204/4	0.9		Smooth	
V2-2204/4	0.7			
V2-22230/2	1.3			
V2-22230/2	1.4			
V2-22230/2	1.8			
V2-22230/2	0.8	Rounded		
V2-22230/2	0.7		Smooth	
V2-22230/2	1	Rounded	Smooth	
V2-22230/2	0.9			
V2-2331/6	1.3	Truncate	Smooth	
V2-2331/6	1.6	Rounded	Reticulate	
V2-2331/6	1.7	Rounded	Reticulate	
V2-2331/6	1.4		Smooth	
V2-2331/6	1.5	Rounded	Smooth	
V2-2331/6	1.6	Truncate	Smooth	
V2-2255/8	1.5	Truncate	Smooth	
V2-2255/8	1.4		Smooth	
V2-2255/8	1			
V2-2255/8	1.4		Smooth	
V2-2255/8	1.4			
V2-2255/8	1		Smooth	
V2-2255/8	0.9		Smooth	
V2-2255/8	0.8		Smooth	
V2-2255/8	1.1		Smooth	
V2-2255/8	0.5		Smooth	
V2-2256/11	1.4	Rounded	Smooth	
V2-2256/11	1.8	Rounded	Smooth	
V2-2256/11	1.2			
V2-2256/11	1.2	Rounded	Smooth	
V2-2256/11	1.5	Truncate	Smooth	
V2-2256/11	0.5	Rounded	Smooth	
V2-2256/11	0.9		Smooth	
V2-2256/11	0.6	Rounded	Smooth	
V2-2256/11	0.7		Smooth	
V2-2256/11	0.7			
V2-2259/5	1.4	Truncate	Smooth	
V2-2259/5	1.5	Truncate	Smooth	
V2-2259/5	1.6	Rounded	Smooth	
V2-2259/5	1.6	Rounded	Smooth	
V2-2259/5	1.6	Rounded		
V2-2259/5	0.8	Rounded	Smooth	
V2-2259/5	0.8	Rounded	Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-2259/5	0.9		Smooth	
V2-2259/5	0.5		Smooth	
V2-2259/5	0.7		Smooth	
V2-2305/5	1.7	Truncate	Smooth	
V2-2305/5	1.3		Smooth	
V2-2305/5	1.7		Smooth	
V2-2305/5	1.2			
V2-2305/5	1.4			
V2-2305/5	1.2		Smooth	
V2-2305/5	0.6		Smooth	
V2-2305/5	0.9		Smooth	
V2-2305/5	0.9	Rounded	Smooth	
V2-2305/5	0.8			
V2-2305/23	1.6	Truncate	Smooth	
V2-2305/23	1.7			
V2-2305/23	1.6			
V2-2305/23	1.8	Truncate	Smooth	
V2-2305/23	1.4			
V2-2305/23	1.8	Truncate	Smooth	
V2-2305/23	0.7		Smooth	
V2-2305/23	0.8		Smooth	
V2-2305/23	1	Truncate	Smooth	
V2-2305/23	0.9		Smooth	
V2-2305/23	0.5		Smooth	
V2-2329/3	0.7	Rounded	Smooth	19.4
V2-2329/3	1	Equatorially Banded	Reticulate	11.3
V2-2329/3	1	Rounded	Smooth	7.6
V2-2329/3	0.6		Smooth	
V2-2329/3	0.8	Rounded	Smooth	12.6
V2-2329/3	0.8	Rounded	Smooth	12.2
V2-2329/3	0.7	Rounded	Smooth	10.1
V2-2329/3	1	Rounded	Smooth	14.9
V2-2329/3	0.8		Smooth	11.9
V2-2329/3	0.7	Rounded	Smooth	10
V2-2329/3	0.8	Rounded	Smooth	10.1
V2-2329/3	1.5	Truncate	Smooth	
V2-2329/3	1.4	Rounded	Smooth	
V2-2329/3	1.3		Canaliculate	
V2-2329/3	1.7	Rounded		
V2-2329/3	1.5	Rounded	Canaliculate	
V2-2329/3	0.9			
V2-2329/3	0.7		Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-2329/3	0.5		Smooth	
V2-2329/3	0.9	Rounded	Canaliculate	
V2-2329/3	1			
V2-2331/6	1.5	Truncate	Reticulate	8.1
V2-2331/6	1.4	Truncate	Smooth	3.7
V2-2331/6	1.6	Rounded	Reticulate	7
V2-2331/6	1.5	Rounded	Reticulate	8.1
V2-2331/6	1.5	Truncate	Reticulate	6.1
V2-2331/6	1.5	Truncate	Smooth	5
V2-2331/6	1.6	Rounded	Smooth	4.5
V2-2331/6	1.4	Rounded	Smooth	6.2
V2-2331/6	1.8	Rounded	Smooth	8.9
V2-2331/6	1.4	Truncate	Smooth	3.8
V2-2331/6	1.5	Truncate	Smooth	23.2
V2-2331/6	1.5	Truncate	Smooth	
V2-2331/6	1.5	Rounded	Smooth	9.8
V2-2331/6	1.5	Truncate	Smooth	2.5
V2-2331/6	1.7	Truncate	Smooth	4
V2-2331/6	0.8	Rounded	Smooth	16.4
V2-2331/6	0.9	Rounded	Smooth	11.2
V2-2331/6	0.8	Rounded	Smooth	12.1
V2-2331/6	0.9	Rounded	Smooth	5.8
V2-2331/6	0.8	Rounded	Smooth	10.1
V2-2331/6	0.9		Smooth	13.5
V2-2331/6	0.7		Smooth	10
V2-2331/6	0.9	Rounded	Smooth	4
V2-2331/6	0.8	Rounded	Smooth	10.3
V2-2331/6	0.8	Rounded	Smooth	7.6
V2-2340/6	1.5	Truncate	Smooth	
V2-2340/6	1.5	Truncate		
V2-2340/6	1.3			
V2-2340/6	1.6	Rounded	Smooth	
V2-2340/6	1.2		Smooth	
V2-2340/6	0.6		Smooth	
V2-2340/6	0.6		Smooth	
V2-2340/6	0.7		Smooth	
V2-2340/6	0.7		Smooth	
V2-2340/6	0.8			
V2-2354/27	1.5	Truncate	Smooth	
V2-2354/27	1.6	Truncate	Smooth	
V2-2354/27	1.6	Rounded	Canaliculate	
V2-2354/27	1.5		Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (µm)
V2-2354/27	1.4	Rounded	Reticulate	
V2-2354/27	0.7		Smooth	
V2-2354/27	0.7		Smooth	
V2-2354/27	0.6			
V2-2354/27	0.5			
V2-2354/27	1		Canaliculate	
V2-2355/29	1.7		Smooth	
V2-2355/29	1.5		Smooth	
V2-2355/29	1.2	Rounded	Smooth	
V2-2355/29	1.7	Rounded	Smooth	
V2-2355/29	1.6		Smooth	
V2-2355/29	1	Rounded	Smooth	
V2-2355/29	0.8		Smooth	
V2-2355/29	0.7		Smooth	
V2-2355/29	1			
V2-2355/29	0.6		Smooth	
V2-2357/21	1.3		Canaliculate	
V2-2357/21	1.6		Smooth	
V2-2357/21	1.5			
V2-2357/21	1.8		Smooth	
V2-2357/21	1.3		Canaliculate	
V2-2357/21	0.6		Smooth	
V2-2357/21	1	Rounded	Smooth	
V2-2357/21	0.9	Biconvex	Smooth	
V2-2357/21	0.7			
V2-2357/21	0.7		Smooth	
V2-2359/1	1.5		Smooth	
V2-2359/1	1.7	Truncate	Smooth	
V2-2359/1	1.6	Truncate		
V2-2359/1	1.3			
V2-2359/1	1.4	Truncate		
V2-2359/1	0.8	Rounded	Smooth	
V2-2359/1	0.6		Smooth	
V2-2359/1	0.8	Biconvex	Canaliculate	
V2-2359/1	0.8		Smooth	
V2-2359/1	0.9		Smooth	
V2-2361/1	1.2			
V2-2361/1	1.3		Reticulate	
V2-2359/1	1.3	Truncate		
V2-2359/1	1.5			
V2-2359/1	1.4		Reticulate	
V2-2359/1	0.9	Biconvex	Smooth	

Locus #	Chenopod Diameter (mm)	Margin	Testa texture	Testa Thickness (μm)
V2-2359/1	0.7			
V2-2359/1	0.9			
V2-2361/1	0.8		Smooth	
V2-2361/1	0.8			
V2-2506/4	1.5	Truncate	Smooth	
V2-2506/4	1.8	Truncate	Smooth	
V2-2506/4	1.7	Truncate	Smooth	
V2-2506/4	1.8	Truncate	Smooth	
V2-2506/4	1.9	Rounded	Smooth	
V2-2506/4	1.8	Truncate	Smooth	
V2-2506/4	1.7	Truncate	Smooth	
V2-2506/4	1.5			
V2-2506/4	1.8	Truncate	Smooth	
V2-2506/4	1.6	Truncate	Smooth	
V2-2506/4	1.6	Truncate	Smooth	5.5
V2-2506/4	1.7	Rounded	Smooth	3.1
V2-2506/4	1.6	Truncate	Smooth	6.6
V2-2506/4	1.8	Truncate	Smooth	5.2
V2-2506/4	1.7	Truncate	Smooth	6.8
V2-2506/4	1.4	Truncate	Smooth	8.3
V2-2506/4	1.6	Truncate	Smooth	7.4
V2-2506/4	1.6	Truncate	Smooth	4.5
V2-2506/4	1.8	Truncate	Smooth	6.3
V2-2506/4	1.5	Rounded	Smooth	3
V2-2506/4	1.6	Rounded	Smooth	5.7
V2-2506/4	1.5	Truncate	Smooth	3.6
V2-2506/4	1.8	Rounded	Smooth	3
V2-2506/4	1.8	Rounded	Smooth	2.6
V2-2506/4	1.7	Truncate	Smooth	2.4
V2-2506/4	1.7	Truncate	Smooth	4.5
V2-2506/4	1.6	Rounded	Smooth	6.2
V2-2506/4	1.6	Truncate	Smooth	4.2
V2-2506/4	1.7	Rounded	Smooth	16.1
V2-2506/4	1.8	Truncate	Smooth	2.2

Appendix H. Formative and Mixed Time Period Macrobotanical Samples

Locus #	V2-1075/5	V2-1101/5	V2-1307/2	V2-2210/6	V2-2213/4	V2-2257/3	V2-2260/18	V2-2316/9	V2-2318/1
Unit	**44B**	**44B**	**44C**	**118A**	**118A**	**118C**	**118C**	**6A**	**6A**
Phase Assignment	LIP	Formative/LIP	Mixed	LIP (TPQ)	Mixed, Formative	Mixed	Mixed	Formative	Formative
	Cultural deposit inside structure A	Hearth (structure A)	Fill below floor	Fill with Formative Material	Hearth or burning event, Formativo	Exterior (patio) fill or mixed midden	Fill	Use surface with Formative artifacts in siut	Fill with ash and burnt soil, burnt bone
Volume (liters)	5	10	10	10	10	10	10	10	8
Taxa Raw Count									
Chenopodium spp. seeds	44	80	50	71	134	29	28	29	4
Poaceae seed type #1	1								
Poaceae seed type #2		2		2	5				
Poaceae seed type #3	1								
Poaceae type #6			1			5			
Unknown Poaceae seed type	1				7				
Malvaceae seed type #1	2		6	2	11			2	
Malvaceae unknown seed		2	3						
Cyperaceae seed Type #1					2				
Trifolium amabile seeds	6	1		2	15	1			
Relbunium sp. seeds				2	14				
Plantago sp. seeds					1				
Verbena sp. seeds				2					
>2 mm Wood fragments Ct.	8	13	4	6		38	15		
>2 mm Wood Wt. (g)	0.13	0.09	0.06	0.03		0.23	0.21		
>2 mm Parenchyma Ct.	69	39							
>2 mm Parenchyma Wt. (g)	2.68	0.68							
Burned Bone							10		7
Unidentifiable seeds	10			4	1				

Appendix I. Artifacts from Terrace Excavations

Inventory of Artifacts from TZ-3

Box #	Locus	Unit	Material	Count	Weight (g)
201	V2-3128/3	TZ-3	human bone	1	0
201	V2-3130/1	TZ-3	human bone	1	23
201	V2-3130/2	TZ-3	human bone	4	29
201	V2-3130/3	TZ-3	human bone	2	29
201	V2-3130/4	TZ-3	human bone	1	112
201	V2-3130/6	TZ-3	human bone	3	12
202	V2-3101/1	TZ-3	ceramic sherd	4	65.1
202	V2-3102/1	TZ-3	ceramic sherd	34	97
202	V2-3103/1	TZ-3	ceramic sherd	38	183
202	V2-3104/1	TZ-3	ceramic sherd	35	158
202	V2-3105/1	TZ-3	ceramic sherd	62	264
202	V2-3106/1	TZ-3	ceramic sherd	36	322
202	V2-3107/1	TZ-3	ceramic sherd	72	314
202	V2-3107/4	TZ-3	ceramic sherd	6	16
202	V2-3108/1	TZ-3	ceramic sherd	14	53
202	V2-3109/1	TZ-3	ceramic sherd	5	12
202	V2-3110/1	TZ-3	ceramic sherd	26	90
202	V2-3111/1	TZ-3	ceramic sherd	41	131
202	V2-3111/4	TZ-3	ceramic sherd	22	54
202	V2-3111/6	TZ-3	ceramic sherd	60	216
202	V2-3111/9	TZ-3	ceramic sherd	40	141
202	V2-3112/1	TZ-3	ceramic sherd	13	74
202	V2-3113/1	TZ-3	ceramic sherd	38	206
202	V2-3114/1	TZ-3	ceramic sherd	27	138
202	V2-3115/1	TZ-3	ceramic sherd	18	106
202	V2-3116/1	TZ-3	ceramic sherd	36	130
202	V2-3117/1	TZ-3	ceramic sherd	74	378
202	V2-3119/1	TZ-3	ceramic sherd	56	285
203	V2-3120/1	TZ-3	ceramic sherd	17	34
203	V2-3121/2	TZ-3	ceramic sherd	51	283
203	V2-3122/1	TZ-3	ceramic sherd	33	230
203	V2-3123/1	TZ-3	ceramic sherd	30	177

Box #	Locus	Unit	Material	Count	Weight (g)
203	V2-3123/4	TZ-3	ceramic sherd	79	568
203	V2-3124/3	TZ-3	ceramic sherd	1	16
203	V2-3124/4	TZ-3	ceramic sherd	10	71
203	V2-3125/2	TZ-3	ceramic sherd	16	102
203	V2-3125/4	TZ-3	ceramic sherd	30	350
203	V2-3126/1	TZ-3	ceramic sherd	9	41
203	V2-3127/1	TZ-3	ceramic sherd	68	256
203	V2-3127/3	TZ-3	ceramic sherd	64	391
203	V2-3127/6	TZ-3	ceramic sherd	21	104
203	V2-3127/8	TZ-3	ceramic sherd	79	395
203	V2-3128/1	TZ-3	ceramic sherd	131	576
203	V2-3129/1	TZ-3	ceramic sherd	9	47
203	V2-3130/7	TZ-3	ceramic sherd	5	29
203	V2-3130/8	TZ-3	ceramic sherd	49	227
203	V2-3131/1	TZ-3	ceramic sherd	95	392
203	V2-3132/1	TZ-3	ceramic sherd	109	643
203	V2-3133/1	TZ-3	ceramic sherd	23	100
203	V2-3134/1	TZ-3	ceramic sherd	3	5
204	V2-3102/2	TZ-3	lithic	1	6
204	V2-3103/2	TZ-3	lithic	13	366
204	V2-3104/2	TZ-3	lithic	4	44
204	V2-3105/2	TZ-3	lithic	2	16
204	V2-3106/2	TZ-3	lithic	11	39
204	V2-3107/2	TZ-3	lithic	5	318
204	V2-3107/5	TZ-3	lithic	1	4
204	V2-3108/2	TZ-3	lithic	1	2
204	V2-3111/11	TZ-3	lithic	6	55
204	V2-3111/3	TZ-3	lithic	4	136
204	V2-3111/5	TZ-3	lithic	8	155
204	V2-3111/7	TZ-3	lithic	2	2
204	V2-3114/3	TZ-3	lithic	3	24
204	V2-3115/2	TZ-3	lithic	4	60
204	V2-3116/2	TZ-3	lithic	6	37
204	V2-3117/2	TZ-3	lithic	6	24
204	V2-3122/3	TZ-3	lithic	2	5
204	V2-3123/2	TZ-3	lithic	2	1176
204	V2-3123/6	TZ-3	lithic	1	144
204	V2-3124/2	TZ-3	lithic	4	154

Box #	Locus	Unit	Material	Count	Weight (g)
204	V2-3125/5	TZ-3	lithic	1	413
204	V2-3126/2	TZ-3	lithic	1	277
204	V2-3127/4	TZ-3	lithic	4	61
204	V2-3127/7	TZ-3	lithic	2	8
204	V2-3128/2	TZ-3	lithic	8	158
204	V2-3130/9	TZ-3	lithic	5	8
204	V2-3131/2	TZ-3	lithic	3	63
204	V2-3132/3	TZ-3	lithic	2	37
204	V2-3133/2	TZ-3	lithic	6	5
204	V2-3134/3	TZ-3	lithic	1	0
205	V2-3106/3	TZ-3	carbon	27	3
205	V2-3107/3	TZ-3	carbon	23	11
205	V2-3121/1	TZ-3	carbon	1	0.18
205	V2-3121/3	TZ-3	carbon	2	1.03
205	V2-3111/10	TZ-3	animal bone	3	1
205	V2-3111/2	TZ-3	animal bone	7	3
205	V2-3111/8	TZ-3	animal bone	6	2
205	V2-3114/2	TZ-3	animal bone	2	24
205	V2-3115/3	TZ-3	animal bone	1	2
205	V2-3121/4	TZ-3	animal bone	30	45
205	V2-3122/2	TZ-3	animal bone	6	32
205	V2-3123/3	TZ-3	animal bone	8	27
205	V2-3123/5	TZ-3	animal bone	40	104
205	V2-3124/1	TZ-3	animal bone	9	24
205	V2-3124/5	TZ-3	animal bone	13	16
205	V2-3125/1	TZ-3	animal bone	20	20
205	V2-3125/3	TZ-3	animal bone	30	145
205	V2-3127/2	TZ-3	animal bone	8	20
205	V2-3127/5	TZ-3	animal bone	14	34
205	V2-3127/9	TZ-3	animal bone	2	9
205	V2-3132/2	TZ-3	animal bone	13	52
205	V2-3134/2	TZ-3	animal bone	21	27
205	V2-3135/1	TZ-3	animal bone	1	0
205	V2-3119/3	TZ-3	flotation sample	N/A	29

Inventory of Artifacts from TZ-4

Box #	Locus	Unit	Material	Count	Weight (g)
202	V2-3001/1	TZ-4	ceramic sherd	65	170.1
202	V2-3002/1	TZ-4	ceramic sherd	89	302.5
202	V2-3002/3	TZ-4	ceramic sherd	1	399
202	V2-3003/1	TZ-4	ceramic sherd	16	92.8
202	V2-3004/1	TZ-4	ceramic sherd	7	16.3
202	V2-3005/1	TZ-4	ceramic sherd	18	51.4
202	V2-3006/1	TZ-4	ceramic sherd	9	39.6
202	V2-3008/1	TZ-4	ceramic sherd	83	197
202	V2-3009/1	TZ-4	ceramic sherd	49	91
202	V2-3010/1	TZ-4	ceramic sherd	36	55
202	V2-3011/1	TZ-4	ceramic sherd	75	204
202	V2-3012/1	TZ-4	ceramic sherd	38	107
202	V2-3013/1	TZ-4	ceramic sherd	27	62
202	V2-3014/1	TZ-4	ceramic sherd	26	51
202	V2-3015/1	TZ-4	ceramic sherd	42	112
202	V2-3016/1	TZ-4	ceramic sherd	3	15
204	V2-3001/2	TZ-4	lithic	2	70
204	V2-3001/3	TZ-4	lithic	1	880
204	V2-3002/2	TZ-4	lithic	29	79.3
204	V2-3003/2	TZ-4	lithic	2	97.3
204	V2-3004/2	TZ-4	lithic	2	1.4
204	V2-3005/2	TZ-4	lithic	1	1.4
204	V2-3008/2	TZ-4	lithic	1	2
204	V2-3009/2	TZ-4	lithic	6	13
204	V2-3010/2	TZ-4	lithic	4	5
204	V2-3011/2	TZ-4	lithic	5	78
204	V2-3012/2	TZ-4	lithic	2	2
204	V2-3013/2	TZ-4	lithic	1	5
204	V2-3015/2	TZ-4	lithic	1	2
205	V2-3004/3	TZ-4	flotation sample	N/A	86
205	V2-3010/3	TZ-4	flotation sample	N/A	203
205	V2-3014/3	TZ-4	flotation sample	N/A	88

Inventory of Artifacts from TZ-5

Box #	Locus	Unit	Material	Count	Weight (g)
203	V2-3201/1	TZ-5	ceramic sherd	2	4.1
203	V2-3202/1	TZ-5	ceramic sherd	4	2.6
203	V2-3203/1	TZ-5	ceramic sherd	4	5.9
203	V2-3204/1	TZ-5	ceramic sherd	5	13.5
203	V2-3207/1	TZ-5	ceramic sherd	3	72
203	V2-3208/1	TZ-5	ceramic sherd	3	37
203	V2-3209/3	TZ-5	ceramic sherd	3	6
203	V2-3212/1	TZ-5	ceramic sherd	2	2
203	V2-3213/1	TZ-5	ceramic sherd	1	0.4
203	V2-3214/2	TZ-5	ceramic sherd	3	10
203	V2-3215/2	TZ-5	ceramic sherd	5	44
204	V2-3202/2	TZ-5	lithic	4	6.1
204	V2-3203/2	TZ-5	lithic	1	2
204	V2-3204/2	TZ-5	lithic	2	18.8
204	V2-3205/1	TZ-5	lithic	1	9.4
204	V2-3206/1	TZ-5	lithic	1	8
204	V2-3208/2	TZ-5	lithic	1	141
204	V2-3209/1	TZ-5	lithic	1	353
205	V2-3215/1	TZ-5	flotation sample	N/A	117
205	V2-3209/2	TZ-5	animal bone	1	1.13
205	V2-3214/1	TZ-5	animal bone	9	3.29

Inventory of Artifacts from TZ-6

Box #	Locus	Unit	Material	Count	Weight (g)
203	V2-3301/1	TZ-6	ceramic sherd	6	11.2
203	V2-3302/1	TZ-6	ceramic sherd	43	104
203	V2-3302/4	TZ-6	ceramic sherd	9	35
203	V2-3303/1	TZ-6	ceramic sherd	15	69
203	V2-3304/1	TZ-6	ceramic sherd	6	9
203	V2-3305/2	TZ-6	ceramic sherd	2	3
203	V2-3306/1	TZ-6	ceramic sherd	1	3
203	V2-3307/1	TZ-6	ceramic sherd	2	13
203	V2-3308/1	TZ-6	ceramic sherd	8	37
203	V2-3309/1	TZ-6	ceramic sherd	5	42
203	V2-3310/1	TZ-6	ceramic sherd	4	47
203	V2-3311/1	TZ-6	ceramic sherd	3	9
203	V2-3315/2	TZ-6	ceramic sherd	3	16
203	V2-3317/2	TZ-6	ceramic sherd	1	5
203	V2-3318/1	TZ-6	ceramic sherd	1	0
203	V2-3319/1	TZ-6	ceramic sherd	12	82
203	V2-3320/2	TZ-6	ceramic sherd	6	32
203	V2-3321/2	TZ-6	ceramic sherd	3	6
203	V2-3322/1	TZ-6	ceramic sherd	3	9
203	V2-3325/1	TZ-6	ceramic sherd	9	39
204	V2-3302/2	TZ-6	lithic	2	2
204	V2-3312/1	TZ-6	lithic	1	17
204	V2-3324/1	TZ-6	lithic	3	99
204	V2-3325/2	TZ-6	lithic	6	15
205	V2-3317/1	TZ-6	carbon	1	19
205	V2-3320/1	TZ-6	carbon	1	8
205	V2-3302/3	TZ-6	animal bone	4	0.2
205	V2-3305/1	TZ-6	animal bone	12	14
205	V2-3308/2	TZ-6	animal bone	1	0.48
205	V2-3309/2	TZ-6	animal bone	1	19
205	V2-3314/1	TZ-6	animal bone	4	4
205	V2-3315/1	TZ-6	animal bone	9	6
205	V2-3317/3	TZ-6	animal bone	6	9
205	V2-3318/2	TZ-6	animal bone	5	2

Box #	Locus	Unit	Material	Count	Weight (g)
205	V2-3319/2	TZ-6	animal bone	4	0
205	V2-3320/3	TZ-6	animal bone	8	16
205	V2-3321/1	TZ-6	animal bone	4	8
205	V2-3323/1	TZ-6	animal bone	7	25
205	V2-3313/1	TZ-6	flotation sample	N/A	147