FOOD, FEASTS, AND THE CONSTRUCTION OF IDENTITY AND POWER IN ANCIENT TIWANAKU: A BIOARCHAEOLOGICAL PERSPECTIVE

By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

State Formation and Social Identity: Insights from Tiwanaku

In this dissertation, I investigate early state development from a bioarchaeological perspective, elucidating how access to food and food choices may reflect and structure social identity as well as how food related practices, such as feasting, are involved in the construction of political authority. Specifically, I analyze human skeletal remains to examine the relationship between dramatic changes in Andean culinary traditions and the development of one of the earliest state level societies in the New World, Tiwanaku. By analyzing the diets of individuals who lived in the Tiwanaku heartland before, during, and after the development of the state, it will be shown that the manipulation of certain socially valued foods played an important role in the actual constitution of power structures within Tiwanaku society. Further, once these structures of power were established, certain food practices continued to legitimize and naturalize asymmetries of social power. However, before delving further into the specifics of the Tiwanaku case study, it is necessary to provide a brief discussion of anthropological approaches to state development, in order to clarify my own research perspective.

Approaches to studying cultural change and early state development have changed significantly over the past half century. In the 1960's, cultural evolutionists, noting the common developmental trajectories of many societies, developed typologies based on what they saw as increasing levels of political, social, and economic organization. They argued that this evolutionary ordering reflected sequential stages of social development through which societies passed, and that categorization facilitated comparisons between societies. The most influential of these typologies were Fried's (1960) egalitarian-ranked-stratified and Sahlins and Services' (1960) band-tribe-chiefdom-state categories. Because these typologies encouraged archaeologists to fit societies in pre-defined categories, such models were heavily criticized for representing each stage of evolution (i.e. chiefdom, state, etc…) as overly static and lacking diversity (Crumley 1987, 1995; Ehrenreich et al. 1995; Mann 1986; Patterson and Gailey 1987). Ancient states were generally conceived of as "the same sort of thing: large territorial systems ruled by totalitarian despots who controlled the flow of goods, services, and information and imposed true law and order on their subjects." (Yoffee 2005:2). Such a perspective led many early researchers to take a "top-down" approach to the study of ancient states, which was primarily concerned with how more hierarchical and centralized social, political, and economic structures of the state managed resources and people. This approach treated "the state" as though it were a living entity with its own purposes and motivations and largely ignored the role of individual or collective human agency in social change. Archaeologists now recognize the enormous diversity of the kinds of states that existed, their dynamic nature, and the recursive relationship between social structure and human agency (see Giddens 1979). This shift in perspective has led many to embrace a "bottom-up" perspective, which seeks to understand what social actors at *all* levels in these state societies did and the variety of ways their actions created, maintained, and contested the structures of political authority, even as their actions were recursively being shaped by those structures.

This dissertation makes a contribution to the study of early states by offering both a top-down perspective, in its consideration of the larger political economy, and a bottom-up perspective, considering how individual choices about food consumption contributed to and were impacted by political transformation. Bioarchaeological studies are uniquely suited to accessing the bottom-up perspective by providing insight into individual life histories, highlighting not only the experience of those in positions of power but also those perceived as being on the fringes of the economic and social core.

The Tiwanaku Case Study

At 3,800 meters above sea level, the site of Tiwanaku located in the seemingly barren Southern Lake Titicaca Basin of Bolivia (Fig. 1.1) appears an unlikely setting for the growth of a major urban center. Yet, at its height around 800 A.D., the city supported an estimated population of 15,000-20,000 people, completed construction of the colossal Akapana pyramid, and likely managed more than 70 km^2 of raised field agriculture in the surrounding pampas (Kolata 1986: 759). Tiwanaku influence eventually spread well beyond the Titicaca Basin and into the eastern lowlands and western valleys of what are now southern Peru and northern Chile (Berengeur 1978, 2004; Blom 1999; Blom et al. 1998; Goldstein 1985, 1989, 1993a, 1993b, 2005; Knudson et al. 2004; Owen 2005; Stanish 2003). Tiwanaku elites went to great lengths to secure access to lowland resources, building strategic trade alliances and, in some cases, establishing colonial enclaves in order to obtain tropical fruits, chili peppers, psychotropic plants, coca, and maize, the last of which was used for the production of *chicha* (maize beer).

Notably, many of these agricultural imports were significant, not as dietary supplements, but for their ritual value, as their archaeological associations with ceremonial spaces used for public feasting as well as much ethnohistoric and ethnographic data attest (Hastorf and Johannessen 1993). Evidence suggests that public feasts have been an important arena for commensal politics in the region since at least the Middle Formative (800-200 B.C.) (Hastorf 2003). However, at the height of Tiwanaku's expansion, the scale of public feasts increased to an unprecedented level, as evidenced by the construction of massive public platforms and plazas littered with the remains of butchered llamas, communal serving wares, and hallucinogenic snuff tubes (Alconini 1995; Couture and Sampeck 2003; Janusek 2004a; Kolata 2003; Manzanilla 1992). However, the most dramatic change in consumption patterns accompanying the spread of Tiwanaku influence reflects what Goldstein (2003: 144) has described as a sudden "mania for maize beer" (*chicha*). This beverage was an essential component of feasting events and work projects that cemented social and political ties between individuals and communities. New ceramic forms used exclusively for the production and consumption of *chicha* appear throughout the South Central Andes in association with evidence of public feasting. Thus, research shows that within Tiwanaku society feasting was a significant forum through which social relationships were negotiated, political and economic ambitions were pursued, and state ideology and authority were reproduced and contested. Given this strong connection between food and politics, I intend to demonstrate how changes in food consumption, both within the context of feasting as well as everyday life, shaped Tiwanaku social relations and actually contributed to development of the state.

Models suggested for the nature of Tiwanaku political authority have included that of a highly centralized imperial state whose power derived from control of the production and redistribution of agricultural surplus (Kolata 1986, 1991, 1993, 2003). Proponents of this model maintain that Tiwanaku society was intensely hierarchical, as reflected in its urban landscapes, which were believed to have been structured according to concentric gradients of social status with elites living closest to the city's ceremonial core (Kolata 1993, 2003). Others have suggested that Tiwanaku political authority was more indirect, acting as a major hub of trade for llama caravans as well as an important ceremonial center, allowing for more autonomy among local leaders (Browman 1978; 1981; 1994; Dillehay and Nuñez 1988). More recently, much research has shed light on the ethnic heterogeneity of Tiwanaku society (Blom 1999, 2005a, 2005b; Janusek 1994, 1999, 2002, 2003, 2004, 2005, 2008; Knudson et al. 2004) and the importance of non-hierarchical means of social differentiation (Albarracin-Jordan 1996a, 1996b, 1999, 2003; Browman 1994). Excavations indicate that Tiwanaku residential compounds may have been organized according to distinct ethnic affiliations, similar to modern Andean kin based groups known as *ayllus* (Couture 2003; Janusek 1999, 2003, 2004b).

Critical to testing models of Tiwanaku political authority is determining the degree to which state formation processes impacted the domestic economy of surrounding communities. Changing demands on production, as prescribed by the imperial state model, should be reflected in changes in the domestic economy. If the state took direct control of the redistribution of a large agricultural surplus, patterns of food consumption would be expected to change, as the labor force was directed at state productive activities and the population became increasingly dependent on staple crops distributed by the state. In addition, a state redistribution system may have favored certain segments of society. To address this issue, I analyzed data reflecting the diet and nutrition of individuals associated with specific residential compounds at the capital site of Tiwanaku and sites throughout the Southern Titicaca Basin, including other ceremonial centers and many small rural settlements. These data allow me to determine the consumption and by inference the distribution of dietary resources acquired through trade and/or local production, in particular, highly valued lowland imports such as maize. Although studies have examined such changes through analysis of material culture (Berman 1994, 1997, 2003; Janusek 2003; Wright et al. 2003), most reflect patterns of production. My research fills a dearth in knowledge by revealing patterns of *consumption*, which, according to Hastorf and D'Altroy, may be the most revealing activity when studying domestic economy, as it is the "end result of all productive activities," allowing one to see "the dynamics of wealth, power, and decision making within households as well as stratification within communities" (Hastorf and D'Altroy 2001:8; also see Giddens 1979; Orlove and Rutz 1989).

Thus, this dissertation addresses three broad issues within the social sciences. First, this research provides a unique case study for examining how differential food distribution is both a marker of and a generator of increasing social complexity. In particular, I examine how the manipulation of food and beverages, in the context of communal feasting events (and other mundane arenas), contributed to the processes of social change that led to the development of the archaic state *and* its eventual collapse ca. 1100 A.D. Over the past fifteen years a growing body of cross-cultural anthropological and archaeological literature has documented a link between escalation in feasting and sociopolitical development (e.g. Clark and Blake 1994; Dietler 1996, 2001; Dietler and Hayden 2001; Hayden 1996, 2001; Junker 1999, 2001).

Second, this study provides insight into the nature of political authority within archaic states. In what ways was the Tiwanaku state politically centralized, particularly as it related to the extent that leaders controlled agricultural production and distribution? In order to assess this, I examine how state formation impacted the domestic economy and thus, affected daily lives. I also consider how the activities of individuals helped to undergird authority and shape state policies and strategies. This aspect of the study directly addresses the competing models of Tiwanaku political authority offered by Kolata (1986, 1991, 1993, 2003), Browman (1978, 1981, 1994), Dillehay and Nuñez (1988), Albaracin-Jordan (1996a, 1996b, 1999, 2003) and others.

Third, this study also elucidates how culinary choices may be used to mark identity, creating and maintaining social boundaries. I examine patterns of food consumption as a means of providing insight into the micro-politics of Tiwanaku social organization. That is, rather than assume that all dietary practices are determined by the state, one must consider the choices of people at the local level. For example, women, who are often the primary food preparers, are uniquely suited to make choices about food consumption at the household level— often deciding what is eaten and by whom (see Weismantel 1988). This aspect of interpretation draws on the work of Bourdieu (1984), whose study of modern French consumption patterns has shown the degree to which seemingly mundane aspects of life, such as food choice, are influenced, if not largely dictated by the class specific *habitus* of the individual. Bourdieu recognized that food and the etiquette surrounding it are basic ways people define social boundaries, in terms of status, gender, kinship, ethnicity, age, and sometimes occupation. Therefore, studies of food distribution and consumption have the potential to provide significant insight into human relations, particularly issues of power and politics. Although modern French patterns of consumption seem an unlikely source of inspiration to elucidate ancient Andean dietary practices, cross-cultural anthropological research into diet clearly supports the link between power, status, gender, and food choice (e.g. Bourdieu 1984; Goody 1982; Mintz 1985, 1996; Weismantel 1988) (discussed further in Chapter 3).

Research Questions

This study of Tiwanaku diets specifically addresses the following questions:

1) Did patterns of food consumption change following the rise of Tiwanaku and how might that vary between and within sites (N = 12)? Did patterns of food consumption vary according to sex, status, or ethnicity?

If food consumption patterns (when viewed as a proxy indicator for the domestic economy) were dramatically altered following the rise of Tiwanaku, it may be suggested that the state was directly controlling the production and distribution of certain agricultural resources, particularly if the distribution of those resources selectively favors specific segments of society, such as high status individuals. In addition, changes in the consumption of foods closely associated with feasting activities (e.g. maize *chicha*) may reveal the role public feasting played in the political transformations taking place. Finally, the extent to which consumption patterns vary among subpopulations will provide information regarding the degree to which certain factions contributed to and were affected by the processes giving rise to the archaic state. For example, sex based differences in diet, particularly the consumption of valued imports, may reveal much about gender relations and the extent to which men and women contributed to and participated in commensal politics. Further, examination of food practices among the lower levels of the social hierarchy (e.g. those living in rural communities and the common households of urban centers) may reveal the extent to which these individuals embraced and ultimately re-enforced state culture.

2) Do patterns of food consumption reflect an intensely hierarchical division of society, such that the capital city was spatially organized in concentric gradients, with elites occupying the ceremonial core? Or, was access to dietary resources more linked to ethnic or kin ties with populations in other ecological zones?

If dietary reconstruction reveals variation based on proximity to the site's ceremonial core, it may be suggested that social organization was highly centralized, such that status was a prime determinate of access to dietary resources. This would further suggest that distinctions in food consumption were a prime means of marking social boundaries. However, if diets vary according to residential compound (believed to be associated with distinct ethnic groups), but irrespective of proximity to site cores, it may be suggested that ethnic groups maintained some autonomy or at least benefited from ties to other ecological zones.

3) Did patterns of food consumption change following the collapse of the Tiwanaku state?

If food consumption patterns changed significantly following the collapse of the Tiwanaku state it may be suggested that the state had significant control over agricultural production and distribution which was lost upon its dissolution.

Materials and Methods

In order to address these research questions, I utilized standard dental observations, stable isotopic analysis, and analysis of plant microfossils from human dental calculus (mineralized plaque) to assess patterns of consumption among 188 individuals[1] recovered from 12 sites in the Southern Titicaca Basin spanning the periods before, during, and after the rise of the Tiwanaku state (see Table 2.1). The human remains date from the Late Formative Period (150 B.C.-500 A.D.) through the Post Tiwanaku/Pacajes Period (1150- 1570 A.D.) and are derived from both rural and urban sites within the three major valleys of the basin: the Tiwanaku, Katari, and Desaguadero valleys.

I analyzed the human dentition to document the presence and location of carious lesions (cavities), abscesses, dental calculus, dental attrition (tooth wear) and antemortem tooth loss. These observations provide an indirect yet good measure of diet and nutrition (Hillson 1996; Larsen 1991; 1997), which can be compared at the intra-population, inter-population, and inter-regional levels. The benefit of a dental health study is that it offers an effective and efficient means of assessing the health consequences of a particular diet not provided by chemical analyses. Dental data also provide another means to estimate the diet and food preparation techniques because certain foods are more cariogenic than others, while some food preparation styles lead to more dental attrition than others.

In addition, I collected samples of human bone from 110 individuals for analysis of stable carbon and nitrogen isotope ratios in bone apatite and collagen, providing an accurate means of reconstructing individual food consumption profiles (Ambrose and De

[1] Sample sizes are discussed in detail in Chapter 5, note that sample sizes differed for the dental, isotopic, and phytolith data sets.

Niro 1986; Katzenberg 2000; Schwartz and Schoeninger 1991; van der Merwe 1982). Animal and plant foods contain diagnostic ratios of carbon and nitrogen, which are incorporated into the hard tissues of the consumer. Carbon isotopes can be used to distinguish between the consumption of highland staples, such as tubers and grains, versus lowland maize. Nitrogen isotopes can distinguish between the consumption of marine/lacustrine versus terrestrial resources, while also providing an indication of the proportion of meat in the diet.

Finally, this research included the examination of plant microfossils recovered from human dental calculus, including phytoliths and starch grains. Micro-botanical analyses allow researchers to identify the *specific* foods consumed (Pearsall et al. 2003; 2004). Of particular interest to this study was the identification of maize, coca, and certain psychotropic plants, all lowland imports thought to have had significant ritual and/or medicinal value in the prehistoric Andes (Allen 2002; Johannesen and Hastorf 1989; Hastorf 2003; Hastorf and Johannesen 1993).

Organization of the Dissertation

I begin this dissertation by providing the contextual background for the study (Chapter 2), introducing the environmental and temporal setting in which the study takes place and describing each of the twelve sites sampled. Proposed models of Tiwanaku's social and political organization are also discussed. In the following chapter (Chapter 3), I present the theoretical perspectives linking food, feasting, identity, and politics that have informed the present study. I also discuss the archaeological evidence for commensal politics in the Southern Titicaca Basin. In Chapter 4, I describe the probable menu for ancient Southern Titicaca Basin inhabitants based on ethnohistoric, archaeological, and paleobotanical data, providing an essential foundation for the interpretation of bioarchaeological evidence of subsistence patterns. In Chapter 5, I describe the skeletal samples utilized in this study, the demographic distribution of the skeletal samples, and provide a detailed discussion of the bioarchaeological methods employed in the dental, stable isotopic, and phytolith data analyses. In Chapter 6, I discuss the results of the dental analyses, providing frequencies of dental caries, dental abscesses, and antemortem tooth loss as well as scores reflecting the severity of dental wear and calculus. I compare the distribution of these conditions according to temporal period, valley, site, sector, and sex. I then provide a summary and interpretations. Chapter 7 presents the results of the stable isotopic analyses. I first provide the results of tests reflecting sample preservation, and then report the stable carbon and nitrogen isotope results according to temporal period, site, valley, sector, and sex—a summary and interpretations follow. I discuss the results and interpretations of the micro-botanical data in Chapter 8. I provide an in depth discussion of the results for all three lines of data in relation to the original research questions in Chapter 9. Finally, I offer a brief summary of this study and its conclusions in Chapter 10. By comparing patterns of consumption before, during, and after the rise of the Tiwanaku state, this dissertation documents the impact of state formation and collapse on the lives of individuals living in one of the earliest state level societies in the New World, offering a fresh perspective on the micro-politics of archaic states.

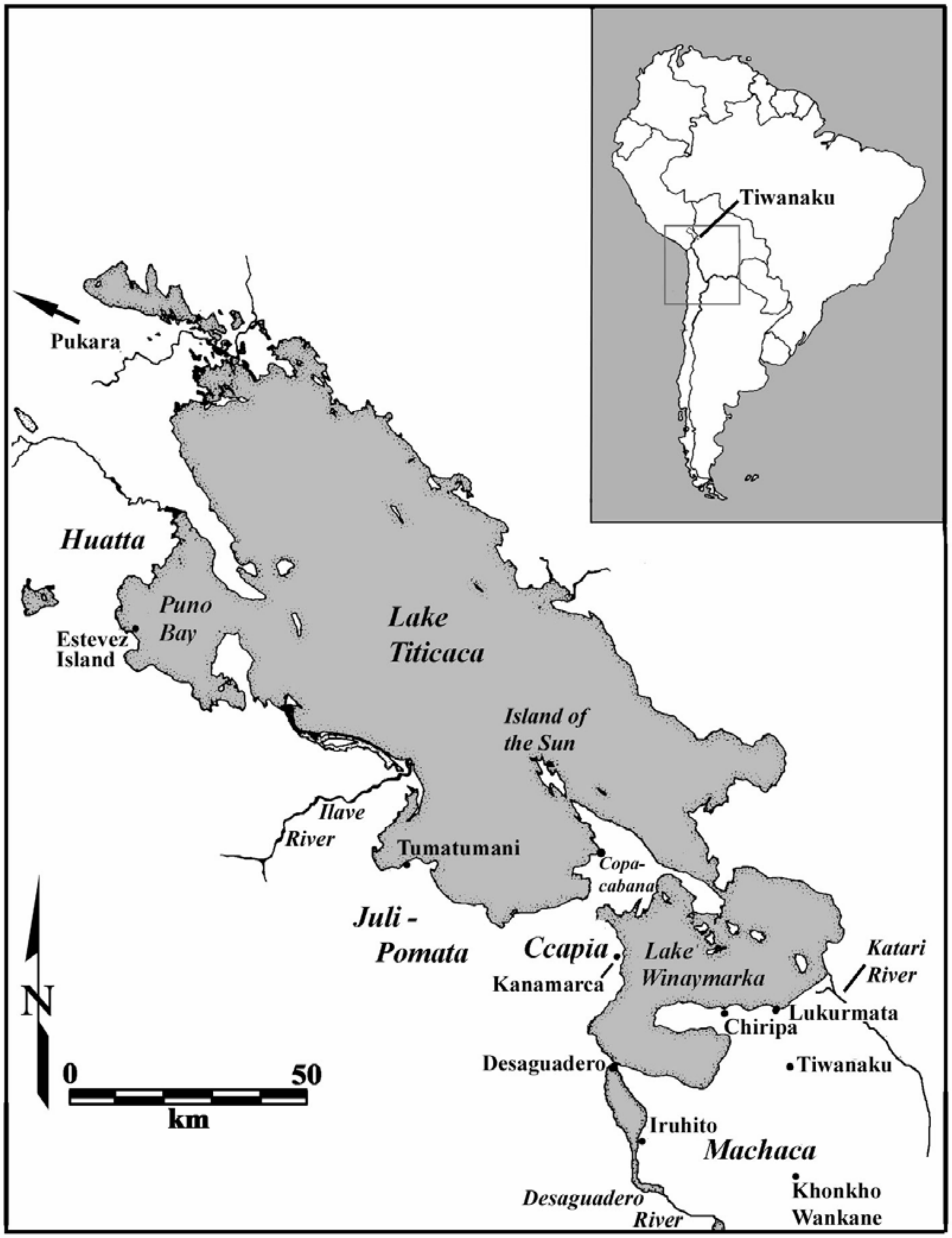

Figure 1.1 Map of the study area in the South Central Andes (Janusek 2006: Fig. 1.1)

CHAPTER II

ARCHAEOLOGY IN THE SOUTHERN TITICACA BASIN

Introduction

Since the time of European contact, the imposing pre-Hispanic ruins of Tiwanaku found in Bolivia's Southern Titicaca Basin have fascinated colonial writers, travelers, and explorers. Over the past century, the site and others in the region have been the focus of intense archaeological research significantly advancing knowledge of Tiwanaku's cultural history. In this chapter I describe the environmental setting of the Southern Titicaca Basin, summarize the culture history of the region as currently understood by archaeologists, and provide descriptions of the sites sampled for this study. Finally, I compare and contrast current perspectives regarding the nature of Tiwanaku sociopolitical organization.

The Environmental Setting

The Southern Titicaca Basin is the northern portion of the altiplano, or high plateau, situated between the Cordillera Negra (west) and the Cordillera Blanca (east) of the South Central Andes[2]. The basin forms the southern border of Lake Titicaca and is divided by the Kimsachata range and the Taraco hills into three valleys—the Desaguadero, Tiwanaku, and Katari valleys (see Figure 2.1). Each of the valleys is crossed by a river (the Rio Desaguadero, Rio Tiwanaku, and Rio Katari respectively),

[2] Background information on the environmental setting is summarized from Bermann 1994, Janusek 2008, and Kolata 1993.

providing drainage to Lake Titicaca. The Rio Desaguadero is by far the largest, continuing across the southeastern altiplano and draining into Lake Poopo. The basin encompasses three environmental microzones based on altitude and proximity to the lake. These include the rocky upper piedmont (3860-4600 masl), an area too cold for agriculture; which is primarily used for grazing camelid herds; the lower piedmont (3820-3880 masl), an area suited to cultivation of high altitude crops including a wide variety of tubers, grains such as quinoa and *kañiwa*, and some legumes; and the often waterlogged valley bottoms or pampas (<3840 masl), which are farmed and used for pasturage[3]. The agricultural cycle revolves around two seasons: a dry season (April-November) and a wet season (December-March), during which 700 millimeters of rain falls on average. Average temperatures range from 45°F (June-August) to 54° C (November-January) and, during the dry season, often dip well below freezing at night.

The lakeshore environment provides a plentiful supply of easily accessible lacustrine resources including a large variety of migratory birds, fish, and edible aquatic plants. The *totora* reed that thrives along the shores of the lake was and is used to thatch roofs, build boats, twine rope, and weave. Temperatures along the lakeshore tend to be milder and fluctuate less than elsewhere in the basin. Given the abundance of resources and the milder climate, it is no wonder that the lakeshore districts have sustained dense human populations for thousands of years.

[3] For a more detailed overview of altiplano subsistence strategies see Chapter 4.

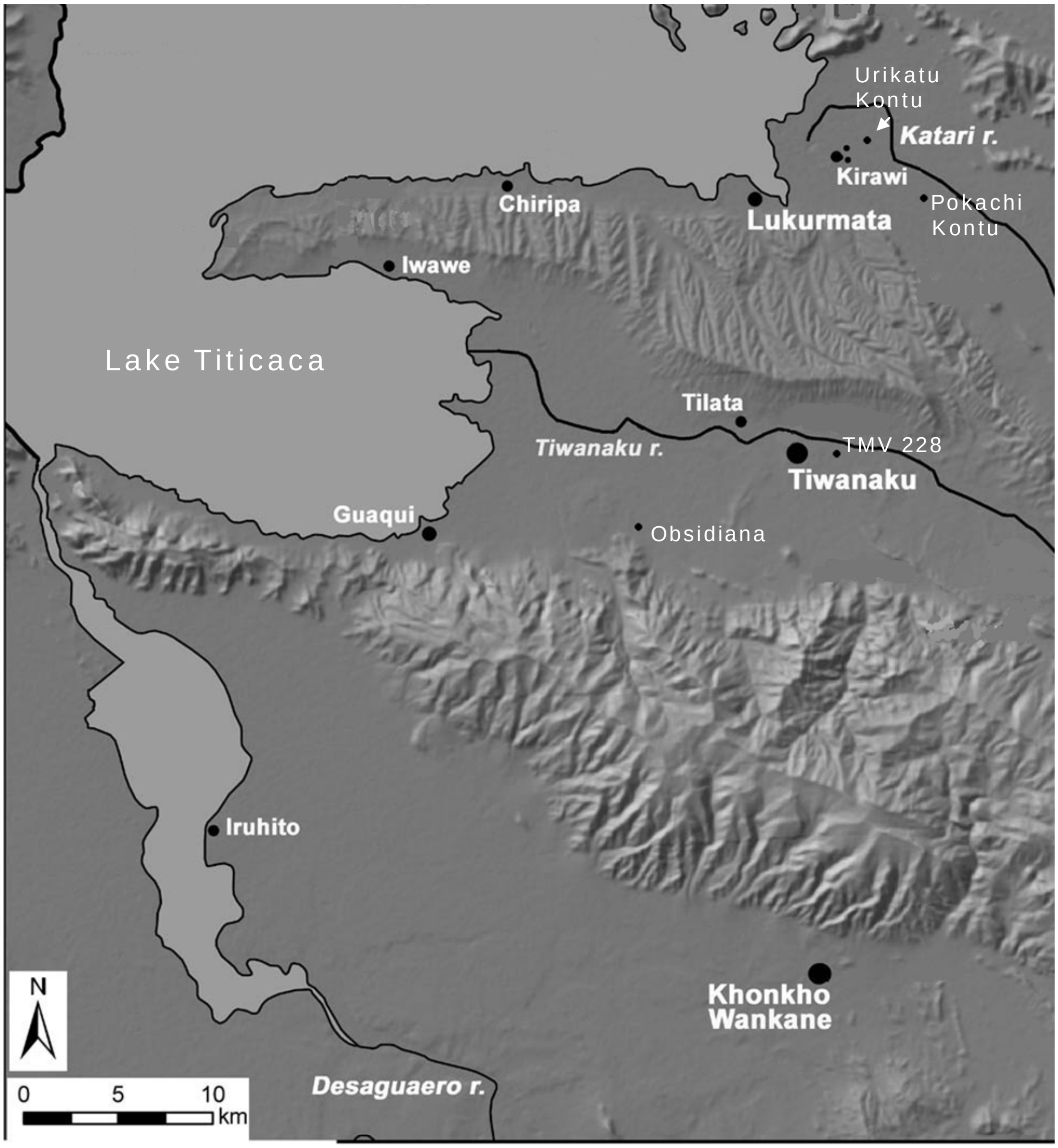

Figure 2.1 Southern Titicaca Basin sites mentioned in this text (modified from Janusek 2008: Fig. 3.4)

Cultural History of the Titicaca Basin

Early Formative

The onset of the Early Formative (1500-800 B.C.; see Figure 2.2) is marked by the first production of ceramics in the region and by the appearance of the first small sedentary villages along rivers and near the lake's edge (sees Figure 2.1). These settlements consisted of small clusters of undifferentiated households, whose subsistence strategies relied heavily on fishing, herding, hunting and foraging. There is also evidence of small scale agriculture or horticulture of quinoa (Browman 1986; Bruno and Whitehead 2006; Erickson 1976) and tubers (Browman 1989; Erickson 1976; Whitehead 2006). This is further supported by the recovery a few hoes in the region dating to this period (Bandy 2001). Research also indicates that pastoralism was practiced by Early Formative populations. Herhan (2004) has documented evidence seasonal camps used by groups of mobile pastoralists, while Moore et al. (1999) have shown that domesticated camelids were being consumed at Chiripa. Camelid caravans were likely already being used for long distance trade, as non-local items from as far away as northern Chile and southern Peru have been recovered Early Formative contexts (Browman 1998)

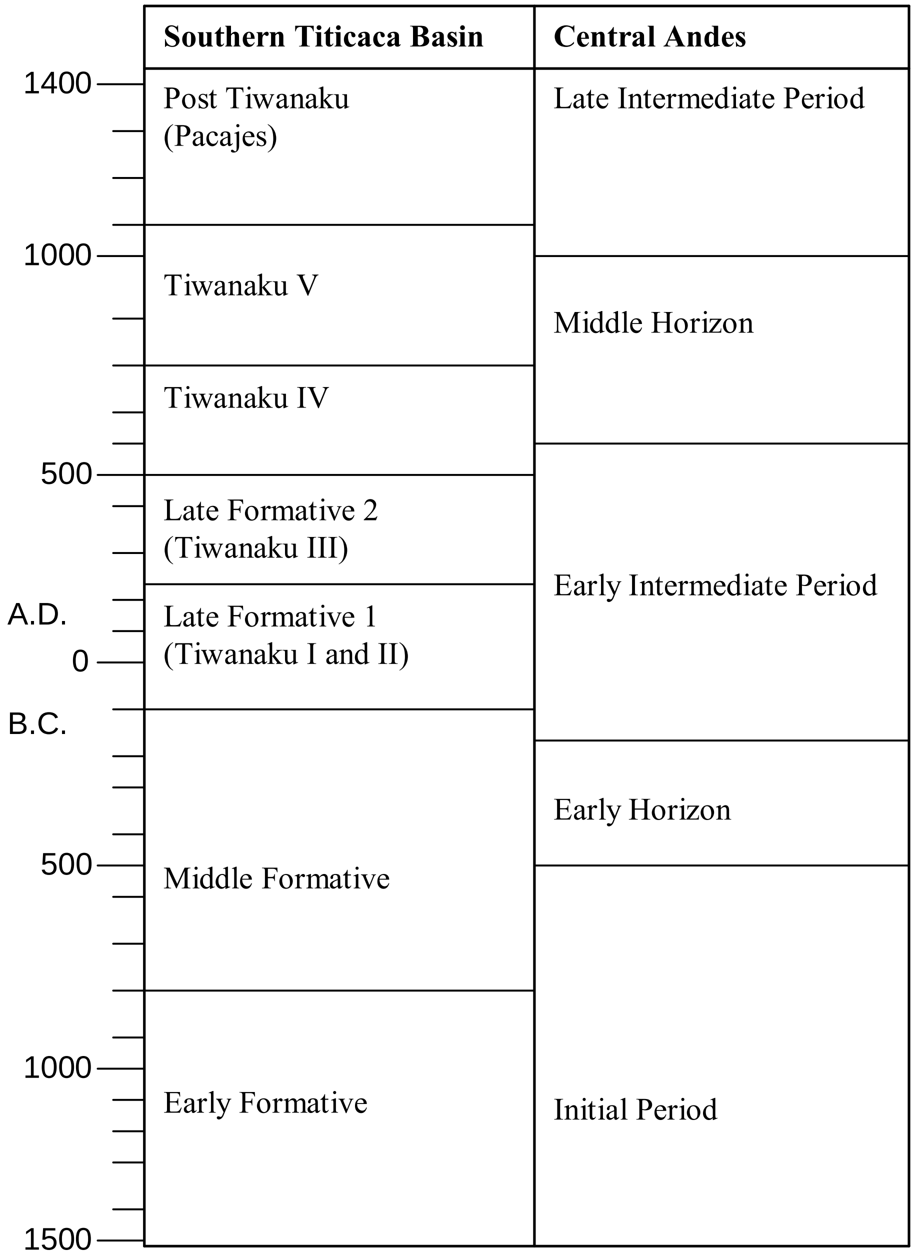

Figure 2.2 Southern Titicaca Basin and Central Andean Chronologies (after Janusek 2008: Figure 1.7)

Middle Formative

During the Middle Formative (800-100 B.C.), some sites in the basin developed into regional ceremonial centers distinguished by their size and the presence of monumental architecture, including the first sunken courts and stone stelae. In the northern basin, the Pucara valley site of Qaluyu measured roughly 7 ha. and included dense domestic occupation and a ceremonial complex that included five sunken courts (Stanish 2003). Qaluyu style ceramics are found throughout the northern basin during this time. Similarly, the southern basin site of Chiripa, located on the Taraco Peninsula, extended to approximately 7.5 ha (Bandy 1999) and included one of the earliest sunken courts in the region, an elaborate semi-subterranean temple, and significant domestic occupation[4]. The ceremonial complexes at these sites are hallmarks of a larger ritual tradition, known as the Yayamama tradition, which was shared by settlements throughout the Titicaca basin during this period (K. Chavez 1988; S. Chavez and K. Chavez 1975). The Yayamama tradition describes shared artistic and architectural styles including distinctive stone stelae, sunken courts, and the presence of ritual paraphernalia such as ceramic trumpets and incense burners (K. Chavez 1988; S. Chavez 1988; Chavez and Chavez 1975). The spread of these traditions was likely facilitated by increasing trade during the Middle Formative (most likely by llama caravans), as evidenced by the distribution of olivine basalt[5] and obsidian throughout the region (Bandy 2005).

There is also evidence that agriculture began to intensify during this period, as the frequency of stone hoes increased dramatically relative to Early Formative contexts (Bandy 2001; Janusek and Kolata 2004) and tuber remains also increased (whitehead 2007). Several studies indicate that quinoa was being more selectively farmed during this period, resulting in larger seed sizes and less of the more weedy variety, known as *quinoa*

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[4] Note that Chiripa and Qaluyu were not the only sites with ceremonial architecture at this time but, are among the largest and best studied.
[5] Olivine basalt most likely originated form quarries recently discovered on the western side of Lake Tititcaca (Bandy 2005).

negra (Browman 1989; Bruno and Whitehead 2006; Whitehead 2006). Both fish and camelids continued to be important dietary components in the Middle Formative (Capriles 2006; Capriles et al. 2007; Moore et al. 1999)

Late Formative

By the Late Formative (100 B.C-500 A.D.), a number of significant ceremonial centers had developed in the Titicaca Basin and trade networks expanded considerably. Early in the Late Formative I (100 B.C.-250 A.D.)[6], Middle Formative period sites were abandoned and new larger ceremonial centers rose to prominence. In the northern basin, the site of Pukara expanded to cover 200 ha. and included a ceremonial core composed of a series of immense terraces topped by two sunken courts (Stanish 2003). According to Stanish (2003), the site was the first to become a primary center of a regional polity in the basin, dominating the northern basin throughout the Late Formative. In the southern basin, no site comparable to Pukara developed until the end of Late Formative I. At this time, "numerous ritual-political centers, each the head of a multicommunity polity, arose in the region, including Palermo in Juli, Ckackachiipata in Ccapia, Lukurmata in the Katari Valley, Kala Uyuni on the Taraco Peninsula, Khonkho Wankane in Machaca, and Tiwanaku in the Tiwanaku Valley" (Janusek 2008: 21; also see Stanish 2003). Archaeological evidence suggests that a central element of ceremonial practice at these centers involved the use of sunken court complexes as sacred spaces associated with commensal rituals.

Trade intensified during the Late Formative and included interaction with distant lowland communities. Unfortunately, many of the products likely imported from the

[6] This period also corresponds to the Tiwanaku I and II phases.

lowlands are typically not preserved in the archaeological record, items such as fruit, coca, maize, chili peppers, and hallucinogenic plants; however, limited evidence does suggest such products were reaching the highlands. Berman (1994: 81) recovered sodalite beads from Cochabamba in Late Formative Lukurmata contexts and Berman (1994) and Janusek (2004) have noted the presence of paraphernalia associated with lowland hallucinogens at Lukurmata, Tiwanaku, and Khonkho Wankane during this period. In addition, imported Tiwinaku style ceramic vessels are found in Cochabamba by approximately 400A.D.

Subsistence strategies also underwent changes in the Late Formative. Cultivation of local tubers and quinoa continued to provide an important economic base, but there are indications that agriculture further intensified during this period. Stanish and colleagues (1997) have linked raised fields to Late Formative settlements in the Juli-Pomata region while Lemuz-Aguirre (2001) reports evidence of terracing associated with Late Formative sites on the Santiago de Huatta Peninsula[7]. Janusek and Kolata (2004) report evidence of agricultural intensification, as evidenced by high frequencies of stone hoes, among certain sites in the Katari Valley. Bruno (2008) also reports paleobotanical evidence of agricultural intensification on the Taraco Peninsula during this period; however, she notes that intensification appears to be for local household producers rather than for the production of surplus due to exterior political pressure. There is a growing body of evidence that suggests fish consumption decreased in this period, even within lakeside settlements, while camelid consumption increased. In sum, it appears altiplano populations were becoming increasingly focused on agropastoral subsistence strategies.

[7] Note the dating of these terraces and raised fields is based on their proximity to Late Formative sites, not any absolute dating. Thus, the dating of these features remains debatable.

Finally, the most significant transformation to occur during the Late Formative involved social and political relations. As Janusek (2004: 148) succinctly states, "the selective distribution of monumental architecture, sculpted monoliths, elaborate ceramic wares, and agricultural tools together mark the emergence of different roles in local political economies, tied to increasing status differences and social hierarchies." These social and political distinctions within and among competing polities in the Tititcaca basin continued to intensify until the end of the Late Formative, when monumental construction at most centers ceased[8], and Tiwanaku emerged as head of the first pan regional polity in the South Central Andes.

Tiwanaku IV

During Tiwanaku IV (500-800 A.D.), a period corresponding to the first half of the Middle Horizon, Tiwanaku became the first truly urban center in the Titicaca Basin. Well-organized barrios sprung up around the ceremonial core of the site, housing ethnically, socially, and occupationally diverse populations. Kolata (1993) contends that the site was organized into concentric clines of social statuses with elites living closest to the ceremonial core. The massive Akapana and Pumapunku ritual complexes were constructed at this time (see Vranich 1999), each a testament to the impressive manpower available to Tiwanaku's rulers. These complexes hosted state-sponsored feasts, a key element of which was the consumption of *chicha,* or maize beer as well as psychotropic plants. Corresponding with these consumption patterns was the introduction of a new suite of ceramic vessels, including *keros, ollas*, and *tinajas*, dedicated to the storage, fermentation, and consumption of *chicha.* These new styles appear throughout the South

[8] Lukurmata was an important exception to this trend (see Berman 1994).

Central Andes during the Middle Horizon and become a hallmark of Tiwanaku influence (Goldstein 2003). Interestingly, in the Tiwanaku heartland, almost everyone now had access to elaborate vessels associated with feasting, whereas these items were more selectively distributed during the Late Formative (Janusek and Kolata 2003). Janusek and Kolata suggest this may indicate payment in the form of fine ceramics with food and drink for services, and thus, the "widespread distribution of state productive obligations among communities" (2004: 416)

In the Katari valley, the size and number of settlements increased, and wide spread raised field agriculture began in the Koani Pampa. Lukurmata expanded to become an urban center with a significant ritual complex, although not on the scale of Tiwanaku, it was clearly the center of civic-ceremonial life in the Katari valley. Berman's (1994) data suggest Lukurmata's relationship to Tiwanaku was that of a second order administrative center involved in surplus mobilization, overseeing agricultural production on the Koani Pampa.

Tiwanaku's influence also spread well beyond the Titicaca Basin into the eastern lowlands (*yungas*) and western valleys of what are now southern Peru and northern Chile, where strategic trade alliances and, in some cases, colonial enclaves were established (see Figure 2.3). Tiwanaku presence in these regions was highly selective with the most concentrated interaction occurring in areas capable of intensive agricultural production. The best evidence of Tiwanaku colonization comes from the Moquegua valley of what is now southern Peru, some 300 km. away from Tiwanaku. This fertile valley was well-suited for the large-scale production of maize and thus, as the scale of communal feasting events in the altiplano increased during Tiwanaku IV, Tiwanaku affiliated sites dedicated to maize production sprung up in the valley. In fact, an abundance of archaeological and bioarchaeological evidence indicates that some of these sites were colonized by altiplano natives (Blom 1999; Blom et al. 1998; Goldstein 1985, 1989, 1993a, 1993b, 2005; Knudson et al. 2004; Stanish 2003). The Cochabamba valley of central Bolivia, some 165 km from Tiwanaku, was also a fertile region for the cultivation of lowland crops such as maize that became closely affiliated with Tiwanaku after 500 A.D. (Anderson 1999; Agüero 2001; Cèspedes et al. 1998), however, the nature of Cochabamba's relationship with Tiwanaku is not as clear as that of Moquegua. To date, the data do not reflect direct colonization. Cochabamba most likely remained a semi-autonomous polity with political allegiance to its key trade partner—Tiwanaku. However, it is possible altiplano natives were intermarrying and living in Cochabamba at this time. Further from the Tiwanaku heartland, many regions such as San Pedro de Atacama in northern Chile (Bereguer 2004; Knudson and Blom 2009; Llagostera 1995; Torres-Rouf 2002) and La Aguada in western Argentina (Gonzalez 1998) demonstrate evidence of Tiwanaku interaction after 500 A.D., particularly in the form of Tiwanaku-style grave goods. Areas such as these likely remained politically autonomous and were incorporated into Tiwanaku hegemony via trade relations and, to a certain extent, a shared ideology.

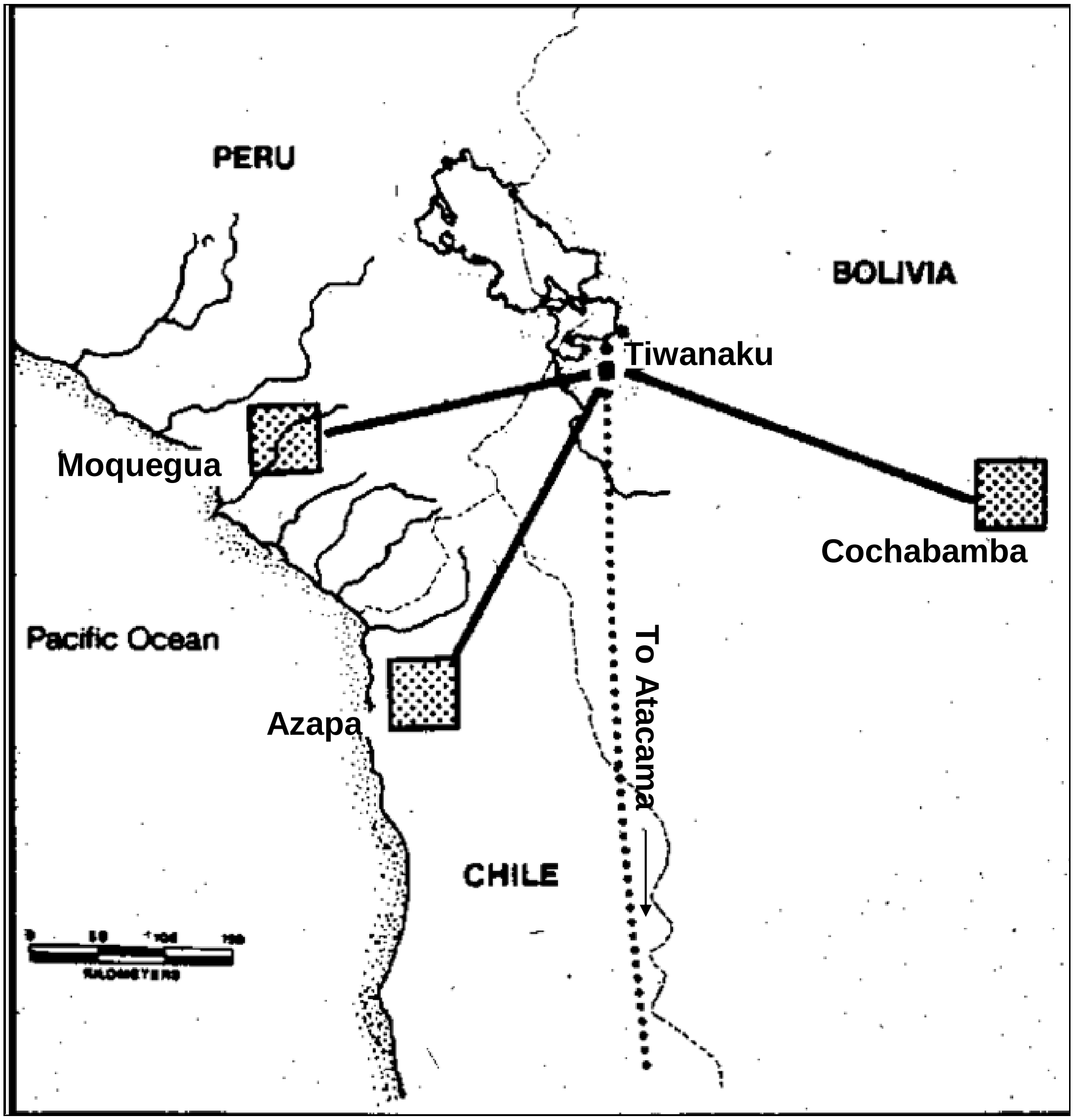

Figure 2.3 Areas of Tiwanaku influence outside the Titicaca Basin

Tiwanaku V

Between 800-1100 A.D., Tiwanaku grew to support an estimated population of 15,000- 20,000 people (Janusek 2004: 127-128). The ceremonial core of the site was transformed as part of an enormous construction project. Tiwanaku-style ceramics began to look more mass produced (Janusek and Kolata 2004). In the Katari valley, Lukurmata was virtually abandoned, but agriculture was intensified on an unprecedented scale, now incorporating more than 70 km² of the Koani Pampa for raised field agriculture (Kolata 1986: 759; Janusek and Kolata 2004), becoming the "single most important productive regime" during the Tiwanaku Period (Janusek 2008: 192). Interaction with key maize producers such as Moquegua and Cochabamba also increased sharply after 800 A.D. According to Janusek and Kolata, many of these changes indicate a tightening of state control over the production and distribution of valuable resources as well as the "increasing frequency and significance of communal consumption and large-scale feasting" (2004: 417; also see Janusek 2004, 2008). The increasingly burdensome and exploitative nature of Tiwanaku politics likely created a volatile political environment that was exacerbated by the long term drought thought to have begun around 1000 A.D. (Binford et al. 1997; Kolata et al. 2000; Kolata and Ortloff 1996; Moseley 1997; Ortloff and Kolata 1993; Erickson 1999), ultimately contributing to Tiwanaku's collapse.

Post Tiwanaku

After 1100 A.D. Tiwanaku's population dispersed. The number of small sites in the Tiwanaku and Katari valleys increased significantly and many hilltop settlements, also known as *pukaras,* were founded (Albaracìn Jordan 1992; Janusek and Kolata 2003; Mathews 1992; Stanish 2003). *Pukara* settlements were generally defensive in nature and their presence lends support to the idea that the Post Tiwanaku or Pacajes period (1100-1400 A.D.) was a tumultuous time marked by politically fragmentation. In addition, ceramic assemblages changed significantly, as the large *ollas* and *tinajas* necessary for large-scale feasting events, which were ubiquitous during Tiwanaku times, disappeared (Janusek 2003). In the Katari valley, raised field agriculture ceased and, in striking contrast to Tiwanaku period assemblages, agricultural implements are rare in Post Tiwanaku contexts (Janusek and Kolata 2003: 157). The causal factor for the apparent decrease in agricultural production remains unclear but may have involved both the dispersion of the Tiwanaku polity as well as the onset of long term drought, which would have left raised fields cut off and stranded from the lake. It is clear that by Post Tiwanaku times large-scale agriculture in the Titicaca Basin was over, populations were now more likely dependent on pastoralism, as Tiwanaku's decedents successfully adapted and thrived in a new environmental and political landscape.

Archaeological and Environmental Background of Tiwanaku Valley Study Sites

Table 2.1 Overview of sites sampled for this study

Site	Valley	Rural/ Urban	Public Architecture	# Burials Sampled[1]	Burial Context[2]	Temporal Periods
Tiwanaku	TW	urban	Y	87	dedicatory/ domestic	LF I- TW V
Tilata	TW	rural	N	4	domestic	LF I- INKA
TMV 228	TW	rural	N	3	domestic	TW V-PACAJE
Guaqui	TW	rural	N	1	domestic	TW IV- V
Iwawi	TW	rural	Y	1	domestic	LF- TW V
Obsidiana	TW	rural	N	1	domestic	TW V
Lukurmata	KT	urban	Y	45	domestic	LF I- PACAJE
Kirawi	KT	rural	N	13	domestic	LF I- TW V
Urikatu Kontu	KT	rural	N	9	domestic	LF II- PACAJE
Pokachi Kontu	KT	rural	N	3	domestic	TW IV- V
Khonkho Wankane	DS	rural[3]	Y	17	dedicatory/ domestic	LF I- PACAJE
Iruihito	DS	rural	Y	4	dedicatory/ domestic	MF- TW V

[1]These figures include the total number of burials analyzed for dental, isotope, and phytolith studies.
[2]Dedicatory contexts include interments in ceremonial mounds (e.g. Akapana or Mollo Kontu mound), as well as possible human sacrifices in Tiwanaku's Putuni sector. Domestic contexts include standard burials found in and around dwellings (e.g. Akapana East, Chiji Jawira, La Karaña, and Mollo Kontu residential), as well as those found in discrete cemeteries (e.g. Markapata).
[3]Although Khonkho Wankane is identified as rural, it should be noted that the site was a significant regional ceremonial center during the Late Formative.

Tiwanaku

Tiwanaku is located 15km east of Lake Titicaca on a broad alluvial plain in the middle Tiwanaku valley. Bounded by the Kimsachata range to its south and the Taraco hills to its north, the site is surrounded by grasslands and marshy pampa well-suited to pastoralism. Given the seemingly desolate surroundings, the presence of imposing pre-Hispanic ruins caught the attention of early colonial chroniclers.

The earliest colonial accounts of Tiwanaku provided descriptions of the visible architecture (Cieza de Leon 1959 [1553]; Cobo1990 [1567]), recorded myths regarding its origins (Betanzos 1987 [1551]; Cieza de Leon 1959 [1553]; Sarmiento de Gamboa 1999 [1572]), speculated on the relationship of Tiwanaku to the Inca culture (Acosta 1954 [1590]), and noted the ethnic diversity of the local population (Molina 1575)[9]. Throughout the eighteenth century there is an absence of information regarding Tiwanaku, attributed to an atmosphere of revolt and colonial resistance in the region during this period (Albarracin-Jordan 1999). However, with the establishment of the Bolivian Republic in the early nineteenth century, Tiwanaku once again became a destination for curious travelers and foreign explorers. These researchers developed a number of hypotheses regarding the nature of Tiwanaku. Some claimed ancestors of the local Aymara had built the monuments (Mitre 1879; Stuebel and Uhle 1892) while others asserted Tiwanaku was the result of diffusion from another region (Posnansky 1914, 1945). Some speculated Tiwanaku was once a large urban center (Bandelier 1910; Stuebel and Uhle 1892) while others maintained the site was a sparsely populated ceremonial center (Squier 1877).

Following the turn of the twentieth century several minor excavations of the site were undertaken (Casanova 1934a, 1934b; also see Albarracín-Jordán regarding the unpublished work by Crequi-Montfort and George Courty) but it was not until 1932 that Wendell Bennett (1934, 1936) carried out the first systematic excavations of the site. Bennett excavated 10 deep stratigraphic units with the primary goal of establishing a ceramic chronology. His work divided Tiwanaku's chronology into what he defined as the Early, Classic and Decadent periods. Other small systematic excavations followed (Kidder 1956; Ryden 1947). In 1958, the first large scale excavations of the monumental

[9] A more complete account of the history of Tiwanaku studies may be found in Albarracin-Jordan (1999) and Kolata (1993).

core of the site began following the formation of the *Centro de Investigaciones Arqueológicas* en Tiwanaku (CIAT), a group of Bolivian researchers led by Carlos Ponce Sanguinès (Ponce 1969, 1971, 1972, 1981). CIAT conducted research at the site for more than fifteen years, reconstructing much of the monumental core and refining Bennett's chronology. Sporadic work continued throughout the 1970s and 80s under Bolivia's *Instituto Nacional de Arqueología* (INAR), however results from many of these projects were not published.

Between 1988 and 1992, extensive multidisciplinary archaeological research was carried out by Proyecto Wila Jawira, a joint project organized by the University of Chicago and INAR and directed by Alan Kolata and Oswaldo Rivera Sundt. The project performed excavations throughout Tiwanaku's residential sectors, providing much insight into the social and ethnic diversity of the site (Couture 1993, 2002, 2003; Couture and Sampeck 2003; Escalante 2003; Janusek 1994, 1999, 2002, 2003, 2004, 2008; Rivera 1994, 2003). In addition, project members undertook extensive survey and excavation in the surrounding Tiwanaku (Albarracin-Jordan 1992, 1996, 1999; Albarracin-Jordan and Mathews 1990; Mathews 1992, 2003) and Katari valleys (Janusek and Kolata 2003, 2004) helping to contextualize Tiwanaku studies. Currently, Proyecto Jach'a Marka, a multidisciplinary project began in 2001 and directed by Nicole Couture of McGill University and Deborah Blom of the University Vermont, is working to provide additional insight into Tiwanaku residential life and the nature of urbanism at the site (Couture and Blom 2004). The cumulative knowledge of Tiwanaku's cultural history produced by archaeological projects is presented in the following pages.

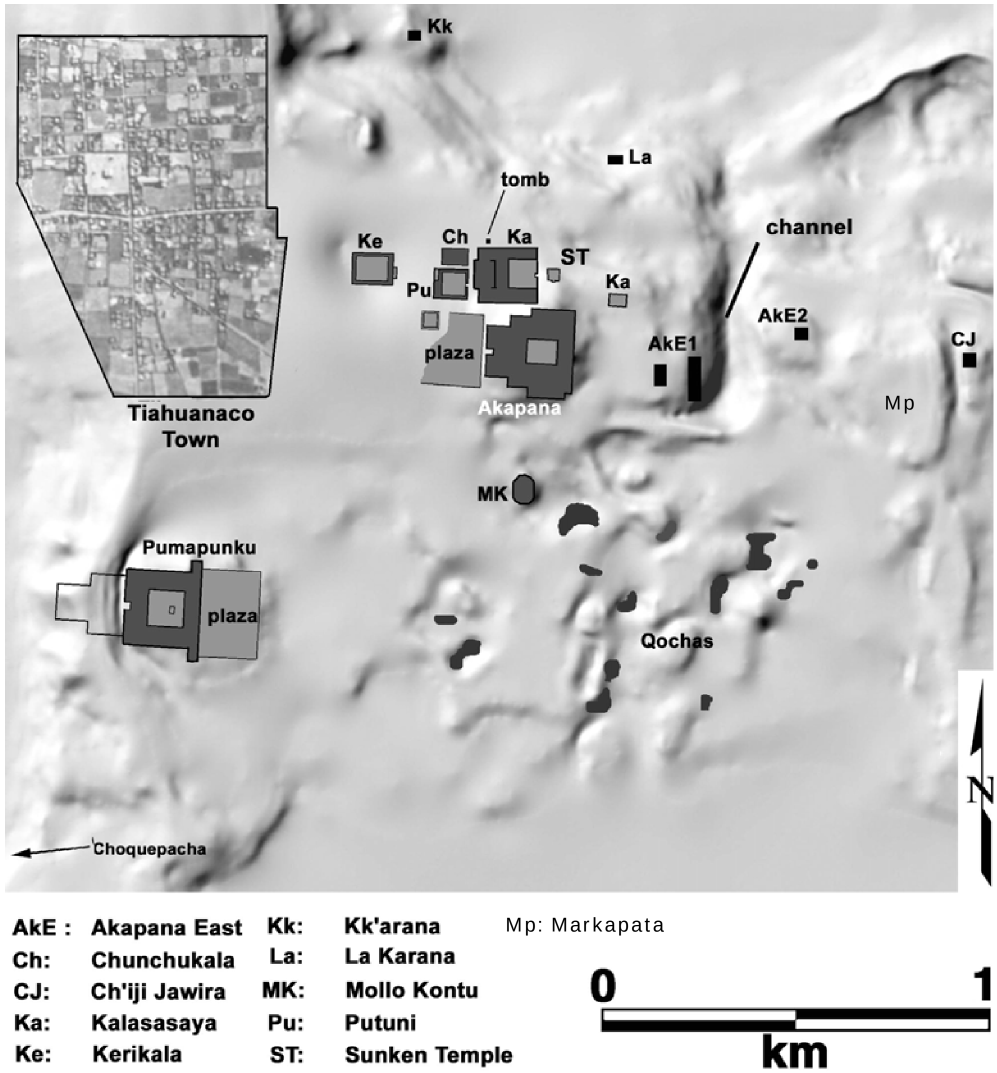

Figure 2.4 Map of Tiwanaku (modified from Janusek 2008: Fig. 4.1)

Based on more than eighty radiocarbon dates provided by CIAT (Ponce 1981) and Proyecto Wila Jawira (Janusek 2003), the earliest occupation of Tiwanaku dates to the Late Formative I period (Tiwanaku I and II). Excavations by Bennett (1934), Kidder (1956), and Ponce (1993) revealed Late Formative I domestic occupations near the Akapana and below the Kalasasaya that included semicircular and rectangular stone wall foundations, cobble patios, hearths, and midden deposits. Ponce's (1993) excavations under the Kalasasaya (see Figure 2.4) uncovered two elaborate human burials accompanied by more than 35 ceremonial vessels. Domestic structures associated with these burials yielded unusual artifacts including a ceramic trumpet and a ceramic whistle molded in the form of a domestic structure or temple (Ponce 1993). Given the elaborate nature of these occupations, it is likely Tiwanaku housed a relatively high status group, perhaps rivaled only by Khonkho Wankane during this period.

Recently, Janusek (2004:109) has compared the sunken temple at Tiwanaku with a similar sunken temple at Khonkho Wankane dated to the Late Formative I and, based on associated ceramics, similarities in architectural orientation,[10] and similarities in iconography on the stone stelae within the temples, concluded that they were likely built during the same period. This is consistent with Ponce's (1990) assertion that the Sunken Temple predates the Kalasasaya. Thus, it is likely a small group of high status individuals living near what would continue to be the ceremonial core of the site for the next thousand years were already coordinating important local ceremonies that involved commensalism and feasting as early as the Late Formative I.[11]

During the Late Formative II period (Tiwanaku III), the Kalasasaya platform was constructed just to the west of the sunken temple, overlaying Late Formative I domestic structures (Ponce 1961, 1981, 1993). The walls of the 130 x 120m. earthen platform were constructed of alternating sandstone and andesite blocks. In the center was a semi subterranean temple flanked by a series of small square stone rooms. Unlike the Sunken Temple, the entrance to the Kalasasaya faced the rising sun to the east. Observing this

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[10] Both temples are trapezoidal in shape and have a southern entrance distinct from other monuments at either site.

[11] Unfortunately, no human remains from Late Formative I burials were available for analysis.

change in axiality in both Tiwanaku and Khonkho Wankane Late Formative II monumental architecture, Janusek (2006) suggests this may reflect the emergence of a solar/celestial cult that later became a critical element in the rise of Tiwanaku (also see Kolata 2003: 179-180).

A trench or moat encircling the approximately 1 square kilometer ceremonial core of the site has not been definitively dated, but Janusek (2004:131; also see Posnansky 1945) suggests that it was first excavated during the Late Formative II, as the Kalassasaya is located in the center of the island created by the moat and much of the fill for its construction likely came from the moat's excavation. During this period the moat appears to have defined the borders of the settlement (Janusek 2004).

Accompanying the Late Formative II changes in monumental architecture was a moderate population increase. Domestic occupation was still concentrated in the ceremonial core of the site, in areas such as the Putuni sector (Couture and Sampeck 2003), but further expanded to the Akapana East (Janusek 1994, 2003, 2004) and Chiji Jawira (Rivera-Casanovas 2003) sectors and at least one Late Formative burial was discovered in the Markapata cemetery (pers. comm. M. Giesso 2010)[12]. By the end of the Late Formative II, Tiwanaku had expanded to cover approximately one square kilometer (Janusek 2004: 117). It is noteworthy that excavations in these residential areas did not yield significant quantities of stone hoes relative to contemporary rural sites in the Katari and Tiwanaku valleys (Giesso 2000), indicating that agricultural production was not a focus of activity at the site; while the abundance of camelid remains throughout Late

[12] Only three Late Formative II burials were available for analysis as part of the present study, two from Chiji Jawira (CJ-36995-1 and CJ-36995-2) and one from Markapata (MP-230).

Formative excavation contexts indicates that pastoralism was already a critical component of Tiwanaku's subsistence economy (Webster and Janusek 2003: 345-347).

During the Tiwanaku IV period (500-800 A.D., Middle Horizon) the population increased significantly, as large well-planned walled residential compounds, including Mollo Kontu (Couture 2003), Akapana East (Janusek 1994, 2003, 2004), Chiji Jawira (Casanovas 2003), and La Karaña (Escalante 2003) compounds, sprung up outside of the moat defining the Late Formative settlement (Figure 2.4). By the end of this period the site expanded to cover approximately six square kilometers and housed an estimated 10,000-20,000 people (Janusek 2004: 127-128). Construction of the massive Akapana and Pumapunku platform mounds was also undertaken during this period. Although many other monuments were constructed during this time, I limit the following discussion to the Akapana and Pumapunku, as they are the largest and most impressive architectural achievements at Tiwanaku and a testament to the ingenuity of Tiwanaku engineers and the significant manpower available during the Middle Horizon.

Just south of the Kalasasaya, close to the center of the island created by the moat, the Akapana is the largest structure at Tiwanaku measuring 204 x 192 meters at its base and 17 meters in height (Kolata 1993: 104; 2003: 183). Kolata (1993) interprets the Akapana as a sacred shrine or *huaca* constructed to mimic the revered mountains surrounding Tiwanaku. Rituals carried out here likely honored the ancestors of the Tiwanaku elite as well as promoted "fertility and agricultural abundance" (Kolata 1993: 117). Constructed in the shape of half of an Andean cross (Kolata 1993), the Akapana consists of seven terraces composed of finely executed stone revetments and earthen fill. Although the summit of the Akapana was largely destroyed by extensive looting during the colonial period, a large sunken court once sat in the center. The courtyard was drained by an extremely complex stone lined drainage system that alternated from terrace surfaces back into subterranean canals all the way to the base of the Akapana. Extensive archaeological evidence suggests that the Akapana was the site of commensal feasting, as its terraces are littered with the remains of butchered llamas, communal serving wares, hallucinogenic snuff tubes, as well as vessels associated with *chicha* consumption (Couture and Sampeck 2003; Kolata 2003; Manzanilla 1992; Janusek 2004a). In addition, numerous large offering assemblages that included the partially disarticulated remains of llamas and humans were found at the base of the Akapana (Manzanilla and Woodard 1990; Kolata 1993). Some of the human remains revealed extensive evidence of cutting and trauma and may represent sacrificial victims (Blom 1999; Blom and Janusek 2004), an interpretation underscored by the repeated use of human trophy head iconography on Akapana monuments and ceramics. Recently, strontium isotope analysis of bone samples from some of these individuals revealed non-local signatures, indicating some were likely foreign to the altiplano (Knudson et al. 2004).

Outside of the island created by the moat, the ruins of the Pumapunku are located on what was the western edge of the ancient settlement. The base of the T-shaped structure measures a half kilometer from east to west and includes four stone lined terraces with a formal entrance on its western side. Here, visitors passed through stone gates and a narrow passageway into an inner courtyard. Atop the eastern platform stood a "portico of carved stone portals set on megalithic sandstone slabs" (Janusek 2008: 121-122). As found in the Akapana, a finely engineered system of stone lined canals drained the courtyard through the terraces (Kolata 1993). Kolata interprets the Pumapunku as a "twin" to the Akapana and likely the "principal earth shrine and emblem of the sacred mountain for Tiwanaku's southern moiety division" (1993: 129; also see Ponce et al. 1971). However, as Janusek (2004: 133) points out, the two are significantly different in form and likely function. Given its location on the outer edge of the city, Vranich (1999) suggests the Pumapunku functioned as an entrance for pilgrims—a space for indoctrination into Tiwanaku religion and cosmology.

The population explosion that occurred at Tiwanaku during the Tiwanaku IV period was also accompanied by clear evidence of social, ethnic, and economic diversification. The moat that defined the Late Formative boundaries of the settlement now demarcated a sacred core that included exclusively elite residences. Beyond the moat, new residential compounds declined in status relative to their distance from the core, in what Kolata described as a "concentric cline of the sacred" (1993: 93). These status distinctions are reflected in architecture, sanitation, and the quality of ceramic assemblages (Janusek 2002; 2004). Within the core, elite residences such as Putuni were constructed on finely hewn andesite foundations, adobe walls were plastered and painted, and elaborate drainage canals removed waste from the compound. Excavation of an elite mortuary complex in the Putuni sector uncovered a high concentration of prestige goods and high quality ceramics (Couture and Sampeck 2003: 239-243). Outside the moat, residents in the Akapana East 2, Mollo Kontu, and La Karaña sectors constructed their homes over adobe and field stone foundations. Crude canals drained waste into the street and ceramic assemblages from both mortuary and domestic contexts were not of the same quality as those seen in the Putuni (Janusek 2004: 153-157). Furthest from the core, the Chiji Jawira sector, situated on the far eastern edge of the site, included adobe dwellings lacking stone foundations. Residences were surrounded by dense layers of waste, indicating poorer sanitation management relative to other sectors and ceramic assemblages included crudely manufactured serving wares and a number of non-local vessels (Janusek 1999; 2002; 2004; Rivera 1994; 2003).

Interrelated to the clear status distinctions observed at the site during this period, there is significant evidence supporting the presence of diverse ethnic groups, including migrants from outside the altiplano. Bioarchaeological study of strontium isotopes (Knudson et al. 2004) and patterns of cranial modification used as markers of group identity (Blom 1999, 2005) all point to a heterogeneous urban population. Blom's comparison of cranial modification patterns in the altiplano and Moquegua Valley revealed a preference for fronto-occipital modification in the Moquegua Valley and annular style modification in the Katari Valley. Only at Tiwanaku were the two styles displayed equally within the population, suggesting Tiwanaku was a place of convergence for ethnic groups throughout the region (Blom 1999: 60-61). Interestingly, no clear spatial patterns in cranial modification were observed at the site (i.e. individuals with different modification styles were found buried in the same residential compounds)[13], indicating individuals of different ethnic backgrounds likely intermarried. Strontium isotope research by Knudson and colleagues (2004) has also identified likely migrants at the site, particularly among individuals buried as offerings and/or sacrifices in the Putuni and Akapana sectors. In addition, the diversity of ceramic assemblages observed among residential compounds also supports a heterogeneous population (Janusek 1999, 2002, 2003, 2004). Although most shared the same basic suite of

[13] Recent analyses by Blom (Berryman et al. 2009) of human remains from the Mollo Kontu mound and residential areas have provided an exception to this pattern, demonstrating that individuals buried in the mound and residential areas exhibited distinct styles of cranial modification.

Tiwanaku-style vessels, “each compound group simultaneously acquired and used a distinct array of serving and ceremonial wares” (Janusek 2004: 160). Some, such as Chiji Jawira, suggest ties to the Cochabamba region.

Finally, occupation was a further dimension likely accounting for the social divisions observed at Tiwanaku. In contrast to contemporary Katari and Desaguadero Valley sites, a lack of agricultural implements indicates that agriculture was not a focus of activity among Tiwanaku inhabitants during this time (Giesso 2000). While the abundance of camelid remains and camelid iconography indicate llama trade caravans likely played a key role in the Tiwanaku economy (Webster and Janusek 2003; also see Dillehay and Nuñez 1995). Evidence for economic specialization within individual compounds is provided by Rivera (2003), who documented the production of specialized ceramic wares in the Chiji Jawira compound and further supported by Giesso’s (2000, 2003) lithic analyses, indicating the production of projectile points was likely carried out by specialists in specific compounds.

By the end of the Tiwanaku IV period, Tiwanaku was a cosmopolitan city and an unrivaled regional ceremonial center, which emerged as head of the first pan regional polity in the South Central Andes. During the Tiwanaku V period (800-1100 A.D.), Tiwanaku’s movement toward increasing status divisions accelerated and new construction projects altered Tiwanaku’s sacred core. On the northeastern side of the Akapana’s summit, numerous small stone rooms were constructed that likely housed an elite group,[14] perhaps priests who presided over Tiwanaku’s most sacred ceremonial activities (Kolata 1993: also see Manzanilla and Woodard 1990). The Putuni palace was

[14] These rooms were associated with fragments of utilitarian pottery and food remains indicating their domestic function.

razed and replaced by a large monumental complex. The event was marked by the burial of numerous individuals as dedicatory offerings, found in construction fill and canals (Couture and Sampeck 2003). In addition, the Akapana East 1, a residential compound on the eastern edge of the site, was transformed into a site for large-scale *chicha* production. A northern compound that featured an interior sunken court was also added to the Akapana East 1 (Janusek 1999, 2003, 2004). Archaeological data indicate the area likely hosted elite ceremonies involving feasting. Ceramic analyses for this period document a significant increase in vessels associated with the storage and fermentation of *chicha* in the sacred core of the site. The variety of ceramics utilized by individuals living in the sacred core increased and included elaborate styles, while those living in compounds outside the core had a more limited selection, reflecting "an increasing emphasis on mass production and widespread distribution" (Janusek 2004: 225). Overall, the evidence supports increasingly centralized control over the production and distribution of valued goods throughout the Tiwanaku V period (Janusek 2004).

Near the end of the Tiwanaku V period, Tiwanaku's population began to slowly disperse into the surrounding valleys. By 1000 A.D. monumental construction stopped at the site, the Putuni palace was razed, and numerous sculptures and monuments associated with elite ancestors were ritualistically defaced and buried. The site was essentially abandoned by 1100 A.D. It is speculated that an extreme drought around 1100 A.D. exacerbated tensions already simmering as a result of increasingly oppressive elite control thus, leading to the disintegration of the state (Binford and Kolata1996; Binford et al. 1997; Janusek 2004, 2008; Kolata and Ortloff 1996; Ortloff and Kolata 1993).

Tiwanaku Middle Valley Sites: Tilata (TMV 101) and Mollo Kontu (TMV 228)

Several rural Middle Tiwanaku Valley sites were excavated by James Mathews (1992; Albarracin-Jordan and Mathews 1990) as part of the Middle Tiwanaku Valley Survey he undertook between 1989 and 1990. Tilata (TMV 101) is a 7-8 ha site roughly 4 km northwest of Tiwanaku. Tilata was a rural town with a continuous stratigraphic sequence spanning the Late Formative I through the Inka periods. In contrast to the nearby urban center of Tiwanaku, excavations at Tilata uncovered an abundance of stone hoes indicative of an emphasis on agriculture. Faunal assemblages were predominately comprised of camelid remains. The remains of three individuals excavated at Tilata dating to the Tiwanaku V period were available for analysis as part of the present study.

Mollo Kontu[15] (TMV 228) is a small 1 ha site 2.5 km to the east of Tiwanaku. The site consisted of a light surface scatter of ceramics and a single burial mound that contained the remains of three individuals. The burials are associated with Early Pacajes period ceramics. No domestic structures were located at Mollo Kontu. Cultural material from the site dated to the Tiwanaku V through Late Pacajes periods.

Tiwanaku Lower Valley Sites: Guaqui (LV 55), Iwawi (LV 150), and Obsidiana (LV 109)

Several Lower Tiwanaku Valley sites were excavated as part of the Lower Tiwanaku Valley Survey conducted by Juan Albarracin Jordan (1992; Albarracin-Jordan and Mathews 1990). The site of Guaqui is near the lake shore on the southern edge of the Tiwanaku Valley and just west of the modern town of the same name. The site measures 5 ha and is crossed by a water canal connecting it to Lake Titicaca. Cultural material

[15] This site should not be confused with the Mollo Kontu sector of Tiwanaku.

recovered from the site primarily date to the Tiwanaku IV-V period. The single burial that was excavated also dates to this period. Fauanl remains included fish, bird, and llama. Paleobotanical remains included chenopodium (Albarracin-Jordan 1992).

The site of Iwawi is located on the shore of Lake Titicaca at the southern base of the Taraco Hills. The site covers 4 ha and its occupation spans the Late Formative through the Tiwanaku V period. During the Tiwanaku period, Iwawi served as an important port linking Tiwanaku with other communities surrounding the lake (Isbell and Burkholder 2002). Andesite blocks left by the lake shore indicate that Iwawi received stone quarried from the Copacabana area, which was then transported to Tiwanaku for the construction of monuments such as the Pumapunku and Akapana. The center of Iwawi includes a mound 200 m in diameter and 3-4 m in height. Atop the mound, a rectangular area defined by protruding andesite blocks can be discerned, indicating a ceremonial component to the site. The mound is surrounded by evidence of domestic occupation and excavations uncovered evidence of ceremonial feasting and the use of hallucinogenic drugs as early as the Late Formative (Albarracin-Jordan 1999: 70). Faunal remains included fish, birds, and llama remains. Paleobotanical remains included abundant chenopodium; no tuber remains were recovered. Two human burials dating to the Tiwanaku V period were excavated by Albarracin-Jordan (1992).

The small site of Obsidiana is approximately 7km southwest from Tiwanaku and covers approximately 4.5 ha. The site dates to the Tiwanaku V period. Excavations uncovered a thin lense of cultural materials including a great deal of obsidian debitage but no domestic structures were identified. A single cyst burial was recovered. Faunal remains were dominated by camelid, although a few fish remains were also encountered. Paleobotanical remains included both chenopodium and tubers.

Archaeological and Environmental Background of Katari Valley Study Sites

Lukurmata

The Katari valley site of Lukurmata is located near the shore of Lake Titicaca on the southwestern edge of the Koani Pampa (Figure 2.5). Throughout its history Lukurmata's exact proximity to the shore has varied greatly as a result of fluctuating lake levels. When the lake level was high, Lukurmata occupied a small peninsula jutting into the southern edge of the lake. When the lake level was low, Lukurmata may have been several kilometers away from the shore. In any event, Lukurmata's location provided excellent access to both lake resources and agricultural resources from the Koani Pampa. Lukurmata was also connected to Tiwanaku by a footpath that crosses the Taraco range and is visible to this day—an approximate two to three hour walk (Janusek 2004:56).

Lukurmata was first identified as an archaeological site by Max Uhle, who noted the presence of a sunken temple at the site (Ponce 1989; Uhle 1912). The first systematic excavations were undertaken by Wendell Bennett of the American Museum of Natural History in 1934. Bennett's excavations concentrated on the sunken temple complex but a few units were also excavated to the north and south of the temple, exposing domestic occupations (Bennett 1936). Extensive excavation of domestic sectors began in 1986 as part of Alan Kolata's Proyecto Wila-Jawira (Kolata 1989; Bermann 1990, 1994; Janusek 1994). Additional excavations of the sunken temple were also undertaken as part of the project (Bermann 1989; Rivera 1989). All Lukurmata human skeletal remains analyzed for the present study were recovered by Proyecto Wila-Jawira.

Proyecto Wila Jawira excavations revealed that Lukurmata's earliest occupation dates to the Late Formative I period (200 B.C. – 300 A.D.). Bermann (1990, 1994) excavated several domestic structures as well as a small cemetery[16] dating to this period. He describes Lukurmata during this time as a small village of socially undifferentiated and politically independent households with an economy based on a mixture of fishing, herding, and agriculture. There is no evidence that the site was any different from other small lakeside villages. It was certainly not a significant regional center. Most burials were found in simple cyst tombs in a seated-flexed position. Most individuals were not accompanied by grave goods, although three were buried with single "Tiwanaku-style" vessels (Bermann 1994: 81). Recovery of numerous Tiwanaku I-style bowls from domestic contexts indicates that Lukurmata residents were involved in regional exchange networks. However, there is little evidence of participation in long-distance exchange, with the exception of four sodalite beads recovered in an adult male burial (Bermann 1994: 81). The nearest source for sodalite is in Cochabamba, approximately 165 km to the south (Browman 1981).

[16] Four individuals from this cemetery were sufficiently preserved to be included in the present study.

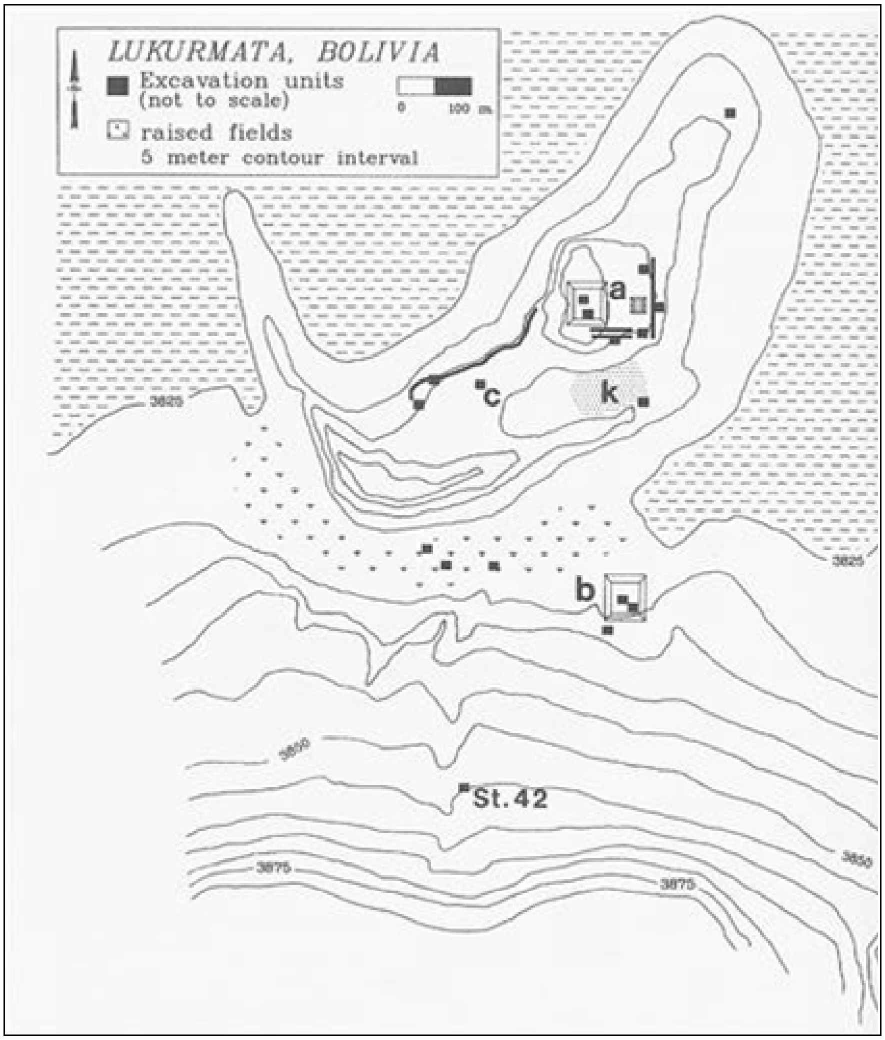

Figure 2.5 Map of Lukurmata. *Key*: (a) temple and enclosure complex, (b) raised burial platform, (c) Bermann's main excavations, (k) Bennett's section K (from Bermann 1994: 160).

During the Late Formative II (300 A.D. – 500 A.D.), Lukurmata remained a small egalitarian village lacking public or ceremonial architecture; however, Bermann (1990; 1994) found evidence of some significant changes occurring during this time. First, there was a dramatic increase in the percentage of imported Tiwanaku-III style pottery, indicating intensified relations between Lukurmata and the emerging regional ceremonial center of Tiwanaku. Second, although domestic architectural styles did not change, functional differences emerged, in particular, the appearance of a storage structure indicates changes in the importance of certain household activities (Bermann 1994: 146). Third, preliminary faunal analyses indicate a significant change in local diets from the Late Formative I, indicative of decreased consumption of lake resources (Bermann 1994: 117). These dietary changes, coupled with the appearance of specialized storage structures, indicate increased dependence on agricultural resources. Fourth, there is evidence of increased participation in long distance exchange networks as non-local materials including sodalite (Cochabamba), marine shell (Pacific coast), obsidian (Puno or Arequipa), basalt (near Lake Poopó), and non-local pottery were found in domestic contexts (Bermann 1994: 125). Finally, evidence of hallucinogenic drug use appears at Lukurmata during the Late Formative II, in the form of small bone spatulas and snuff tube (Bermann 1994: 142). Such paraphernalia is considered a hallmark of Tiwanaku influence in the region (Browman 1978).

At the onset of the Middle Horizon, the Tiwanaku IV period, Lukurmata underwent dramatic changes. First, the site expanded to cover approximately 120 ha., housing an estimated population of five to ten thousand people (Bermann 1994: 159). Second, a new variety of Tiwanaku-style ceramics appeared throughout the site, including forms associated with feasting activities, such as *keros*, large *ollas,* storage *tinajas,* and new serving-ceremonial wares. Forms associated with the production, storage and consumption of fermented beverages, such as *chicha*. Evidence for the presence of maize beer at Lukurmata during this time comes from flotation samples that yielded the first maize kernels at the site (Bermann 1994:185). Third, construction of public architecture was undertaken in what is referred to as the Wila Kollu sector, including a Tiwanaku-style semi-subterranean temple made of large andesite blocks and several terraced platforms. As at Tiwanaku, Lukurmata's central ceremonial sector was also bounded by a moat that separated sacred space from surrounding domestic areas (Kolata 1993). However, Janusek (2004: 173-174) points out that despite the similarities between the two ceremonial centers, Lukurmata remained distinct in many ways. Unlike the large entrances accessing Tiwanaku's monumental structures, the smaller scale and more restrictive entrances in Lukurmata's sunken temple suggest more intimate rituals took place there. There is also no evidence of large-scale communal feasting taking place in Lukurmata's monumental core; such activities were apparently restricted to domestic patios (Janusek 2004: 188). In addition, the smaller offerings interred in and around Lukurmata's monumental architecture, including unique feline-effigy *incensarios* and fetal camelids, are distinct from the grand scale of offerings associated with Tiwanaku's monuments.

Finally, there is ample evidence of increased social diversification among Lukurmata inhabitants during Tiwanaku IV. Walls, terraces, and canals now divided various sectors of the site into distinct barrios (Bermann 1994: 163). The quality of home construction, internal spatial organization of homes, and ceramic assemblages were highly diverse among residential sectors (Bermann 1994; Janusek 2004: 1190-194). Mortuary practices and patterns of cranial modification also varied significantly (Blom 1999). In some sectors, individuals were now buried close to or under homes while others continued to bury their dead in discrete cemeteries. Taken together, these changes clearly indicate the emergence of status and likely ethnic distinctions within Lukurmata's population. However, as Janusek (2004: 197) points out, Lukurmata does not exhibit a concentric gradient of social statuses, which Kolata describes for Tiwanaku. Status differentiation at Lukurmata was not as clearly patterned and appears to have been "tied to other specialized activities and important locations, ritual and otherwise that were widely dispersed across the urban landscape" (Janusek 2004: 197).

During the Tiwanaku V period, when nearby Tiwanaku was reaching its height, the site of Lukurmata suddenly fell into decline. Excavations by Bermann (1990; 1994) found only refuse pits and burials dating to this period. Most residential sectors were apparently abandoned and use of andesite blocks from the monumental core of the site to line tombs indicates that the temple had fallen into disuse. In two small discrete cemeteries on the ridge overlooking the core of the site, an area that was once a major residential barrio, Bermann (1994: 220-221) excavated nine bell-shaped stone lined tombs, several contained multiple individuals and an array of Tiwanaku V vessels. Explaining the decline in population at Lukurmata, Bermann (1994: 223) suggests that due to increasing centralization of Tiwanaku during this time, Tiwanaku elites may have taken over the direct administration of agricultural production on the Pampa Koani. This scenario is supported by the research of Browman (1981), Albarracin-Jordan and Mathews (1990), and Janusek and Kolata (2004), who suggest the state underwent substantial re-organization during this time.

Evidence of Post Tiwanaku period occupation dating to 1200-1300 A.D. was found on the same ridge as the Tiwanaku V tombs. There, Bermann (1990; 1994) excavated a partial residential structure and sixty-five Post Tiwanaku tombs; very few of these individuals were accompanied by grave goods. His research indicates that

Lukurmata once again became a small, independent, egalitarian village with families living in single, all-purpose dwellings rather than extended patio groups (Bermann 1994: 235). Storage structures disappeared and there was little evidence for long distance exchange, except for some obsidian and imported ceramics from the eastern Andean valleys. Bermann suggests trade was now occurring on a much smaller scale and probably between individual households. Thus, after the collapse of Tiwanaku, life at Lukurmata returned to a pattern very similar to the way it had been during the Late Formative.

Kirawi (CK65)

Located in the center of the Katari Valley pampa zone and approximately 2 km west of the Katari River, the site of Kirawi (CK65), was excavated under the supervision of Kolata and Rivera (Kolata 1986) and later Janusek and Kolata (2003) as part of a systematic study of rural settlement patterns and the use of raised-field agricultural systems in the Southern Titicaca Basin. Kirawi and the nearby site of Urikatu Kontu (CK70) are part of a larger mound group that was designated the Quiripujo cluster (Janusek and Kolata 2003:133).

Kirawi is composed of two large platform mounds—the western (110m x 67m x 3.10m) and larger eastern (120m x 75m x 3.75m) mound. Excavation of the eastern mound revealed substantial occupation during the Late Formative 1 and 2 periods marked by multiple superimposed occupation layers including adobe domestic structures and patios littered with ceramic, faunal, and lithic debris (Janusek and Kolata 2003: 140). Several flexed Late Formative burials were also found in cyst tombs near the edges of patios. Simple grave goods consisted of slate hoes buried with adult males and females and undecorated vasijas.

During the Tiwanaku Period, evidence of occupation at Kirawi is less dense. Midden deposits are thin and there is no evidence of the more permanent adobe construction seen in the Late Formative. Occupation of the site consisted of what appear to be moveable temporary pole structures over compact platforms (Janusek and Kolata 2003: 150-151). Based on ethnographic analogy, this pattern of occupation is interpreted by Janusek and Kolata (2003) to indicate potential use of the site by rotating field guardians known as *kamani*. Kirawi's location in the center of the Pampa Koani makes it an ideal location for the placement of such field guardians.

Several Tiwanaku period burials were uncovered along the edges of the mounds. Like the Late Formative burials, these individuals were flexed and placed in simple cyst tombs. Grave goods included grinding stones and decorated vasijas.

Evidence of Pacajes period occupation of the site consisted of several hearths and midden pits but no clear dwelling structures. No Pacajes period burials were recovered.

Urikatu Kontu (CK70)

Also part of the Quiripujo Mound group and less than 1 km to the east of Kirawi, the site of Urikatu Kontu (CK70) consists of a large L-shaped platform mound covering 0.74 hectares. Occupation spans the Late Formative 2 through Late Pacajes periods. Urikatu Kontu was excavated under the direction of Kolata and Rivera (Kolata 1986) and later Janusek and Kolata (2003) as part of Proyecto Wila Jawira. Unlike Kirawi, no permanent adobe structures dating to the Late Formative were found. Occupation at the end of the Late Formative and through the Tiwanaku period consisted of what were likely temporary wooden pole structures believed by Janusek and Kolata (2003: 144) to be indicative of a pattern of temporary use by field guardians. One Tiwanaku period burial was recovered (CK70-3283).

As with most Koani pampa mound sites during the Pacajes period, evidence of human activity at Urikatu Kontu consisted of scattered hearths, midden pits, and human burials. Several human burials from the Pacajes period were excavated at Urikatu Kontu. These included both simple cyst tombs, typical of the Tiwanaku period, as well as a new form, referred to as a slab-cyst tomb (Janusek and Kolata 2003: 155), one contained the remains of three adults (CK70-3144). Unlike traditional Tiwanaku period burials, slab-cyst tombs were formed with stone slabs that formed the walls of the tomb and jutted above the ground's surface, providing a visible surface marker. Such tombs also appear in the Tiwanaku valley during the Pacajes period (Albarracin-Jordan 1996: 292).

Pokachi Kontu (CK 104.1/ CK 104.2)

Approximately four kilometers southeast of the Quiripu mound cluster is the central Katari valley pampa zone site of Pokachi Kontu, which consisted of two small mounds identified as CK 104.1 and CK 104.2. This site was also excavated by Janusek and Kolata (2003) as part of Proyecto Wila Jawira. Pokachi Kontu was first occupied in the Tiwanaku IV period, was converted into a probable field guardian mound in Tiwanaku V, and finally used as a burial mound toward the end of the Tiwanaku V period (Janusek and Kolata 2003: 153). Occupation at the site closely resembles the sequence observed at Kirawi and other rural Katari valley sites during the Tiwanaku IV and V period. Approximately seven poorly preserved burials were recovered from the site.

Archaeological and Environmental Background of Desaguadero Valley Study Sites

Khonkho Wankane

The site of Khonkho Wankane is located approximately 20 km. directly south of Tiwanaku in the upper basin of the Desaguadero valley, at the base of the Kimsachata range. Small scale investigation of the site was first undertaken in 1937, 1938, and 1941 under the direction of Maks Portugal Zamora, who was then director of the National Museum of La Paz. In subsequent publications, Portugal (1941, 1955) described the iconography of three five meter tall monoliths found at the site (*Tata Kala, Jinchun Kala*, and *Wila Kala*), noted the presence of two rectangular platform mounds and numerous circular domestic structures, described several burials, and correctly concluded that most of the site predated what is now referred to as the Tiwanaku IV/V period. Around the same time, Swedish archaeologist Stig Ryden (1947) excavated eight units at the site and, based primarily on assumptions regarding the monumental architecture and its similarities to Tiwanaku, incorrectly dated it to the late Tiwanaku period (800-1100 A.D). The site was not subjected to further excavations until 1987 when Alan Kolata, director of *Proyecto Wila Jawira,* oversaw the excavation of several test units in and around the sunken temple and the dual patio complex. Like Ryden, Kolata (1993) incorrectly dated the site to the Tiwanaku IV/V period. Kolata concluded Khonkho was a secondary or satellite city of Tiwanaku similar Lukurmata (1993: 174)[17].

In 2001, *Proyecto Jach'a Machaca*, directed by John Janusek, began the first large scale excavations at Khonkho Wankane and the surrounding areas. The project is ongoing but thus far archaeological research and 17 radiocarbon dates indicate that Khonkho was first occupied near the end of the Late Formative I period, probably between 150 – 200 A.D (Janusek and Ohnstad 2006). An abundance of camelid remains (Gladwell 2007: 32) and stone hoes (Giesso 2006: 205) found at the site indicate Khonkho residents practiced an agro-pastoral lifestyle. During the earliest occupation, residents of the site's principle mound resided in circular structures with stone foundations which faced each other around a "U"-shaped common patio (Smith 2007; Smith and Pèrez 2007). Two such patio groups (Compounds K-1 and K-3) were uncovered on the principle mound and at some point shortly after their construction each was walled off, clearly separating these residential compounds from each other and from those who resided below the mound (see Figure 2.6). The circular domestic structures were between 2.4 and three meters in diameter with the exception of one (structure 12.C9), which measured 4.9 m. (Smith and Pèrez 2007). In contrast to the smaller structures, the artifact assemblage of the larger structure clearly indicates a non-domestic use. Excavations recovered the disarticulated human remains of at least 28 individuals (primarily represented by teeth and phalanges) exhibiting cut marks and covered in a gesso-like material, as well as bone and shell beads, and small ceramic vessels containing paint residue (Smith and Pèrez 2007). Because analyses of these materials are not yet

[17] For a more detailed overview of previous research at Khonkho Wankane, see Janusek (2005).

complete, researchers are hesitant to offer any definitive interpretations however, it is clear the structure was the site of significant mortuary rituals.

Adjacent to Compound K-1 was an approximately 24 m. x 27 m. trapezoidal sunken court very similar to the one found at Tiwanaku during this period. Although the most prominent entrance to the temple was on its southern side, residents of Compound K-1 also accessed it through a private corridor on its northern side (Janusek et al. 2003; Janusek and Pérez 2005: 99). Excavations inside the court uncovered fragments of fired bricks, remains of butchered camelids, and fragments of ceramic vessels, indicating the space was the site of rituals of consumption (Janusek and Pérez 2005).

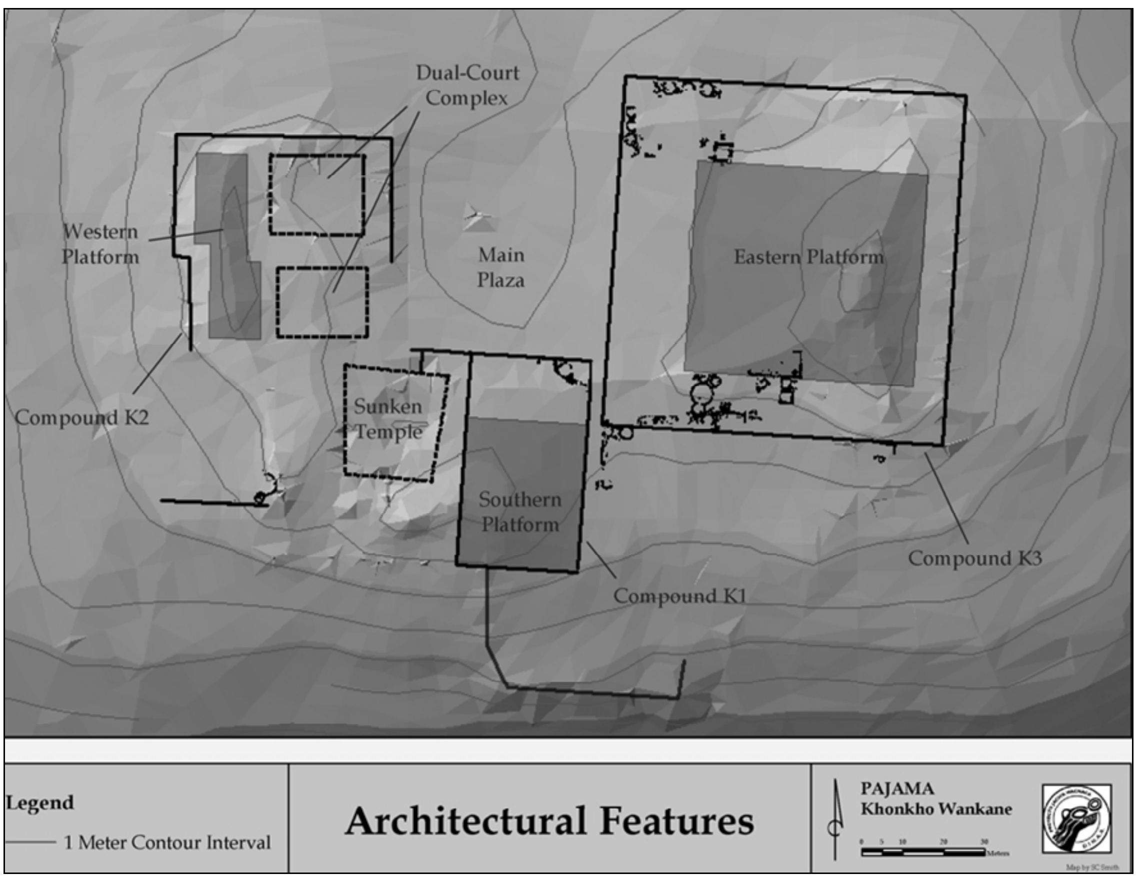

Figure 2.6 Map of Khonkho Wankane (Janusek 2008: Fig. 3.14)

Ohnstad, Smith, and Janusek (2006) assert that Late Formative ceremonial life at Khonkho contrasted sharply with that of Middle Formative ceremonial centers such as Chiripa, where it is suggested public ceremonies held in sunken courts functioned to unify disparate social lineages (Hastorf 2003). Ohnstad and colleagues cite the close proximity of ritual and domestic space on the principle mound, the absence of private ritual areas in the ceremonial sector (as seen at Chiripa), and the exclusive access to the sunken court given to residents of one residential compound as evidence of increasing social ranking. They further suggest that ceremonies now primarily honored a single lineage.

By the onset of the Late Formative II period (300 A.D.), Khonkho Wankane underwent a number of significant changes. First, the sunken temple ceased to be used. The earliest of the site's four monoliths, the Portugal monolith, was decapitated, split down the center, and interred in the western portion of the mound (Ohnstad et al. 2006). Large portions of the K-1 and K-3 residential compounds were filled-in forming large platforms. A double sunken court complex was constructed to the north west of the original sunken temple leaving a large plaza between the site's principle ceremonial structures, in the center of which stood the five meter tall Tata Kala monolith. Contemporaneous monoliths include the Wila Kala and Jinchuan Kala monoliths. All were made of red sandstone from the nearby Kimsachata range and each depicted a single anthropomorphic figure thought to represent a mythic ancestor or diety accompanied by feline, llama, and zoomorphic serpentine images (Janusek et al. 2003; Ohnstad 2005). Finally, the north-west axis orientation of structures, as seen in the Late Formative I, shifted to an east-west orientation during the Late Formative II period (Janusek 2006;

Ohnstad 2005). Similar changes are observed at Tiwanaku during this period. As previously mentioned, Janusek (2006) suggests that these changes in axiality as well as architecture and iconography, reflect the emergence of a solar/celestial cult that later became a critical element in the rise of the Tiwanaku state.

Thus, by the Late Formative II, Khonkho was a major regional ceremonial center; only one other center in the Southern Titicaca Basin (Tiwanaku) reflected a similar scale of ceremonial activity. However, by the Middle Horizon, monumental construction at the site ceased, the ceremonial core was abandoned, and only a small residential population remained. New ceramic styles reflected Tiwanaku affiliation. A small population remained at the site through the Pacajes period. Human skeletal remains included in the present study were recovered from Late Formative, Middle Horizon, and Pacajes period contexts at Khonkho Wankane.

Iruihito

The Desaguadero valley site of Iruihito is approximately 20 km. south of Lake Titicaca on the eastern shore of the Desaguadero River. The site covers approximately 29 ha, although the full area does not appear to have been occupied during any one temporal period, and includes an approximately 60 x 80m ceremonial mound that stands roughly four meters in height. First recognized as an archaeological site by Wendell Bennett (1950) but did not become the subject of systematic excavation until 2002 and 2006 as part of Proyecto Arqueológico Jacha Machaca (PAJAMA), directed by John Janusek. Project member Adolfo Pérez-Arias excavated test units throughout the site in an attempt to establish its chronology and relationship to other important centers in the region, including Chiripa, Khonkho Wankane, and Tiwanaku (Pérez 2004, 2007).

Excavations closest to the river revealed that this portion of the site was occupied from at least the Middle Formative period (800-200 B.C.), while sectors further from the river were not occupied until the Late Formative (200 B.C. – 500 A.D.) and Tiwanaku (500-1100 A.D.) periods (Pérez 2007). Until the Tiwanaku IV period, the site is similar to other small independent, self-sufficient villages in the region. Residents fished, hunted, raised camelids, and were likely involved in small-scale agriculture. Research by Maribel Pérez-Arias (2005, 2007) noted little evidence for significant prehispanic agriculture in the area, which she attributed to the salinity of local soils. Two Formative period burials were recovered during the 2006 excavations. Each individual exhibited cranial modification and each was found in a seated-flexed position, one was associated with a batán and the other was found with a small bowl.

By the end of the Tiwnaku III/Late Formative II period (300-500 A.D.), construction of the ceremonial mound began. This mound was in use throughout the Tiwanaku IV and V periods. The surface was littered with the remains of Tiwanaku-style ceramics used for the storage, fermentation, and consumption of fermented beverages (Peréz 2004). Clearly Iruihito inhabitants were now participating in communal feasting events considered the hallmark of Tiwanaku influence. In addition, Maribel Perez-Arias (2005) noted another significant change that occurred during the transition from the Late Formative to the Tiwanaku period. Her analysis of micro- and macro-fauna revealed a significant decrease in the consumption of micro-fauna during this period and an increasing dependence on camelids as a protein resource. She attributes this to increasing prestige associated with an agro-pastoral lifestyle which may have accompanied Tiwanaku influence (Perez-Arias 2005: 150-151). Support for this theory comes from Lukurmata where similar trends were observed in the faunal data (Bermann 1994). Finally, three poorly preserved burials were excavated in the mound. Like the Formative period burials, each individual exhibited cranial modification and each was buried in a seated-flexed position. No grave goods accompanied any of the individuals.

Competing Models of Tiwanaku Political and Social Organization

The far reaching influence of Tiwanaku during the Middle Horizon has led to a number of theories regarding the nature of Tiwanaku politics and social organization, although the details vary widely, the most credible can be grouped into two schools of thought: those that interpret Tiwanaku as the head of a highly centralized imperial state and those that interpret Tiwanaku as an important regional ceremonial and/or trade center that did not exert direct control over surrounding communities. In the following sections, I summarize arguments for these models, as each has important implications for potential changes in local food consumption practices.

Tiwanaku as a Centralized State

Many archaeologists interpret Tiwanaku as the head of a highly centralized imperial state (Kolata 1986, 1991, 1993, 2003; Ponce1972, 1981; 2003). Although the details of their arguments vary, proponents of this model contend that Tiwanaku's power derived from the direct control of the production and distribution of agricultural surplus. They maintain that the construction and maintenance of impressive hydraulic works, including more than 70 km² of raised field agriculture in the Koani Pampa and an extensive network of dykes, canals, and causeways, necessitated organization by a centralized bureaucracy. They further assert that Tiwanaku society was intensely hierarchical, as reflected in its urban landscapes, which Kolata (199, 1996) believes were structured according to concentric gradients of social status with elites living closest to the city's ceremonial core. Communities in the heartland, including the Desaguadero, Tiwanaku, and Katari valleys, were also organized in a multi-tiered hierarchy with larger administrative centers such as Lukurmata directly controlling local agricultural production on behalf of the state. Finally, the presence of Tiwanaku material culture in distant lowland territories such as Moquegua and Cochabamba is considered evidence of strategic colonization of agriculturally productive lands by the Tiwanaku state. As previously discussed, there is substantial supporting evidence that natives of the Tiwanaku heartland did in fact establish colonies in Moquegua during the Middle Horizon (Bandy et al. 1986; Blom 1999; Blom et al. 1998; Goldstein 1989); although, the evidence for other regions is not as straightforward.

If Tiwanaku was a highly centralized imperial state, I would expect to see evidence of significant changes to the domestic economy as a result of state management of agricultural production and distribution. In particular, food consumption patterns likely would have changed as the scale of production increased and populations became more dependent on certain crops redistributed by the state. In addition, I would expect patterns of food consumption to reflect an intensely hierarchical division of society with significant disparities in access to highly valued foods, such as imported maize. Also, a dramatic increase in the consumption of lowland imports (e.g. maize) in the altiplano would further support growing evidence that regions such as Moquegua were colonized by Tiwanaku during the Middle Horizon due to their agricultural potential; although, the dietary data alone could not rule out the possibility that changes in trade relations rather than colonization account for the Tiwanaku connections to these regions. Finally, I would expect regional consumption patterns to change again following the abandonment of Tiwanaku, due to the loss of centralized control over agricultural production and distribution as well as a potential loss of regional trade networks.

Local Autonomy and "Integrated Nested Hierarchies"

In contrast, other archaeologists argue that the data do not support a centralized state model in which Tiwanaku directly controlled other regions, rather, they propose that Tiwanaku was simply "the political head of a loosely organized group of semi-independent trade centers" (Browman 1981:415) or, a "conglomerate node of converging regional caravan networks" (Dillehay and Nuñez 1988: 616). These models stress the risks inherent in altiplano agriculture and the need to establish trade networks to access more diverse resources but, both reject Tiwanaku as an example of Murra's model of verticality (see Murra 1964, 1972). Neither model recognizes evidence for Tiwanaku control of distant regions; however, they differ in that Browman acknowledges limited political centralization within the Tiwanaku heartland, while Dillehay and Nuñez do not. A critique of these models is offered by the significant archaeological evidence of large scale production of staple crops within the altiplano capable of providing inhabitants with a dependable surplus. However, these models were proposed prior to the extensive archaeological research in the Koani Pampa that revealed the extent of agricultural production (Janusek and Kolata 2003, 2004).

A more recent critique of the centralized state model is offered by Albarracín-Jordán (1996a, 1996b, 1999, 2003; also see Erickson 1987, 1988, 1993,1999 and Graffam 1990, 1992) who, basing his case largely on ethnographic and ethnohistoric sources, argues that proponents are guilty of imposing Western paradigms of sociocultural evolution onto non-Western peoples (Albarracín Jordán 1996, 1999, 2003). Citing the organization of Formative and Middle Horizon settlement clusters in the Tiwanaku valley, Albarracín-Jordán asserts that Tiwanaku sociopolitical organization was based in historically documented *ayllu*-like[18] groupings that formed a "nested hierarchy" of semiautonomous communities loosely integrated through religious ideology. Thus, he terms Tiwanaku a "segmentary society" rather than a centralized state. In this model, the site of Tiwanaku was an "emblem of solidarity" for local communities (Albarracín Jordán 1999: 79). Drawing on the work of Erickson (1987, 1988, 1993) and Graffam (1990, 1992), he contends that the extensive agricultural engineering in the Koani Pampa did not necessitate management by a centralized bureaucracy but was the product of local management by autonomous communities. He cites the diversity of raised field construction, consistent with management by independent groups, as support for this theory.

If Tiwanaku was an important regional ceremonial and/or trade center that did not exert direct control over local agricultural production and distribution, the data should not

[18] According to Albarracín-Jordán (2003: 96), "The common denominator of the ayllu rests on consanguinial or fictive kin ties that unite a given number of families. The social grouping is organized economically and politically and can be incorporated into separate, larger political and economic hierarchy."

show sudden and significant changes to the domestic economy following the rise of the urban center, specifically as it relates to food consumption patterns. I would also not expect dramatic changes following its abandonment, as trade and agricultural production that was locally managed by autonomous groups should not have been significantly impacted. Further, there should be little evidence of an intensely hierarchical division of society with significant disparities in access to highly valued foods, such as imported maize. Finally, given the linkage between distinctive types of feasting events and political consolidation that have been noted by many researchers (see Clark and Blake 1994; Dietler 1996, 2001; and Kirch 2001 among others), evidence of specific types of feasting events hosted at Tiwanaku and other regional centers will provide further insight into the extent to which Tiwanaku was a centralized state. This aspect of the study is detailed in Chapter 4.

Current Approaches

More recently, other archaeologists have also moved away from models stressing the role of social *inequality* in the formation of the archaic state, examining *integrative* strategies of state formation and the heterogeneity of Tiwanaku populations (Janusek 2004; Janusek and Blom 2006). At Tiwanaku, research indicates that residential compounds were organized according to distinct ethnic affiliations, with some having ties to other geographical regions and/or practicing different craft specializations (Couture 2003; Couture and Blom 2004; Janusek 2002, 2003, 2004, 2005; Rivera 2003). At the culturally affiliated urban centers of Lukurmata in the nearby Katari Valley (Bermann 1994, 1997, 2003; also see Janusek 1994) and Khonkho Wankane in the Desaguadero

Valley (pers. comm. J. Janusek 2009), excavations have shown that while Tiwanaku influence was present, local styles of architecture and material culture were maintained, suggesting, at least to some extent, the preservation of local autonomy.

Recent bioarchaeological research has also underscored the heterogeneity of Tiwanaku society. Study of epigenetic traits and distinctive patterns of cranial shape modification[19] by Blom (1999, 2005; Blom et al. 1998) indicate that the Tiwanaku capital was a site of convergence for diverse ethnic groups throughout the region. In contrast, other altiplano urban centers such as Lukurmata remained primarily inhabited by local peoples. Strontium isotope analysis by Knudson (2004) also found numerous individuals at the Tiwanaku capital who appear to be of foreign origin. In addition, the work of both Blom and Knudson has identified apparent altiplano migrants in the Moquegua valley of Southern Peru, indicating significant population movement throughout the region. Using multiple lines of data, these researchers are documenting the complexity of Tiwanaku society. The present study will further contribute to the more nuanced vision of life in the Tiwanaku state and provide new insight into the nature of Tiwanaku's political authority.

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[19] Blom's work (1999) has shown that distinct styles of cranial shape modification were used as markers of group identity in the region.

CHAPTER III

FOOD, FEASTS, AND THE CONSTRUCTION OF IDENTITY AND POWER

> It is probably in tastes in *food* that one would find the strongest and most indelible mark of infant learning, the lessons which longest withstand the distancing or collapse of the native world and most durably maintain nostalgia for it. The native world is, above all, the maternal world, the world of primordial tastes and basic foods… (Bourdieu 1984: 79).

Introduction

This chapter presents the theoretical perspectives that have influenced the present study, drawing on a large body of literature linking food, feasting, identity, and politics. In the first section, I discuss how food consumption is a significant marker of identity. It is used to reflect, maintain, and create social boundaries. I then discuss how food related practices such as feasting may actually invoke processes of social change. Finally, I review the evidence for the central role of feasting in the development of Tiwanaku, demonstrating the important connections between food and politics and the potentially valuable insight into social and political dynamics to be gained through bioarchaeological study of individual food consumption profiles.

The Anthropology of Food

Anthropologists, sociologists, and historians have become increasingly aware that the study of food and culture is more than an investigation into how basic biological needs are met; rather, food consumption is significantly involved in the construction of meaning and identity. What one eats, who it is eaten with, where it is eaten, and how it is eaten, whether consciously or not, communicates a great deal about social relationships.

During the 1960's and 1970's, structuralists were among the first to move beyond functionalist considerations of food and culture (Douglas 1971, 1983, 1984; Hugh-Jones 1978, 1979; Lévi-Strauss 1966, 1969, 1978; also see Barthes' related approach drawing on semiotics 1997 [1961]). Lévi-Strauss examined how cooking operated as a "symbolic marker between a series of binary oppositions" (raw/cooked, inedible/edible, nature/culture) that exist as organizing principles explaining a wide range of divergent cultural phenomenon sharing a common structural basis (Ashley et al. 2004). Although structuralism has been heavily critiqued for ignoring the role of human agency within the structure and its assumptions regarding universals of human thought, oppositions such as nature/culture and raw/cooked have remained important means of thinking about the symbolism and meaning of food (e.g. Williamson 1978). In addition, Lévi-Strauss's (1969) consideration of cultural transformation (e.g. raw/nature → cooked/culture), as related to the stages of food preparation, also continues to offer insight into the value associated with various foods in specific cultural contexts (e.g. Hastorf and Johannessen 1993:120-122; Allen 2002: 126).

Post-structuralists have focused on the ways in which food consumption, like other aspects of material culture, is involved in the creation, maintenance, and manipulation of identity and meaning that structure wider relations of power (Adams: 1990; Ashley et al. 2004; Counihan 1998, 1999; Goody 1982; Kahn 1998; Johnsson 1986; Mintz 1985, 1996; Pollock 1998; Scholliers 2001; Weismantel 1988). Much of this research draws on the work of Pierre Bourdieu (1984), whose novel approach to modern French consumption patterns suggested that food choices are influenced, if not largely dictated by internalized class specific social conditioning (i.e. the *habitus*) that begins in infancy and continues throughout the developmental years; thus, when it comes to food, individuals often "have a taste for what they are condemned to" (Bourdieu 1984: 177). Although individuals may have a range of food choices, in practice they are subconsciously constrained to a certain extent by *doxa*, a set of core beliefs and values that are taken to be inherently true and favor the dominant class. His work recognized that food and the etiquette surrounding it are basic ways people define social boundaries, in terms of status, gender, kinship, ethnicity, age, and sometimes occupation. Therefore, studies of food distribution and consumption have the potential to provide significant insight into issues of class identity and how that intersects with power relations and politics.

In Bourdieu's original study (1984), he found that the upper class French valued cuisine that was original and exotic, with an emphasis on the quality of the food. They also adhered to relatively formal rules of table etiquette. Their knowledge and appreciation of these foods and rules of etiquette marked their tastes as distinct from that of working class laborers who valued quantity over quality and observed few formal rules of etiquette. Such tastes provided members of the upper class with what Bourdieu refers to as cultural capital; that is, the most basic form of capital prescribing value to certain culturally authorized tastes, skills, or knowledge, the possession of which helps to legitimize or naturalize differences in social status. The dominant power position of the upper class or other institutions (religious, political, or social) provides them the authority to designate what legitimate capital is (in this case, which foods are socially valued), often reflecting their own interests and ultimately perpetuating relations of domination and inequality. However, in the absence of sumptuary laws or other restrictions, emulation of upper class tastes by the lower class necessitates the introduction of novel consumptive practices by the dominant to maintain their distinct status. Thus, Bourdieu views interpersonal relations essentially as a competitive game to acquire status and prestige.

Bourdieu's work has rightfully been criticized for its rather one-sided portrayal of the relationship between structure and agency[20], in that he fails to adequately account for how individual actors affect social change, focusing too heavily on how practice maintains inequality rather than how it might resist it. Bourdieu's theoretical framework has also been criticized for its tendency to reduce human motivation to Western notions of self-interest that ultimately seek economic or political gain, as well as its emphasis on inequality in terms of class distinctions, while largely overlooking other forms of inequality that stem from gender or ethnic differences (see Knauft 1996:122-128 for a more robust critique). Despite these shortcomings, Bourdieu's insight into consumptive practices and how they shape social identity in relation to structures of power remains a useful starting point for exploring how access to food and food choices articulate with the construction of political authority.

Other anthropologists have highlighted how *changes* in food habits may reflect larger social, political, and/or ideological changes. Weismantel's (1988) work among the impoverished highland Zumbagua of Ecuador has revealed how Westernization and the associated socio-economic changes have impacted gender relations, resulting in

[20] The recursive relationship between structure and social actors or agency is more thoughtfully considered in the work of Giddens (1979).

controversies and conflicts that are played out in the daily practices of cooking, serving, and consuming food. Her work also highlights the ways in which women, as the primary food preparers, may manipulate traditional food practices to assert their power in the household[21]. Goody's *Cooking, Cuisine, and Class* (1982), contrasted what he perceived to be a lack of internally differentiated cuisines among traditional African societies with the development of *huate cuisine* in Europe and Asia in order to demonstrate how cuisine may reflect social organization. Although he has been criticized for over-generalizing the case for Africa (see Dietler 2001: 68), his study of long term changes in consumption was among the first to consider how differential access to food may be used to create and maintain social hierarchy. Mintz's (1985, 1996) study of the history of sugar consumption following its introduction to Europe is a revealing example of how power relations structure patterns of food consumption. Given the cost of procuring sugar from early colonies, it was initially a luxury only afforded by wealthy elites. Its rare and costly status meant that "its very consumption came to express a kind of power" (Mintz 1996:12). As production increased and prices fell, desire for this symbolically charged food associated with elite identity resulted in emulation, and sugar trickled down to the lower European classes. Eventually, the general population became deeply dependent on it and has remained so to this day.

Although all foods have the potential to provide insight into human relations, as Mintz's study suggests, certain foods can become more symbolically charged with meaning than others. As such, their distribution and consumption may offer the greatest

[21] For example, Weismantle (1988:1831-182) noted that in response to a husband returning home exceedingly drunk, some women would prepare particularly elaborate and heavy meal, which, according to traditional etiquette, the husband could not refuse. Such a meal left the hungover husband quite sick and the wife feeling somewhat vindicated. In this way we can see one example of how the manipulation of food practices can be a source of empowerment

insight into social dynamics. These socially valued foods have variably been described as prestige or luxury foods (Hastorf 2003a; van der Veen 2003). Van der Veen (2003: 405) defines luxury foods as "those foods that offer a refinement in texture, taste, fat content or other quality (such as stimulant or inebriant) and offer distinction, because of either their quantity or quality." Luxury foods are often foods that are foreign, rare, or difficult to obtain or may be unusually labor intensive to produce. However, Hastorf (2003a) cautions that focusing on rare and costly foods can be elite-centric, as luxury foods also existed for the non-elite, typically in the form of locally produced foods served in unusually large quantities and prepared in special or labor intensive ways.

Within the Andes, a number of prestige or luxury foods have been identified. Based on archaeological, ethnohistoric, and ethnographic data, Hastorf (2003a:546-547) has noted three types of luxury foods often consumed on special occasions in the Andes. The first is not actually a particular food, rather it is marked by the consumption of large quantities of locally available food (e.g. tubers, quinoa, etc...) often prepared in special ways. Hastorf observed such a pattern of festive consumption dating as far back as the Middle Formative at the altiplano site of Chiripa (Hastorf 2003a: 550). The second is meat, which is not consumed on a regular basis among most modern Andean populations. Meat is primarily reserved for festive occasions (see Johnsson regarding the modern Aymara 1986: 40). Cobo's (1990 [1653]: 198) observations of Inca eating habits allows this pattern of consumption to be projected as far back as early colonial times, noting— "the plebians ate very little meat, and when they did it was at festivals and banquets." Finally, fermented beverages were and are extremely valued and necessary components of most special occasions in the Andes[22]. Traditionally, these fermented beverages, known as *chicha*, could be made of a variety of plants including quinoa, molle, and manioc, but the most prized was made from maize (Hastorf 2003a). The changing distribution of these symbolically charged foods through time can provide significant insight into Andean social and political dynamics, as demonstrated by Hastorf's study of food consumption patterns and the impact of Inca political authority on peripheral populations within the Mantaro Valley of Peru. Hastorf (1990, 2001; Hastorf and Johannessen 1993) documented significant changes in maize and meat consumption patterns following Inca conquest. On average, the proportion of maize in the diet increased, with certain males consuming more maize than the remainder of the population. This suggested state provisioning of maize *chicha* for males fulfilling labor obligations to the state. However, meat consumption became less variable, suggesting a "leveling effect" as the power of local leaders was undermined by Inca authority.

This discussion has highlighted the ways in which food may reflect and structure social identity and human interaction. In the following section I discuss current perspectives on how one particular food consumption practice, communal feasting, played a significant role in processes of social change.

Commensal Politics

In recent years, anthropologists have increasingly recognized feasts as extremely important aspects of social life in past and present societies around the globe (Bray 2003; Clark and Blake 1994; Cook and Glowacki 2003; Dietler 1996, 1996 2001; Dietler and

[22] Many studies have noted the central role of alcohol in the social and ritual life of historic and modern societies around the globe (Allen 2002; Arnold 1999; DeBoer 2001; Dietler 1990, 1996; Heath 1962; Joffe 1998; Netting 1964; Pollock 1998; Sangree 1962; March 1998).

Hayden 2001; Dietler and Herbich 2001; Gero 1992; Hayden 1996, 2001; Junker 1999, 2001; Kelly 2001; Kirch 2001; Knight 2001; LeCount 2001; Phillips and Sebastian 2002; Spielmann 2002; Van Keuren 2002 ; Wells 2003, 2007; Wiessner 2001; Wills and Crown 2002;). Following Dietler, I define feasts as "forms of ritual activity that involve the communal consumption of food and drink" (Dietler 2001: 65). It is the ritual component, often associated with public performance (e.g. dance, music, oration, use of special costumes, etc…) and the heightening of the senses through inebriation, which most clearly differentiates feasts from everyday meals (Dietler 2001: 69-75).

Mauss (1954 [1925]) was one of the first to write about the social and political significance of feasts, observing that the hospitality displayed through the redistribution of food, drink, and prestige goods during feasts was not free of self-interest. Rather, these gifts demonstrated the giver's social status and prestige and were an important means of creating and defining social hierarchy. "To give is to show one's superiority [while to] accept without returning or repaying more is to face subordination, to become a client and subservient" (Mauss 1954 [1925]: 72). Further, Mauss demonstrated that putting people under obligation through public displays of generosity was ultimately an important means of winning followers, establishing alliances with other groups, and mobilizing labor. Despite Mauss' insightful contribution, most archaeologists largely overlooked the political significance of feasting rituals until recently. As Dietler (2001: 69) points out, few moved beyond functionalist considerations, viewing feasting events merely as important means of encouraging social solidarity—i.e. *communitas* (Turner 1969).

Not until the mid 1990s did archaeologists begin to recognize the potential significance of feasting events in processes of social change, particularly as it related to the development of novel social distinctions. Clark and Blake (1994) working at the site of Paso de la Amada, Mexico, were the first to clearly articulate such a theory. They proposed that local "aggrandizers" sponsored feasts in competitive displays of generosity to gain prestige and social esteem and build alliances—"over time, some aggrandizers became chiefs with institutionalized authority, parlaying temporary prestige into legitimate authority" (Clark and Blake 1994: 17). People allied themselves with aggrandizers not as a result of coercion but because it was in their own self interest. Successful aggrandizers were able to supply them with something they desired on a regular basis. "Aggrandizers are strongly motivated to increase rewards through increased production and innovation"—often seeking foreign contacts to secure access to socially valued exotic resources, the possession and redistribution of which garnered them even more prestige (Clark and Blake 1994: 21). Thus, Clark and Blake envision the transformation from an egalitarian to a hierarchical society as a long-term unintended consequence of self-interested competition among ambitious individuals seeking prestige.

Based on an extensive body of archaeological and ethnographic research, Dietler (1996, 2001) has significantly expanded on the relationship between feasts and politics, or what he refers to as commensal politics. Similar to Clark and Blake (1994), Dietler considers feasting events as prime arenas of social change and assumes the underlying motivation for social actors who sponsor feasts is the optimization of cultural, social, or economic capital in order to acquire and/or maintain symbolic capital (i.e. prestige), the accumulation of which may ultimately lead to social influence and power. Dietler's work draws on political economy and practice theory, and regards feasting as a significant "social practice by which people actually negotiate relationships, pursue economic and political goals, compete for power, and reproduce and contest ideological representations of social order and authority" (Dietler 2001: 66). Thus, his work brings attention to the potential of commensal politics to promote social solidarity while also defining social boundaries such as class, ethnic, or gender divisions. These divisions are often marked by differences in the foods served to specific groups, the etiquette surrounding their consumption, the spatial organization of participants, and who is invited to participate.

The role of feasting in social and political transformations also draws on the anthropology of food and ideas about identity construction discussed previously. As Dietler (2001: 72) notes, it is the centrality of food and drink which lend feasts their ritual and political potency:

> Food and drink are highly charged symbolic media because they are 'embodied material culture': that is, a special form of material culture produced specifically for ingestion into the body. They are a basic and continual human physiological need, which are also a form of 'highly condensed social fact' (Appadurai 1981: 494) embodying relations of production and exchange and linking the domestic and political economies in a highly personalized way. Moreover, although eating and drinking are among the few biologically essential acts, they are never simply biological acts. Rather, they are learned 'techniques du corp' (Mauss 1935)—culturally patterned techniques of bodily comportment that are expressive in a fundamental way of identity and difference.

This dissertation demonstrates how a symbolically charged drink (maize *chicha*) was used to mark identity within Tiwanaku society, and how, in the context of feasting, it played a central role in altiplano social and political change.

Many have observed that alcohol often plays a particularly important role in feasting and other ritual events (Arnold 1999; Bray 2003b; Clark and Blake 1994; Cook and Glowaski 2003; Heath 1962; DeBoer 2001; Dietler 1990, 1996, 2001; Joffe 1998; Johnsson 1986; Sangree 1962), likely due to its psychoactive properties, which may heighten the theatrical aspects of the event. Further, alcohol is a food transformed through the "quasi-magical" process of fermentation, which ultimately transforms human consciousness, adding to its symbolic value (Dietler 2001: 73; also see Hastorf and Johannessen 1993). In the Andes, a wealth of ethnographic, ethnohistoric, and archaeological data attest to the symbolic importance of maize alcohol in communal feasting events and other ritual activities. This study will show that despite its antiquity and distance from maize growing regions, Tiwanaku was no exception to this Andean tradition.

Modes of Commensal Politics

Dietler (1996, 2001) has developed a useful typology of feasting events, describing three different modes of commensal practices based on the functions these types of feasting events serve in the political economy: 1) empowering feasts, 2) patron-role feasts, and 3) diacritical feasts (note that these types are not mutually exclusive). This typology is heuristically useful for archaeologists, as it has important implications for identifying the political function of feasting in past societies based on which subgroups attended, how many people attended the feast, what sort of spaces were utilized, what was served to whom, and other material correlates that may have been involved.

Empowering feasts are the most basic form of commensal politics and may be found in the greatest diversity of contexts from small egalitarian communities to state level societies. At such events large quantities of commonly available food and drink are served to all guests with the expectation that the feast will one day be reciprocated. Empowering feasts may be hosted by an individual, a kin group, or a whole community and may mark life cycle events such as births, deaths, and marriages. According to Dietler, the goal of the host(s) of empowering feasts, whether overtly recognized or not, is the acquisition of symbolic capital—i.e. prestige. Work feasts, in which the host provides food and drink in exchange for labor, also fall under this mode of commensal politics (Dietler and Herbich 2001). Weissner's (2001) study of feasting among the Enga of Papua New Guinea provides an excellent example of how empowering feasts may be used by "Big Men" to gain prestige (for other ethnographic examples of empowering feasts see Clark 2001 and DeBoer 2001; for an archaeological example see Brown 2001).

Patron-role feasts differ from empowering feasts in that there is no expectation that the feast be reciprocated. These feasts legitimize and naturalize existing, often institutionalized, asymmetries of power and create social debt that can only be repaid through allegiance and labor. By accepting their role as guests, participants are acknowledging their subordinate status and entering into a patron/client relationship. Hosting of such feasts is often expected of chiefs and kings and involves the redistribution of agricultural tribute. Large quantities of commonly available food and drink are served at these feasts, which are often held in public spaces and may mark significant dates on a religious or agricultural calendar. This type of feast may also be sponsored to fulfill obligations of reciprocity to corvée laborers and others serving the state. Feasting events sponsored by the Inca state offer an excellent example of the patron-role mode of commensal politics. Ample ethnohistoric and archaeological data demonstrate that the Inca sponsored large public feasts throughout the empire, which functioned to "maintain the facade of reciprocity and obligate labor tribute in order to ensure the continued operation of the state" (Cook and Glowacki 2003: 183; Bray 2003; Rostworowski 1977). This model of patron-role feasts practiced by the Inca appears to have Middle Horizon precedents in the Wari empire, where commensal feasts were hosted by elites in large public plazas at the site of Conchopata (Cook and Glowacki 2003).

Finally, diacritical feasts are more exclusive elite events involving "the use of differentiated cuisine and styles of consumption as a diacritical symbolic device to naturalize and reify concepts of ranked differences in the status of social orders or classes" (Dietler 2001: 85). The elite status membership of the feast's participants is marked by the use of rare, exotic, or expensive foods, elaborate serving wares, or complex patterns of food preparation or consumption requiring specialized knowledge or specially developed tastes (i.e. "cultural capital," Bourdieu 1984), the possession of which distinguishes them from the lower classes (Dietler 2001: 86). Diacritical feasts are often held in more exclusive intimate settings. These feasts are often a type of competition among elites and, in the absence of sumptuary laws, result in emulation by non-elites. This mode of consumption is present in most highly stratified societies, as exemplified by the lavish feasts reported among historic Hawaiian nobility (Kirch 2001), the symposia attended by ancient Greek aristocrats (Alcock 2006), and intra-elite feasting among Maya elites (Hendon 2003; LeCount 2001).

This discussion has demonstrated how the manipulation of food and drink in the context of communal feasting events played an active role in processes of social change. The growing interest in commensal politics among archaeologists reflects a post-processual concern with individual agency, as it offers new insight into the specific means by which human relations and social interaction affect social change. Due to its often archaeologically recognizable material correlates, the study of commensal politics provides archaeologists a unique opportunity to study the "'micro-politics' of ancient societies as negotiated in the arena of everyday life" (Bray 2003: 2). In the following section I will discuss the role of food and feasting in the development of Tiwanaku.

Food and Feasting in Altiplano Prehistory

Evidence of communal feasting events in the altiplano can be traced back to at least the Early Formative period (1500- 800 B.C.). At the site of Chiripa, Early Formative deposits reported by Hastorf (2003b) include a trapezoidal sunken court enclosure associated with deposits of specialized jars and bowls for consumption, forms which are found infrequently in other sections of the site, as well as an adjacent upper enclosure associated with food preparation. The sunken court could have held as many as fifty people at a time. Analyses indicate the foods consumed at such events were of local origin but were likely served in unusually large quantities for special events (Hastorf 2003a). Hastorf (2003b) suggests that these public feasting events were associated with ancestor veneration. By the Middle Formative (800-100 B.C.), the evidence for communal feasting events at Chiripa increases significantly. Dense deposits of cooking and serving vessels are found in sunken court enclosures also associated with ritual paraphernalia including incenses burners and ceramic trumpets, indicating music was part of the festivities. The later sunken enclosure was atop the main mound and was surrounded by fourteen small rooms divided into two groups of seven. Hastorf (2003b: 325) proposes these rooms belonged to two local moieties, each containing seven lineages (a pattern of social organization that continues to this day on the Taraco Peninsula). Numerous subfloor burials that appear to have been periodically reopened for the placement of offerings were found inside the rooms. The proximity of these rooms to the sunken court indicates that public feasting events at Chiripa revolved around ancestor veneration. The separate rooms likely hosted more restricted rituals marking social boundaries between lineages, while the sunken court hosted communal consumption rituals encouraging social solidarity.

By the Late Formative, new larger ceremonial centers arose in the southern basin, including Khonkho Wankane and Tiwanaku. Ceremonial life at each of these sites also revolved around trapezoidal sunken court complexes reflecting continuity with Early and Middle Formative practices. At Khonkho Wankane, excavations revealed the surface of the sunken court was littered with ceramic sherds and the remains of butchered camelids (Janusek and Pérez 2005), indicating the space was associated with rituals of communal consumption. Greater quantities of camelid meat were apparently consumed at Late Formative feasts, when compared to Early and Middle Formative feasting deposits. Adjacent to the complex was a residential compound with private access to the court, which may have housed a high status group or ritual specialists who coordinated local ceremonies. Given the similar architecture of the contemporaneous sunken court at Tiwanaku and the adjacent high status residential compound, it is assumed that

Tiwanaku's court served a similar purpose. In fact, recent excavations within Tiwanaku's core by Gustavo Cortez indicate that the area known as the Chunchukala was likely used for food and drink production for Late Formative communal consumption events associated with the Kalasassaya platform (Cortez 2009).

By the beginning of the Tiwanaku Period (Tiwanaku IV), the site of Tiwanaku becomes the preeminent regional ceremonial center and feasting intensifies. Middens associated with feasting indicate that local staples along with large quantities of camelid meat likely continued to be important elements of feasts; however, much data indicates that imported maize, served in the form of *chicha,* became a central element of feasting events during this period. As Paul Goldstein (2003) points out, the onset of the Tiwanaku Period coincides with an abrupt change in ceramic assemblages. New forms dedicated to the large-scale preparation, storage, and consumption of maize beer appear in the Southern Titicaca Basin and quickly spread throughout the South Central Andes. Far away regions ideally suited for maize agriculture are colonized (e.g. Moquegua) while other maize growing regions become important trade partners (e.g. Cochabamba and the eastern lowlands). These developments reflect radical changes in food, drink, and politics. It is increasingly clear that an intensification of competitive feasting, featuring maize beer, was a key element in Tiwanaku's rise to power. However, prior to discussing Tiwanaku Period feasting any further, I will first provide a brief background on the role of maize beer in the Andes at the time of contact,[23] as it is important for considering its potential significance to Tiwanaku populations.

According to the accounts of early Spanish chroniclers, the symbolic and economic importance of maize *chicha* in the pre-Hispanic Andes cannot be overstated.

[23] For an in depth discussion of the history of maize in the Andes see Chapter 4.

The Inca resettled whole populations and transformed landscapes for the large-scale production of maize surpluses for the state. The redistribution of maize *chicha* was a central component of all state sponsored ceremonies and festivities, creating social debt and reinforcing hierarchical relationships. In fact, as Hastorf and Johannessen point out, an alternate name for the Inca capital of Cuzco was *akha mama*, or *chicha* mother. "Cuzco was thus the source and home for *chicha*, an appropriate metaphor for the capital in view of the role of *chicha* in Andean power relations, flowing abundantly from the leader to the followers in exchange for allegiance" (Hastorf and Johannessen 1993: 118). Production of maize *chicha* for state sponsored festivities was undertaken by sequestered groups of chaste women known as the *aqllakuna*. The Inca army and state sponsored work parties were also supplemented with maize *chicha*. At the local level, social relationships were cemented through reciprocity involving the consumption of maize beer. As Staller (2006: 456) notes, when one "offered and consumed maize beer as part of a social exchange, one was perceived as entering into a symbolic union of sorts"—drinking *chicha* together was both a reflection of alliance and a way to create and maintain alliances. Within the spiritual realm, maize *chicha* was offered to local *huacas* and the ancestors in exchange for good weather, bountiful crops, and good health. Studying the circumstances surrounding the apparently sudden popularity of maize *chicha* among Middle Horizon populations can provide important insight into why and how it achieved the status it did within Andean culture.

In the altiplano, maize *chicha* became a critical component of competitive feasting events that accompanied Tiwanaku expansion during the Middle Horizon. However, Goldstein argues that Tiwanaku never developed the "redistributive patron-role feasts of the Inca state-sponsored model" (Goldstein 2003: 165). He contends that most evidence of feasting at Tiwanaku (including *keros* and other serving vessels) is found in the plazas of residential compounds rather than in association with public architecture (e.g. the Akapana) and is thus indicative of what Dietler (1996, 2001) refers to as empowering rather than patron-role feasts. The absence of specialized structures for the preparation of maize *chicha,* such as the *acllawasi* of the Inca, is cited as further evidence of a more decentralized mode of feasting. Thus, Goldstein (2003: 165) concludes:

> Accepting the politically charged nature of feasts, this suggests that the Tiwanaku diaspora relied on intermediate levels of social organization, rather than unitary state governance, for its articulation. The decentralized nature of Tiwanaku feasting suggests that Tiwanaku's *chicha* economy was not part of a fully developed centralized political economy but a system run through a heterarchy of *ayllu*-like corporate groups operating within a loose confederative state.

Although I agree that smaller empowering feasts were a frequent occurrence at the household level, I do not agree with Goldstein's assertion that public patron-role feasts did not occur at Tiwanaku. Given the Early, Middle, and Late Formative precedents for public feasting events associated with sunken court complexes and associated plazas in the altiplano, it is inconceivable to me that sunken courts like the one that topped the Akapana and the adjacent plaza were not the site of some form of commensal consumption. Goldstein argues that the rituals carried out at the Akapana centered around offerings and sacrifice rather than commensal consumption and although I agree that offerings and sacrifice were certainly significant aspects of the Akapana rituals, there is substantial evidence of feasting in the form of communal serving wares, faunal remains, hallucinogenic snuff tubes, and vessels associated with *chicha* consumption littering its terraces (Alconini 1995; Kolata 2003; Manzanilla 1992; Janusek

2004a). In fact, current excavations at the base of the northwest corner of the Akapana, directed by Jose Luis Paz, have revealed what preliminarily appear to be dense middens containing refuse produced by rituals of consumption (pers. comm. J. Janusek 2010). There is also evidence of specialized food and drink production areas for elite sponsored (patron-role) feasting events. During the latter half of the Tiwanaku Period (Tiwanaku V), the Akapana East 1 was apparently used for this purpose (Janusek 2003, 2004). Given these data, I maintain that there is ample evidence of patron-role feasting at Tiwanaku during the Middle Horizon, a mode of commensal politics that I argue played a central role in actually constituting the structures of power in Tiwanaku society. Once established, these structures of power continued to be legitimized and naturalized through such feasting events. Thus, the scale of these feasting events and the construction of a massive complex (i.e. the Akapana) dedicated to feasts indicate that Tiwanaku's political economy was likely more centralized than Goldstein acknowledges.

In addition, I suspect that by the latter half of the Tiwanaku Period, diacritical forms of feasting were also practiced among Tiwanaku elites. Preliminary evidence of this comes from distinctions in ceramic assemblages. Janusek (2003: 293) reports that during this period "ceramic assemblages in the Putuni Palace and the north compound of Akapana East 1 were strikingly diverse, well-made, and iconographically elaborate," while in other residential compounds assemblages become more standardized. Finding dietary distinctions among the individuals in these compounds, particularly in foods associated with feasting such as maize or meat, would substantiate my assertion that diacritical feasting was practiced.

Following the abandonment of Tiwanaku, Post Tiwanaku (Pacajes) populations dispersed throughout the altiplano, and although vessels associated with *chicha* consumption continued to be produced, the large *ollas* and *tinajas* necessary for large-scale feasting disappeared (Janusek 2003), indicating feasting likely continued, but on a much smaller scale. As I will discuss in subsequent chapters, these changes in feasting behavior were also accompanied by major changes in altiplano diet, offering significant insight into the processes leading to the collapse of Tiwanaku.

It is clear from this discussion that ceremonial feasting played a significant role in building, maintaining, and defining social relationships throughout altiplano prehistory. During the Tiwanaku Period, these activities intensified on a grand scale as elites hosted increasingly lavish feasts in order to legitimate their elevated status, maintain the allegiance of a growing urban population, and likely obligate labor tribute. The evidence also suggests that dramatic changes in local culinary traditions coincided with the intensification of feasting and interrelated political transformations. I suspect the more dramatic changes were the result of innovation on the part of local aggrandizers who sought to secure access to exotic resources, such as maize, in order to attract and maintain more followers. But, who had access to these resources and in what amounts? How did this change over time? To what extent did eating habits and the daily lives of altiplano people change and what might that reveal about the nature of Tiwanaku political authority? The present study seeks to answer these questions using food as a window into Tiwanaku socio-political relations through time.

The bioarchaeological methods utilized by this study reveal consumption patterns at the level of the individual and are thus uniquely suited to contribute to discussions of food and politics in past societies, documenting changes in consumption among individuals from different segments of society. Such a study can provide significant insight into the micro-politics of gender and class relations. For example, numerous bioarchaeological studies within the Maya region have revealed that elite diets were often marked by a wider variety of resources relative to non-elites (Reed 1994; White 1997; White et al. 2001), while others have demonstrated that elite diets, at least within the Petén region, were distinguished by greater access to maize and meat relative to non-elites (Wright 1994). In North America, bioarchaeological analyses at Cahokia revealed that elite males consumed significantly more meat than low status females, whose diets were more heavily dependent on the staple crop maize (Ambrose et al. 2003). In contrast, research in the Ecuadorian highlands of South America demonstrated that elites consumed more maize relative to non-elites (Ubelaker et al. 1995). By analyzing samples with considerable temporal depth from throughout the Tiwanaku heartland, this study aims to document changes in social relations accompanying the political transformations that occurred during the Late Formative, Tiwanaku, and Post Tiwanaku Periods. I consider how food was used to mark identity and create social boundaries and I examine how the manipulation of food became an active force in political transformations.

CHAPTER IV

ANCIENT CUISINE OF THE SOUTHERN TITICACA BASIN

Introduction

In order to reconstruct ancient Southern Titicaca Basin subsistence patterns using bioarchaeological methods, it is first necessary to establish what resources were potentially on the menu during the periods of interest (i.e. the Late Formative through the Post Tiwanaku/Pacajes periods). Altiplano diets were significantly altered during the colonial period due to the introduction of Old World cultigens such as wheat, barley, and oats as well as domesticates, including sheep, pigs, and chickens. Thus, studies of modern consumption practices alone do not provide an accurate picture of past diets. Fortunately, this study benefits from a wealth of previous ethnohistoric, archaeological, and paleobotanical research in the region that provide an excellent baseline for interpreting my bioarchaeological data in Chapters 6-8. In this chapter, I synthesize current knowledge of ancient subsistence strategies in the Southern Titicaca Basin and consider how the contribution of certain resources to the diet may have changed through time. I first discuss the use of local crops, followed by potential lowland imports, then fish, and finally, bird and mammalian resources.

Local Altiplano Cultigens

Despite the basin's altitude of more than 3800 masl, a variety of well-adapted tubers, grains, and legumes have been cultivated there to some extent since at least the

Early Formative period (Bruno and Whitehead 2003; Eisentraut 1998; Towle 1961). Paleobotanical research indicates that these local cultigens were the staples of southern basin diets during the periods of interest to this study. There is no indication that any local wild food plants were a substantial component of the diet, although Bruno and Ramos (2009: 4) did recently report finding low densities of cactus seeds "from edible fruits of the species *Opuntia, Maithenopsis*, and *Cactoideae*" in soil samples from the Mollo Kontu residential sector of Tiwanaku. However, these cacti fruit were not a major component of local diets and it is clear the bulk of locally produced plants consumed were the tubers, grains and legumes discussed in the following sections.

Tubers

Tubers are by far the most important staple crop in the Southern Titicaca Basin today, especially the potato (*Solanum tuberosum*), known as *ch'uqi* in Aymara, followed by oca (*Oxalis tuberosus*), isanu (*Trapeolum tuberosum*), and ulluco (*Ullucus tuberosa*) (Carter 1976; Bruno 2008; Johnsson 1986). Modern farmers typically plant a variety of tubers due to their variation in frost resistance, so if one crop fails, another will hopefully survive to provision the family (Johnsson 1986). Over 200 named varieties of tubers have been documented in the altiplano (Carter 1976; Le Barre 1947). Murra (1980) suggests that the enormous variety of potatoes is an indication of the great interest in high altitude cultivation throughout the history of human occupation in the South Central Andes. One benefit of the cold climate at this altitude is that it allows for preservation and long term storage of tuber crops, which would have been advantageous to growing populations. Specialized techniques such as freeze drying potatoes to produce *chuñu* or *tunta* allow the crops to be stored from three to five years (Carter 1976) and have been practiced since at least the time of Spanish contact (Cobo 1990).

The modern Aymara boil or steam potatoes and serve them with most meals. In fact, Painter (1981:143) notes that if a meal lacks potatoes, it is not considered a true meal. The importance of the crop is also indicated by modern planting and harvesting rituals that exist exclusively for the potato but not for other highland crops (Carter 1976: 6). Summing up both the religious and secular importance of potatoes, Carter (1976:13) cites a proverb told by the Aymara about their people: "Without potatoes they would be like loose threads on a loom, for potatoes are what bind life together."

The results of paleobotanical research reflecting the importance of tubers to the diets of past inhabitants of the region have reported conflicting results. However, preservation issues may be a factor, as tuber preparation often involves boiling rather than roasting and only charred tuber fragments would be preserved in the archaeological record. Evidence of tuber cultivation dates back to at least the Early Formative (Browman 1989; Erickson 1976; Whitehead 2006). Recent research at Formative period sites on the Taraco peninsula by Bruno (2008) indicates that tuber cultivation increased in importance from the Middle to the Late Formative, while quinoa production apparently declined. While study by Wright, Hastorf, and Lennstrom (2003) at Tiwanaku, Lukurmata, and rural Tiwanaku valley sites found that Late Formative and Tiwanaku period populations were far more dependent on quinoa than tubers. In general, they found that tubers were surprisingly uncommon at most sites and decreased in density from the Late Formative to the Tiwanaku Period. Interestingly, at the site of Tiwanaku, disparities in tuber presence among high and low status residences, suggest tubers were more dominant in low status diets (Wright et al. 2003).

Recent paleobotanical research by Bruno and Ramos (2009) in the Mollo Kontu residential sector of Tiwanaku also provided results that conflict with those of Wright and colleagues (2003). Wright et al. reported tuber densities and ubiquities for 27 samples from the sector at zero percent, while study of 32 samples from the same sector by Bruno and Ramos (2009) reported 100% tuber ubiquity and high densities. Bruno and Ramos suggest the difference in tuber remains reported by the two studies may reflect Bruno and Ramos' focus on activity areas where food remains would be higher, such as hearths, pits, and middens. Sampling by Wright and colleagues was more generalized and included samples from every locus excavated.

Grains

The most important native grains in the altiplano are the chenopods, including quinoa (*Chenopodium quinoa*) and, to a lesser extent, its close relative kañiwa (*Chenopodium pallidicaule*). Traditionally, quinoa has been second only to the potato in terms of its importance to altiplano diets. However, chenopods are increasingly being replaced in the modern Aymara diet with barley, a less nutritious Old World staple crop (Johnsson 1986). Quinoa seeds may by boiled and used in soups, toasted and ground into flour to make bread, or used to make *chicha.*

Paleobotanical research by Bruno and Whitehead (2003) indicates altiplano inhabitants were harvesting quinoa on a small scale during the Early Formative period while more careful seed selection during the Middle Formative reflects increasingly formal agriculture. By the Late Formative, quinoa was a significant staple and by the Tiwanaku Period it became the most important crop in the southern basin (Wright et al. 2003). Paleobotanical research by Wright and colleagues (2003) found chenopods to have the highest densities and ubiquities of any crop throughout all the Late Formative and Tiwanaku Period sites they studied, including Tiwanaku, Lukurmata and several rural Tiwanaku valley sites. During the Tiwanaku period, Lukurmata had the most chenopodium of any site. Due to the site's proximity to the raised fields on the Koani Pampa, they suggest this is evidence the fields were constructed to produce quinoa. Interestingly, at the site of Tiwanaku, quinoa, although present in all residences, is less common in elite residences and more common in low status residences, indicating quinoa, like potatoes, may have been more dominant in the diets of lower status individuals (Wright et al. 2003).

Legumes

The only legume of dietary significance native to the altiplano is a small bean known as *tarwi* (*Lupinus mutabilis*). Currently it is usually grown in small quantities along the periphery of fields containing other crops and may be boiled and added to soups or eaten alone, but can also be dried and ground to make flour (Johnsson 1986). No ethnohistoric or archaeological data indicate that tarwi was ever a major crop for altiplano inhabitants but it was certainly cultivated and consumed. Paleobotanical research by Wright and colleagues (2003) found that legume densities were low at Tiwanaku, Lukurmata, and rural Tiwanaku valley sites and decreased from the Late Formative to the Tiwanaku Period.

Lowland Imports

At the time of the Spanish conquest it was apparent that most Andean communities had access, either through exchange networks or the establishment of distant colonies, to a wide variety of resources grown outside the ecological zones in which they lived. Lowland communities specialized in fishing, farming and other activities and exchanged with one another along the coast (Rostworowski 1977, 1989), while highland communities obtained resources such as *aji (*peppers), cotton, fruits, coca, hallucinogenic and medicinal plants, and perhaps most importantly maize from the lowlands (Rowe 1946). Based on review of Spanish colonial documents, Murra (1964, 1968, 1972) produced a series of influential publications in which he articulated a model of "verticality" or "zonal complementarity" to explain the relationship between highland Andean societies and their unique environment. Murra's model and its variants became key theoretical frameworks within Andean anthropology and archaeology and its implications for altiplano diets require further consideration.

Zonal Complementarity

Murra's model was based on study of the *Visita de Garci Diez de San Miguel* of 1567, a colonial document in which an inspector for the Spanish crown, Garci Diez, visits an Aymara señorio known as the Lupaqa, living on the western shore of Lake Titicaca, to assess their tribute potential. Based on the information provided by Garci Diez, Murra hypothesized that Andean polities, in order to minimize risk in unpredictable environments, such as the altiplano, strategically established direct control of lands outside their core region (i.e. in different ecological zones), in order to diversify their potential resources. According to Murra, verticality was a unique Andean adaptation that functioned through systems of reciprocity and redistribution as well as kinship ties and led to the development of complex political economies in the absence of market mechanisms. Such networks resulted in what Murra describes as an "archipelago" like patchwork of diverse ethnic groups and political divisions.

Although Murra's concept was based on colonial documents, he hypothesized that the vertical archipelago model of resource exploitation extended well into the pre-Hispanic and pre-Inca Andean past (Murra 1968), largely due to its persistence among groups such as the Lupaqa long after the arrival of the Spanish as well as archaeological evidence of highland goods at pre-Hispanic coastal sites. Murra's ideas were further supported by a wealth of ethnographic data documenting its continuity and variance among modern Andean communities despite more than 400 years of European influence (Bastien 1978, 1995; Brush 1973, 1976; Burchard 1972; Custerd 1977; Flores 1985; Gade 1967; Harris 1978, 1985; Mayer 1971; Fonesca Martel 1972; and Webster 1971); however, much research has also revealed the limitations of Murra's model, demonstrating the danger of over-generalizing what was once considered an ideal of Andean socio-political organization (Browman 1980, 1981; Dillehay and Nuñez 1988; Mujicas 1985; Nuñez and Dillehay 1995; Rostworowski 1977, 1989; Stanish 1989; Van Buren 1996).

In the case of Tiwanaku, a wealth of archaeological data supports the presence of Tiwanaku colonies in the Moquegua valley (Blom 1999; Blom et al. 1998; Knudson et al. 2004; Goldstein 1985, 1989, 1993a, 1993b, 20005; Stanish 2003). As discussed in Chapter 2, the presence of Tiwanaku material culture in other lowland regions is currently interpreted as the result of trade relations. Murra's model, in its purest form, would contend that Tiwanaku established lowland colonies for economic reasons, diversifying their resource base to combat the inherent risks of agriculture in the altiplano and meet their subsistence needs. This implies that lowland resources significantly contributed to the diets of altiplano inhabitants. However, as Van Buren (1996) points out, it is too simplistic to view colonization of lowland areas as an ecological adaptation to balance resources and populations (i.e. a food quest). Motives for colonization were more often political than economic, as colonies typically produced goods necessary for maintaining political power (1996: 346-347). Upon examining the imports valued by Tiwanaku, Van Buren's assessment appears quite accurate. Although, fruits, medicinal and hallucinogenic plants, and coca were all likely imports, the only potential dietary staple coming into Tiwanaku was maize, and, as discussed in Chapter 3, maize was instilled with powerful social and ritual significance and it is doubtful it was initially sought as a subsistence resource. Thus, it is more plausible that altiplano diets were dominated by local resources, while culturally valued imports such as maize were more selectively distributed.

Maize

Spanish chroniclers extensively documented the role maize *chicha* played in Inka culture at the time of contact. Cobo (1979, 1990), whose writings repeatedly express his disdain regarding the Inka affinity for *chicha*, comments that "water is their worst enemy; they never drink it pure unless they are unable to obtain their beverages [*chicha*], and there is no worse torment for them than being compelled to drink water (a punishment which the Spaniards sometimes give them, and they resent it more than a whipping)" (Cobo 1979: 27). Although Cobo was almost certainly exaggerating, it is clear that maize *chicha* was a highly valued dietary resource among most Andean peoples by the Late Horizon.

Archaeological research has traced the history of maize in the Andes as far back as the early Initial Period[24] at sites such as Loma Alta (Pearsall 2003; Piperno and Pearsall 1998; Raymond 2003), Real Alto (Pearsall et al. 2004; Raymond 2003), La Emerenciana (Staller and Thompson 2002), Rio Chico (Pearsall 1980), and La Ponga (Lippi et al. 1984) in Ecuador and La Galgada (Greider et al. 1988; Smith 1988), Cardal (Burger 1987; Burger and Burger Salazar 1981; Umlauf 1988) and Caral (Burger 1987; Burger and Burger Salazar 1981; Greider et al. 1988; Shady and Leyva 2003) in Peru. Although never a staple at these early sites (Tykot and Staller 2002; Tykot et al. 2006), it had already obtained a dominant role as an offering in ceremonial contexts (Bonzani and Oyuela-Caycedo 2006); a pattern that continued through the Early Horizon (Burger and Van Der Merwe 1990). Toward the end of the Early Intermediate Period, there is clear stable isotopic evidence that maize was now becoming a significant staple in local diets in Ecuador and among Gallinazo peoples along the coast of northern Peru (Ericson et al. 1989; Gagnon 2006; Ubelaker et al. 1995). The extent to which maize was consumed in the South Central Andes during the Early Intermediate Period remains unclear; however, by the Middle Horizon, stable isotopic evidence indicates that maize became the dominant staple in the diets of the Wari (Finucane 2006) and among residents of Chen Chen in the Moquegua valley (Tomzcak 2001, 2003). A preliminary study by Tomczak

[24] There is also evidence for maize at several Pre-Ceramic sites, however, the dating of the contexts in which the maize was recovered remains a matter of debate (Bonavia and Grobman 1989, 1999; Grobman 1982; Lynch 1980; MacNeish et al. 1981; Willey and Corbett 1954).

(2001) of ten Middle Horizon individuals from Tiwanaku indicates certain individuals at the site were also consuming maize in significant quantities. Coastal sites as far south as Central Chile reveal a significant increase in maize consumption in the Middle Horizon as well (Falabella et al. 2007). It is safe to say that by at least the Middle Horizon, significant changes in Andean consumption practices had occurred that would later become important elements in the Inka expansion.

The altiplano however was far removed from traditional maize growing zones, and although preliminary isotopic data suggests maize was consumed by some at the Tiwanaku capital (Tomczak 2001), it is not clear how much maize was consumed and by whom nor when it began entering the altiplano and from where. Given the social and political significance of maize in the Andes and the association of its large scale cultivation with the rise of early Andean states (i.e. Moche, Wari, and the Inka), these are important questions to answer in order to understand the rise of Tiwanaku and the nature of its political authority. Fortunately, a wealth of recent paleobotanical research is beginning to shed light on the history of maize in the altiplano.

The earliest evidence of maize in the altiplano dates to Middle Formative contexts (800-100 B.C.) and comes in the form of microbotanical maize phytoliths recovered from pot residues from the Copacabana Peninsula (Chavez and Thompson 2006) and four sites on the Taraco Peninsula (Logan 2007). Interestingly, according to these data, the appearance of maize in the altiplano coincides with the florescence of the Yayamama Religious Tradition. Sparse macrobotanical evidence of maize exists for the Late Formative Period (Bruno 2008; Wright et al. 2003). However, in the Middle Horizon, there is a dramatic increase in maize in the altiplano according to analysis of paleobotanical remains by Wright and colleagues at Tiwanaku, Lukurmata, and rural Tiwanaku valley sites (2003). These data compliment changes in ceramic production, including a new range of Tiwanaku vessels dedicated to the production, fermentation, and consumption of *chicha* as well as the construction of the massive Akapana and Pumapunku ritual complexes, which sponsored state-sponsored feasts, a key element of which was *chicha* consumption.

The study by Wright et al. (2003), found maize to be the second most important crop after Chenopodium (quinoa), more abundant than tubers. Comparison of sites revealed Tiwanaku had the highest percent presence of maize (32%) followed by Lukurmata (13%) and rural Tiwanaku valley sites (6%). Within Tiwanaku, maize is selectively distributed. Maize was more dense in high status residential contexts (i.e. Akapana East and Putuni) than low status ones (i.e. Mollo Kontu residential). In addition, they interpret high kernel-to-cob ratios, indicating transport to Tiwanaku off the cob, as evidence of efficient state provisioning. The highest kernel-to-cob ratios were found in the Akapana East 1, this is consistent with Janusek's (2003) interpretation of the compound as a residence for retainers attached to nearby elite compounds charged with making *chicha* for elite-sponsored feasts (Wright et al. 2003: 397-398). They suggest that low kernel-to-cob ratios among other sectors may indicate smaller scale provisioning, perhaps through kin connections in maize producing regions. It should be noted however, that recent research by Bruno and Ramos (2009) revealed somewhat conflicting results relative to Wright et al (2003). Their study of samples from the Mollo Kontu residential sector of Tiwanaku indicate that, at least within this compound, maize, although found in significant quantities, was not the second most important crop. Rather, it was third in importance, at 69% ubiquity, following quinoa (100%) and tubers (100%).

Where did the abundance of maize in Tiwanaku come from? It is doubtful maize was grown within the altiplano in the quantities indicated by the paleobotanical data. As Hastorf and colleagues (2006) point out, the pampa is too cold and lake cores taken near ancient raised fields did not reveal maize pollen (Binford 1996), and although the lake shores provide a more temperate climate in which maize can be grown, it is doubtful the area could produce the quantities indicated by the paleobotanical data[25]. Recent comparison of maize kernel and cupule measurements from Tiwanaku with varieties from Moquegua and Cochabamba indicate these lowland areas supplied at least some of the maize entering Tiwanaku, as well as another, as of yet, unidentified supplier (Hastorf et al. 2006). There has been little research into Tiwanaku interaction with valleys on the eastern slopes of the Andes; these maize producing regions offer other potential sources.

Despite its substantial presence in Tiwanaku Period contexts, it is improbable lowland maize was being sought as a staple crop, to help meet the subsistence needs of altiplano populations. Given the crop's highly valued status, maize distribution was likely selective, as indicated by the study by Wright et al. (2003). The present study contributes to this data by revealing levels of actual *consumption* among altiplano inhabitants.

Fish

The rich aquatic resources provided by Lake Titicaca attracted the earliest sedentary villages in the altiplano to primarily cluster along the lake shore. Their

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[25] It is worth noting that Chavez and Thompson (2006) report that modern maize has been documented growing in abundance on the Copacabana Peninsula at 3810-4200 masl, an altitude at which it was thought maize cultivation was impossible (S. Chavez 2004; S. Chavez in press).

economies focused on fishing, gathering lake plants such as *totora* reeds (used for building material), and hunting birds (Janusek 2008). Although their diets were supplemented by small scale farming, fish provided their primary source of protein (Moore et al. 1999). Native fish species consumed by ancient populations included two genera—the *Trichomycterus*, a type of catfish, and *Orestrias* or killifish (Binford and Kolata 1996; Capriles et al. 2008; Miller et al. 2010; Parenti 1981). During the Late Formative, the largest settlements moved inland and several studies indicate that fish consumption overall decreased, even at lakeside settlements, while pastoralism and agriculture increased in importance (Berman 1994; Carpiles 2003; Capriles et al. 2008). This shift becomes even more pronounced during the Tiwanaku Period, and although people continued to consume fish, agropastoralism was becoming the primary productive regime in the southern basin and camelid meat an increasingly important source of protein (Berman 1994; Perez 2005).

Janusek (2008: 178-180) hypothesizes that fishing, foraging, and hunting came to be viewed as "primitive" technologies as the focus shifted to agriculture and pastoralism and perhaps those who continued to depend on such technologies were relegated to a lower status position. Further, he suggests this distinction between agriculture and pastoralism versus foraging and fishing eventually "manifested as a distinction between Aymara and Uru" ethnic groups (Janusek 2008: 178). This is an interesting hypothesis that requires further evaluation. Unfortunately, there remains a lack of detailed research into the history of fish consumption in the southern basin. Capriles, whose work is beginning to fill in some of the gaps, attributes this to the difficulty of microfaunal fish studies resulting from their small size and complex osteology (Caprilies et al. 2008).

Data on fish consumption among the various sectors of Tiwanaku would be particularly helpful.

Mammalian and Bird Fauna

Native species of terrestrial fauna that would have been potential protein sources for ancient altiplano inhabitants include three varieties of camelids, including llamas (*Lama glama*), alpacas (*Lama pacos*), and vicunas (*Lama vicugna*); deer (*Odocoileus viginiensis* and *Hippocamelus antisiensis*); many rodents including guinea pig (*Cavia tschudi*), viscacha (*Lagidium viscacia*), and *Galea musteloides*; foxes (*Conepatus chinga res* and *Dusicyon culpaeus, Dusicyon griseu*); and the now likely extinct wild cats (*Telis jacobita* and *Felis concolor*) (Binford and Kolata 1996). In addition, there are more than fifty species of birds in the altiplano, many inhabiting the marshy lake shore environment (DeJoux 1992). Although there is little hunting of birds in the region today, Binford and Kolata (1996) suggest three types may have been important dietary resources for past populations, including the Andean goose, five species of ducks, and three species of marsh dwelling rails.

As discussed in the previous section, fish species provided the bulk of dietary protein for Early and Middle Formative populations. However, from the Late Formative forward, there is a significant shift in the diet as major settlements move further from the lake. Analysis of terrestrial fauna from Tiwanaku, Lukurmata, and rural Tiwanaku valley sites revealed wild species, especially guinea pig and viscacha, were more abundant than domesticates in Middle and Early Formative contexts (Webster 1993; Webster and Janusek 2003). During the Late Formative, domesticates, especially camelids, begin to dominate the assemblages at sites that become major Tiwanaku centers (i.e. Tiwanaku and Lukurmata). Faunal analyses by Gladwell (2007) found that camelids also dominated Late Formative assemblages at Khonkho Wankane, indicating pastoralism was a vital economic focus at the site. It is likely, as Janusek (2008) suggests, the increasing predominance of camelids in Late Formative assemblages indicates the growing prestige associated with agropastoralism during this time. In the Tiwanaku Period, this trend intensifies and camelids dominate faunal assemblages, distantly followed by small numbers of guinea pig[26], viscacha, and deer (listed in order of importance) (Webster 1993; Webster and Janusek 2003). Webster's (1993) analyses reveal that primarily young camelids were butchered, indicating they were bred for consumption. Camelids were clearly the most important protein resource in Tiwanaku Period diets. In addition, their socio-economic importance is further underscored by their presence as offerings in ceremonial and ritual contexts throughout these sites. They are found as offerings associated with construction events in residential contexts (Bermann 1994, Janusek 1994), accompanying human burials (Janusek 1994), and in great number as part of lavish offerings on ceremonial platform mounds such as the Akapana (Manzanilla 1992).

The importance of camelids to altiplano populations indicated by the archaeological data is no surprise. Murra's (1968) ethnohistoric research concerning the Lupaqa, indicates massive camelid herds were pastured in the altiplano. Some witnesses reported local leaders owning as many as 50,000 head of cattle[27] (Murra 1968: 120). For

[26] Guinea pig is commonly consumed in the region today and is often assumed to have been significantly utilized in the prehistoric past, however, recent microfaunal analysis by Pokines and colleagues (2009) found no guinea pig remains at the site of Khonkho Wankane or the Mollo Kontu sector of Tiwanaku. They caution that some researchers may be mistaking other common rodent species in the region with guinea pig based on its assumed importance in the past.
[27] Murra (1968) suggests that this figure is likely an exaggeration.

this reason, the Europeans considered the Lupaqa wealthy. Citing Garci Diez (1567), Murra states:

> there is little doubt about the 'secret' of Lupaqa wealth: the hundreds of thousands of alpacas and llamas still grazing on the altiplano. 'In Inca times,' said Cubito, a well informed, older witness, 'there was a vast quantity of community herds, so many that despite the many lands in this province, there were insufficient pastures for the many animals grazing in those days.'…Since pre-Inca times alpacas and llamas had been used as banks in times of drought, frost, and other calamities.

Camelids are important as pack animals connecting the altiplano to lowland colonies and trade partners. They are also valued for their wool and as important sources of protein. At the time of European contact, camelid meat was reportedly served in stews, roasted, or dried and preserved for consumption as *charqui* (Cobo 1990). Charqui was an important protein resource that could be easily stored and consumed during long distance travel. Among Inca subjects Cobo (1990) reports that meat was reserved for special occasions and was consumed more regularly by elites. Fuanal analyses by Sandefur (1988) supports his assessment, indicating elites among the Xuaxa of central Peru, received the best cuts of meat. The present study will determine the place of meat in the diet of pre-Inca altiplano populations and the degree to which its consumption was linked to factors such as status, ethnicity, or sex.

Summary

Given the archaeological, paleobotanical, faunal, and isotopic research to date, it is likely that southern basin populations, during the periods of interest to this study, were heavily dependent on local staple crops such as quinoa and tubers as carbohydrate resources and camelid meat, and to a lesser extent fish, guinea pig, viscacha, deer, and legumes as protein sources. The population likely became much more intensely dependent on staple crops and camelids during the Tiwanaku Period, as indicated by the dramatic increase in evidence of agricultural intensification and the abundance of camelid remains in deposits from this time. Unfortunately, there is little data available regarding Post Tiwanaku diets. Finally, isotopic and paleobotanical evidence indicates that lowland imports such as maize were entering the altiplano in substantial quantities during the Tiwanaku Period. The extent to which maize was distributed among and consumed by the general population remains unclear. In the following chapter, I outline the methods I utilized to determine patterns of food consumption among southern basin populations prior to, during, and after the spread of Tiwanaku hegemony.

CHAPTER V

RESEARCH DESIGN

Introduction

This research employs bioarchaeological methods to examine the dynamic relationship between food and politics in the Southern Titicaca Basin from the Late Formative through the Post-Tiwanaku period. Dental, stable isotopic, and micro-botanical data were collected to determine the distribution and consumption of dietary resources, which can provide insight into changes in Tiwanaku social and economic organization throughout the periods of interest. The following presents the skeletal sample size, age-at-death and sex distributions, and the methodologies for the dental, stable isotopic, and micro-botanical data collection and analyses.

The Study Sample

The data for this study are derived from previously excavated human skeletal remains from Tiwanaku affiliated sites within the Tiwanaku, Katari, and Desaguadero valleys of the Southern Lake Titicaca Basin (Figure 2.2, Table 2.1). Within the Tiwanaku Valley, I analyzed remains from the principle urban center of Tiwanaku as well as small rural settlements throughout the middle and lower sections of the valley. Tiwanaku skeletal materials derive from the Akapana (Manzanilla 1992; Manzanilla and Woodward 1990; Kolata 2003), Akapana East (Janusek 2003), Chiji Jawira (Rivera 1994), La Karana (Escalante 2003), Markapata (Giesso 2003), Mollu Kontu (Couture

1993; 2003), and Putuni (Couture and Sampeck 2003; Sampeck 1991) excavations. Rural sites within the Tiwanaku valley are represented by remains from Guaqui, Pukara, Iwawe (Albarracín-Jordán 1992; 1996; 2003), Tilata, and TMV 228 (Mathews 1992; 2003). Katari valley sites include the urban center of Lukurmata (Bermann 1990; 1993; 1994; 2003) as well as several rural sites including Kirawi (CK 65), Urikatu Kontu (CK70), CK 101.1, and CK 101.2 (Janusek 1997; Janusek and Kolata 2003; Kolata 1993). Tiwanaku and Katari valley human remains were excavated as part of Proyecto Wila Jawira (1986-2000) directed by Alan Kolata. Skeletal remains from the Mollo Kontu residential sector of Tiwanaku were excavated by Proyecto Arqueológico Jach'a Marka during the 2004 and 2005 field seasons directed by Nicole Couture and Deborah Blom. Desaguadero valley sites included the settlements of Khonkho Wankane and Iruihito. Human remains from these sites were excavated by Proyecto Arqueológico Jach'a Machaca (2001-2006) directed by John Janusek.

Although the available sample of human skeletal remains from the Southern Titicaca Basin includes more than 450 individuals, only 188 were appropriate for dental, isotopic, and/or phytolith analysis. The distribution of the sample is different for the dental, isotopic, and phytolith data sets. Tables 5.1 and 5.6 present the individual sample breakdowns for specific data sets according to temporal period, site, and sex. Skeletal and dental preservation and estimated age-at-death were the basis for inclusion in this study. Only adult individuals greater than 18 years of age were included due to the age progressive nature of dental pathologies and the confounding effects of breastfeeding and other differences in childhood diet that might skew intra- and inter-site comparisons for isotopic data.

Based on various publications, dissertations, excavation notes, and reports, samples were grouped into the following broad temporal categories: Late Formative (Tiwanaku II-III, 150-500 AD), Tiwanaku (Tiwanaku IV-V, 500-1150 AD) and Post-Tiwanaku (Pacajes, 1150-1570 AD). For analysis, different subsets of the sample were compared based on temporal period, valley, site, site sector, and sex.

Age Distribution of the Sample

Critical to the dental health component of this study was establishing age-at-death estimates for the individuals analyzed, as most dental pathologies are age progressive. Thus, when comparing populations, it is necessary to first establish that their age distributions are not significantly different; otherwise differences in dental health may reflect age differences in the samples rather than actual differences in diet (Hillson 1996).

Age at death estimates were based on the criteria recommended by Buikstra and Ubelaker (1994). Dental eruption (Buikstra and Ubelaker 1994; Ubelaker 1989) and fusion of epiphyses (Buikstra and Ubelaker 1994) were first assessed to ensure estimate age-at-death of the individual was 18 years or older. Individuals less than 18 years-old at the time of death were excluded from the study. Adult age ranges were determined, in preferential order, based on eruption of the third molar (Buikstra and Ubelaker 1994; Ferembach et al. 1980), sequence of epiphyseal fusion (Buikstra and Ubelaker 1994), morphological changes to the pubic symphysis (Brooks and Suchey 1990; Suchey and Katz 1986), and morphological changes to the auricular surface (Meindl and Lovejoy 1989). In the absence of more accurate age estimators, cranial suture closure (Meindl and Lovejoy 1985) and the extent of dental wear (Lovejoy 1985) were assessed, placing individuals in broad age categories: young adult (18-34), middle adult (35-49), and old adult (50+). Finally, for some individuals, no age range could be discerned beyond the category of “adult” (20+ years). Age distributions for the study sample are presented in Figures 5.1, 5.2, 5.3, and 5.4.

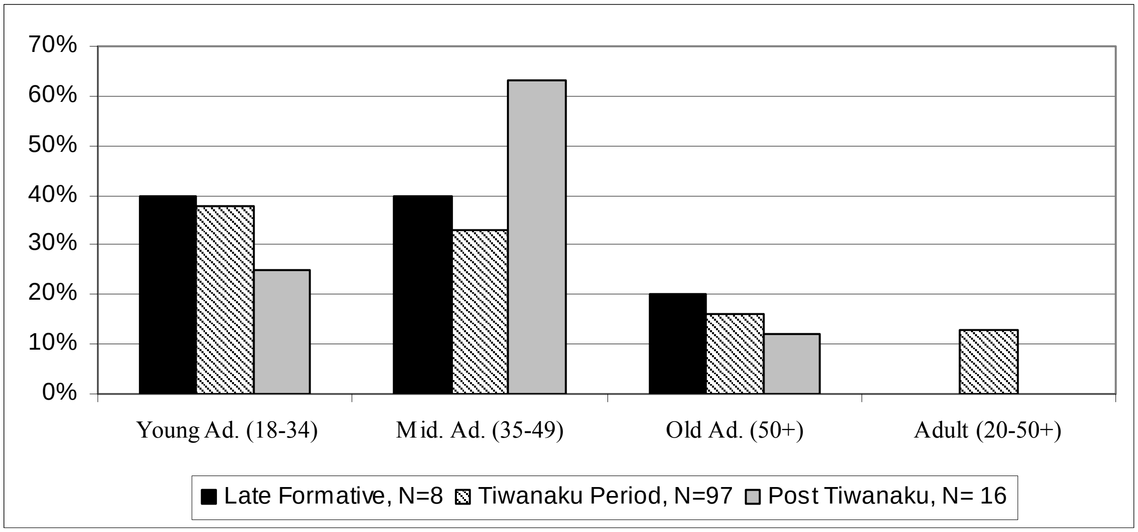

Figure 5.1. Age distribution of the study sample by temporal period

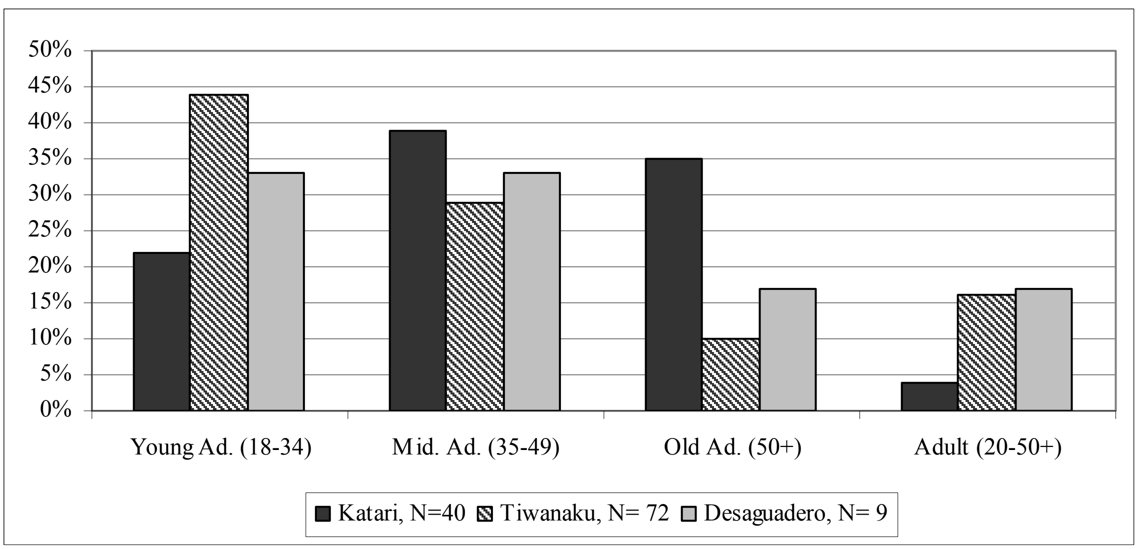

Figure 5.2. Age distribution of the study sample by valley (Tiwanaku Period)

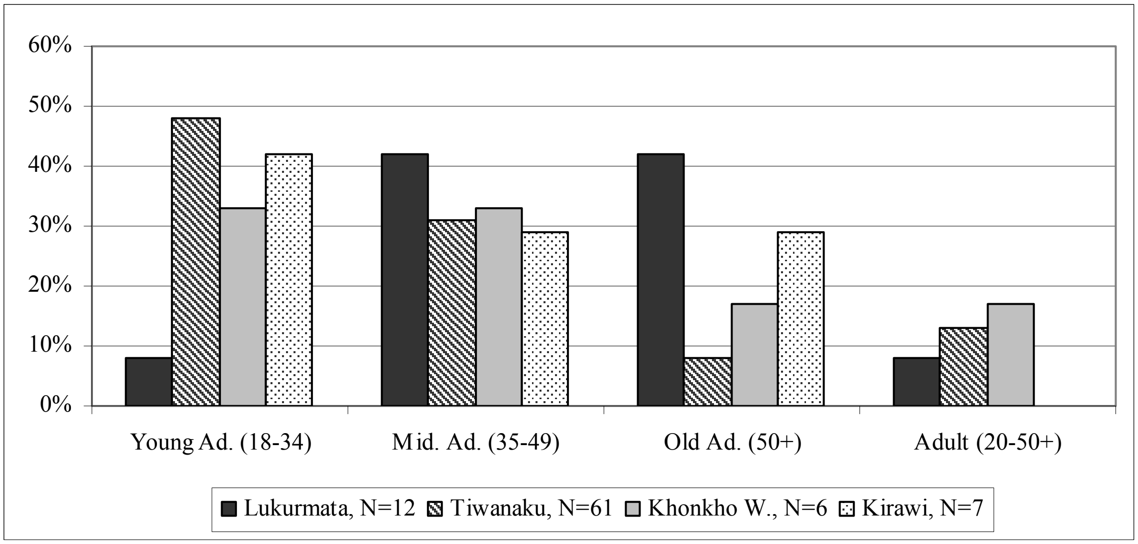

Figure 5.3. Age distribution for Tiwanaku Period sites

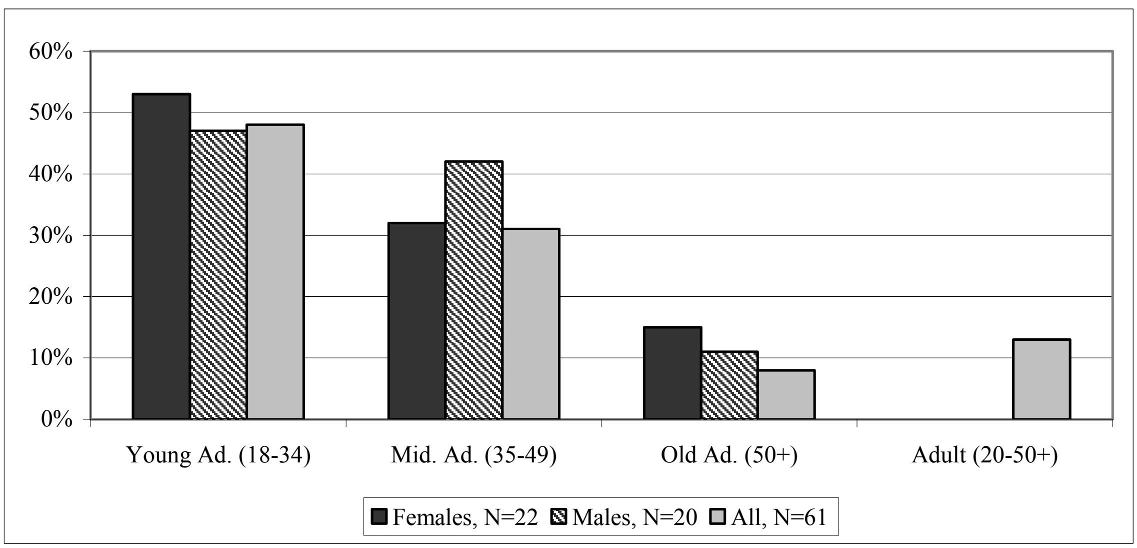

Figure 5.4. Age distribution for the site of Tiwanaku (Tiwanaku Period)

Sex Distribution of the Sample

The sex of individuals was determined whenever possible in order to assess the existence of any sex specific differences in diet. Determination of sex followed the recommendations of Buikstra and Ubelaker (1994) and involved assessment of morphological variation in the os coxae and crania. Because the os coxa is the most reliable portion of the skeleton for sex determination, assessment began with this element when it was present. The morphology of the os coxae was first examined for presence of the three Phenice characteristics (Phenice 1969) - ventral arc, subpubic concavity, and ischiopubic ramus ridge. These traits are associated with a wide pelvis and thus their expression is indicative of a female individual. In addition, the width of the greater sciatic notch and the presence of a pre-auricular sulcus were also noted (Buikstra and Ubelaker 1994: 18). Although less reliable than pelvic observations, certain cranial features may also be used to estimate the sex of an individual. The robustness of the following cranial features was scored using the system recommended by Buikstra and Ubelaker (1994): nuchal crest, mastoid process, supra-orbital margin, supra-orbital ridge, and mental eminence. The more robust these features appear, the more likely the cranium belonged to a male individual. After accessing all pelvis and cranial features, individuals were placed in one of five categories- female, male, probable female, probable male, or unknown. Of those for whom sex could be determined (N=99), 47% were female and 53% were male. Sex distributions for the study sample are presented in Figure 5.5.

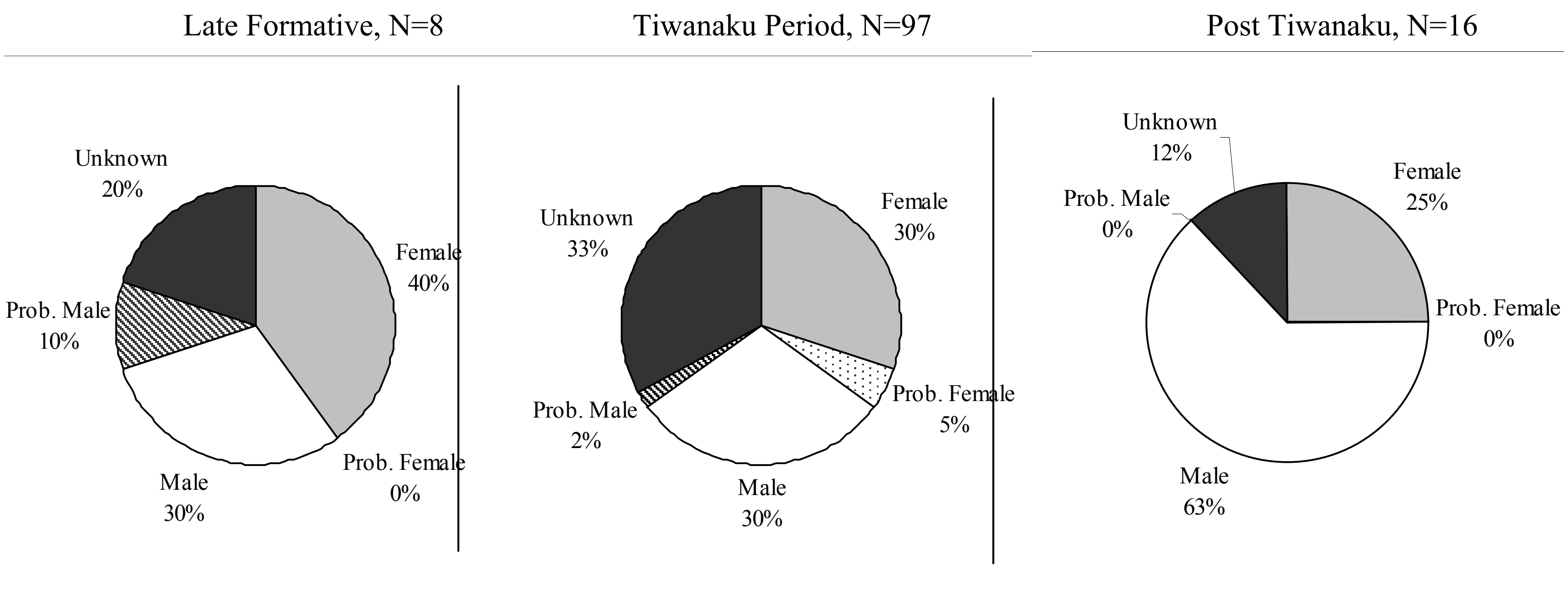

Figure 5.5 Sex distribution of the study sample by temporal period

Dental Indicators of Diet

Dental analyses included documenting the presence, location, and size of carious lesions, abscesses, and dental calculus, as well as recording dental wear scores (Scott 1979; Smith 1984) and antemortem tooth loss. These criteria provide an indirect yet good measure of diet and nutrition (Hillson 1996; Larsen 1997; Powell 1985), which can be compared at the intra-population, inter-population, and inter-regional levels. The benefit of a dental health study is that it offers an effective and efficient means of assessing the oral health consequences of a particular diet not provided by chemical analyses. In addition, dental data, as opposed to costly chemical or microscopic analyses, are more often available from other populations, providing greater potential for regional comparisons.

Dental data were collected for all available permanent teeth following the recording standards recommended by Buikstra and Ubelaker (1994). Only individuals 18 years of age were included in this study, therefore, deciduous teeth were not observed. Dental data were obtained for 72 individuals from the Tiwanaku Valley, 40 from the Katari Valley, and 9 from the Desaguadero Valley, for a total sample of 121 individuals (see table 5.1).

Table 5.1 Distribution of individuals available for dental analyses according to temporal period, site, sex, and mean age-at-death*

Site	Female/ PF	Mean Age	Male/ PM	Mean Age	Unknown Sex	All Adults	Mean Age
Late Formative							
Lukurmata	1	40.0	3	39.3	0	4	39.5
KhonkhoWankane	1	42.5	1	50.0	0	2	46.3
Kirawi (CK65)	2	32.5	0		0	2	32.5
TOTAL N--						**8**	
MEAN AGE AT DEATH, ALL ADULTS--							**39.4**
Tiwanaku Period							
Tiwanaku	22	33.0	20	35.8	19	61	33.5
Lukurmata	7	42.7	4	43.0	1	12	43.0
Khonkho Wankane	2	50.0	1	42.5	3	6	39.0
Kirawi (CK65)	1	22.5	3	42.5	3	7	38.6
Pokachi Kontu (CK104)	1	50.0	0		2	3	39.2
Urikatu Kontu (CK70)	1	40.0	0		0	1	40.0
Obsidiana	1	50.0	0		0	1	50.0
Tilata (TMV 101)	3	42.5	0		1	4	42.5
Iwawi	1		0		1	1	NA
Guaqui	0		1	55.0	0	1	55.0
TOTAL N--						**97**	
MEAN AGE AT DEATH, ALL ADULTS--							**36.4**
Post Tiwanaku							
Lukurmata	3	46.7	3	41.5	1	7	44.0
Khonkho Wankane	0		0		1	1	55.0
Urikatu Kontu	0		3	27.5	1	4	30.6
Pukara	0		1	45.0	0	1	45.0
TMV 228	1	27.5	2	41.3	0	3	36.6
TOTAL N--						**16**	
MEAN AGE AT DEATH, ALL ADULTS--							**40.2**

*The age at death for thirteen individuals could not be specified beyond the adult category. These individuals were excluded when quantifying mean age-at-death.

All teeth, present or missing, were inventoried using the categories provided by Buikstra and Ubelaker (1994; see table 5.2). This system helps account for missing dentition that can lead to statistical biases when calculating dental pathology frequencies.

Table 5.2 Dental inventory categories (Buikstra and Ubelaker 1994:49)

1- Present, but not in occlusion
2- Present, development completed, in occlusion
3- Missing, with no associated alveolar bone
4- Missing, with alveolus resorbing or fully resorbed
5- Missing, with no alveolar resorption: postmortem loss
6- Missing, congenital absence
7- Present, damage renders measurement impossible, but other observations are recorded
8- Present, but unobservable (e.g. deciduous or permanent tooth in crypt)

Dental Caries

Dental caries is a progressive focal demineralization of dental hard tissues by organic acids produced by bacterial fermentation in dental plaque (Menaker 1980; Silverstone et al. 1981). Carious lesions may lead to the development of dental abscesses and ultimately to antemortem tooth loss. The primary factors contributing to the development of dental caries include: 1) diets high in fermentable carbohydrates including sugars and starches, which provide food for bacteria (Goodman et al. 1984; Larsen et al. 1991; Ortner and Putschar 1981), 2) poor oral hygiene resulting in the retention of excessive plaque and the bacteria it retains, and 3) the susceptibility of the dental morphology- for example pits, fissures, hypoplasias, or root exposures that may trap plaque or expose more vulnerable hard tissues. Thus, the numerous pits and fissures that characterize molars and premolars, as well as their larger inter-proximal contact facets where plaque may be trapped, make these teeth more vulnerable to dental caries relative to incisors and canines. Other factors which may influence the rate of carious lesion formation include the presence of fluoride in local water sources and individual variation in oral and plaque pH.

Due to the strong relationship between diet and caries frequencies in human populations, dental caries data has been a primary means used by physical anthropologists to study diet in past populations. Studies have revealed that significant changes in subsistence technology are typically reflected by changes in caries rates. For example, many researchers in both the Old and New World have documented significant increases in caries frequencies for human populations following the adoption of agriculture (for a review of the extensive literature on this topic see Larsen 1997: 78-81). The more varied diets of foragers resulted in lower caries frequencies relative to diets relying heavily on cariogenic domesticates such as maize or wheat.

Variation in caries frequencies at the intra-population level may also be informative, as differences linked to sex and status have been found in many populations, providing insight into the distribution of dietary resources as well as sexual divisions of labor. Study of modern and ancient populations from around the globe has revealed a strong tendency for females to exhibit higher caries frequencies relative to males (Akins 1995; Burns 1979; Danforth et al. 1997; Dickel et al. 1984; Hillson 1979; Larsen et al. 1991; Lukacs 1992; Lukacs et al. 1989; Schucker 1985; Whittington 1989). This trend is thought by many to reflect a sexual division of labor in which men are responsible for hunting while women gather plant resources and/or work in horticulture or agriculture. Thus, males more often consume greater quantities of meat while women supplement their diets with more cariogenic plant resources. However, Lukacs (2008) has recently argued that the pattern of worse oral health among women following the transition to agriculture was not the result of cultural factors but was more likely due to increases in fertility that accompanied an increasingly sedentary lifestyle. He points to clinical and epidemiological studies linking worse oral health among women to the affects of estrogen levels, which peak during pregnancy, as well as lower saliva flow relative to males, changes in the biochemical composition of saliva during pregnancy, suppression of the immune system during pregnancy, and food cravings and aversions during pregnancy. These studies underscore the need to always consider both cultural and biological explanations when interpreting variation in caries frequencies.

Status linked differences in caries frequencies in many populations often reveal a pattern in which higher status individuals have lower caries frequencies resulting from a more varied diet relative to lower status individuals who are often more dependent on cariogenic staple crops (Frayer 1984; Hodges 1985; Walker and Hewlitt 1990; White 1994). However, if the cariogenic crop is a more socially valued food, such as maize, elites, with greater access to such valued foods, may exhibit higher caries rates.

For the present study, dental evidence of maize and coca consumption are of particular interest, as they have been correlated with distinctive dental pathologies, and appear to have been imported to the altiplano during the Middle Horizon (Wright et al. 2003; Tomczak 2001). The high sucrose content of maize makes it a cariogenic food that can lead to high frequencies of carious lesions and subsequent antemortem tooth loss among consumers (Larsen 1997; Hardinge 1965). Also, Indriati and Buikstra (2001) have demonstrated that high frequencies of bucco-cervical caries and root exposures on the posterior dentition are often correlated with coca chewing.

I examined all permanent dentition for evidence of caries. Carious lesions were counted when clear focal demineralization of the dental hard tissue could be observed that was not the result of attrition or developmental defects (Figure 5.6). I recorded the presence and location of carious lesions using the categories recommended by Buikstra and Ubelaker (1994:55; after Moore and Corbett 1971):

0. No lesion present
1. Occlusal surface carie: all grooves, pits, cusps, dentin exposures, and the buccal and lingual grooves of the molars
2. Interproximal surface carie: includes the mesial and distal cervical regions
3. Smooth surface carie: buccal (labial) and lingual surfaces other than grooves
4. Cervical carie: originates at the cemento-enamel junction (CEJ), except the interproximal regions
5. Root caries: below the CEJ
6. Large caries: cavities that have destroyed so much of the too that they cannot be assigned a surface of origin
7. Non-carious pulp exposures: exposure of the pulp chamber, often the result of excessive dental wear or dental trauma

Figure 5.6. Interproximal carious lesion of an upper left second molar

Dental Abscesses

Periapical abscesses occur when the flora of oral bacteria or the bacteria themselves enter the pulp cavity of a tooth, either through a carious lesion or exposure of the pulp due to dental wear or fracture of the enamel, resulting in infection and the production of pus (for a review see Hillson 1996: 284-287). The build-up of pus and other toxins in the pulp chamber is released through the apical foramen of the tooth causing inflammation in the surrounding alveolar tissue. Increasing inflammation and pus production inside the alveolar bone create pressure that is often released through a focal demineralization of bone, known as a fistula (Figure 5.7). Fistulae may form on the buccal/labial or lingual alveolar surface or may open directly into the maxillary sinuses. These well-defined circular perforations in the alveolar bone that open at the apex of tooth roots are easily identifiable in skeletal remains, though, care must be taken to distinguish them from postmortem breaks in the fragile alveolar bone.

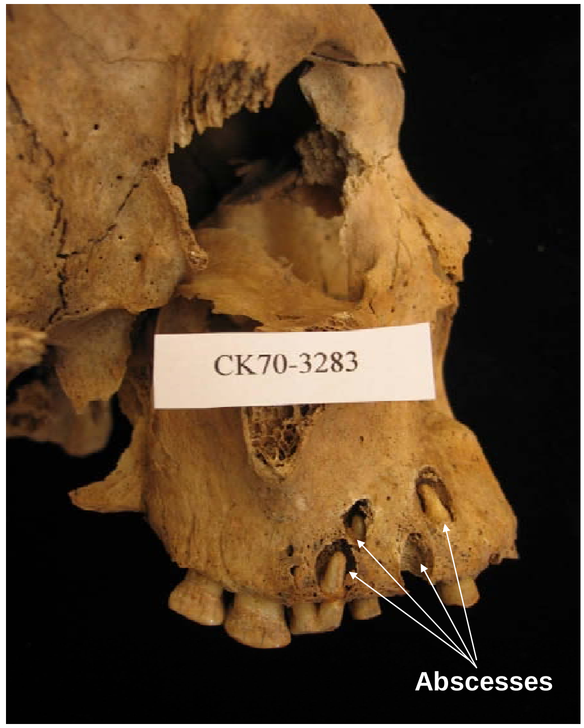

Figure 5.7 Fistulae formation as a result of dental abscesses

Although almost always recorded as part of standard skeletal/dental analysis, abscesses are rarely the sole focus of research by physical anthropologists; they are most often discussed as they relate to caries frequencies or dental wear. High frequencies of dental abscesses may correspond to high rates of dental caries, indicating a cariogenic diet. However, abrasive diets resulting in heavy wear and/or enamel fractures may also result in high dental abscess frequencies. Thus, it is important to note the apparent cause of the abscess before drawing any conclusions regarding diet. In general, it is relatively easy to determine the cause. Abscesses resulting from heavy wear may result because the pulp chamber is eventually exposed (Figure 5.8). Abscesses associated with teeth that do not exhibit this distinctive pattern are typically the result of one or more easily observable carious lesion. Occasionally, enamel fractures result in abscesses and although it may be possible to observe the original fracture, this condition may result in a carious lesion that obscures the original crack in the enamel.

Figure 5.8. Pulp exposures resulting from extreme dental wear leading to abscesses

I examined all available alveolar tissues and associated dentition for evidence of dental abscesses and their location. Recording categories followed the recommendations of Buikstra and Ubelaker (1994: 55):

0. No abscess present
1. Buccal or labial alveolar perforation
2. Lingual perforation

I also noted, whenever possible, whether the abscess was the result of a carious lesion, extreme dental wear, or fractured enamel.

Antemortem Tooth Loss

Often, the eventual result of progressive dental caries, gingivitis, and abscesses is antemortem tooth loss (Ortner and Putschar 1985). All available alveoli were observed for evidence of alveolar resorption indicative of tooth loss prior to death (Figure 5.9).

Figure 5.9 Antemortem loss of the lower left second and third molars

Dental Wear

Dental wear is the result of two processes: attrition and abrasion. Attrition is the result of tooth to tooth contact and abrasion is the result of contact between a tooth and food or any other abrasive foreign material. The result of both processes is the progressive removal of enamel and eventually dentin from the occlusal tooth surface. As enamel is worn away, odontoblasts in the underlying pulp chamber respond by producing secondary dentin to protect the living portion of the tooth. Typically, secondary dentin production keeps pace with enamel wear and the pulp chamber is never exposed. However, when the rate of wear is more rapid than the production of secondary dentin, the pulp chamber will be exposed resulting in infection, abscess, and ultimately tooth loss. Rose and Ungar (1998:349; also see Armelagos et al. 1984 and Rose et al. 1993) note that this condition is rare in ancient human groups and is most often observed during times of dietary transition.

Observations of patterns and rates of dental wear are used by physical anthropologists to estimate age and examine diet in past populations. Variables influencing dental wear include the consistency of foods consumed and manner of food preparation, such as the use of grinding stones that may introduce abrasive particles into the diet. Dental wear is often examined by anthropologists studying major changes in human subsistence strategies. Many studies of ancient Old and New World populations reveal a significant decrease in wear rates corresponding to increased dependence on domesticated plants (Anderson 1965, 1967; Greene et al. 1967; Patterson 1984; Powell 1985; Rose et al. 1991; Scuilli and Carlisle 1977; Smith 1982). Patterns of wear may also differ between groups relying on different subsistence strategies. For example, Hunter-gatherers often exhibit a higher angle of occlusal wear relative to agriculturalists (Smith 1984). Dental wear studies have also contributed to research into sex specific differences in diet (Frayer 1988; Molner et al. 1989; Morris 1992; Reinhard et al. 1994; Richards

1984), noting that activity patterns, such as the use of teeth as tools for processing hides or plant fibers also have a profound effect on dental wear (Bennett 1994; Blakely and Beck 1984; Cybulski 1974; Larsen 1985; Larsen and Thomas 1982; Milner and Larsen 1991; Schultz 1977; Turner and Machado 1983).

Finally, recording dental wear is an essential part of any study of dental health, as wear rates share an inverse relationship with dental caries frequencies. Studies demonstrate that highly abrasive diets remove cariogenic plaque from teeth and usually result in low caries frequencies (Corbett and Moore 1976; Maat and Van der Velde 1987; Milner 1984; Powell 1985). Thus, it is not possible to draw conclusions regarding diet and dental health based solely on dental pathology data; dental wear data are also essential.

I evaluated dental wear for all fully erupted permanent teeth. Incisors, canines, and premolars were scored on a scale of 1-8 according to the Smith (1984) system (1= unworn or small wear facets, 8= complete loss of crown). Molars were recorded using the Scott (1979) system, which scores the four molar cusps independently on a scale of 0-10 (1= no wear or small wear facets, 10= complete dentin exposure with no remaining enamel). This system allows the observer to document varying patterns/angles of molar wear.

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Dental Calculus

Dental calculus is mineralized plaque, composed of an inorganic matrix of apatite, whitlockite, brushite and other minerals and an organic component including, but not limited to, amino acids, proteins, peptides, and carbohydrates (Damen and ten Cates

1989; Hillson 1996). Calculus forms at the base of plaque deposits, adhering to the tooth surface, and is typically well preserved in archaeological skeletal remains. The extent of calculus formation in conjunction with other dental data has been used by physical anthropologists to infer past diets for decades (for an overview see Lieverse 1999).

Numerous studies have documented a relationship between increased dependence on carbohydrates and larger deposits of dental calculus in ancient populations (Evans 1973; Hillson 1979; Allison 1984; Cassidy 1984; Lukacs 1989). However, as Lieverse (1999) has pointed out, the etiology of calculus formation remains poorly understood and many studies grossly oversimplify the relationship between diet and calculus formation. Calculus formation appears to be multi-causal and may be affected by such factors as the mineral content of drinking water, biological affinity (which may affect the Ph of salivia), or cultural factors-- such as diet, oral hygiene, the use of teeth as tools, or coca chewing.

While taking into account these sources of variation, the present study evaluated calculus deposits in conjunction with other dietary indicators in order to determine whether certain segments of Tiwanaku society were more dependent on carbohydrate rich staple crops than others. In addition, the potential relationship between coca chewing and calculus formation was evaluated. Klepinger et al. (1977) reported that coca chewing and the associated use of lime introduced minerals into the oral environment that increased calculus formation. In contrast, research by Indriati and Buikstra (2001) found no support for the association between coca chewing and heavy calculus deposits.

I evaluated calculus deposits for all fully erupted permanent teeth, scoring the buccal/labial and lingual sides of each tooth separately. Calculus was scored as (0) absent, (1) small amount, (2) moderate amount, (3) large amount, or (NA) when unobservable. Following the recommendations of Greene et al. (2005), I defined a small amount as a band of calculus covering 1/3 of the crown surface or less, a moderate amount as calculus covering between 1/3 and 2/3 of the crown surface, and a large amount as calculus covering more than 2/3 of the crown (Figure 5.10).

Figure 5.10 Mild calculus formation on the lower central incisors

Statistical Methods for Dental Data

The various dental data include both categorical (i.e. caries, antemortem tooth loss, and abscesses) and numeric (i.e. dental wear and calculus scores) data sets, requiring different quantitative methods. Categorical data were analyzed at the level of the individual tooth or alveolus and at the level of the individual. At the tooth level, the frequency of dental pathologies was calculated for the total number of observed teeth or alveoli. At the individual level, the frequency of dental pathologies was calculated based on the number of individuals having one or more teeth or alveoli. Because tooth classes (i.e. incisors, canines, premolars, and molars) differ in their susceptibility to dental caries, frequencies for this condition were also calculated according to tooth class. Chi square tests were used to test for significant differences in the frequency of dental caries, abscesses, and antemortem tooth loss among temporal periods, valleys, sites, site sectors, and among the sexes.

Dental wear and calculus scores are numeric data and required different quantitative methods. These data were analyzed at the level of the individual only and not at the level of the individual tooth; this was due to the consistency of dental wear and calculus patterns within an individual's mouth and the large discrepancy in the number of teeth representing each individual. If these data were analyzed at the level of the individual tooth, certain individuals would be grossly over-represented and render any statistical conclusions meaningless[28].

Mean dental wear scores for anterior teeth (i.e. incisors and canines pooled), premolars, first molars, second molars, and third molars were calculated for each individual, pooling mandibular and maxillary teeth. A calculus score for each individual was calculated based on the maximum expression of dental calculus observed, using a scale of 0-3. Summary statistics, including the means and standard deviations, were calculated for dental wear and calculus scores and Mann Whitney U tests statistics were

[28] Although this is certainly a concern for data on caries, antemortem tooth loss, and abscesses, these data are more varied within an individual's mouth and have traditionally been calculated by physical anthropologists at the level of the individual tooth as well as the individual. Thus, by analyzing these data at both levels, the results can more easily be compared to dental data from other regions.

used to identify significant differences among temporal periods, valleys, sites, site sectors, and among the sexes.

Finally, the progressive nature of dental pathologies makes age an important consideration when comparing samples. Mann Whitney U test statistics were run on the age distributions of the samples being compared to discern if the age-at-death[29] profiles of the two samples were significantly different, and thus might be responsible for differences in caries rates or other dental conditions.

Stable Isotopic Indicators of Diet

Human bone was sampled for analysis of stable carbon and nitrogen isotope ratios in bone apatite and collagen, providing an accurate means of reconstructing individual food consumption profiles, which cannot be obtained through visual analysis of the dentition.

Isotopes are elements that share the same number of protons and electrons but differ in the number of neutrons. Radioactive isotopes (such as ^{14}C) decay over time, but stable isotopes (such as $^{13}C/^{12}C$) do not. The methodology underlying the use of stable isotopes for dietary analysis is based on the fact that certain food resources contain diagnostic ratios of stable isotopes such as carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$), which are incorporated into the hard tissues of the consumer, thus, providing a means of reconstructing individual food consumption profiles (for literature reviews see Ambrose and Krigbaum 2003; Katzenberg 2000; Katzenberg and Harrison 1997; Schoeninger and

[29] In order to avoid establishing a circular relationship between age at death estimates and dental wear stages, age estimates were based on criteria other than dental wear whenever possible.

Moore 1992; Schwarcz and Schoeninger 1991). The stable isotopic elements most commonly used to reconstruct diet are carbon and nitrogen.

Carbon Isotopes

Carbon ($^{13}C/^{12}C$) isotope ratios have primarily been used to investigate three types of dietary data: consumption of plants utilizing distinct photosynthetic pathways (see Table 5.3), consumption of marine versus terrestrial plants, and, most recently—the relative protein content of diets. This section explains the basis for interpreting diet from stable carbon isotope signatures.

Plants utilize different photosynthetic pathways (C_3, C_4, or CAM pathway) based on the environment in which they flourish, resulting in differences in the ratio of ^{13}C to ^{12}C (expressed using the delta [δ] notation as parts per thousand [‰]: $\delta^{13}C$‰). C_3 plants are associated with temperate environments and include trees, shrubs, tubers, and some grasses. C_3 plants imbibe less of the heavier ^{13}C isotopes relative to C_4 plants, exhibiting $\delta^{13}C$ ratios between -20 to -35‰ (Deines 1980; also see van der Merwe 1982).

In contrast, C_4 plants are associated with hot arid environments and include maize, sorghum, millet, amaranths and some chenopods. C_4 plants intake more of the heavier ^{13}C isotope during photosynthesis resulting in a more positive $\delta^{13}C$ ratio--between -9 to -14‰ (Deines 1980; van der Merwe 1982). Finally, a few plants utilize the CAM pathway; these plants may utilize either the C_3 or C_4 pathway depending on the environment in which they are grown. CAM plants include succulents such as cacti and may exhibit $\delta^{13}C$ ratios intermediate to C_3 and C_4 plants; however, this has not been a significant obstacle for isotopic analysis of diet, as succulents rarely constitute a major food source for humans. Distinguishing between diets composed of C_3 versus C_4 plants has proven particularly fruitful for researchers working in the Americas, where the only significant C_4 plant of dietary significance grown during prehistoric times was maize.

Table 5.3 Overview of $\delta^{13}C_{co}$‰ values associated with differing photosynthetic pathways

Photosynthetic Pathway	**Environment**	**Associated Plants**	**$\delta^{13}C_{co}$ Value**
C_3	Temperate	Tubers, trees, some grasses	-20 and -35‰
C_4	Hot, arid	Maize, sorghum, millet, amaranth, some chenopods*	-9 and -14‰
CAM	Use C_3 or C_4 depending on enviro.	Many succulents such as cacti	intermediate

*chenopods are typically thought to be C_4 plants but DeNiro and Hastorf (1985) demonstrated that it has a C_3 signature in the Altiplano (also see Miller 2005; Miller et al. 2008)

In regions where human groups have little or no access to C_4 plants, $\delta^{13}C$ ratios can sometimes distinguish between terrestrial and marine diets due to differences in the carbon sources for each environment. Terrestrial plants derive carbon from the atmosphere while marine organisms primarily derive carbon from dissolved carbonates, which have a more positive $\delta^{13}C$ value (Chisholm et al. 1982). Freshwater organisms may obtain carbon from several different sources and thus, carbon values may vary greatly depending on which part of the freshwater ecosystem the fauna or flora being consumed are derived. This was of particular concern for the present study. Obtaining $\delta^{13}C$ values for potential freshwater resources is critical to accurately interpreting local diets. In addition, when the possibility exists that C_4 plants also contributed significantly to the diet, other means must be used to ensure that high $\delta^{13}C$ ratios are the result of consumption of marine/lacustrine resources and not C_4 plants. As discussed below, recent insight into the differential incorporation of carbon isotopes into consumer tissues has largely resolved this problem (Ambrose and Norr 1993, Ambrose et al. 1997, 2003; Tieszen and Fagre 1993).

Traditionally, bone collagen has been the tissue used in isotopic studies due to the familiarity with using it for radiocarbon dating as well as the perceived difficulty of removing contaminants from the apatite portion of bone. Sullivan and Krueger (1981) were the first to suggest using carbon from bone apatite when collagen was too degraded. However, skeptics noted discrepancies between $\delta^{13}C$ ratios derived from collagen versus apatite and believed that contaminants and diagenesis might be affecting the carbon values in apatite (Nelson et al. 1986; Schoeninger and DeNiro 1982). Recently, improved pretreatment procedures for removal of contaminants and new methods for identifying the effects of diagenesis (Lee-Thorp 2000; Koch et al. 1997; Kohn et al. 1999; Sponheimer and Lee-Thorp 1999) have alleviated many of these concerns. In addition, the discrepancies between $\delta^{13}C$ ratios derived from apatite versus collagen are also better understood (Ambrose and Norr 1993; Ambrose et al. 1997, 2003; Tieszen and Fagre 1993).

Controlled feeding experiments have confirmed that collagen mostly reflects the protein component of an individual's diet, while apatite more accurately reflects the *whole* diet (Ambrose and Norr 1993, Tieszen and Fagre 1993). Thus, studies of $\delta^{13}C$ values from apatite provide a more sensitive indicator of the proportion of C_4 versus C_3 plants in the diet (i.e. C_4 plants such as maize are detected in apatite when they form only a small portion of the diet, whereas C_4 plants must form a more significant portion of the diet to be detected in collagen) (Ambrose et al. 1997, 2003). In addition, discrepancies between $\delta^{13}C$ values for collagen and $\delta^{13}C$ values for apatite ($\delta^{13}C_{ap-coll}$) provide information regarding the relative protein content of the diet. When $\delta^{13}C_{coll-ap}$ is greater than 4.4‰, the $\delta^{13}C$ value of dietary protein is more negative than the whole diet (Ambrose et al. 1997: 351). When $\delta^{13}C_{coll-ap}$ is less than 4.4‰, the $\delta^{13}C$ value of dietary protein is more positive than the whole diet (i.e., the primary source of high $\delta^{13}C$ values is a protein rich resource) For the present study, carbon isotopes were analyzed in human bone collagen and apatite for each sample to provide a more complete picture of prehistoric diets.

Nitrogen Isotopes

Schoeninger, DeNiro, and Tauber (1983) were the first to test the utility of nitrogen isotope ratios for addressing issues of diet. Nitrogen isotope ratios ($^{15}N/^{14}N$) are primarily used to look at two different aspects of diet: an organism's relative position along the trophic chain within a given environment and consumption of marine/lacustrine versus terrestrial resources.

Plants obtain nitrogen directly from the soil and pass this nitrogen along to herbivores that in turn pass more along to carnivores. Each step in the trophic chain is associated with a 3-4‰ increase in $\delta^{15}N$ ratios, reflecting an enrichment of the ^{15}N isotope relative to ^{14}N in each trophic level. This occurs because during metabolism, the bonds between ^{12}C and ^{14}N are broken more easily than those between ^{12}C and ^{15}N, thus more ^{14}N is excreted in urea than ^{15}N (see Schoeninger and Moore 1992 for a more complete discussion). For this reason, study of nitrogen isotopes provides an indication of the proportion of an individual's diet that was composed of meat, as nitrogen values increase as one moves up the trophic chain (note: values will be geographically specific and analysis requires first establishing nitrogen isotope end values for the study environment for comparison). However, as Schoeninger et al. (1983) point out, when comparing human diets, $\delta^{15}N$ values will only be statistically significant when dietary differences are extreme, as the difference between herbivores and carnivores is only 3-4‰ and among human populations, researchers are typically looking at much smaller distinctions. Schoeninger and Moore (1992: 261) estimate that a 15% difference in the proportion of meat consumed by humans would result in only a 0.5‰ difference in $\delta^{15}N$ values.

Nitrogen isotope ratios may also distinguish between consumption of marine versus terrestrial resources, as aquatic and terrestrial plants fix nitrogen through different means. Terrestrial plants obtain nitrogen through bacterial nodules found on their roots and intake less ^{15}N relative to ^{14}N thus, exhibit a low $\delta^{15}N$ ratio (note: some marine organisms fix nitrogen made available by blue-green algae and may have $\delta^{15}N$ ratios similar to terrestrial plants, for this reason it is critical to be aware of environmental factors that could potentially confound results). Marine plants typically obtain nitrogen as it is released through the bacterial breakdown of nitrogen containing molecules released by decaying organisms, which contain more of the heavier ^{15}N isotope and thus result in higher $\delta^{15}N$ ratios relative to terrestrial plants. Table5.4 compares $\delta^{15}N$ values derived from agriculturalists and marine dependent populations (according to Schoeninger et al. 1983). Research by Katzenberg (1989) also demonstrated the utility of nitrogen isotopes in distinguishing between freshwater fish and terrestrial diets. Prior to this, it had been assumed that freshwater fish had nitrogen isotope ratios similar to terrestrial resources. Finally, $\delta^{15}N$ values have also been used to study weaning. Fogel and colleagues (1989, 1997) demonstrated a 2-3‰ enrichment in $\delta^{15}N$ ratios for breast feeding infants relative to their mothers. The $\delta^{15}N$ values drops to approximately the same level as the mother following weaning. Data on weaning ages can provide insight into birth spacing, fertility, as well as overall health and childhood mortality patterns for early historic and prehistoric populations.

Table 5.4 Example $\delta^{15}N$ values for marine and terrestrial diets (Schoeninger et al. 1983)

Associated Diet	**$\delta^{15}N$ values**	**Example Populations**
Primarily Marine Diet	17-20 ‰	Tlingit North American salmon fishers
Primarily Agricultural Diet	6-12 ‰	Mesoamerican agriculturalists North American agriculturalists

Southern Titicaca Basin Flora and Fauna

Due to variability in isotopic signatures among different environments and foodwebs, it is necessary to determine the specific isotopic signatures for local dietary resources most likely consumed by past peoples before attempting to interpret the results of isotopic ratios in human bone samples. The most extensive study of carbon and nitrogen stable isotope ratios for altiplano fauna and flora are provided by Miller (2005; Miller et al. 2008, 2010). As part of the Taraco Archaeological Project, directed by Christine Hastorf and Mathew Bandy, Miller's work documented isotopic signatures for a wide range of terrestrial and aquatic plant resources as well as Lake Titicaca fish. Due to the scarcity of archaeological plant samples in the altiplano, the majority of plant data is of modern origin. Thus, as Miller notes (2005:21), using these results for interpreting past diets must be approached with caution, due to potential changes in the environment and agricultural practices, such as the use of fertilizers. Fish analyzed were of both modern and archaeological origin, however, due to differences in the carbon isotope values obtained for modern and archaeological fish samples (Miller et al. 2010)[30] only the results for archaeological fish were considered for the present study. Finally, I collected a small sample of archaeological faunal bones and fish scales for isotopic analysis from excavations dating to the Tiwanaku period from the Mollo Kontu sector of Tiwanaku and the site of Khonkho Wankane (see Table5.5). These data, when considered relative to other isotopic studies of central and southern Andean fauna and flora, such as the Mantaro Valley of Peru (DeNiro and Hastorf 1985), Conchopata, Peru (Finucane et al. 2006) and Atacama, Chile (Tieszen and Chapman 1992), provide an excellent foundation for interpreting ancient altiplano diets.

Table 5.5 Isotopic values for altiplano fauna sampled for this study

Specimen ID	Taxon	$\delta^{13}C$	$\delta^{15}N$	Origin
KW-1.26N2R1	Camelid	-18.6	7.4	Khonkho Wankane
KW-12.29N3R1	Camelid	-17.3	7.1	Khonkho Wankane
KW-9.20N6	Camelid	-18.8	4.8	Khonkho Wankane
MK-D-3634	Camelid	-18.6	6.2	Mollo Kontu, Tiwanaku
MK-E-3522	Camelid	-18.4	6.1	Mollo Kontu, Tiwanaku
MK-D-3387	fish scale*	-16.9	6.1	Mollo Kontu, Tiwanaku

* A low collagen yield for this sample indicated unreliable results, thus this sample was not included in calculating averages for local fauna.

Based on Miller's (2005; Miller et al. 2008) analysis, altiplano food crops, including potatoes, quinoa, oca, paiko, and amaranth, fall into the C_3 category, having

[30] See Miller et al. 2010 for an in depth discussion of potential factors that would result in differences in modern and archaeological $\delta^{13}C$ values for Lake Titicaca fish.

low $\delta^{13}C$ values (mean $\delta^{13}C = -24.3‰$)[31]. Nitrogen values for these crops were elevated (mean $\delta^{15}N = 7.9‰$) relative to results reported by Tiezsen and Chapman (1992) for C_3 crops from the Atacama Desert region of northern Chile (mean $\delta^{15}N = 5‰$), but well within the range provided by DeNiro and Hastorf (1985) for plants from the Upper Mantaro valley of Peru. Legumes fall within the C_3 range (mean $\delta^{13}C = -25.4‰$) but have $\delta^{15}N$ values close to 0‰ (mean $\delta^{15}N = 0.4‰$). The only C_4 plant found in the altiplano was *Zea mays*, having a more positive $\delta^{13}C$ value (mean $\delta^{13}C = -9.8‰$) and nitrogen values similar to other plants (mean $\delta^{15}N = 7.0‰$)[32].

Based on my analysis of altiplano fauna, $\delta^{13}C$ values for terrestrial herbivores reflect a diet primarily derived C_3 plant sources (mean $\delta^{13}C = -20.3‰$). As expected, $\delta^{15}N$ values for terrestrial herbivores are elevated relative to the plants they consumed (mean $\delta^{15}N = 8.3‰$). However, this is not a significant difference relative to the mean $\delta^{15}N$ value for local altiplano crops (7.9‰). This is likely because the mean $\delta^{15}N$ value reported for local altiplano crops only includes domesticates, whose values may be inflated due to the use of fertilizers or other factors. Many wild species, which may have been utilized by grazing herbivores, have significantly lower $\delta^{15}N$ values (Miller 2005 provides values for many additional local species).

The most surprising results came from Miller and colleagues (2010) study of archaeological fish remains. Lake Titicaca fish had unexpectedly positive $\delta^{13}C$ values (mean $\delta^{13}C = -10.2‰$), which overlap with values for maize, and nitrogen values similar

[31] For the $\delta^{13}C$ values reported for modern plant remains, I have include a +1.5‰ adjustment to account for ^{12}C enrichment in the atmosphere due to the burning of fossil fuels in the modern era (see Tieszen 1991).
[32] As noted in chapter 4, maize can only be grown in relatively small quantities in the altiplano, primarily along the warmer shores of Lake Titicaca.

to terrestrial herbivores (mean $\delta^{15}N = 8.3‰$). Plants and therefore plant consuming fish from freshwater lakes typically have $\delta^{13}C$ values in the C_3 range (Boutton 1991). However, more positive $\delta^{13}C$ ratios in the C_4 range for freshwater fish are not without precedents. Results for Lake Baikal fish reported by Katzenberg and Weber (1999) and Lake Malawi fish reported by Hecky and Hesslein (1995), both revealed unexpectedly positive $\delta^{13}C$ values. Due to the variety of ways aquatic plants obtain carbon, it has been difficult for researchers to pinpoint the exact cause of the variation in $\delta^{13}C$ values relative to other freshwater systems. For a more detailed discussion of the potential sources of carbon isotope variation in Lake Titicaca see Miller et al. (2010).

For the present study, the most problematic aspect of the unexpectedly positive $\delta^{13}C$ ratios found in Lake Titicaca fish is distinguishing the consumption of fish from the consumption of C_4 plants (maize), as both the carbon and nitrogen isotope ratios overlap. This problem underscores the value of obtaining carbon isotope ratios in humans from both bone collagen and apatite. As previously noted, bone collagen carbon is primarily derived from dietary protein, whereas carbon in bone apatite is a reflection of the whole diet (Ambrose and Norr 1993, Ambrose et al. 1997, 2003). Thus, since fish are predominately a protein resource and maize contains very little protein, the spacing between $\delta^{13}C_{coll}$ and $\delta^{13}C_{ap}$ ($\delta^{13}C_{coll\text{-}ap}$) may be used to determine the source of high carbon isotope ratios in humans (fish versus maize). A $\delta^{13}C_{coll\text{-}ap}$ value greater than 4.4‰ indicates that the $\delta^{13}C$ value of dietary protein is more negative than the whole diet (i.e., the primary source of high $\delta^{13}C$ values is a protein depleted resource such as a C_4 plant--maize) (Ambrose et al. 1997: 351). A $\delta^{13}C_{coll\text{-}ap}$ value of approximately 4.4‰ or less indicates that the $\delta^{13}C$ value of dietary protein is more positive than the whole diet (i.e., the primary source of high δ^{13}C values is a protein rich resource, such as C_4 enriched fish) (Ambrose 1997).

Based on the comprehensive work by Miller (2005) and Miller et al. (2008, 2010) and my own analysis of local fauna, the isotopic values of potential food resources for the altiplano are presented in Figure 5.11. Boxes represent the mean isotopic ratios ± 1 standard deviation. δ^{13}C values for modern plants have been adjusted by +1.5‰ to account for carbon enrichment in the atmosphere due to fossil fuel combustion in the modern era (Tieszen 1991). For ancient faunal samples, standard adjustments of -2‰ for δ^{13}C values and +2‰ for δ^{15}N values were made to account for differences in isotopic values derived from hard tissues and those for meat, as it was the meat that was actually consumed by ancient altiplano populations.

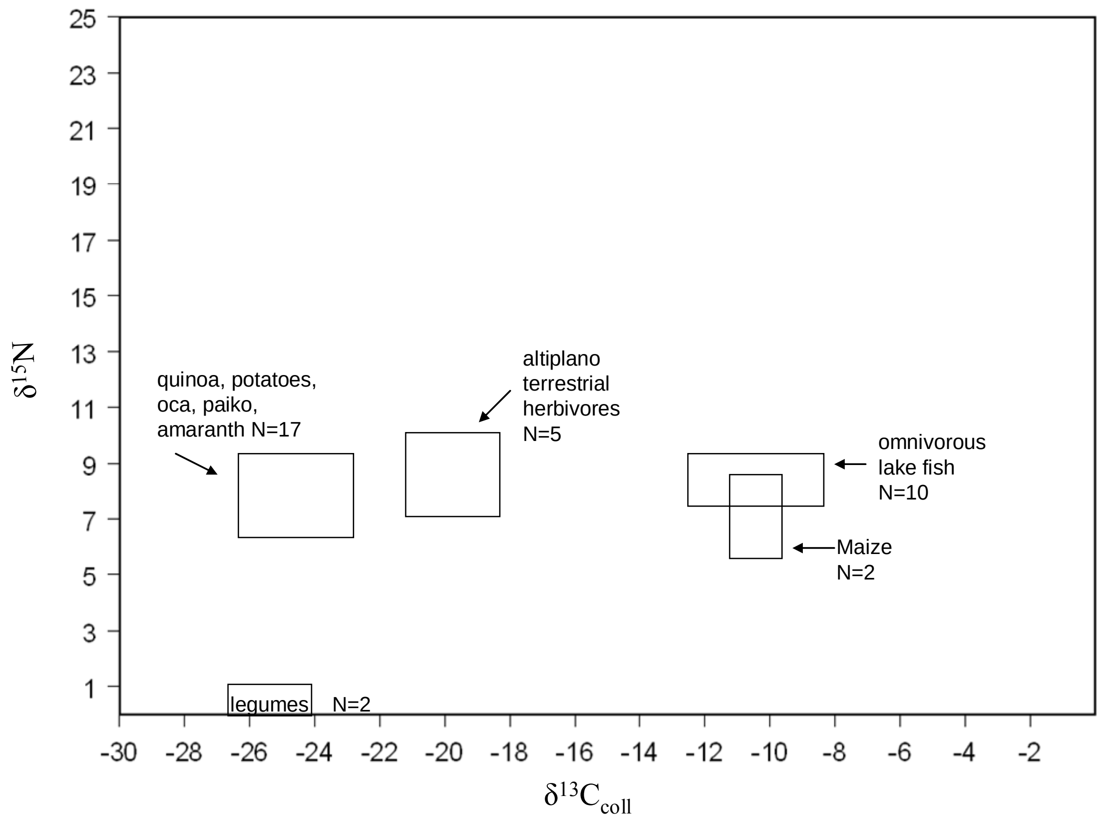

Figure 5.11 Isotopic ranges for altiplano fauna and flora, $\delta^{15}N$ versus $\delta^{13}C_{coll}$ based on values provided by (2005), Miller et al. (2010), and Berryman (this study)[33]

Selection of Human Bone Samples

I obtained human bone samples for isotopic analysis from all available and sufficiently preserved adult individuals from sites within the Tiwanaku, Katari, and Desaguadero valleys. Table 5.6 provides the distribution of all samples I collected according to temporal period, site, and sex. Bone samples were selected from well-

[33] In order to directly compare $\delta^{13}C_{coll}$ and $\delta^{15}N$ values in humans to the values presented for local resources, it is necessary to adjust the human values by -5‰ for $\delta^{13}C_{coll}$ and -3‰ for $\delta^{15}N$ to account for fractionation. This makes the human isotopic values appear as the foods being consumed, allowing direct comparison.

preserved skeletal elements—most often the shafts of femora or tibiae. The shafts of these elements are among the densest in the human body, as they are comprised of compact cortical bone that protects bone collagen from the effects of environmental factors that may lead to decomposition or contamination. Specimens with well-preserved collagen maintain a yellowish brown color, are more difficult to saw or cut, and when cut, a smooth and waxy or greasy cortex is apparent. Poorly preserved specimens are lighter, easy to cut, and possess a chalky white cortex.

Table 5.6 Distribution of individuals sampled for stable isotopic analysis according to temporal period, site, and sex.

Site	Male/PM	Female/PF	Unknown	Site Total
Late Formative				
Tiwanaku	1	--	3	4
Lukurmata	3	1	--	4
Khonkho Wankane	2	1	1	4
Kirawi (CK65)	--	2	1	3
Iruihito	--	--	2	2
TOTAL				**15**
Tiwanaku Period				
Tiwanaku*	15	12	9	36
Lukurmata	5	5	--	10
KhonkhoWankane	1	2	2	5
Kirawi (CK65)	2	1	--	3
Urikatu Kontu (CK70)	1	--	--	1
Tilata (TMV 101)	--	1	--	1
Iruihito	--	--	2	2
TOTAL				**58**
Post Tiwanaku				
Lukurmata	3	3	1	7
Khonkho Wankane	1	--	1	1
Urikatu Kontu (CK70)	4	--	1	5
TMV228	2	--	--	2
TOTAL				**15**

*This total does not include 8 individuals (4 males, 3 females, and 1 unknown) analyzed by Paula Tomzcak (2001), which were presented in a paper co-authored by Berryman and Tomzcak (Berryman et al. 2006). In order to maximize the sample size and strengthen my conclusions, these data, with the permission of Tomzcak, were included in the statistical analyses and results discussed in Chapter 7.

Sample Preparation

All human and faunal bone samples were sent to Dr. Robert Tykot for chemical analysis at the University of South Florida Archaeological Science Laboratory. For each sample, both carbon and nitrogen stable isotopes from bone collagen and carbon stable isotopes from bone apatite were analyzed.

Extraction of bone collagen first involved the removal of base-soluble contaminants, such as humic acids and lipids, with 0.1 sodium hydroxide for 24 hours followed by demineralization of the bone samples in 2% hydrochloric acid for 72 hours. Samples were then treated again with 0.1 M sodium hydroxide for 24 hours to ensure removal of contaminants. Residual lipids were then dissolved in a 2:1:0:8 mixture of methanol, chloroform, and water for 24 hours. Collagen pseudomorphs were freeze dried and analyzed for $\delta^{13}C$ and $\delta^{15}N$ using a CHN analyzer and a Finnigan MAT stable isotope ratio mass spectrometer. For a more detailed description of standard procedures for preparation of collagen samples see Ambrose (1990).

Bone apatite samples were prepared following the recommendations of Koch et al. (1997). 10 milligrams of bone powder was drilled from the center of each well cleaned bone sample. The ground bone was them treated with 2% sodium hydrochlorite for 72 hours to remove all organic components. Non-biogenic carbonates were removed with 1.0 M of buffered acetic acid for 24 hours. Samples were analyzed with a Finnigan MAT mass spectrometer connected to a Kiel III individual acid bath system. Additional information regarding the procedures used at the University of South Florida's Archaeological Science Laboratory may be found on the laboratory website at http://luna.cas.usf.edu/~rtykot/Bone.html (also see Tykot 2006).

Assessing Sample Integrity

Interpretation of results from stable isotopic analyses requires researchers to be aware of factors that may lead to deceptive results. Chief among these are diagenesis and contamination. Pretreatment must be thorough, ensuring that all potential contaminants such as humic acids, carbonates, rootlets, and lipids have been removed prior to testing. Numerous methods have been developed for testing the efficacy of pretreatment and the quality of sample preservation (see Ambrose 1990; Ambrose and Norr 1992; DeNiro 1985; DeNiro and Weiner 1988; and Tuross et al. 1988).

The most common method for testing the integrity of bone collagen samples is to compare the atomic carbon to nitrogen (C:N) ratio of the sample (after testing) to the atomic C:N ratio of modern collagen. The ratio for a reliable specimen should fall between 2.9- 3.6 (Ambrose 1990; DeNiro 1985; Schoeninger and Moore 1992). Ratios outside this range indicate samples which are likely contaminated or have insufficient collagen to produce reliable results.

An additional means of assessing the reliability of results is measuring the percentage of collagen yielded relative to the original bone sample. On average, bone is composed of 20% collagen. A collagen yield of less than 1% is considered unreliable (Ambrose 1990). The percent carbon (%C) and percent nitrogen (%N) measured relative to the size of the original 1 mg. bone sample is also used to indicate the reliability of results. A %C measurement of less than 3-8% and/or %N measurement of less than 1-3% indicates a lack of sufficient collagen to produce reliable results (Ambrose 1990).

The most common method for testing the reliability of stable isotopic results produced from bone apatite samples involves the measurement of apatite yields obtained during the pretreatment process coupled with repeat testing of samples. Combinations of all of the above techniques were utilized in the present study.

Statistical Methods for Isotopic Data

Intra- and inter-site isotopic differences were statistically evaluated using S-PLUS 2000 and SPSS 12.0 software. Because the data are not normally distributed (likely due to social heterogeneity) and samples sizes were small, non-parametric tests were selected for analysis. Specifically, the Mann-Whitney U test was used to assess the significance of mean isotopic differences among and within sites. Significance was defined at the $p<0.05$ level. In addition, Spearman's Rho (rank order) tests were used to assess positive or negative correlations between isotopic indicators ($\delta^{13}C_{coll,}$ $\delta^{13}C_{ap,}$ $\delta^{13}C_{coll\text{-}ap,}$ and $\delta^{15}N$). Such correlations provide a complementary line of data for isotopic interpretations. For example, a significant ($p < 0.05$) negative correlation between $\delta^{13}C_{ap}$ and $\delta^{15}N$ isotopic values signifies that protein consumption decreased as consumption of C_4 enriched resources increased, indicating the primary C_4 resource being consumed was depleted in protein (i.e. it was a carbohydrate such as maize). However, given the small sample sizes for most sites when divided by temporal period, correlations were only useful in the assessment of Middle Horizon Tiwanaku.

Plant Microfossils from Human Dental Calculus

A final component of the present study was the microscopic examination of plant microfossils, including phytoliths and starch grains, recovered from human dental calculus. Phytoliths are microscopically identifiable silica particles found in plant cells, which, like starch grains, may be deposited and preserved in the mineralized dental plaque (calculus) of consumers. This technique is an excellent complement to isotopic and dental analyses, which provide a *broad* overview of diet (Fox et al. 1996; Reinhard et al. 2001). Phytolith and starch grain analyses allow researchers to identify the *specific* foods consumed (Pearsall et al. 2003; 2004; Chandler-Ezell et al. 2006). Of particular interest to this study was the identification of maize, coca (*Erythroxylum coca*), and certain psychotropic plants, such as vilca (*Anadenanthera colubrine* and *peregrine*) and *Banisteriposis*—all lowland imports thought to have had significant ritual and/or medicinal value in the prehistoric Andes (Allen 1988; Johannesen and Hastorf 1989; Torres et al. 1991; Torres 1995; Hastorf 2003; Hastorf and Johannesen 1993; Staller 2006). Identifying the distribution of these resources is crucial to addressing issues of social inequality, trade, and ceremonial life among Tiwanaku communities.

I selected 46 samples of human dental calculus from sites within each of the three major valleys of the Southern Titicaca Basin, including Tiwanaku (n=17), Lukurmata (n=8), Khonkho Wankane (n=8), Kirawi (n=4), Urikatu Kontu (n=3), CK104 (n=2) and the three rural Tiwanaku valley sites of Tilata (n=2), Obsidiana (n=1), and TMV228/Mollo Kontu[34] (n=1). Samples were selected based on the presence of moderate to large calculus deposits, thus, sampling was biased in that only individuals whose particular diet and perhaps hygiene habits predisposed them to form greater quantities of calculus as well as older individuals who have had more time to accumulate calculus deposits. If calculus formation is influenced by the amount of carbohydrates in the diet, as some have argued (Evans 1973; Hillson 1979; Allison 1984; Cassidy 1984; Lukacs 1989), it can be assumed that this sample includes members of the ancient Titicaca Basin population whose diet was more dependent on carbohydrates.

After recording standard dental observations and photographing all samples, calculus was scraped from a single tooth belonging to each individual. These samples

[34] This site is not to be confused with the sector of the Tiwanaku site given the same name.

were placed in vials and sent to Amanda Logan, a paleobotanical specialist and graduate student at the University of Michigan, who, under the direction of Dr. Deborah Pearsall, undertook the microscopic identification of phytoliths and starch grains. Microfossil analyses have generally focused only on the identification of phytoliths. However, as Andean tubers do not produce diagnostic phytoliths (Logan 2006), Logan undertook complimentary starch grain analysis to identify this important Andean staple crop (Logan and Pearsall 2007). Given the focus on phytolith extraction in most studies, standard calculus processing techniques use chemicals that damage the more delicate starch grains. Thus, Logan employed a modified procedure for extracting both phytoliths and starch grains developed by Karol Chandler-Ezell and Deborah Pearsall (Logan and Pearsall 2007). After starch grains had been recovered, samples were processed a second time using stronger chemicals (hydrochloric acid) to extract any remaining phytoliths.

CHAPTER VI

DENTAL DATA RESULTS

Introduction

This chapter presents the results and interpretations of the dental portion of this study. I first report dental caries, dental abscess, and antemortem tooth loss frequencies among individual teeth or alveoli as well as the percentage of individuals with one or more of the aforementioned dental pathologies. I then report dental calculus scores based on the maximal expression of dental calculus for each individual. Finally, dental wear scores are compared based on the mean score for anterior teeth, premolars, first molars, second molars, and third molars for each individual. All dental pathologies are compared according to temporal period (Late Formative, Tiwanaku Period, and Post Tiwanaku Period), valley, site, sector, and sex. A summary including interpretations of the results follows.

Dental Caries

Carious lesions were rare in anterior teeth during all temporal periods and thus the variation among samples is primarily a result of differing caries rates in the posterior dentition, especially molars (Table 6.1). For the Southern Titicaca Basin as a whole, caries rates varied between 1.3 and 10.8 percent when all teeth were pooled, with a clear pattern of decreasing caries rates through time (Figure 6.1). When all individuals are pooled, there is a drop in caries rates from 10.8 percent in the Late Formative to 8.9

percent in the Tiwanaku Period. This drop is statistically significant for males, whose rates dropped form 11.9 to 6.4 percent (molars, chi square p = .045, total teeth, chi square p = .057). However, caries rates for females actually increase from 9.0 to 12.1 percent in the Tiwanaku Period, although the increase is not statistically significant. During the Tiwanaku period, females have a significantly higher rate of caries than males (molars, chi square p = .015; total teeth, chi square p = .002). The decrease in caries rates from the Tiwanaku Period (8.9%) to the Post Tiwanaku Period (1.3%) is statistically significant when all individuals are pooled (molars, chi square p = .000; total teeth, chi square p = .000), as well as for females (molars, chi square p = .020; total teeth, chi square p = .008) and males (molars, chi square = .017; total teeth, chi square p = .031Comparison of the mean age-at-death distributions of the above samples revealed no statistically significant differences, thus, it is assumed dietary differences are responsible for the variation in caries rates.

Table 6.1 Percentage of observable teeth with one or more dental carie

		Late Formative			Tiwanaku Period			Post Tiwanaku		
tooth type	sample	N	carious	%	N	carious	%	N	Carious	%
Incisors										
	All	32	1	3.1	292	3	1.0	52	0	1.0
	Female	20	0	0.0	99	3	3.0	11	0	0.0
	Male	9	1	11.1	100	0	0.0	37	0	0.0
Canines										
	All	24	0	0.0	212	2	1.0	39	0	0.0
	Female	13	0	0.0	71	0	0.0	7	0	0.0
	Male	7	0	0.0	68	2	2.9	30	0	0.0
Premolars										
	All	46	2	4.3	425	21	5.0	69	2	2.9
	Female	27	1	3.7	154	10	6.5	48	2	4.2
	Male	15	0	0.0	134	4	3.0	16	0	0.0
Molars										
	All	56	14	25.0	598	109	18.2	99	2	**2.0**
	Female	40	8	20.0	229	54	**23.6**	23	0	**0.0**
	Male	11	4	**36.0**	179	25	14.0	65	2	**3.1**
Total Teeth										
	All	158	17	10.8	1527	135	8.9	306	4	**1.3**
	Female	100	9	9.0	553	67	**12.1**	89	2	**2.2**
	Male	42	5	**11.9**	481	31	6.4	148	2	**1.4**

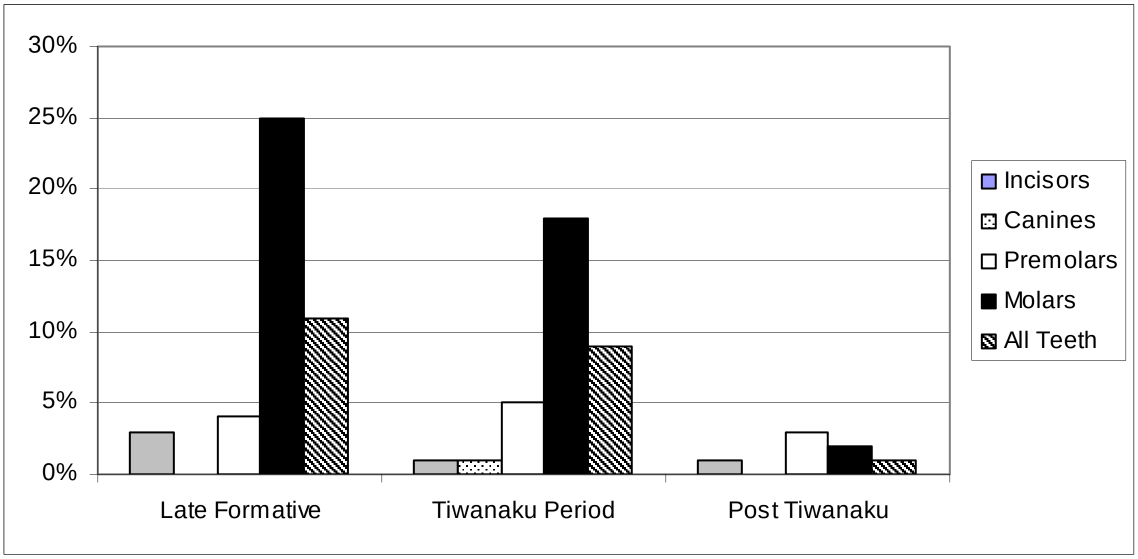

Figure 6.1. Temporal variation in dental caries rates based on the percentage of observable teeth with one or more dental carie within the total Southern Titicaca Basin sample

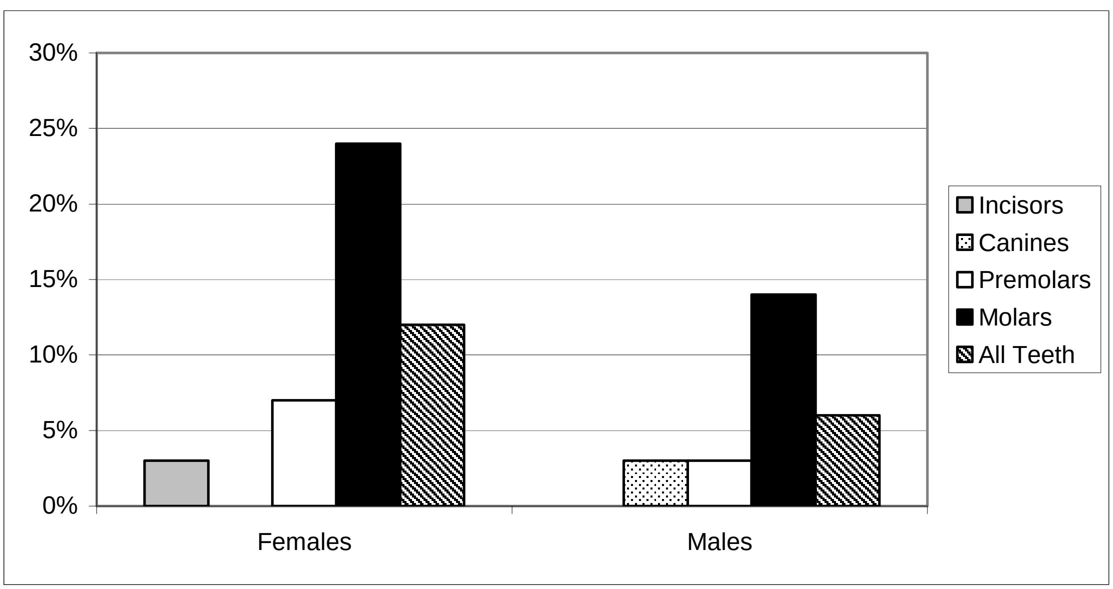

Figure 6.2 Variation in male and female dental caries rates based on the percentage of observable teeth with one or more dental carie, Tiwanaku Period

The percentage of adults with one of more observable dental carie when the total Southern Titicaca Basin sample is pooled varies between 18 and 75 percent (Table 6.2). As observed when analyzed at the level of the individual tooth, there is a clear trend of decreasing caries rates through time (Figure 6.3). Although the decrease in individuals with dental caries from the Late Formative to the Tiwanaku Period is substantial, it is not statistically significant, likely due to the small sample size of Late Formative individuals. The decrease in individuals with dental caries from the Tiwanaku Period (54%) to the Post Tiwanaku Period (0%) is statistically significant for females (chi square p = .040) and approaches significance when all individuals are pooled (chi square p = .063). Comparison of the mean age-at-death distributions of these samples revealed no statistically significant differences, thus, it is assumed dietary differences are responsible for the variation in caries rates.

Table 6.2 Percentage of adults with one or more observable carie

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Sample	N	carious	%	N	carious	%	N	carious	%
All Adults	8	6	75.0	97	42	43.0	16	3	18.0
Females	4	3	75.0	35	19	54.0	4	0	**0.0**
Males	3	2	67.0	27	11	41.0	10	2	20.0

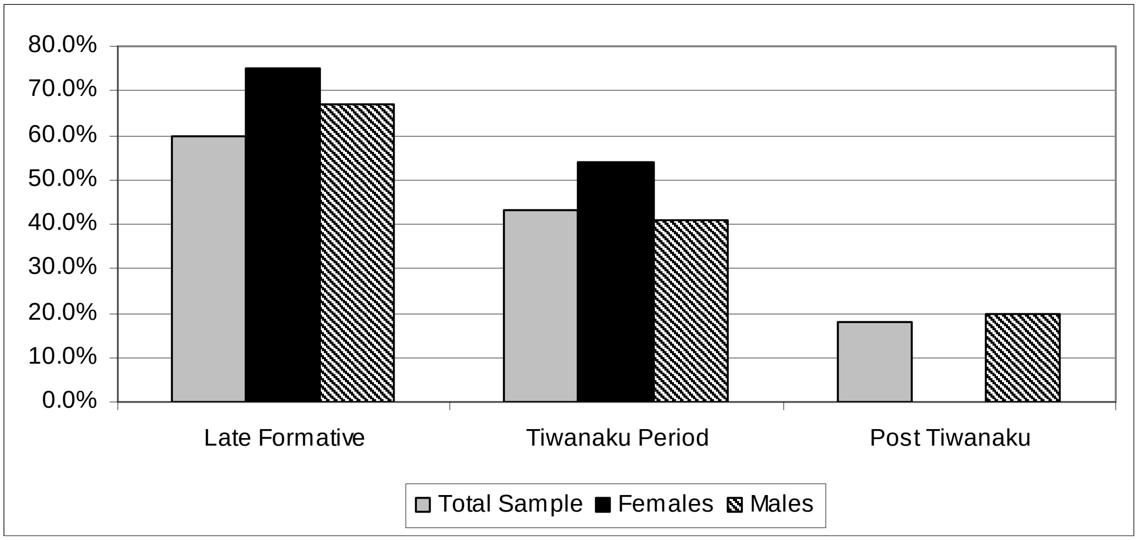

Figure 6.3 Temporal variation in dental caries rates based on the percentage of individuals with one or more dental carie within the total Southern Titicaca Basin sample

This study also compared the number of observable teeth with dental caries among the three major valleys of the Southern Titicaca Basin through temporal periods in order to assess any regional variation that might have existed (Table 6.3). Caries rates varied between 0 and 26.7 percent. The general trend of caries rates decreasing through time is clear among the three valleys (Figure 6.4). Although, when all teeth are pooled, there is no change in caries rates between the Late Formative (10.8%) and Tiwanaku Period (11%) samples[35]. The substantial decrease in caries during the Post Tiwanaku period is clear among all three valleys but, statistically significant for only the Katari valley (molars, chi square p = .000; all teeth, chi square p = .000). In addition, comparison of valleys within the Tiwanaku Period revealed a significantly higher rate of dental caries in the Katari valley when compared to the Tiwanaku valley (molars, chi square p = .020; all teeth, chi square p = .034). However, when the age distributions of

[35] Note there is no sample available from the Tiwanaku valley during the Late Formative.

the Tiwnaku and Katari valleys are compared, the Katari valley sample (mean age at death- 40.9 ± 11) is significantly (z score = -2.347, p = .019) older than the Tiwanaku valley sample (mean age at death- 34.4 ± 11). Thus, it is likely age, rather than diet, is responsible for the variation in caries rates among the two valleys.

The percentage of adults with one of more observable dental carie among the three valleys varied from 0 to 83 percent (Table 6.4). When analyzed at the level of the individual, the decrease in caries rates between the Tiwanaku and Post Tiwanaku Periods is still apparent; however the difference is not statistically significant, likely due to the small Post Tiwanaku Period sample. The decrease in the number of individuals with one or more carie from the Tiwanaku to the Post Tiwanaku Period approaches significance for the Katari valley (chi square p = .060).

Table 6.3 Percentage of observable teeth with dental carie, comparing the valleys of the Southern Titicaca Basin by temporal period

		Late Formative			Tiwanaku Period			Post Tiwanaku		
Tooth type	Valley	N	carious	%	N	carious	%	N	carious	%
incisor										
	Desaguadero	12	0	0.0	23	1	4.3	7	0	0.0
	Tiwanaku				177	1	0.6	15	0	0.0
	Katari	20	1	5.0	92	1	1.1	30	0	0.0
canine										
	Desaguadero	8	0	0.0	14	0	0.0	4	0	0.0
	Tiwanaku				134	1	0.7	11	0	0.0
	Katari	16	0	0.0	64	1	1.6	24	0	0.0
premolar										
	Desaguadero	12	1	8.3	27	3	11.1	7	0	0.0
	Tiwanaku				275	13	4.3	18	1	5.6
	Katari	34	1	2.9	123	5	4.1	44	1	2.3
molar										
	Desaguadero	15	4	26.7	27	3	11.1	11	0	0.0
	Tiwanaku				387	62	16.0	29	2	6.9
	Katari	41	10	24.4	183	44	**24.0**	59	0	**0.0**
All teeth										
	Desaguadero	47	5	10.6	91	7	7.7	29	0	0.0
	Tiwanaku				973	77	7.9	73	3	4.1
	Katari	111	12	10.8	462	51	**11.0**	157	1	**0.6**

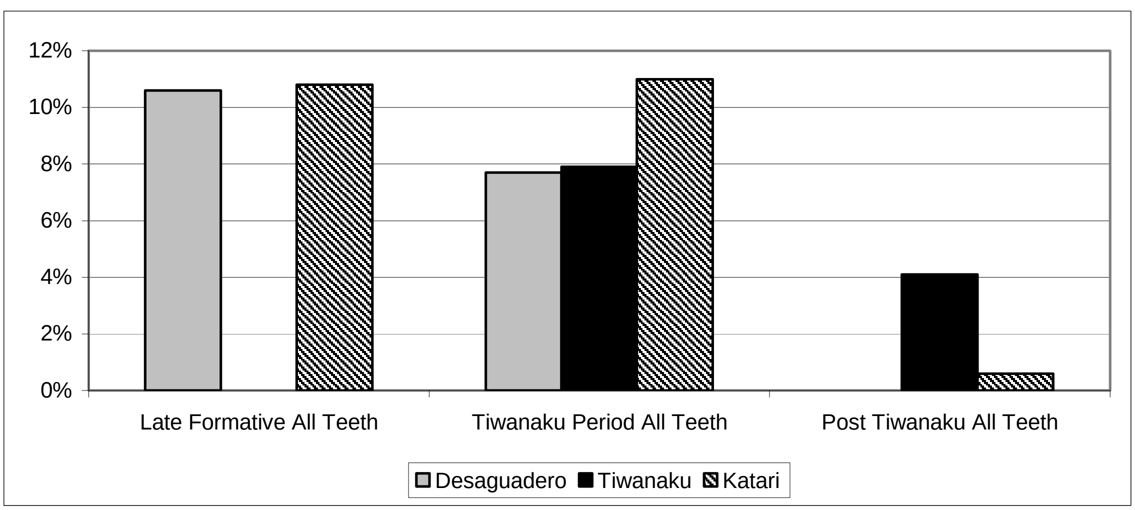

Figure 6.4 Temporal variation in dental caries rates based on the percentage of observable teeth with one or more dental carie among the three valleys of the Southern Titicaca Basin

Table 6.4 Percentage of individuals with one or more dental carie, comparing the three valleys of the Southern Titicaca Basin by temporal period

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Valley	N	Carious	%	N	Carious	%	N	Carious	%
Katari	6	5	83.3	23	11	47.8	11	2	18.2
Tiwanaku	0	0	0.0	68	26	38.2	4	1	25.0
Desaguadero	2	1	50.0	6	4	66.7	1	0	0.0

The number of observable teeth with dental caries among all sites through all temporal periods was also compared in order to assess site specific variation (Table 6.5). Sample sizes were generally small when broken down to this level of analysis. No statistically significant differences in caries rates were observed during the Late Formative Period or when comparing Late Formative and Tiwanaku Period samples. During the Tiwanaku Period, individuals from the site of Kirawi had a significantly higher rate of dental caries when compared to Tilata (molars, chi square p = .000; all teeth, chi square p = .000), Khonkho Wankane (molars, chi square p = .002; all teeth, chi square p = .005), Tiwanaku (molars, chi square p = .000; all teeth, chi square p = .000), Lukurmata (molars, chi square p = .000; all teeth, chi square p = .000), and Pokachi Kontu (all teeth, chi square p = .007). The site of Lukurmata experienced a significant decrease in caries rates from the Late Formative and Tiwanaku Period to the Post Tiwanaku Period (all teeth, chi square p = .024). Comparison of the age distributions of these samples revealed no statistically significant differences, thus, it is assumed dietary differences are responsible for the variation in caries rates.

Table 6.5. Percentage of observable teeth with dental caries, comparing Southern Titicaca Basin sites by temporal period

	Incisors			Canines			Premolars			Molars			All Teeth		
Site	N	Carious	%	N	Carious	%	N	Carious	%	N	Carious	%	N	Carious	%
Late Formative															
Kirawi	8	0	0.0	6	0	0.0	15	0	0.0	21	7	33.3	50	7	14.0
Khonho Wankane	12	0	0.0	8	0	0.0	12	0	0.0	15	4	26.7	47	4	8.5
Lukurmata	12	1	8.3	9	0	0.0	19	1	5.3	19	3	15.8	59	5	8.5
Tiwanaku Period															
Pokachi Kontu	18	1	5.6	13	0	0.0	21	0	0.0	28	5	17.9	80	6	7.5
Kirawi	27	0	0.0	17	1	5.9	38	3	7.9	57	26	**45.6**	139	30	**21.6**
Urikatu Kontu	4	0	0.0	3	0	0.0	5	0	0.0	8	1	12.5	20	1	5.0
Khonkho Wankane	23	0	0.0	14	0	0.0	27	3	11.1	27	3	11.1	91	6	6.6
Lukurmata	38	0	0.0	26	0	0.0	53	2	3.8	82	12	14.6	199	14	7.0
Iwawi	4	0	0.0	2	0	0.0	2	0	0.0	4	0	0.0	12	0	0.0
Obsidiana				1	0	0.0	3	0	0.0	8	1	12.5	12	1	8.3
Tilata	133	0	0.0	11	0	0.0	21	0	0.0	31	2	6.5	75	2	2.7
Guaqui							2	0	0.0	3	2	66.7	5	2	40.0
Tiwanaku	133	1	0.8	101	0	0.0	212	11	5.2	290	46	15.9	736	58	7.9
Post Tiwanaku															
Urikatu Kontu	17	0	0.0	12	0	0.0	20	1	5.0	35	0	0.0	84	1	1.2
Khonkho Wankane	7	0	0.0	4	0	0.0	7	0	0.0	11	0	0.0	29	0	**0.0**
Lukurmata	13	0	0.0	12	0	0.0	24	0	0.0	19	0	0.0	68	0	0.0
TMV228	13	0	0.0	9	0	0.0	16	1	6.3	29	2	6.9	67	3	4.5
Pukara	2	0	0.0	2	0	0.0	2	0	0.0				6	0	0.0

When the percentage of *individuals* exhibiting one or more dental carie is compared among sites through all temporal periods, the rate of dental caries at Kirawi is not statistically significant when compared to contemporary sites (Table 6.6). The dramatic decrease in the number of individuals with one ore more carie at the site of Lukurmata during the Post Tiwanaku Period is statistically significant (chi square p = .024). No additional statistically significant patterns were revealed at this level of analysis.

Table 6.6 Percentage of individuals with one or more dental carie, comparing Southern Titicaca Basin sites by temporal periods

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Site	N	Carious	%	N	Carious	%	N	Carious	%
Pokachi Kontu				3	1	33.3			
Kirawi	2	2	100.0	7	5	71.4			
Urikatu Kontu				1	0	0.0	4	2	50.0
Khonkho Wankane	2	1	50.0	6	4	66.7	1	0	0.0
Lukurmata	4	3	75.0	12	6	50.0	7	0	**0.0**
Guaqui				1	1	100.0			
Iwawi				1	0	0.0			
Obsidiana				1	1	100.0			
TMV228							3	1	33.3
Tilata				4	1	25.0			
Tiwanaku				61	23	37.7			
Pukara							1	0	0.0

Only the site of Tiwanaku, during the Tiwanaku Period, possessed a sample size sufficient for examining intra-site variation. Caries rates were compared among individuals buried in eight sectors of the site, revealing a number of significant differences among the sectors (Table 6.7, Figure 6.5). Mollo Kontu mound and La Karaña had the highest rate of dental caries. La Karaña caries rates were statistically significant when compared to Mollo Kontu residential (molars, chi square p = .002; all teeth, chi square p = .002), Markapata (molars, chi square p = .040; all teeth, chi square p = .040), and Akapana (premolars, chi square p = .014; all teeth, chi square p = .017). The sample size for for Mollo Kontu mound was relatively small and thus, only significant when compared to Mollo Kontu residential (molars, chi square p = .013; all teeth, chi square p = .021). The Mollo Kontu residential area had by far the lowest rate of caries when compared to all other sectors; statistically significant when compared to Akapana East (molars, chi square p = .044; all teeth, chi square p = .020), La Karaña (molars, chi square p = .002; all teeth, chi square p = .002), Mollo Kontu Mound (molars, chi square p = .013; all teeth, chi square p = .021), and Putuni (molars, chi square p = .006; all teeth, chi square p = .014). This is particularly significant, as comparison of sector mean age-at-death distributions revealed Mollo Kontu residential individuals to be by far the oldest (mean age-at-death: 44.4 ± 14.2), while the Akapana East had the lowest mean age-at-death distribution (Mean age-at-death: 24.9 ± 8.8) and had a relatively high rate of dental caries. [36] Thus, it is clear that diet rather than age is responsible for the variation in caries frequencies among sectors.

When the percentage of *individuals* exhibiting one or more dental carie is compared among Tiwanaku sectors (Table 6.8), the low incidence of caries among Mollo Kontu residential individuals (14.3%) is still significant when compare to La Karaña (chi square p = .044). Further, La Karaña's rate of dental caries is also statistically higher than that of the Akapana East (chi square p = .052).

[36] Age-at-death distributions were significantly different for Mollo Kontu Mound and Akapana East (z score = -2.305, p = .021).

Table 6.7 Percentage of observable teeth with dental caries, comparing sectors of the site of Tiwanaku during the Tiwanaku Period

	Incisors			Canines			Premolars			Molars			All Teeth		
Sector	N	carious	%	N	carious	%	N	carious	%	N	carious	%	N	carious	%
Akapana	26	0	0.0	14	0	0.0	34	0	0.0	43	6	14.0	117	6	**5.1**
Akapana East	9	0	0.0	8	0	0.0	27	2	7.4	40	7	17.5	84	9	10.7
Chiji Jawira	3	0	0.0	2	0	0.0	2	0	0.0	3	0	0.0	10	0	0.0
La Karaña	20	0	0.0	12	0	0.0	18	3	**16.7**	30	9	**30.0**	80	12	15.0
Mollo K. mound	28	0	0.0	18	0	0.0	35	2	5.7	50	15	**30.0**	131	17	13.0
Mollo K. residential	15	0	0.0	14	0	0.0	28	1	3.6	39	1	**2.6**	96	2	**2.1**
Markapata	40	1	2.5	36	0	0.0	72	4	5.6	94	13	13.8	242	18	**7.4**
Putuni	20	0	0.0	15	0	0.0	31	1	3.2	41	10	24.4	107	11	10.3

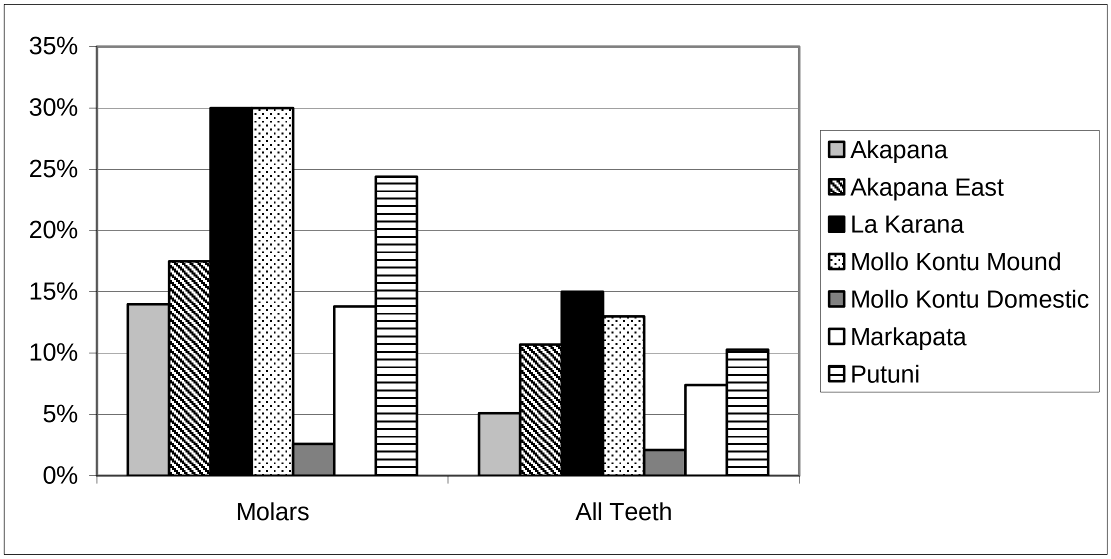

Figure 6.5 Percentage of observable teeth with one or more dental carie among sectors of Tiwanaku, Tiwanaku Period[37]

Table 6.8 Percentage of individuals with one or more dental carie, comparing sectors of the Tiwanaku site, Tiwanaku Period

Sector	N	Carious	%
Akapana	5	3	60.0
Akapana East	10	2	20.0
Chiji Jawira	2	0	0.0
La Karaña	4	3	**75.0**
Mollo Kontu Mound	5	3	60.0
Mollo Kontu Residential	7	1	**14.3**
Markapata	20	7	35.0
Putuni	8	4	50.0

Further examination of intra-site variation in caries rates included comparison of males and females from the site of Tiwanaku, Tiwanaku Period (Table 6.9, Figure 6.6). Based on the percentage of observable teeth, females revealed a significantly higher rate of dental caries

[37] Note: The Chiji Jawira sector is omitted due to insufficient sample size.

relative to males (molars, chi square p = .007; all teeth, chi square p = .000). Comparison of the mean age-at-death distributions for males and females revealed no statistically significant differences; thus, it is assumed dietary differences are responsible for the variation in caries rates.

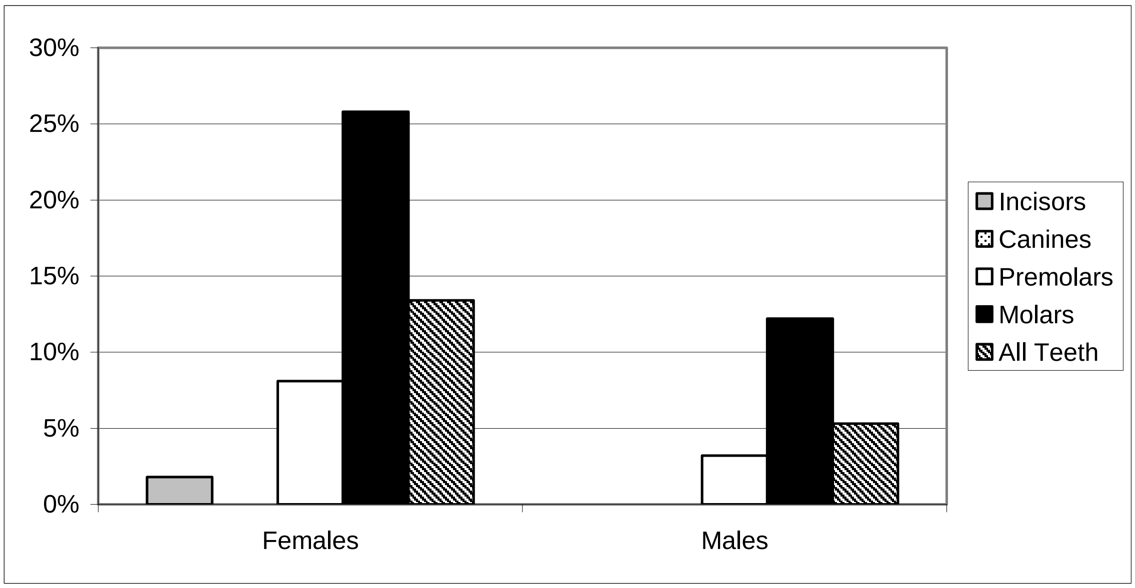

Figure 6.6 Percentage of observable teeth with one or more dental carie among males and females at Tiwanaku, Tiwanaku Period

Table 6.9 Percentage of observable teeth with one or more dental carie, comparing Tiwanaku Period males and females at the site of Tiwanaku

	Incisors			Canines			Premolars			Molars			All Teeth		
Sample	N	Carious	%	N	Carious	%	N	Carious	%	N	Carious	%	N	Carious	%
Females	56	1	1.8	36	0	0.0	86	7	8.1	128	33	**25.8**	306	41	**13.4**
Males	65	0	0.0	47	0	0.0	94	3	3.2	113	14	12.2	321	17	5.3
All	160	1	0.6	116	0	0.0	245	13	5.3	331	57	17.2	736	58	7.9

When the percentage of *individuals* exhibiting one or more dental carie is compared among Tiwanaku period males and females at Tiwanaku (Table 6.10), females have a higher incidence of dental caries, however, this difference is not statistically significant.

Table 6.10 Percentage of individuals with one or more dental carie, comparing Tiwanaku Period males and females at the site of Tiwanaku

Sample	N	Carious	%
Females	19	11	57.9
Males	19	7	36.8
All	61	23	37.7

Finally, this study examined caries location in an effort to identify potential coca chewers, following the recommendations of Buikstra and Indriati (2001), who reported a high incidence of cervical-root caries in the mandibular molars of south central coastal Peruvian coca chewers. Of the 122 individuals, only seven had cervical-root caries in their mandibular molars that might be indicative of coca chewing (Table 6.11): 25 percent of Late Formative individuals, 5.2 percent of Tiwanaku Period individuals, and zero Post Tiwanaku Period individuals. Antemortem tooth loss of lower molars was also considered. Rates of antemortem tooth loss of mandibular molars were higher with 50 percent of Late Formative, 17.7 percent of Tiwanaku Period, and 12.5 percent of Post Tiwanaku Period individuals affected. No statistically significant patterns were observed.

Table 6.11 Percentage of individuals with cervical-root caries or antemortem tooth loss in the mandibular molars

	cervical-root caries			antemort. loss		
Sample	n	affected	%	n	affected	%
Late Formative	8	2	25.0	8	4	50.0
Tiwanaku Period	97	5	5.2	96	17	17.7
Post Tiwanaku	16	0	0.0	16	2	12.5

Dental Abscesses

Between 2.8 and 5.8 percent of teeth were affected by dental abscesses among Southern Lake Titicaca Basin inhabitants, between 1.9 and 4.4 percent among females and 2.8 and 8.2 percent among males (Table 6.12, Figure 6.7). During the Late Formative, males experienced a higher rate of dental abscesses (8.2%) relative to females (1.9%). This difference was statistically significant (chi square p = .047). In addition, when all individuals are pooled there is a decrease in abscess rates from the Late Formative (5.8%) to the Tiwanaku Period (2.8%) that is statistically significant (chi square p = .030). However, abscess rates for females rise during this period, although, the rise is not statistically significant. Abscess rates remain relatively constant from the Tiwanaku Period to the Post Tiwanaku Period. Comparison of the mean age-at-death distributions among these samples revealed no statistically significant differences.

Table 6.12 Alveoli observable for dental abscesses

	Late Formative			Tiwanaku			Post Tiwanaku		
Sample	N	affected	%	N	affected	%	N	affected	%
female	104	2	**1.9**	558	13	2.3	45	2	4.4
male	73	6	8.2	530	21	4.0	217	6	2.8
all	191	11	**5.8**	1449	41	2.8	229	8	3.5

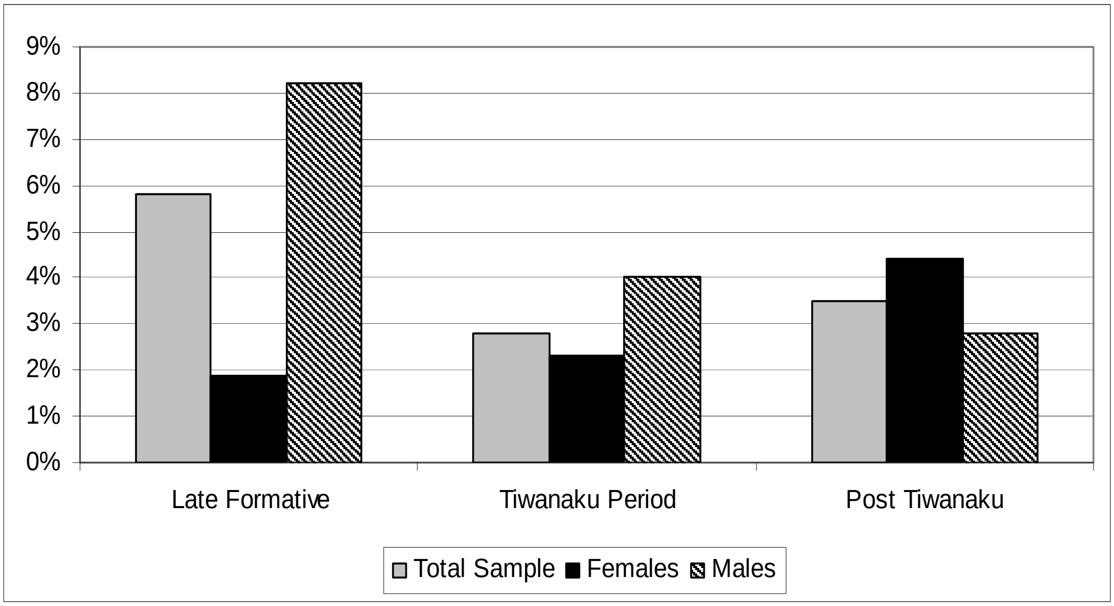

Figure 6.7 Alveoli observable for dental abscesses

The percentage of individuals with one or more dental abscess was also examined. Between 17.5 and 50 percent of individuals had one or more teeth affected by dental abscesses (Table 6.13). The percentage of individuals affected decreased significantly from the Late Formative to the Tiwanaku Period. This decrease was statistically significant when all Late Formative individuals were pooled (chi square p = .030). No significant differences were observed between the Tiwanaku and Post Tiwanaku Periods.

Table 6.13 Individuals with one or more dental abscess

	Late Formative			Tiwanaku			Post Tiwanaku		
Sample	N	affected	%	N	affected	%	N	affected	%
female	4	2	50.0	35	7	20.0	4	2	50.0
male	3	2	66.7	27	6	22.2	10	2	20.0
all	8	5	**50.0**	97	17	17.5	16	3	18.8

Comparison of dental abscess rates among the three valleys of the Southern Titicaca Basin revealed rates between zero and 6.7 percent (Table 6.14, Figure 6.8). Although rates decrease from the Late Formative to the Tiwanaku Period, the differences are not statistically significant nor are differences between the Tiwanaku and Post Tiwanaku Periods. However, the decrease in abscess rates in the Katari valley between the Tiwanaku (4.0%) and Post Tiwanaku Periods (1.1%) approaches significance (chi square p = .065). During the Post Tiwanaku Period, lower abscess rates in the Katari valley (1.1%) relative to the Tiwanaku valley (5.1%) were statistically significant (chi square p = .057). No statistically significant differences in mean age-at-death distributions were found that would explain these discrepancies, thus, diet rather than age is likely responsible.

Table 6.14 Alveoli observable for abscesses among the three valleys of the Southern Titicaca Basin

	Late Formative			Tiwanaku			Post Tiwanaku		
Valley	N	affected	%	N	affected	%	N	affected	%
Katari	132	8	6.1	470	19	4.0	175	2	**1.1**
Tiwanaku				956	22	2.3	79	4	5.1
Desaguadero	59	3	5.1	23	0	0.0	30	2	6.7

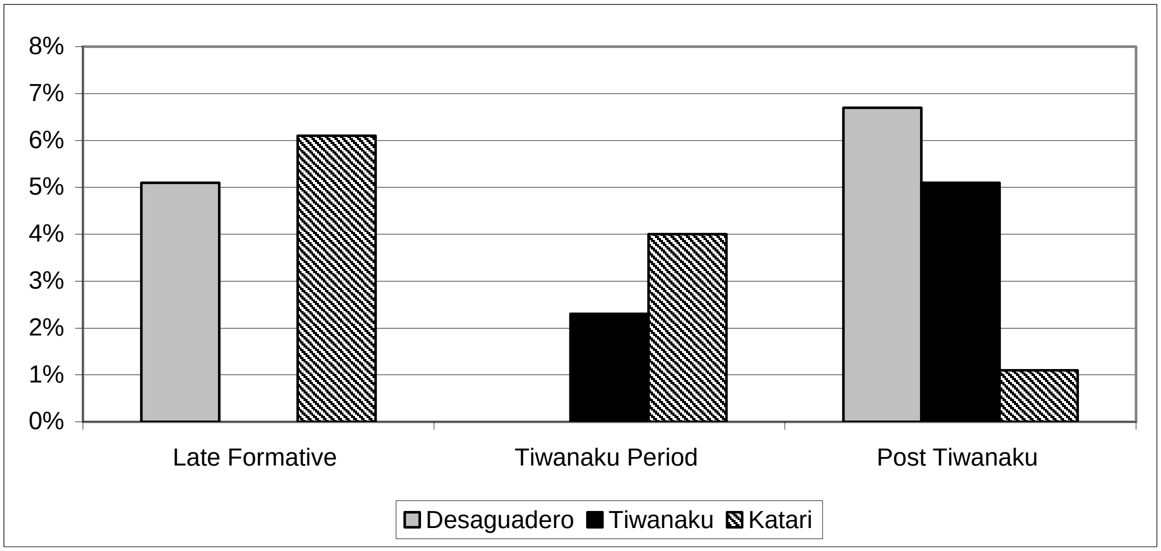

Figure 6.8 Alveoli observable for abscesses among the three valleys of the Southern Titicaca Basin

The percentage of individuals with one or more teeth affected by dental abscesses was also examined among the three valleys (Table 6.15). Again, no statistically significant differences were observed within the Late Formative sample or between Late Formative and Tiwanaku Period samples. Late Formative samples were very small at this scale of analysis. During the Tiwanaku Period, the Katari valley exhibited a higher rate of individuals affected by abscesses (34.8%) than the Tiwanaku valley (13.2%) that is statistically significant (chi square $p = .022$). However, Katari valley individuals had a significantly higher mean age-at-death distribution relative to contemporary Tiwanaku valley individuals. Thus, the discrepancies in abscess rates likely reflect age rather than diet. During the Post Tiwanaku Period, the percentage of individuals affected by abscesses decreased in the Katari valley and increased in the Tiwanaku valley. The increase in the

Tiwanaku valley was statistically significant (chi square p = .047). Desaguadero valley sample sizes were insufficient to detect any significant variation in abscess rates.

Table 6.15 Individuals observable for abscesses in the three valleys of the Southern Titicaca Basin

	Late Formative			Tiwanaku			Post Tiwanaku		
Valley	N	affected	%	N	affected	%	N	affected	%
Katari	6	3	50.0	23	8	**34.8**	11	2	18.2
Tiwanaku				68	9	13.2	4	2	**50.0**
Desaguadero	2	2	100.0	6	0	0.0	1	1	100.0

Rates of dental abscesses were also compared between all sites through all temporal periods. Rates of dental abscesses varied between zero and 18.8 percent (Table 6.1 6). During the Late Formative rates varied between 2.2 and 8.1 percent and no statistically significant differences were found among sites. Lukurmata experienced a statistically significant decrease in abscesses from the Late Formative (8.1%) to the Tiwanaku Period (1.3%) (chi square p = .002). During the Tiwanaku Period, abscess rates varied between zero and 18.8 percent. Urikatu Kontu had higher rates of dental abscesses (18.8) relative to Kirawi (4.6%), Khonkho Wankane (0%), Tilata (2.7%), Lukurmata (1.3%), and Tiwanaku (2.3%) that were statistically significant (chi square p = .006, .028, .004, .000, .000, respectively). During the Post Tiwanaku Period, abscess rates decrease at Urikatu Kontu from 18.8 to zero percent. This difference is statistically significant (chi square p = .000). However, Tiwanaku Period results for Urikatu Kontu are skewed due to a single individual with six abscesses, thus these results are not meaningful in terms of dietary variation among the sites.

Table 6.16 Alveoli observable for abscesses among Southern Titicaca Basin sites

	Late Formative			Tiwanaku			Post Tiwanaku		
Site	N	affected	%	N	affected	%	N	affected	%
Pokachi Kontu				69	4	5.8			
Kirawi	46	1	2.2	130	6	4.6			
Urikatu Kontu				32	6	**18.8**	89	0	**0.0**
Khonkho Wankane	59	3	5.1	23	0	0.0	30	2	6.7
Lukurmata	86	7	**8.1**	239	3	1.3	86	2	2.3
Pukara				18	2	11.1			
Iwawi				8	0	0.0			
Obsidiana				12	0	0.0			
Tilata				73	2	2.7			
TMV228							61	2	3.3
Guaqui				11	0	0.0			
Tiwanaku				852	20	2.3			

The percentage of individuals with one or more teeth affected by dental abscesses was also assessed. Sample sizes for most sites were very small at this level of analysis and no statistically significant patterns were found (Table 6.17). Notably, during the Tiwanaku Period, a larger percentage of individuals at the site of Lukurmata were affected by abscesses (25%) relative to Tiwanaku (13.1%).

Table 6.17 Individuals observable for abscesses among Southern Titicaca Basin sites

	Late Formative			Tiwanaku			Post Tiwanaku		
Site	N	affected	%	N	affected	%	N	affected	%
Pokachi Kontu				3	3	100.0			
Kirawi	2	1	50.0	7	5	71.4			
Urikatu Kontu				1	1	100.0	4	0	0.0
Khonkho Wankane	2	2	100.0	6	0	0.0	1	1	100.0
Lukurmata	4	2	50.0	12	3	25.0	7	2	28.6
Pukara				1	1	100.0			
Iwawi				1	0	0.0			
Obsidiana				1	0	0.0			
Tilata				4	1	0.0			
TMV228							3	1	33.3
Guaqui				1	0	0.0			
Tiwanaku				61	8	13.1			

Rates of dental abscesses were also compared among sectors of the site of Tiwanaku in order to assess intra-site variation during the Tiwanaku Period. Rates varied between zero and 5.1 percent among sectors (Table 6.18, Figure 6.9). The Mollo Kontu residential sector had the highest rate of dental abscesses relative to all other sectors. However, this was only statistically significant when compared to the Putuni sector (chi square p = .010).

Table 6.18 Alveoli observable for abscesses among sectors of the Tiwanaku site, Tiwanaku period

Sector	N	affected	%
Akapana	133	2	1.5
Akapana East	41	0	0.0
Chiji Jawira	4	0	0.0
La Karana	80	3	3.8
Mollo Kontu Mound	101	2	2.0
Mollo Kontu Residential	118	6	**5.1**
Markapata	246	7	2.8
Putuni	129	0	0.0

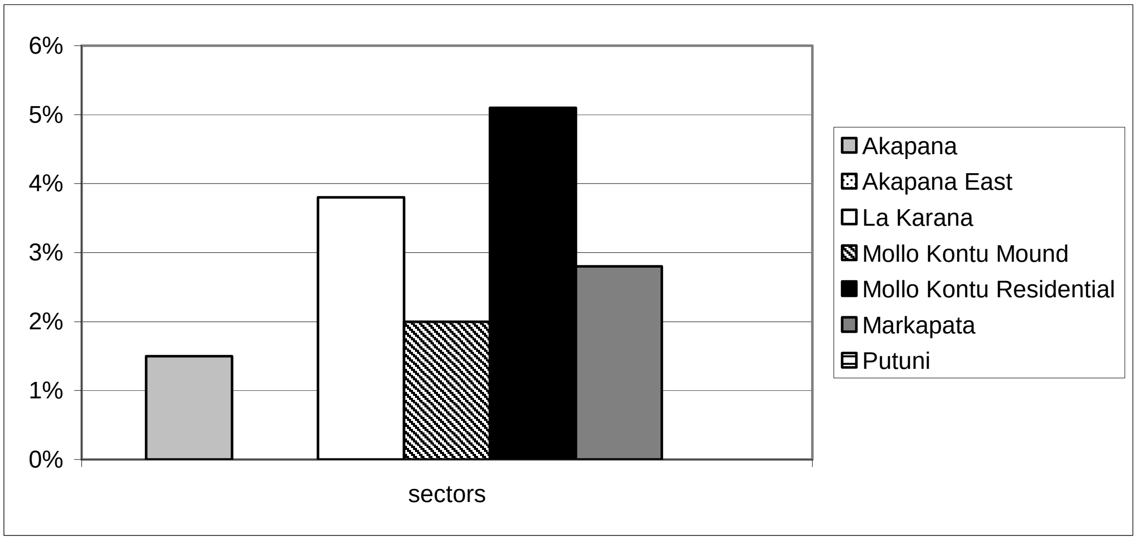

Figure 6.9 Alveoli observable for dental abscesses among sectors of the Tiwanaku site, Tiwanaku Period

The percentage of individuals with one or more dental abscess was also examined among Tiwanaku sectors (Table 6.19). The percentage of individuals affected ranged from zero to 28.6 percent and mirrored the results based on individual alveoli. Mollo Kontu residential had the highest number of individuals affected. No statistically significant patterns were found when sectors were compared, although differences between Mollo Kontu residential and Akapana East approached significance (chi square $p = .072$).

Table 6.19 Individuals observable for abscesses among sectors of Tiwanaku, Tiwanaku period

Sector	N	affected	%
Akapana	5	1	20.0
Akapana East	10	0	0.0
Chiji Jawira	4	0	0.0
La Karana	4	1	25.0
Mollo Kontu Mound	5	1	20.0
Mollo Kontu Residential	7	2	28.6
Markapata	20	3	15.0
Putuni	8	0	0.0

Intra-site variation among the sexes was examined at the site of Tiwanaku (Table 6.20). Rates of dental abscesses were very similar between females (2.5%) and males (2.4%). In addition, the percentage of individuals affected by dental abscesses was exactly 15.8 percent for both males and females (Table 6.21). The mean age-at-death distributions for Tiwanaku males and females were not significantly different. These data suggest that males and females at Tiwanaku had an equal likelihood of developing dental abscesses.

Table 6.20 Alveoli observable for abscesses among males and females at the Tiwanaku site, Tiwanaku period

Sample	N	affected	%
females	317	8	2.5
males	328	8	2.4
all	852	20	2.3

Table 6.21 Individuals observable for abscesses among males and females at the site of Tiwanaku, Tiwanaku period

Sample	N	affected	%
females	19	3	15.8
males	19	3	15.8
all	61	8	13.1

Antemortem Tooth Loss

Between four and 15.2 percent of teeth were lost antemortem among Southern Lake Titicaca Basin inhabitants, between zero and 9.2 percent of females and 5.7 and 31.3 percent of males (Table 6.22). Rates of antemortem tooth loss were highest at 15.2 percent in the Late Formative period, with males (31.3%) having significantly higher antemortem tooth loss rates than females (2.7) (chi square p = .000). There was a statistically significant decrease in the frequency of antemortem tooth loss from the Late Formative to the Tiwanaku Period among males (chi square p = .000) and when all adults were pooled (chi square p = .000), while caries rates increased significantly during these periods for females (chi quare p = .000) (Figure 6.10). During the Tiwanaku Period, males and females had similar frequencies of antemortem tooth loss, between 7.5 and 9.2 percent. No significant changes were observed from the Tiwanaku to the Post Tiwanaku Period; however, during the Post Tiwanaku Period, males had a significantly higher frequency of antemortem tooth loss. Comparison of the mean age-at-death distributions of these samples revealed no statistically significant differences.

Table 6.22 Alveoli observable for antemortem tooth loss within the Southern Titicaca Basin

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Sample	N	affected	%	N	affected	%	N	affected	%
males	96	30	**31.3**	683	51	7.5	264	15	**5.7**
females	112	3	2.7	806	74	**9.2**	80	0	0.0
all	223	34	**15.2**	2114	139	6.6	373	15	4.0

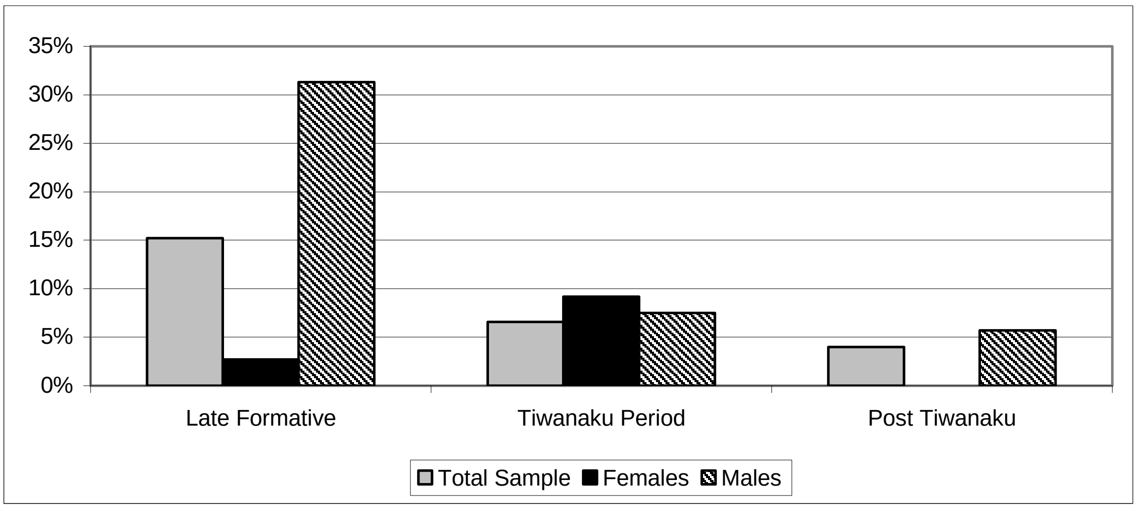

Figure 6.10 Alveoli observable for antemortem tooth loss within the Southern Titicaca Basin

The percentage of individuals who lost one or more teeth antemortem was also examined. Eighteen to 50 percent of Southern Lake Titicaca Basin individuals lost one ore more teeth antemortem, between zero and 66.7 percent of females and 30 and 50 percent of males (Table 6.23). Sample sizes were considerably reduced at the individual level of analysis and no significant variation was encountered. However, it is notable that Tiwanaku Period males and females, groups with the largest sample sizes, experienced similar frequencies of antemortem tooth loss, between 34.3 and 37 percent.

Table 6.23 Individuals observable for antemortem tooth loss within the Southern Titicaca Basin

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Sample	N	affected	%	N	affected	%	N	Affected	%
females	3	2	66.7	27	10	37.0	4	0	0.0
males	4	2	50.0	35	12	34.3	10	3	30.0
all	10	5	50.0	97	29	29.9	16	3	18.8

Comparison of antemortem tooth loss among the three valleys of the Southern Titicaca Basin revealed rates of loss between 1.9 and 15.6 percent (Table 6.24). A decrease in antemortem tooth loss rates from 15.6 percent in the Late Formative to 1.9 percent in the Tiwanaku Period was significant in the Desaguadero valley (chi square p = .001). During the Tiwanaku Period, the Katari valley exhibited a significantly higher frequency of antemortem tooth loss relative to both the Tiwanaku (chi square p = .000) and Desaguadero (chi square p = .002) valleys (Figure 6.11). However, comparison of mean age-at-death distributions reveals that the Katari valley sample (mean age-at-death: 40.8 ± 11.0) was significantly older than Tiwanaku valley sample (mean age at death: 34.4 ± 11.0), thus, age rather than diet could explain the differences in antemortem tooth loss (z score = -2.347, p = 0.019). This is not the case for the Desaguadero valley, where the mean age-at-death (39.0 ± 12.6) was very similar to the Katari valley, thus, dietary differences may explain the discrepancies between these regions. Also in the Katari valley, rates of tooth loss decrease from 11.8 percent during the Tiwanaku Period to 3.7 percent during the Post Tiwanaku Period. This decrease is statistically significant (chi square p = .000) and no significant differences in the mean ages-at-death were found between the two samples.

Table 6.24 Alveoli observable for antemortem tooth loss among the three valleys of the Southern Titicaca Basin

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Valley	N	affected	%	N	Affected	%	N	affected	%
Katari	161	24	14.9	620	73	**11.8**	243	9	**3.7**
Tiwanaku				1388	64	4.6	99	5	5.1
Desaguadero	64	10	**15.6**	106	2	1.9	31	1	3.2

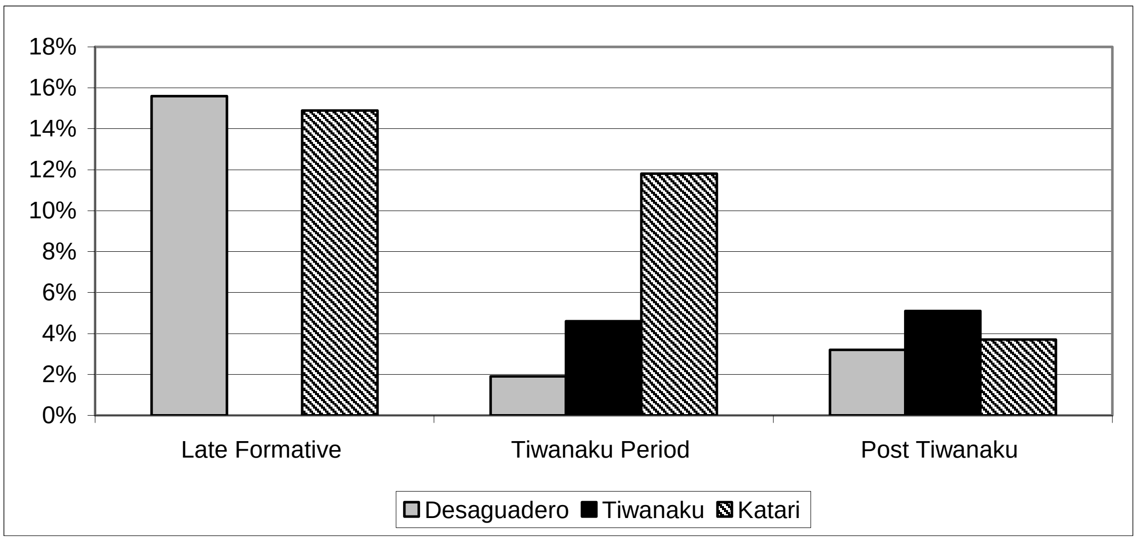

Figure 6.11 Alveoli observable for antemortem tooth loss among the three valleys of the Southern Titicaca valleys

The percentage of individuals that lost one ore more teeth prior to death was also examined among the three valleys of the Southern Titicaca Basin (Table 6.25). At this level of analysis, Katari valley individuals, during the Tiwanaku Period, again exhibited significantly more antemortem tooth loss (47.8%) than those in the Tiwanaku valley (25%) (chi square p = .040). However, as noted above, Katari valley individuals had a significantly higher mean age-at-death distribution relative to contemporary Tiwanaku valley individuals. Thus, the discrepancies in antemortem tooth are not particularly meaningful in terms of diet. Rates of Katari valley individuals affected by antemortem tooth loss dropped significantly in the Post Tiwanaku Period, from 47.8 to 9.1 percent. This differences is statistically significant (chi square p = .027).

Table 6.25 Individuals observable for antemortem tooth loss among the three valleys of the Southern Titicaca Basin

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Valley	N	affected	%	N	affected	%	N	affected	%
Katari	6	3	50.0	23	11	**47.8**	11	1	**9.1**
Tiwanaku	2	0	0.0	68	12	25.0	4	1	25.0
Desaguadero	2	2	100.0	6	1	16.7	1	1	100.0

Rates of antemortem tooth loss were also compared between all sites through all temporal periods. Rates of loss varied between zero and 36.4 percent (Table 6.26). During the Late Formative Period, Lukurmata had a significantly higher rate of loss (21.1%) relative to Kirawi (1.9%) (chi square p = .001). Rates of tooth loss decreased significantly for Khonkho Wankane (from 16.1 to 1.9%) during the Tiwanaku Period (chi square p = .001). During the Tiwanaku Period, Lukurmata had a higher rate of tooth loss (18.8%) relative to Khonkho Wankane (1.9%), Tiwanaku (4.5%), Kirawi (1.9%), and Tilata (3.1%) that was statistically significant (chi square p = .000, .000, .000, and .000, respectively). The mean age-at-death distribution for Lukurmata (43.0 ± 10.7) was not statistically different from Khonkho Wankane, Kirawi, or Tilata, but, it was significantly higher than Tiwanaku (33.5 ± 10.5) (z score = -2.516, p = .012) and thus, age cannot be ruled out as a contributing factor to the discrepancy in antemortem tooth loss among these two sites. During the Post Tiwanaku Period, rates of tooth loss decrease significantly for Lukurmata from 18.8 to 6.8 percent (chi square p = .001); this is still significantly higher than the contemporary sites of Urikatu Kontu (0%) and TMV 228 (0%) (chi square p = .005 and .017, respectively). However, Lukurmata's mean age-at-death distribution (44.2 ± 5.2) is significantly higher than Urikatu Kontu (30.6 ± 6.6) (z score = -2.485, p = .013), thus, age differences likely contribute to the discrepancy in antemortem tooth loss rates.

Table 6.26 Alveoli observable for antemortem tooth loss among Southern Titicaca Basin sites

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Site	N	affected	%	N	affected	%	N	affected	%
Pokachi Kontu				92	3	3.3			
Kirawi	52	1	1.9	161	3	1.9			
Urikatu Kontu				32	4	12.5	110	0	0.0
Khonkho Wankane	62	10	16.1	106	2	**1.9**	31	1	3.2
Lukurmata	109	23	**21.1**	335	63	**18.8**	133	9	**6.8**
Pukara							18	5	27.8
Iwawi				15	0	0.0			
Obsidiana				12	0	0.0			
Tilata				97	3	3.1			
TMV228							81	0	0.0
Guaqui				11	4	36.4			
Tiwanaku				1253	57	4.5			

The percentage of individuals that lost one or more teeth at each site was also examined. The Late Formative sample was small at this level of analysis and revealed no significant patterns (Table 6.27). During the Tiwanaku Period, Lukurmata again exhibited higher rates of tooth loss (66.7%) relative to Tiwanaku (24.6%), Khonkho Wankane (16.7%), and Kirawi (14.3%) that were statistically significant (chi square p = .004, .046, and .027, respectively). However, as discussed above, Lukurmata's higher mean age-at-death distribution relative to Tiwanaku likely contributes to the discrepancy in antemortem tooth loss rate between these two sites. Finally, antemortem tooth loss decreases significantly at Lukurmata during the Post Tiwanaku Period, dropping from 66.7 to 14.3 percent (chi square p = .027).

Table 6.27 Individuals observable for antemortem tooth loss among Southern Titicaca Basin sites

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Site	N	affected	%	N	affected	%	N	affected	%
Pokachi Kontu				2	1	50.0			
Kirawi	2	1	50.0	7	1	**14.3**			
Urikatu Kontu				1	1	100.0	4	0	0.0
Khonkho Wankane	2	2	100.0	6	1	16.7	1	1	100.0
Lukurmata	4	2	50.0	12	8	**66.7**	7	1	**14.3**
Pukara							1	1	100.0
Iwawi				1	0	0.0			
Obsidiana				1	0	0.0			
Tilata				4	1	25.0			
TMV228							3	0	0.0
Guaqui				1	1	100.0			
Tiwanaku				61	15	24.6			

Rates of antemortem tooth loss were also compared between sectors of the Tiwanaku site during the Tiwanaku Period. Only Tiwanaku possessed a sufficient sample size to allow for assessment of intra-site variation. Rates of antemortem tooth loss among the sectors varied from zero to 12.9 percent (Table 6.28, Figure 6.12). Mollo Kontu residential had the highest rate of tooth loss at 12.9 percent, significantly higher than the Akapana (0.8%), Akapana East (0%), Putuni (0%), Mollo Kontu mound (1.3%) and Markapata (chi square p = .000, .000, .000, .000, and .002, respectively). La Karaña had the second highest rate of antemortem tooth loss at 11.4 percent, significantly higher than Akapana, Akapana East, Mollo Kontu mound, Markapata, and Putuni (chi square p = .000, .000, .000, .023, and .000, respectively). Finally, Markapata had the third highest rate of tooth loss at 5.4 percent, significantly higher than Akapana, Akapana East, Mollo Kontu Mound, and Putuni (chi square p = .005, .022, .011, .029). Notably, Akapana East has a significantly lower mean age-at-death distribution (24.9 ± 8.8) than Mollo Kontu residential (44.4 ± 14.2) and Markapata (34.1 ± 9.1), thus age is likely responsible for the lack of antemortem tooth loss within the Akapana East (z score = -2.305, p = .021; z score = -2.262, p = .024). No other statistically significant differences in the age-at-death distributions were observed in these samples.

Table 6.28 Alveoli observable for antemortem tooth loss among Tiwanaku sectors, Tiwanaku Period

Sector	N	affected	%
Akapana	133	1	0.8
Akapana East	116	0	0.0
Chiji Jawira	13	0	0.0
La Karana	105	12	**11.4**
Mollo Kontu mound	158	2	1.3
Mollo Kontu residential	139	18	**12.9**
Markapata	448	24	**5.4**
Putuni	141	0	0.0

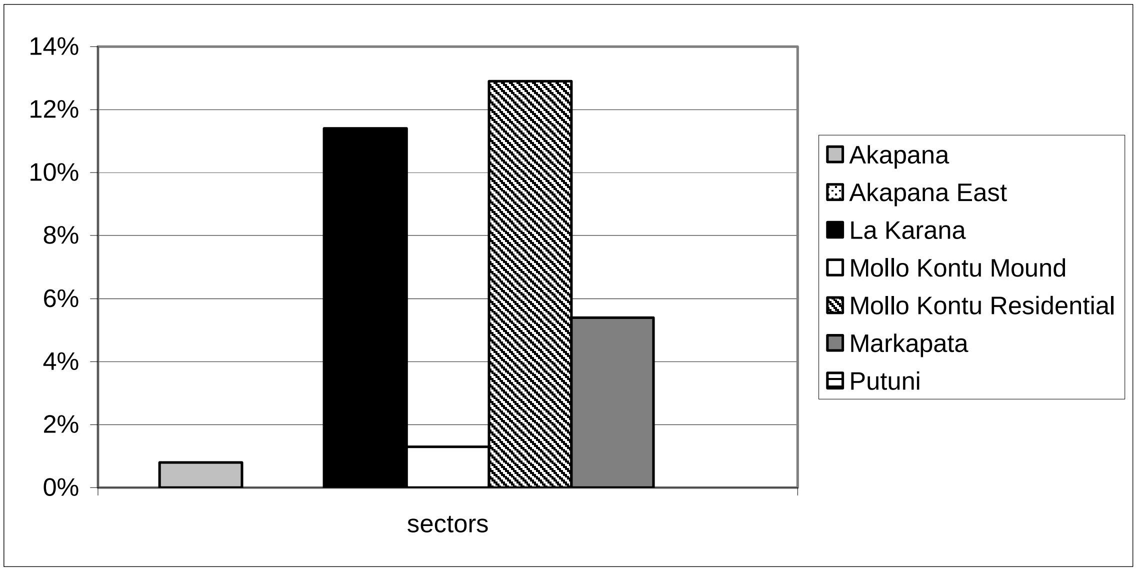

Figure 6.12 Alveoli observable for antemortem tooth loss among Tiwanaku sectors, Tiwanaku Period

The percentage of individuals with one or more teeth affected by antemortem tooth loss was also examined among Tiwanaku sectors (Table 6.29, Figure 6.13). The percentage of individuals affected among sectors varied between zero and 50 percent. No individual in either the Akapana East or Putuni sectors were affected by antemortem tooth loss. Akapana East results were statistically significant when compared to La Karaña, Mollo Kontu mound, Mollo Kontu residential, and Markapata (chi square p = .016, .032, .006, and .053, respectively). However, as noted above, Akapana East individuals have the lowest mean age-at-death distribution of any sector and thus, the lack of antemortem tooth loss among these individuals is likely a result of their younger age rather than differences in diet. Putuni results were statistically significant when compared to La Karaña, Mollo Kontu mound, and Mollo Kontu residential (chi square p = .028, .052, and .013, respectively). Although the mean age-at-death distribution of Putuni individuals is relatively young at 29.9 ± 8.1 years, it is not statistically different from the mean age-at-death distributions for the other sectors. La Karaña had the highest percentage of individuals affected by antemortem tooth loss at 50 percent, followed by Mollo Kontu mound at 40 percent.

Table 6.29 Individuals observable for antemortem tooth loss among Tiwanaku secrtors, Tiwanaku Period

Sector	N	affected	%
Akapana	5	1	20.0
Akapana East	10	0	**0.0**
Chiji Jawira	2	0	0.0
La Karana	4	2	50.0
Mollo Kontu mound	5	2	40.0
Mollo Kontu residential	7	4	25.0
Markapata	20	6	30.0
Putuni	8	0	**0.0**

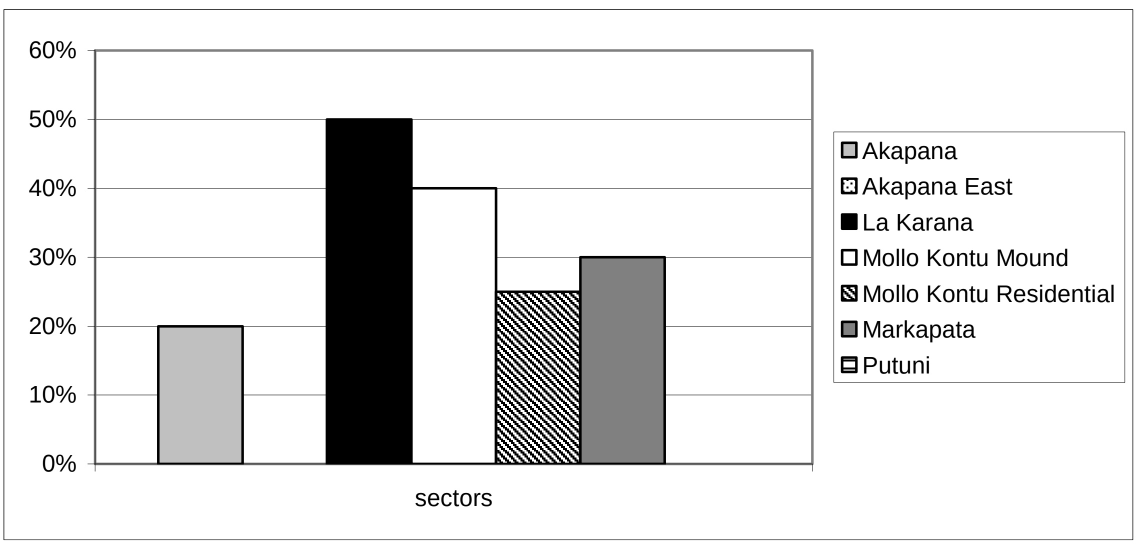

Figure 6.13 Individuals with antemortem tooth loss among Tiwanaku sectors, Tiwanaku Period

Intra-site variation among the sexes was also examined at the site of Tiwanaku (Table 6.30). Rates of antemortem tooth loss were very similar between males (5.8%) and females (4.3%). In addition, the percentage of individuals with one ore more tooth affected by antemortem tooth loss was exactly 26.3 percent for both males and females (Table 6.31). The mean age-at-death distributions for Tiwanaku males and females were also not significantly different. These data suggest males and females at Tiwanaku had an equal chance of experiencing antemortem tooth loss.

Table 6.30. Alveoli observable for antemortem tooth loss among Tiwanaku period males and females at the Tiwanaku site

Sample	N	affected	%
Female	442	19	4.3
Male	451	26	5.8
All	1253	57	4.5

Table 6.31. Individuals observable for antemortem tooth loss among Tiwanaku period males and females at the Tiwanaku site

Sample	N	affected	%
Female	19	5	26.3
Male	19	5	26.3
All	61	15	24.6

Dental Calculus

The maximum expression of dental calculus was mild among Southern Titicaca Basin inhabitants and varied little throughout temporal periods. Mean scores ranged from 1.11 to 1.14 when all individuals were pooled, between 1.12 and 1.33 for females, and between 1.00 and 1.11 for males(Table 6.32). Notably, throughout all temporal periods females had slightly more dental calculus than males, although this difference was not statistically significant.

Table 6.32 Maximum expression of calculus for all Southern Titicaca Basin

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Sample	N	mean	st dev	N	mean	st dev	N	mean	st dev
female	4	1.25	0.96	34	1.12	0.64	3	1.33	0.58
male	3	1.00	1.00	26	1.04	0.72	9	1.11	0.60
all	8	1.13	0.83	90	1.11	0.66	14	1.14	0.53

In order to assess any regional variation, the maximum expression of dental calculus was assessed among the three valleys of the Southern Titicaca Basin throughout all temporal periods. Mean scores ranged from .83 to 2.0 (Table 6.33). Late Formative sample sizes were small but revealed large differences in dental calculus between Katari and Desaguadero valley inhabitants. The mean score for Katari valley inhabitants was .83, indicating very mild dental calculus, while the mean score for Desaguadero inhabitants was 2.0, indicating moderate dental calculus. However, these differences are not statistically significant. Mean scores were consistently mild throughout the Tiwanaku and Post Tiwanaku Periods and revealed no significant variation among valleys.

Table 6.33 Maximum expression of dental calculus among valleys of the Southern Titicaca Basin

Sample	Late Formative			Tiwanaku Period			Post Tiwanaku		
	N	mean	st dev	N	mean	st dev	N	Mean	st dev
Katari	6	0.83	0.75	23	1.30	0.63	9	1.22	0.44
Tiwanaku				61	1.03	0.66	4	1.00	0.82
Desaguadero	2	2.00	0.00	6	1.17	0.75	1	1.00	

In order to assess inter-site variation, the maximum expression of dental calculus was examined among Southern Titicaca Basin sites throughout all temporal periods. Mean scores varied from .75 to 1.71 (Table 6.34). The site of Lukurmata experienced an increase in dental calculus from the Late Formative (mean score: .75) to the Tiwanaku Period (1.08); however, this increase was not statistically significant. During the Tiwanaku Period, Kirawi inhabitants had significantly more dental calculus (mean score: 1.71) relative to inhabitants of Lukurmata (z score = -1.927; p = .054, respectively) and Tiwanaku (z score = -2.508, p = .012). Comparison of mean age-at-death estimates among these samples revealed no differences that might explain the variation in dental calculus expression. During the Post Tiwanaku Period, scores for Lukurmata increased again, but remained in the mild range and were not statistically significant.

Table 6.34 Maximum expression of dental calculus among Southern Titicaca Basin sites*

Sample	Late Formative			Tiwanaku Period			Post Tiwanaku		
	N	mean	st dev	N	Mean	st dev	N	Mean	st dev
Lukurmata	4	0.75	0.50	12	1.08	0.51	5	1.20	0.45
Tiwanaku				54	1.01	0.66			
Khonkho W.				6	1.17	0.75			
Kirawi				7	**1.71**	0.76			

*Note: only sites with sample sizes ≥4 were included.

In order to assess intra-site variation, the maximum expression of dental calculus was compared among sectors of the Tiwanaku site, Tiwanaku Period. Mean scores ranged from 0.57 to 1.67 (Table 6.35). Mollo Kontu individuals exhibited the most calculus, approaching the moderate range, and Akapana East individuals had the least calculus. Given that these sectors had the oldest and youngest mean age-at-deaths, it is likely the amount of dental calculus among their inhabitants is a reflection of their ages rather than diet. No sectors exhibited statistically significant differences in dental calculus scores.

Table 6.35 Maximum expression of dental calculus among sectors of the Tiwanaku site during the Tiwanaku Period

Sample	N	Mean	st dev
Akapana	5	1.00	0.71
Akapana East	7	0.57	0.53
Chiji Jawira	1	1.00	
La Karana	4	1.25	0.96
Mollo Kontu mound	5	1.00	0.00
Mollo Kontu resid.	6	1.67	1.21
Markapata	19	0.95	0.40
Putuni	7	1.00	0.58

Variation in the maximum expression of dental calculus among the sexes was examined at the site of Tiwanaku, Tiwanaku Period (Table 6.36). Mean scores were almost identical for females (mean score: 1.06) and males (mean score: 1.00). The mean age-at-death distributions for Tiwanaku males and females were also not significantly different. These data suggest that Tiwanaku males and females developed dental calculus at similar rates.

Table 6.36 Maximum expression of dental calculus for Tiwanaku Period males and females at the site of Tiwanaku

Sample	N	mean	st dev
female	18	1.06	0.73
male	18	1.00	0.77
all	54	1.01	0.66

Dental Wear

Mean dental wear scores were estimated separately for anterior teeth, premolars, first molars, second molars, and third molars due to variation in their rates of wear. Wear scores ranged from 5.1 to 5.9 for anterior dentition, 4.9 to 5.5 for premolars, 6.9 to 7.8 for first molars, 5.5 to 7.0 for second molars, and 3.7 to 4.3 for third molars (Table 6.37). In general, wear scores did not vary considerably and no statistically significant differences were observed. However, wear scores among all tooth types except third molars decrease from the Late Formative to the Tiwanaku Period. The mean age-at-death for these periods is identical (36 years), thus, changes in diet or food preparation techniques rather than age may be responsible for these differences in dental wear. Finally, there is a slight rise in dental wear during the Post Tiwanaku Period that is not statistically significant. The higher wear scores may attribute to the slightly higher mean age-at-death distribution of the Post Tiwanaku sample (40 years).

Table 6.37 Observable dental wear for Southern Lake Titicaca Basin, maxillary and mandibular teeth pooled.

Sample	Late Formative			Tiwanaku Period			Post Tiwanaku		
	N	mean	st dev	N	Mean	st dev	N	mean	st dev
Anterior									
female	4	5.8	1.3	31	5.0	1.5	3	5.2	1.8
male	3	5.9	2.7	25	5.4	1.4	9	5.4	0.9
all	8	5.9	1.7	82	5.1	1.4	13	5.4	1.0
Premolars									
female	4	5.2	1.6	34	5.0	1.6	3	5.3	2.0
male	3	5.2	2.8	26	5.1	1.5	9	5.1	1.0
all	8	5.5	2.0	89	4.9	1.6	14	5.3	1.1
M1									
female	4	7.7	1.8	31	7.1	1.9	3	7.7	2.4
male	2	7.4	3.7	25	6.9	1.8	8	7.1	1.8
all	7	7.8	2.1	85	6.9	1.9	13	7.3	1.8
M2									
female	4	6.0	2.0	30	5.7	2.1	3	6.1	3.1
male	2	7.8	3.2	26	5.6	1.8	8	5.6	1.9
all	7	7.0	2.3	84	5.5	2.1	13	5.6	2.0
M3									
female	4	2.7	2.1	27	3.8	2.4	3	4.4	2.8
male	1	6.9		19	3.8	1.7	7	3.9	1.7
all	6	3.7	2.4	68	3.7	2.0	12	4.3	2.0

Mean dental wear scores were also compared among the three valleys of the Southern Titicaca Basin in order to assess potential regional variation. Wear scores ranged from 4.7 to 5.8 for anterior dentition, 4.6 to 6.6 for premolars, 6.7 to 9.2 for first molars, 5.0 to 8.0 for second molars, and 3.3 to 4.7 for third molars (Table 6.38). Despite the wider range of variation when analyzed at this scale, the only statistically significant differences observed were between anterior and premolar wear scores for Lukurmata and Tiwanaku during the Tiwanaku Period (z score = -2.335, p = .020; z score = -2.482, p = .013, respectively), revealing worse dental wear among Lukurmata inhabitants. However, as previously discussed, the mean age-at-death distributions for these two sites during the Tiwanaku Period are significantly different, Lukurmata being the oldest. Thus, the differences in wear are more likely a reflection of differences in age rather than diet or food preparation techniques. No other noteworthy patterns were observed in the data.

Table 6.38 Observable dental wear among Southern Lake Titicaca Basin valleys, maxillary and mandibular teeth pooled

	Late Formative			Tiwanaku Period			Post Tiwanaku		
Sample	N	mean	st dev	N	Mean	st dev	N	mean	st dev
Anterior									
Katari	6	5.8	2.0	22	**5.7**	1.3	8	5.7	1.0
Tiwanaku				54	4.9	1.4	4	5.1	1.2
Desaguadero	2	6.4	0.8	6	4.7	1.4	1	5.0	
Premolars									
Katari	6	5.1	2.2	23	**5.7**	1.3	9	5.4	1.1
Tiwanaku				61	4.7	1.6	4	5.0	1.4
Desaguadero	2	6.6	0.8	5	5.0	1.6	1	4.6	
M1									
Katari	5	7.2	2.1	20	7.5	1.8	9	7.5	2.0
Tiwanaku				59	6.7	1.9	3	6.8	1.8
Desaguadero	2	9.2	1.1	6	7.2	2.0	1	7.6	
M2									
Katari	5	6.6	2.3	22	5.7	1.8	9	5.9	2.1
Tiwanaku				56	5.3	2.1	3	5.0	2.0
Desaguadero	2	8.0	2.9	6	6.2	2.7	1	5.2	
M3									
Katari	4	3.7	1.7	19	4.0	1.6	8	4.7	2.2
Tiwanaku				44	3.4	2.1	3	3.3	1.8
Desaguadero	2	3.9	4.3	5	4.7	2.6	1	3.7	

Mean dental wear scores were also assessed among all sites through all temporal periods. Sample sizes were significantly reduced at this scale of analysis and no statistically significant patterns were found in the data (Table 6.39). Mean wear scores ranged between 4.7 and 6.0 for anterior teeth, 4.7 to 5.6 for premolars, 6.7 to 7.3 for first molars, 5.4 to 6.2 for second molars, and 3.4 to 4.7 for third molars. In general, Tiwanaku inhabitants, during the Tiwanaku Period, had the lowest mean scores for all tooth types; however, this is likely an artifact of age rather than differences in dietary or food preparation techniques. The mean ages-at-death for Tiwanaku is substantially lower than the other three sites, a difference that is statistically significant when compared to Lukurmata (z score= -2.516, $p = .012$).

Table 6.39 Observable dental wear among Southern Titicaca Basin sites, maxillary and mandibular teeth pooled

Sample	Late Formative N	Late Formative mean	Late Formative st dev	Tiwanaku Period N	Tiwanaku Period mean	Tiwanaku Period st dev	Post Tiwanaku N	Post Tiwanaku mean	Post Tiwanaku st dev
Anterior									
Lukurmata	4	5.9	2.2	11	5.5	1.2	4	5.9	2.2
Tiwanaku				47	4.9	1.4			
Khonkho W.	2	6.4	0.8	6	4.7	1.4			
Kirawi	2	5.6	2.3	7	6.0	1.7			
Premolars									
Lukurmata	4	5.5	2.4	12	5.6	1.2	5	6.2	0.4
Tiwanaku				54	4.7	1.6			
Khonkho W.	2	6.6	0.8	5	5.0	1.6			
Kirawi	2	4.5	2.3	7	5.6	1.8			
M1									
Lukurmata	3	7.2	2.2	9	7.3	1.8	5	8.9	1.0
Tiwanaku				53	6.7	1.9			
Khonkho W.	2	9.2	1.1	6	7.2	2.0			
Kirawi	2	7.3	2.9	7	7.3	1.7			
M2									
Lukurmata	3	7.5	1.9	11	5.7	1.8	5	6.9	2.4
Tiwanaku				49	5.4	2.1			
Khonkho W.	2	8.0	2.9	6	6.2	2.7			
Kirawi	2	5.3	3.9	7	5.7	1.8			
M3									
Lukurmata	2	5.0	0.7	9	4.2	1.4	5	5.9	1.7
Tiwanaku				38	3.4	2.0			
Khonkho W.	2	3.9	4.3	5	4.7	2.6			
Kirawi	2	3.1	1.1	6	3.5	1.4			

Mean dental wear scores were also compared among sectors of the site of Tiwanaku, Tiwanaku Period, to identify any intra-site variation. Mean wear scores were quite variable ranging from 3.1 to 6.1 for anterior teeth, 3.0 to 6.4 for premolars, 4.3 to 8.7 for first molars, 3.5 to 8.1 for second molars, and 1.3 to 7.3 for third molars (Table 6.40). Mollo Kontu residential consistently had the highest mean wear scores, statistically significant when compared to Akapana (first molars, z score = -2.562, p = .010; third molars, z score = -2.178, p = .029), Akapana East (anterior teeth, z score =-

2.739 , p = .006; premolars, z score = -2.873, p = .004; first molars, z score = -2.887, p = .004; second molars, z score = -2.684, p = .007; third molars z score = -2.640, p = .008), Mollo Kontu mound (second molars, z score = -1.984, p = .047; third molars, z score = -2.205, p = .027), Markapata (premolars, z score= -2.234, p = .025; first molars, z score = -2.358, p = .018; third molars, z score = -2.491, p = .013), and Putuni (anterior teeth, z score = -2.104, p = .035; premolars, z score = -2.445, p = .014; first molars, z score = -2.360, p = .018; second molars, z score = -2.355, p = .019; third molars z score = -2.460, p = .014). La Karaña also had statistically higher dental wear scores relative to Putuni (anterior teeth, z score = -2.132, p = .033). Akapana East generally had the lowest mean wear scores, statistically significant when compared to Mollo Kontu residential (see above), Akapana (anterior teeth, z score = -2.132, p = .033; premolars, z score = -2.030, p = .042; first molars, z score = -2.667, p = .008; second molars, z score = -2.282, p = .023,) and La Karaña (anterior teeth, z score = -2.558, p = .011; premolars, z score = -2.457, p = /014; first molars, z score = -2.566, p = .010; third molars z score = -2.427, p = .015). Comparison of mean age-at-death distributions for Mollo Kontu residential and Akapana East indicate that Akpana East individuals were significantly younger (z score = -2.305, p = .021), thus age differences are likely responsible for the differences in dental wear scores. However no other sectors have statistically significant differences in their mean ages-at-death, thus, differences in diet or food preparation techniques may be at least partly responsible for some of the variation observed in dental wear scores.

Table 6.40 Observable dental wear for sectors of the Tiwanaku site, Tiwanaku Period, maxillary and mandibular teeth pooled

Sample	N	mean	st dev
Anterior			
Akapana	4	5.1	1.4
Akapana East	6	**3.1**	0.8
Chiji Jawira	1	5.0	
La Karana	4	**6.1**	1.0
Mollo Kontu mound	5	5.3	1.4
Mollo Kontu res.	5	**6.1**	1.2
Markapata	16	5.0	1.0
Putuni	6	4.0	1.0
Premolar			
Akapana	5	5.1	1.4
Akapana East	7	**3.0**	1.4
Chiji Jawira	1	5.0	
La Karana	4	5.9	0.8
Mollo Kontu mound	5	4.9	1.4
Mollo Kontu res.	6	**6.4**	1.3
Markapata	19	4.7	1.3
Putuni	7	3.9	1.5
M1			
Akapana	5	6.8	1.6
Akapana East	6	**4.3**	0.4
Chiji Jawira	1	8.7	
La Karana	4	7.5	1.9
Mollo Kontu mound	5	6.8	2.0
Mollo Kontu res.	6	**8.9**	0.7
Markapata	19	6.8	1.8
Putuni	7	5.8	1.8
M2			
Akapana	5	5.7	0.4
Akapana East	7	**3.5**	1.2
Chiji Jawira			
La Karana	4	4.8	1.4
Mollo Kontu mound	5	4.8	1.6
Mollo Kontu res.	5	**8.1**	2.4
Markapata	16	6.0	2.0
Putuni	7	4.5	1.8
M3			
Akapana	4	2.9	1.3
Akapana East	6	**1.3**	0.4
Chiji Jawira	1	5.3	
La Karana	3	3.5	1.0
Mollo Kontu mound	5	3.7	1.0
Mollo Kontu res.	4	**7.3**	2.6
Markapata	10	3.3	1.4
Putuni	5	2.6	1.0

Finally, dental wear scores were compared among males and females at the site of Tiwanaku, Tiwanaku Period. Mean wear scores were very similar, ranging from 4.8 to 5.1 for anterior teeth, 6.7 to 6.8 for first molar, and 5.3 to 5.4 for second molars (Table 6.41). Males and females had identical mean wear scores for premolars (4.8) and third molars (3.6). As previously noted, mean age-at-death distributions for males and females were also very similar. Thus, no apparent differences in diet or food preparation techniques among Tiwanaku males and females are indicated by the dental wear data.

Table 6.41 Observable dental wear for Tiwanaku Period males and females at the site of Tiwanaku, maxillary and mandibular teeth pooled

Sample		N	mean	st dev
Anterior				
	female	16	4.8	1.4
	male	17	5.1	1.3
	all	47	4.9	1.4
Premolars				
	female	18	4.8	1.5
	male	18	4.8	1.4
	all	54	4.7	1.6
M1				
	female	18	6.7	2.0
	male	18	6.8	1.8
	all	53	6.7	1.9
M2				
	female	15	5.4	2.0
	male	18	5.3	1.6
	all	49	5.4	2.1
M3				
	female	14	3.6	2.3
	male	13	3.6	1.4
	all	38	3.4	2.0

Summary

In general, dental health was poorest among Late Formative individuals. However, it is important to note at the outset that the Late Formative sample consisted of only eight individuals and few statistically significant patterns were found when comparing Late Formative data. Frequencies of dental caries, abscesses, and antemortem tooth loss were highest during this period. Dental wear was also more extensive. This likely accounts for the higher frequency of abscesses and antemortem tooth loss, as most of the abscesses observed were the result of extreme wear. Dental wear scores were consistent throughout the Late Formative sample. Dental calculus was mild and no differences in its expression were found among sites, valleys or among the sexes. The caries frequency when all teeth were pooled was 10.8 percent. This is consistent with a mixed subsistence economy, most likely an agro-pastoral lifestyle (Figure 6.14; see Indriati 1998: 121, Turner 1979: 625, or Larsen 1997: 69 for comparative data). Thus, these data suggest that agriculture was a significant component of altiplano subsistence strategies in the Late Formative, even at lakeside communities such as Lukurmata.

In addition, there is some indication of sex based dietary differences within the Late Formative sample. Males had higher abscess and antemortem tooth loss rates than females that were statistically significant. Males also had slightly higher caries rates than females, although not statistically significant. Sex based differences in dental pathologies are often attributed to the presence of a sexual division of labor (see Chapter 5), however, given the small sample size (three males and four females), I am reluctant to speculate on the cause of the poorer dental health among Late Formative males but, it may indicate greater consumption of plant carbohydrates among males and perhaps a more coarse diet leading to abscesses.

During the Tiwanaku Period, caries rates decrease to 8.9 percent when all teeth are pooled. This is still consistent with a mixed agro-pastoral economy. Figure 6.14 compares altiplano caries rates to other South Central Andean populations who practiced a range of subsistence strategies.

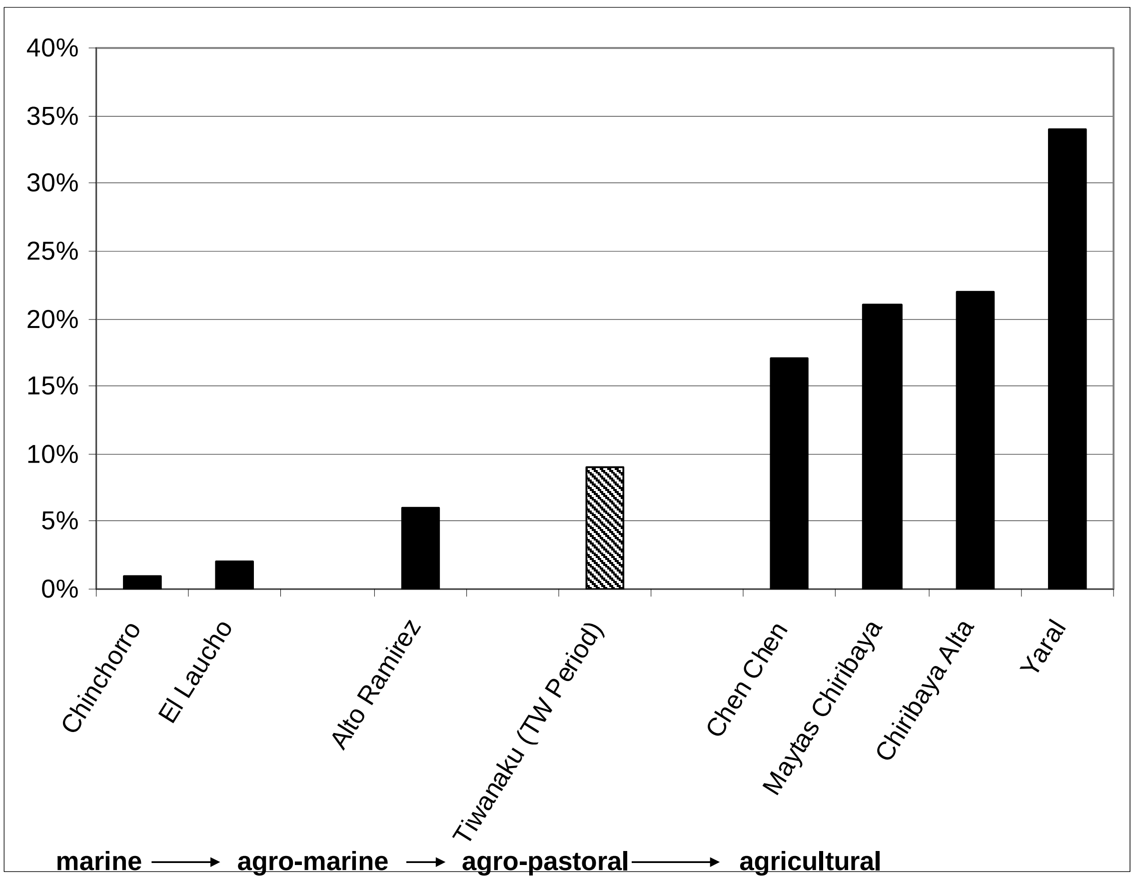

Figure 6.14 Comparative caries rates for ancient South Central Andean populations[38]

[38] Data for Chen Chen were provided Deborah Blom. Data for all other sites are from Indriati (1998: 121)

It is important to note that the decrease in caries rates during the Tiwanaku Period is not statistically significant and may be a result of the small and possibly biased Late Formative sample. When the difference among valleys is examined, it is clear that the only decrease occurs in the Desaguadero valley, Katari valley caries rates remain the same. Regardless, if maize were suddenly entering altiplano sites in large quantities or the population was becoming more dependent on agriculture in general during the Tiwanaku Period, an increase in caries frequencies would be expected. Several scenarios could explain this pattern. First, maize did not enter the altiplano in large quantities during the Tiwanaku Period. Second, maize was already in the altiplano during the Late Formative and no increase occurred in the Tiwanaku Period. Third, maize did begin entering the altiplano in significant quantities during the Tiwanaku Period but the Late Formative sample is too small for an accurate comparison of caries rates. The isotope and phytolith data will provide insight into which of these scenarios best fits the altiplano.

Both abscess and antemortem tooth loss rates experienced a statistically significant decrease in the Tiwanaku Period. Dental wear scores also decreased slightly, although the decrease was not statistically significant. It is possible that diets were becoming more refined and less coarse at this time. This would explain the decrease in abscesses and subsequent antemortem tooth loss; however, without a larger Late Formative sample, this remains speculative. Calculus deposits remained mild.

An additional change from the Late Formative is that females now had higher caries rates than males that were statistically significant; although no significant differences in abscesses, antemortem tooth loss, calculus deposits, or dental wear were seen among males and females. Given the much larger Tiwanaku Period sample size (35 females and 27 males), these data are more reliable and allow for better interpretation of the caries data. It is possible that males had a more varied diet and perhaps access to more meat while females were more dependent on cariogenic staple crops. It is also possible that a sexual division of labor is responsible for the discrepancies. Elsewhere in the Andes, ethnographic and ethnohistorical sources have reported a sexual division of labor in which females are exclusively responsible for the mastication of maize for the production of *chicha* (Cobo 1990; Hastorf 1991; Malpass 1996). Such activities would lead to higher caries rates among females.

In comparing the three valleys, no significant differences were found that were not related to age differences in the samples, specifically, Katari valley individuals had a significantly higher mean age-at-death distribution relative to the other valleys. However, inter-site comparisons revealed interesting results for the small site of Kirawi. Individuals buried at this site in the Koani Pampa had higher caries rates (21.6%) and heavier calculus deposits (moderate rather than mild) that were statistically significant when compared to contemporary sites. This is significant, as Janusek and Kolata (2004) interpret the site as an agricultural outpost for tending raised fields in the surrounding pampa. The dental data indicate that these individuals were heavily dependent on plant carbohydrates; in fact, the caries rates place these individuals well within the range of pure agriculturalists (see Figure 6.9).

The large sample size at Tiwanaku provided the best opportunity for this study to investigate intra-site variation. As observed at the basin wide level, females at Tiwanaku had a significantly higher dental caries rate than males, reflecting a diet more dependent on plant carbohydrates. Wide variation in dental health among the various sectors of the site indicates that status and/or ethnicity also influenced the diet of Tiwanaku inhabitants. Individuals associated with the Mollo Kontu residential sector, a barrio well outside the ceremonial center of the site, had distinctly different diets relative to all other sectors. Despite having the oldest mean age-at-death distribution, these individuals had, by far, the lowest caries rates (2.1%), placing them in a range similar to hunter gatherers when compared to other populations. I suggest these individuals were more involved with pastoralism rather than agriculture, and thus, were eating more meat relative to other sectors. In addition, they have the highest rate of abscesses, antemortem tooth loss, and dental wear. It is my opinion that the advanced age of many of these individuals is responsible for the heavier dental wear and resultant abscesses and antemortem tooth loss.

In contrast, results for three sectors within the marked bounds of the city's ceremonial core (La Karaña, Putuni, and Akapana East) and individuals interred in the Mollo Kontu ceremonial mound, just to the south of the ceremonial core, had the highest caries rates, indicating significant consumption of plant carbohydrates that may have included maize. Caries rates for La Karaña (15%) and Mollo Kontu mound (13%) are similar to those for pure agriculturalists (Figure 6.9). Interestingly the Akapana East has been interpreted by Janusek (1999, 2003, 2004) as a compound dedicated to the large-scale production of maize beer for elite sponsored feasts. Despite the very young mean age-at-death for Akapana East individuals (24.9 ± 8.8 years), they have high caries rates, which are consistent with maize consumption. Caries rates for Markapata and the

Akapana were intermediate between Mollo Kontu residential and the others, indicating a mixed agro-pastoral lifestyle.

Another component of dental analyses was examining potential evidence for coca consumption. Buikstra and Indriati (2001; Indriati 1998) found cervical-root caries of the lower molars accompanied by alveolar recession more than three mm. from the cemento-enamel junction to be the strongest indicators of habitual coca use. Antemortem tooth loss of the lower molars was also considered a strong indicator. Indirati (1998) analyzed a small sample of altiplano individuals from Tiwanaku and Lukurmata in her dissertation and reported coca use rates of 49 percent. This study revealed relatively low rates of both cervical-root caries and antemortem tooth loss of the lower molars among altiplano populations that do not indicate extensive use of coca. Murphy's (2004) study of a Late Horizon Inca population from the central Peruvian coast also reports lower rates of coca use relative to those reported by Indriati (1998) for other central Peruvian sites. Like Murphy, I attribute the discrepancies in our results to inexperience with Indriati's technique. Indriati and Buikstra (2001) reported that alveolar recession was typically accompanied by cervical root caries and I expected a similar pattern in the altiplano. However, review of photographs of altiplano mandibles indicates that severe alveolar recession was often unaccompanied by cervical-root caries, and severe lower molar alveolar recession alone may be a strong indicator of coca use in the altiplano (Figure 6.15). Unfortunately, I do not have standardized data on the frequency of this condition. In future analyses I hope to review data for periodontal disease that might provide better insight into coca use. Based on iconographic evidence of coca use in Tiwanaku portrait vessels, it is apparent that coca was used in the altiplano during the Tiwanaku Period (Figure 6.16).

Figure 6.15 Alveolar recession likely associated with coca use; note the absence of cervical root caries

Figure 6.16 Coca quid depicted in the cheek of an elite individual on a Tiwanaku portrait vessel

The lack of cervical-root caries might be the result of higher rates of dental wear among altiplano inhabitants. Comparison of Tiwanaku dental wear with contemporary Chen Chen inhabitants reveals Tiwanaku diets were significantly coarser (Figure 6.17). I attribute this to the common use of sandstone grinding stones in the altiplano that add a significant amount of grit to the diet. In contrast, Moquegua grinding stones were made of rhyolite, a harder and more fine-grained material (pers. comm. M. Bandy 2010).

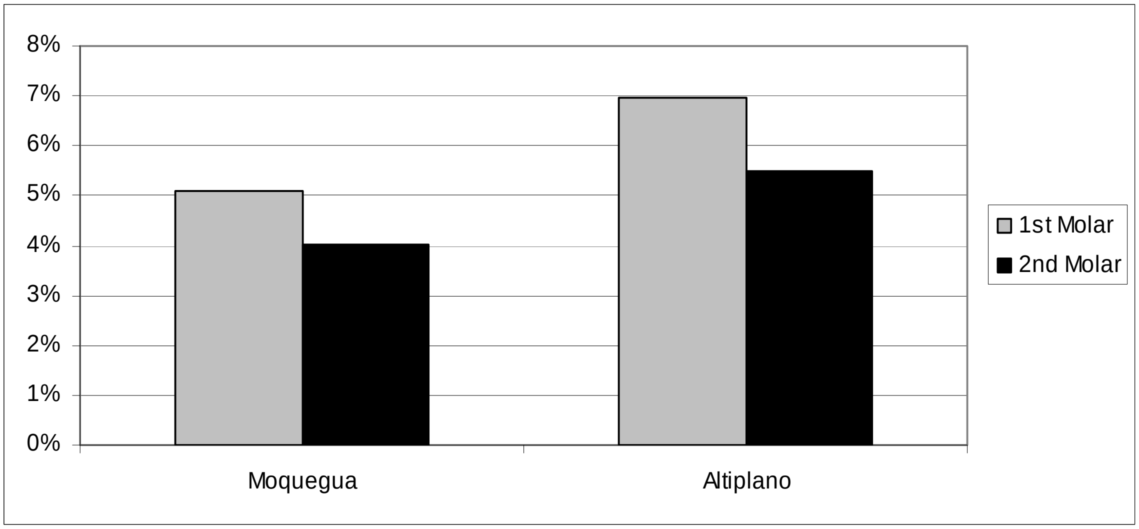

Figure 6.17 Comparison of dental wear among Middle Horizon Moquegua valley and altiplano populations (Moquegua data provided by Deborah Blom)

These data indicate that despite archaeological data clearly indicating extensive agricultural intensification accompanying Tiwanaku's development, altiplano populations never became completely dependent on agriculture. Pastoralism remained a key component of altiplano subsistence strategies. Both Late Formative and Tiwanaku Period dental data clearly indicate an agro-pastoral lifestyle. Also, dental health varied widely among sectors of Tiwanaku, indicating marked differences in diet. Those associated with residential compounds inside the marked bounds of the city's ceremonial core and the Mollo Kontu ceremonial mound had higher caries rates relative to other sectors, indicating greater consumption of plant carbohydrates. Only the isotopic data can determine whether those cariogenic resources included maize. Regardless, the patterns of dietary variation suggest that Tiwanaku barrios likely housed distinct social and perhaps ethnic groups.

Finally, dental data for the Post Tiwanaku Period indicate a dramatic change in diets relative to both the Late Formative and Tiwanaku Period. Caries rates drop to 1.3 percent, a rate similar to hunter gatherer populations. This decrease was statistically significant for males, females, and when all individuals were combined. Certainly agriculture was no longer a significant component of altiplano subsistence strategies. Many have speculated that an extreme drought in 1100 AD was the final blow that led to the collapse of Tiwanaku (Binford and Kolata 1996; Binford et al. 1997; Janusek 2004; 2008; Kolata and Ortloff 1996; Ortloff and Kolata 1993). These data are consistent with such a theory, in that agriculture may have become a fruitless endeavor.

CHAPTER VII

RESULTS OF STABLE ISOTOPE ANALYSES

Introduction

This chapter presents the results, interpretations, and discussion of the stable isotopic portion of this study. Stable isotopic data were collected in order to provide individual food consumption profiles, which could not be obtained through visual inspection of the dentition or recovery of plant microfossils from human dental calculus. I begin by presenting the results for preservation indicators that assess the reliability of the isotopic results. I then report the stable isotopic results according to temporal period (Late Formative, Tiwanaku Period, and Post Tiwanaku Period) and site, addressing intra- and inter-site dietary variation. A summary of the results follows.

Sample Preservation

Preservation of bone collagen samples was assessed through examination of percent carbon, percent nitrogen, carbon to nitrogen ratios, and percent collagen yield. The integrity of bone apatite samples was assessed through examination of apatite yields following the pretreatment process. Results for each sample are presented in Appendix A. Mean values for preservation indicators for each site are presented in Table 7.1 Eleven samples for which only apatite percent yield is recorded (AKE-30902, AKE-8908, KW-0125, KW1205, KW-1855, KW-5374, KW-5748, MK-833/834, MK-874-2, MK-874-2, and MK-985) were part of the original pilot study in 2005. Carbon and nitrogen yields for these samples were measured by the mass spectrometer but only raw uncalibrated numbers were produced at that time, however, all samples produced reliable carbon to nitrogen ratios (pers. comm. R. Tykot 2007). An additional means of assuring the integrity of apatite samples involved repeat testing of some samples. These results are presented in Appendix A. Results were very consistent for each sample, indicating the reliability of the values produced. When discrepancies were found between the two tests, the average of the two values was reported for the sample and used in further analyses.

Table 7.1 Mean values of preservation indicators for altiplano sites

Site	%C	%N	C:N	Collagen % Yield	Apatite % Yield
Tiwanaku	38.5	14.7	3.0	15.4	67.9
Lukurmata	40.8	15.7	3.1	18.9	65.7
Khonkho Wankane	41.0	15.9	3.0	18.3	57.3
Kirawi	NA	NA	3.1	NA	58.9
Urikatu Kontu	33.6	12.8	3.2	19.7	60.9
Tilata/TMV228	NA	NA	2.9	NA	71.6
Iruihito	37.3	14.1	3.1	18.4	65.7

Overall, preservation of altiplano bone samples was excellent and consistent among sites (Table 7.1). Of the 109 bone samples processed at the University of South Florida's Archaeological Science Laboratory (both human and faunal), only three samples produced questionable results (LKM-10407, MK-D-3387, and MK-890). LKM-10407 had a C:N ratio above the acceptable 2.7-3.6 range and was thus not included in this study. MK-D-3387 is a fish scale, which fell below the 1% collagen yield cut off point. This sample was not included in the faunal analysis. MK-890 has a low C:N ratio, however, its isotopic values are very consistent with the seven other individuals from the Mollo Kontu residential sector of Tiwanaku (see Appendix A). This individual was included in the study.

Late Formative

For the altiplano sites to which I had access, human skeletal remains dating to the Late Formative period are relatively scarce. Samples from fifteen individuals from five sites—Tiwanaku, Khonkho Wankane, Lukurmata, Kirawi, and Iruihito—were analyzed. Isotopic values for all Late Formative sites are compared in Table 7.2 and statistically significant differences are highlighted. The mean $\delta^{13}C_{coll}$ value for the combined Late Formative altiplano samples was -18.09 ± 1.15‰ and the mean $\delta^{13}C_{ap}$ value was -10.53 ± 2.48‰ (n=15). The mean difference between carbon in collagen and apatite ($\delta^{13}C_{ap\text{-}coll}$) was 7.57 ± 2.26‰. The mean $\delta^{15}N$ value was 10.83 ± 0.92‰ (n=15).

These data suggest that Late Formative period altiplano diets may be characterized by reliance on local C_3 resources, such as tubers and quinoa, for a carbohydrate source and C3 feeding herbivores such as camelids, deer, and guinea pig for protein. As the inter- and intra-site comparisons of carbon and nitrogen stable isotopes will show, the contribution of C_4 enriched fish to diets varied considerably among the altiplano sites. In particular, Katari valley communities derived significantly more protein from lake fish relative to other sites. Also, small quantities of lowland maize were clearly imported to the altiplano. During this period, maize consumption varied substantially within and between sites. Certain individuals at sites with ceremonial architecture (Khonkho Wankane and Tiwanaku) and the small rural site of Iruihito consumed the greatest quantities. Intra-site variation in consumption practices cannot be attributed to sex-based dietary differences, as no statistically significant differences were found among the sexes (Table 7.3). The following sections provide a detailed assessment of inter- and intra-site variation during the Late Formative period.

Table 7.2 Descriptive statistics and Mann-Whitney U test comparisons for Late Formative sites

Site	N	Mean	SD	Tiwanaku	Lukurmata	Khonkho Wankane	Kirawi
(a) $\delta^{13}C_{co}$							
Tiwanaku	3	-18.47	0.76				
Lukurmata	4	-18.80	0.37	z=-0.18			
				p= 0.86			
Khonkho Wankane	4	-18.05	0.50	z=-1.06	**z=-2.02**		
				p= 0.29	**p= 0.04**		
Kirawi	2	-16.95	3.18	z=-0.13	z=-0.46	z=-1.49	
				p= 0.90	p= 0.64	p= 0.14	
Iruihtio	2	-17.35	0.21	z=-1.73	z=-1.85	z=-1.39	z= 0.00
				p= 0.08	p= 0.06	p= 0.17	P= 1.00
(b) $\delta^{13}C_{ap}$							
Tiwanaku	3	-10.27	1.43				
Lukurmata	4	-13.20	0.67	**z=-2.12**			
				p= 0.03			
Khonkho Wankane	4	-9.93	1.88	z=-0.18	**z=-2.31**		
				p= 0.86	**p= 0.02**		
Kirawi	2	-10.90	1.13	z=-1.81	z=-1.85	**z=-2.13**	
				p= 0.07	p= 0.06	**p= 0.03**	
Iruihito	2	-6.4	1.98	z=-1.73	z=-1.85	z=-1.85	z=-1.55
				p= 0.08	p= 0.06	p= 0.06	P= 0.12
(c) $\delta^{13}C_{co-ap}$							
Tiwanaku	3	8.20	0.70				
Lukurmata	4	5.60	1.03	**z=-2.12**			
				p= 0.03			
Khonkho Wankane	4	8.13	2.20	z= 0.01	z=-1.60		
				p= 1.00	p= 0.11		
Kirawi	2	6.05	2.05	**z=-2.20**	z=-0.46	z=-1.60	
				p= 0.03	p= 0.64	p= 0.11	
Iruihito	2	10.95	1.77	z=-1.73	z=-1.85	z=-0.93	z=-1.55
				p= 0.08	p= 0.06	p= 0.36	P= 0.12
(d) $\delta^{15}N$							
Tiwanaku	3	10.17	0.55				
Lukurmata	4	10.88	1.51	z=-0.35			
				p= 0.72			
Khonkho Wankane	4	11.28	0.51	**z=-1.96**	z=-1.16		
				p= 0.05	p= 0.25		
Kirawi	2	10.60	1.13	z=-0.52	z=-0.24	z=-1.28	
				p= 0.60	p= 0.81	p= 0.2.0	
Iruihito	2	11.05	0.07	z=-1.73	z=-0.93	z=-0.24	z= 0.00
				p= 0.08	p= 0.36	p= 0.81	P= 1.00

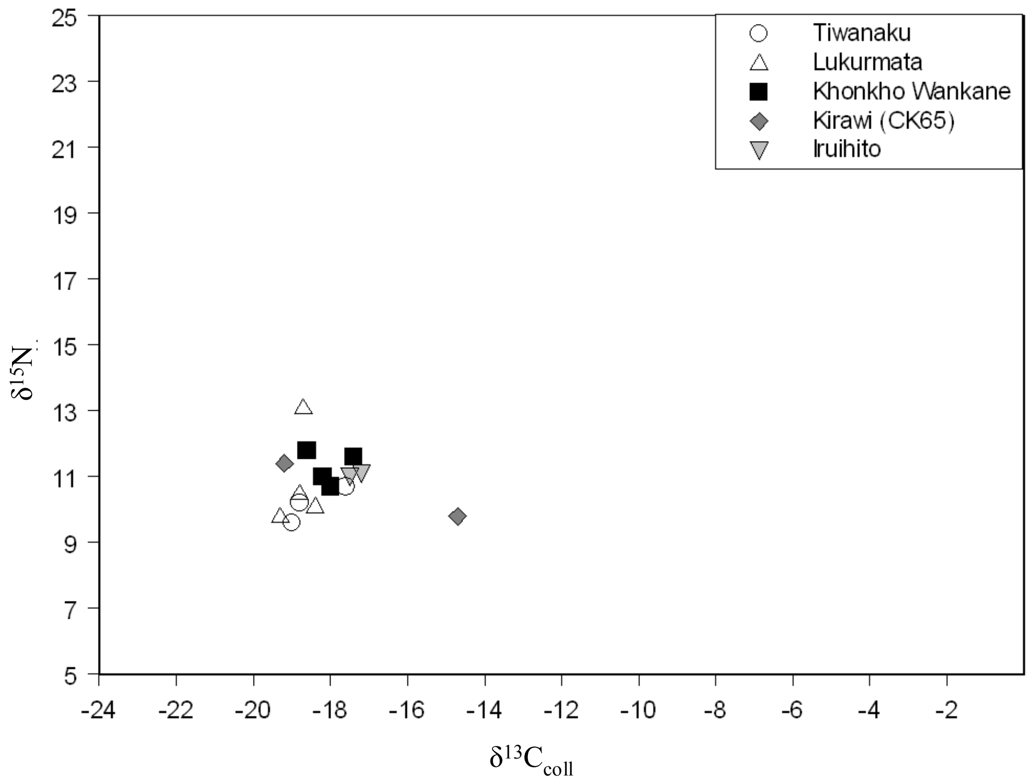

Figure 7.1 Isotopic values for Late Formative sites, $\delta^{15}N$ vs. $\delta^{13}C_{coll}$

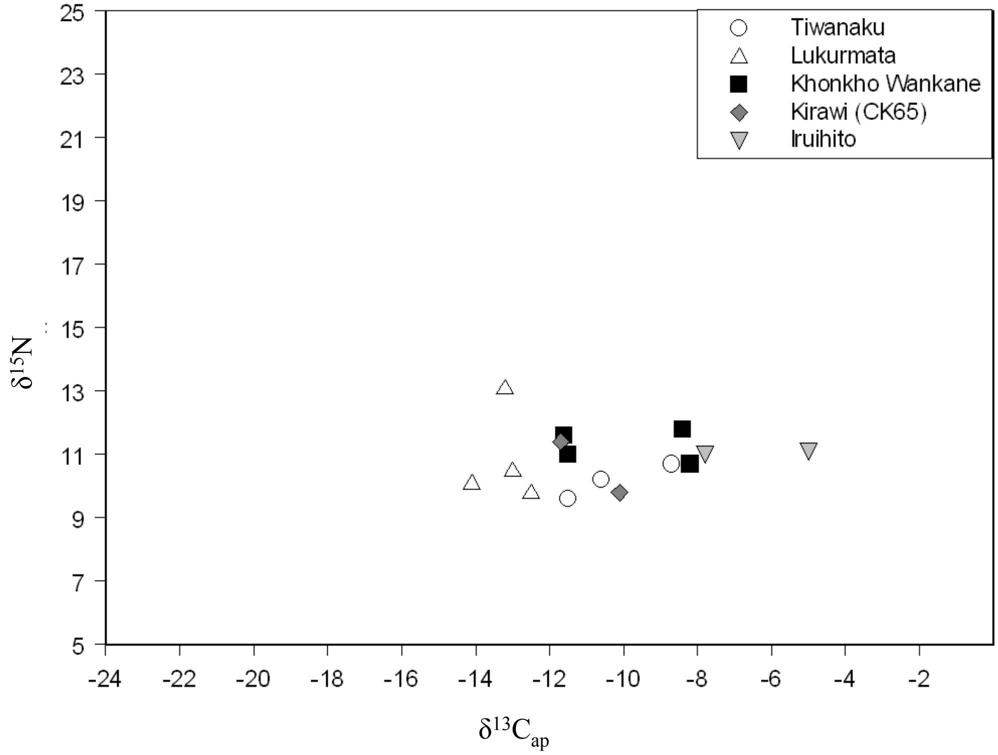

Figure 7.2 Isotopic values for Late Formative sites, $\delta^{15}N$ vs. $\delta^{13}C_{ap}$

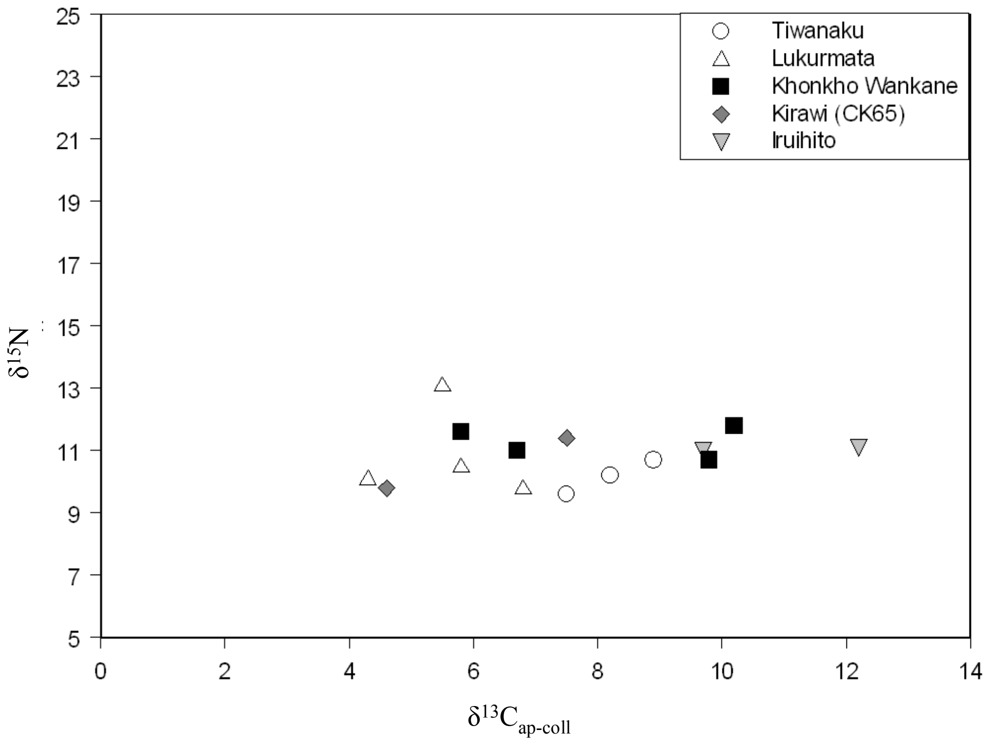

Figure 7.3: Isotopic values for Late Formative sites, $\delta^{15}N$ vs. $\delta^{13}C_{ap\text{-}coll}$

Tiwanaku

The Late Formative Period sample for Tiwanaku was small, consisting of two adults of unknown sex from the Chiji Jawira sector (CJ-36996-2, CJ-36995-3) and one adult male from the Markapata sector (MP-230); both areas are well outside Tiwanaku's ceremonial core. The mean carbon stable isotope value from bone collagen ($\delta^{13}C_{coll}$) for the three was -18.47 ± 0.76‰ and the mean $\delta^{13}C_{ap}$ value was -10.27 ± 1.43‰. Using the Ambrose et al. (2003) [39] formula to calculate percentage of C_4 resources in the diet, the bone collagen value suggests that C_4 foods composed 9.5 ± 10% of the overall diet while the bone apatite value suggests that, on average, 35.5 ± 10% of the overall diet was

[39] Percentage C_4 calculated based on formulas provided in Ambrose et al. (2003: 221):
$\%C_4 = (-25 – (\delta_b - \Delta))/15 \times 100$, where δ_b is the $\delta^{13}C$ value of collagen or apatite, Δ is the diet-collagen (5.1‰) or diet-apatite (9.4‰) spacing.

composed of C_4 resources. Notably, the collagen and apatite mean values indicate that the C_4 component of the diet was underestimated by the former.

Comparison of the $\delta^{13}C$ spacing between collagen and apatite ($\delta^{13}C_{ap\text{-}coll}$) provides insight into the source of C_4 enrichment. Recall from Chapter 5, that a $\delta^{13}C_{coll\text{-}ap}$ value greater than 4.4‰ indicates the primary source of elevated $\delta^{13}C$ values is a protein depleted resource such as a C_4 carbohydrate (maize) (Ambrose et al. 1997: 351). While a value of approximately 4.4‰ or less indicates the primary source of elevated $\delta^{13}C$ values is a protein rich resource, such as C_4 enriched lake fish (Ambrose et al. 1997). The mean $\delta^{13}C_{ap\text{-}coll}$ at Late Formative Tiwanaku was very high, 8.20 ± 0.70‰, indicating the C_4 enriched resource being consumed was very low in protein. Thus, maize consumption is the most likely explanation for the discrepancy in carbon stable isotope values in collagen and apatite.

The mean $\delta^{15}N$ value for Late Formative Tiwanaku was 10.17 ± 0.55‰. When compared with nitrogen stable isotope endvalues for the local foodweb outlined in Chapter 5 (see Figure 5.11), this value indicates a diet relatively low in protein. Consumption of legumes may have also contributed to low nitrogen stable isotope values.

Overall, low $\delta^{15}N$ values coupled with $\delta^{13}C_{ap\text{-}coll}$ values well above 4.4‰ indicate a diet that was heavily dependent on carbohydrates, including plant resources that fall in both the C_3 and C_4 range, and low in protein. Protein was primarily derived from C_3 feeding terrestrial herbivores such as camelids and guinea pig rather than lake fish. Interestingly, maize was present and may have constituted an average of 35.5% of the diet for these three Tiwanaku inhabitants. In fact, one individual (CJ-36995-3) had a $\delta^{13}C_{ap}$ value of -8.7‰, indicating 46 ± 10% of the overall diet was composed of maize

($\delta^{13}C_{ap-coll}$ for this individual was a very high 8.9‰). Thus, this study provides the first direct evidence of the presence of significant quantities of maize in the altiplano prior to the Middle Horizon.

Khonkho Wankane

Located in the Desaguadero river valley, the site of Khonkho Wankane provided samples from four individuals dating to the Late Formative period, including 2 males, 1 female, and 1 adult of unknown sex. Carbon stable isotope values for Khonkho Wankane were similar to those at Tiwanaku, but slightly more positive. The mean $\delta^{13}C_{coll}$ value was -18.05 ± 0.50‰ (C_4 foods comprised 12.3% of diet) and the mean $\delta^{13}C_{ap}$ value was -9.93 ± 1.88‰ (37.8% C_4). As at Tiwanaku, values derived from collagen underestimated the contribution of resources that fall in the C_4 range. $\delta^{13}C_{coll}$ values estimate that an average of 12.3 ± 10% of the diet was composed of resources with C_4 signatures, while values derived from apatite estimated an average of 37.8 ± 10% of the diet was derived from a C_4 enriched resource. The mean difference between collagen and apatite values ($\delta^{13}C_{ap-coll}$) was again very high, 8.13 ± 2.20‰ (>4.4‰), indicating that the $\delta^{13}C$ value of dietary protein was more negative than the whole diet. Thus, maize consumption, rather than C_4 enriched fish consumption, is the most likely source of the relatively high $\delta^{13}C_{ap}$ values.

Although carbon stable isotope values were very similar to Tiwanaku, values for nitrogen were significantly higher. The mean $\delta^{15}N$ value for Khonkho Wankane individuals was 11.28 ± 0.51‰, which is 1.1‰ higher than Tiwanaku. This is substantial when one considers that the difference between herbivores and carnivores in a given lly significant difference in nitrogen values between the two sites ($z = 1.96$, $p = 0.05$).

These data suggest that during the Late Formative period, inhabitants of Khonkho Wankane and Tiwanaku were eating similar diets, which were dominated by local C_3 plant resources but had a substantial amount of maize. In fact, an average of 37.8 ± 10% of the diet for these four individuals was likely maize. However, nitrogen values indicate that Khonkho residents were likely including more meat and/or less legumes in their diets relative to those at Tiwanaku.

Variation in $\delta^{13}C_{ap}$ values within Khonkho Wankane are apparent, as two individuals cluster around -8‰ and the other two cluster around -12‰, indicating differential access to a C_4 resource, likely maize. Interestingly, the two individuals with the more positive values are males and those with the more negative values are a female and an individual of unknown sex. Thus, there is some indication that dietary differences may have been related to sex, with males consuming more C_4 plants (maize); however, the sample size is small and the differences are not statistically significant (Table 7.3).

Lukurmata

The Katari valley site of Lukurmata is the closest to Lake Titicaca of all the Late Formative sites sampled. Thus, it was hypothesized that aquatic resources may have been a more central component of Lukurmata diets. Four individuals dating to this period were available for analysis, including three males and one female. These burials correspond to burials 1-4 described by Bermann (1994: 80). The mean $\delta^{13}C_{coll}$ value was -18.80 ±

0.37‰, lower than both Tiwanaku and Khonkho Wankane. Results of a Mann Whitney U test revealed that the mean $\delta^{13}C_{coll}$ value was significantly lower than Khonkho Wankane ($z = -2.02$, $p = 0.04$). The mean $\delta^{13}C_{ap}$ value, -13.20 ± 0.67‰, was also significantly lower than Tiwanaku ($z = -2.12$, $p = 0.03$) and Khonkho Wankane ($z = -2.31$, $p = 0.02$). Results indicate that resources that fall in the C_4 range (fish and/or maize), were not consumed as frequently by Lukurmata inhabitants relative to those at Tiwanaku and Khonkho Wankane. As at the other sites, values derived from collagen underestimated the contribution of resources that fall in the C_4 range. $\delta^{13}C_{coll}$ values estimate that, on average, a negligible 7.3 ± 10% of the diet was composed of C_4 enriched resources, while values derived from apatite estimated an average of 16 ± 10% of the diet was in the C_4 range.

The mean difference between bone apatite and collagen ($\delta^{13}C_{ap-coll}$) at Lukurmata was 5.60 ± 1.03‰, which is still well above 4.4‰, indicating that the $\delta^{13}C$ value of dietary protein is more negative than the whole diet. Thus, maize consumption was at least partly responsible for the elevated $\delta^{13}C_{ap}$ values. However, the mean $\delta^{13}C_{ap-coll}$ value at Lukurmata was still significantly lower than that of Tiwanaku and Khonkho Wankane and likely indicates the presence of more C_4 enriched fish in the diet. In fact, a 40-50 year old male (LKM-3045) who had the lowest $\delta^{13}C_{ap}$ value at Lukurmata ($\delta^{13}C_{ap} = -14.1$‰) had an exceptionally low $\delta^{13}C_{ap-coll}$ value, 4.3‰ (<4.4‰), indicating that the small percent of C_4 resources present in the diet came exclusively from a protein resource—i.e. lake fish.

The mean nitrogen stable isotope value, 10.88 ± 1.51‰, was not significantly different than other sites, though it was slightly higher than Tiwanaku and less than

Khonkho Wankane. In conjunction with carbon ratios, Lukurmata $\delta^{15}N$ values suggest heavy reliance on C_3 feeding terrestrial herbivores as a protein source. However, there was variation in nitrogen isotope values among the four individuals. One elderly male (LKM-3048) had extremely high $\delta^{15}N$ values (13.1‰) relative to the other three individuals, indicating greater access to protein resources. Interestingly, the one female (LKM-3043) had the lowest $\delta^{15}N$ value (9.8‰) and the highest $\delta^{13}C_{ap}$ (-12.5‰) and $\delta^{13}C_{ap\text{-}coll}$ (6.8‰) values of the four individuals, this indicates that she had less access to protein rich resources and more reliance on maize relative to the three men. Thus, although the sample is too small to conclude notable sex based differences in diet, there is preliminary evidence to suggest sex-based disparities.

In general, Late Formative people at Lukurmata primarily consumed local C_3 carbohydrates, as well as C_3 feeding fauna (camelids, deer, guinea pig, etc…) as their protein source. On average, 16 ± 10% of the diet included C_4 carbohydrates (maize) and C_4 enriched fish. This is significantly less than the contemporary sites of Tiwanaku and Khonkho Wankane. This is a significant finding for two reasons. First, the presence of small amounts of maize in the altiplano during the Late Formative period could be attributed to locally grown maize along the warmer lake margins rather than lowland importation. If this were the case, Lukurmata would have offered a better environment for small-scale maize cultivation relative to Tiwanaku and Khonkho Wankane. Thus, if maize cultivation was taking place near Lukurmata on a scale significant enough to supply Khonkho or Tiwanaku, I would expect inhabitants to reveal more evidence of maize in their diets than is presently documented. This begs the question, what was the origin of the maize at Tiwanaku and Khonkho Wankane during the Late Formative?

These data support importation from a lowland source. Second, it is surprising that so little dietary protein for these Formative period inhabitants at Lukurmata came from fish (this is indicated by the relatively low $\delta^{13}C_{ap}$ values and $\delta^{13}C_{ap\text{-}coll}$ values well above 4.4‰)—an abundant and reliable resource that would have been easy to exploit. Also, the four Lukurmata individuals were found in the same area of the site and may represent a single family and thus, it may not be wise to extrapolate these results for the whole site. However, dietary variation did exist and at least one person sampled (LKM-3045) obtained C_4 enrichment exclusively from a protein source (i.e. lake fish).

Kirawi (CK65)

Only two adult females were available for analysis from the small Katari valley site of Kirawi. The mean $\delta^{13}C_{coll}$ value for Kirawi was -16.95 ± 3.18‰ (19.7% C_4), higher than any of the Late Formative sites. The mean $\delta^{13}C_{ap}$ value was -10.90 ± 1.13‰ (31.3% C_4) and, as at other sites, reveals that $\delta^{13}C_{coll}$ values have underestimated the contribution of C_4 enriched resources to the overall diet. The mean $\delta^{13}C_{ap}$ value at Kirawi is lower than Tiwanaku and significantly lower than Khonkho Wankane ($z = -2.13$, $p = 0.03$), suggesting that the Kirawi community had less access to C_4 resources. However, the $\delta^{13}C_{ap}$ value is more positive than Lukurmata—approaching significance at the $p < 0.05$ level ($z = -1.85$, $p = 0.06$). Interestingly, although both Kirawi individuals included C_4 enriched resources in their diets, collagen and apatite spacing ($\delta^{13}C_{ap\text{-}coll}$) indicates that the source of C_4 enrichment was very different for those individuals. CK65-1041 had a $\delta^{13}C_{ap\text{-}coll}$ value of 4.6‰, indicating that C_4 enrichment was primarily the result of consuming a protein rich resource (i.e. lake fish). CK65-1691 had a $\delta^{13}C_{ap\text{-}}$

$_{coll}$ value of 7.5‰, indicating that the primary source of C_4 enrichment came from a protein depleted C_4 resource, like maize.

Nitrogen stable isotope values at Kirawi were not statistically different from other Late Formative sites ($\delta^{15}N = 10.60 \pm 1.13$‰)—slightly higher than Tiwanaku but lower than Lukurmata and Khonkho Wankane.

In general, diet for these Late Formative Kirawi was likely dominated by C_3 carbohydrates, such as tubers and quinoa and C_3 feeding herbivores, such as camelids, deer, and guinea pig, as protein sources. Maize and fish consumption were significant but highly variable.

Iruihito

Located 20km south of Lake Titicaca, the site of Iruihito sits on the eastern shore of the Desaguadero River. For the Late Formative period, two adults of unknown sex were available for isotopic analysis. Results for each were very similar. The mean $\delta^{13}C_{coll}$ value was -17.35 ± 0.21‰ (17% C_4) while the mean $\delta^{13}C_{ap}$ value was an unexpectedly high -6.40 ± 1.98‰ (61.3% C_4). $\delta^{13}C_{coll}$ values alone estimated that 17 ± 10% of the diet included C_4 enriched resources while values derived from $\delta^{13}C_{ap}$ estimated that, on average, 61.3 ± 10% of the diet came from a C_4 enriched resource. The mean $\delta^{13}C_{ap-coll}$ value, 10.95 ± 1.77‰, was extremely high, indicating the C_4 enriched resource these individuals consumed contained virtually no protein and was almost certainly maize.

Iruihito residents revealed the most positive $\delta^{13}C_{ap}$ values and largest differences between stable isotopic values from collagen and apatite ($\delta^{13}C_{ap-coll}$) than all other Late

Formative samples. One individual, IR-4.1R1.1-#2, consumed more maize than any other Late Formative individual sampled. Maize was clearly a major dietary component at Iruihito, at least for these two adults. Where did the maize come from? One possibility is that it was imported from other lakeside communities, as Iruihito's location on the river provided easy access to Lake Titicaca. It is also possible that maize was already being imported from lowland communities during the Late Formative period.

The mean $\delta^{15}N$ value, 11.05 ± 0.07‰, was not significantly different from other Late Formative sites—slightly more positive than Katari and Tiwanaku valley sites and just below the other Desaguadero valley site of Khonkho Wankane (mean $\delta^{15}N$ = 11.28 ± 0.51‰). These results indicate greater consumption of C_3 feeding protein resources, such as camelids and guinea pig, among residents of the Desaguadero valley.

On average, Late Formative diets at Iruihito consisted of carbohydrates in both the C_3 and C_4 range (approximately 40% and 60% respectively). The primary protein resources were likely C_3 feeding herbivores (camelids, deer, guinea pig, etc..). Despite its riverside location and proximity to Lake Titicaca, very little dietary protein came from C_4 enriched fish. However, it is important to note that fish from the Desaguadero River have not been subjected to stable isotopic analysis and their carbon stable isotopic signatures could conceivably fall in the C_3 range.

In short, the isotope data from Iruihito and Khonkho Wankane indicate that maize was more abundant in the Desaguadero valley during the Late Formative than in the Tiwanaku or Katari valleys. This is significant in light of Khonkho's prominence as a major Late Formative ceremonial center and the suspected role of maize in feasting and commensal politics that likely took place at these centers. Notably, Tiwanaku was also rising in prominence during this time and was apparently acquiring a significant amount of maize, but not as much as the Desaguadero valley communities.

Table 7.3 Descriptive statistics and Mann-Whitney U test results comparing isotopic values between the sexes at each site after separating by temporal period

		Male			Female		Mann-Whitney	
Sample	**N**	**Mean**	**s.d.**	**N**	**Mean**	**s.d.**	**z**	**p**
$\delta^{13}C_{coll}$								
LF Tiwanaku	1	-19.00	-	0	-	-	-	-
LF Lukurmata	3	-18.63	0.21	1	-19.30	-	-1.34	0.18
LF Khonkho Wankane	2	-18.30	0.42	1	-18.20	-	0.01	1.00
LF Kirawi	0	-	-	2	-16.95	3.18	-	-
LF Iruihito	0	-	-	0	-	-	-	-
MH Tiwanaku	15	-13.60	3.27	14	-15.26	2.66	-1.20	0.23
MH Lukurmata	4	-16.28	2.91	5	-17.12	2.21	-0.74	0.46
MH Khonkho Wankane	0	-	-	2	-13.70	4.24	-	-
MH Kirawi	2	-15.65	1.34	1	-16.80	-	-1.23	0.22
MH Iruihito	0	-	-	0	-	-	-	-
MH Urikatu Kontu	1	-17.00	-	0	-	-	-	-
MH Tilata	0	-	-	1	-18.30	-	-	-
PT Lukurmata	2	-16.25	2.90	3	-17.93	0.60	-0.58	0.56
PT Khonkho Wankane	1	-17.50	-	0	-	-	-	-
PT Urikatu Kontu	4	-17.78	0.39	0	-	-	-	-
PT TMV228	2	-18.25	0.49	0	-	-	-	-
$\delta^{13}C_{ap}$								
LF Tiwanaku	1	-11.50	-	0	-	-	-	-
LF Lukurmata	3	-13.43	0.59	1	-12.50	-	-1.34	0.18
LF Khonkho Wankane	2	-8.30	0.14	1	-11.50	-	-1.23	0.22
LF Kirawi	0	-	-	2	-10.90	1.13	-	-
LF Iruihito	0	-	-	0	-	-	-	-
MH Tiwanaku	15	-7.86	2.99	14	-10.95	2.46	-1.14	0.26
MH Lukurmata	4	-9.45	2.21	5	-10.26	3.53	0.98	0.33
MH Khonkho Wankane	0	-	-	2	-7.45	4.45	-	-
MH Kirawi	2	-11.25	0.92	1	-11.30	-	0.01	1.00
MH Iruihito	0	-	-	0	-	-	-	-
MH Urikatu Kontu	1	-12.4	-	0	-	-	-	-
MH Tilata	0	-	-	1	-14.30	-	-	-
PT Lukurmata	2	-10.50	2.83	3	-11.97	0.57	-0.58	0.56
PT Khonkho Wankane	1	-12.80	-	0	-	-	-	-
PT Urikatu Kontu	4	-12.60	1.59	0	-	-	-	-
PT TMV228	2	-9.85	5.44	0	-	-	-	-

$\delta^{13}C_{coll\text{-}ap}$								
LF Tiwanaku	1	7.50	-	0	-	-	-	-
LF Lukurmata	3	5.20	0.79	1	6.80	-	-1.34	0.18
LF Khonkho Wankane	2	10.00	0.28	1	6.70	-	-1.23	0.22
LF Kirawi	0	-	-	2	6.10	2.05	-	-
LF Iruihito	0	-	-	0	-	-	-	-
MH Tiwanaku	15	5.73	2.05	14	6.10	1.24	-0.39	0.69
MH Lukurmata	4	6.83	1.32	5	6.86	1.45	-0.12	0.90
MH Khonkho Wankane	0	-	-	2	6.25	0.21	-	-
MH Kirawi	2	4.40	0.42	1	5.50	-	-1.23	0.22
MH Iruihito	0	-	-	0	-	-	-	-
MH Urikatu Kontu	1	4.60	-	0	-	-	-	-
MH Tilata	0	-	-	1	4.00	-	-	-
PT Lukurmata	2	5.75	0.07	3	5.97	0.90	-0.58	0.56
PT Khonkho Wankane	1	4.70	-	0	-	-	-	-
PT Urikatu Kontu	4	5.18	1.46	0	-	-	-	-
PT TMV228	2	8.40	5.94	0	-	-	-	-
$\delta^{15}N$								
LF Tiwanaku	1	9.60	-	0	-	-	-	-
LF Lukurmata	3	11.23	1.63	1	9.80	-	-1.34	0.18
LF Khonkho Wankane	2	11.25	0.78	1	11.00	-	0.01	1.00
LF Kirawi	0	-	-	2	10.60	-	-	-
LF Iruihito	0	-	-	0	-	-	-	-
MH Tiwanaku	15	10.64	1.40	14	10.75	1.05	-0.15	0.88
MH Lukurmata	4	11.35	1.27	5	11.70	0.37	0.01	1.00
MH Khonkho Wankane	0	-	-	2	10.50	0.14	-	-
MH Kirawi	2	10.40	0.28	1	10.00	-	-1.23	0.22
MH Iruihito	0	-	-	0	-	-	-	-
MH Urikatu Kontu	1	11.60	-	0	-	-	-	-
MH Tilata	0	-	-	1	12.00	-	-	-
PT Lukurmata	2	12.85	1.06	3	12.60	2.11	0.01	1.00
PT Khonkho Wankane	1	11.40	-	0	-	-	-	-
PT Urikatu Kontu	4	14.20	0.70	0	-	-	-	-
PT TMV228	2	13.55	0.35	0	-	-	-	-

Tiwanaku Period

Sixty five individuals from seven Middle Horizon (Tiwanaku IV-V period) sites, including Tiwanaku, Lukurmata, Khonkho Wankane, Kirawi, Iruihito, Urikatu Kontu, and Tilata, were analyzed. At many sites, diets changed dramatically from the Late Formative. For the altiplano as a whole, the mean $\delta^{13}C_{coll}$, $\delta^{13}C_{ap,}$ and $\delta^{13}C_{ap\text{-}coll}$ values all experienced changes that are statistically significant (see Table 7.5). The mean $\delta^{13}C_{ap}$ value increased from -10.53 ± 2.48 to -8.73 ± 2.93‰ ($z = -2.25$, $p = 0.02$), indicating a substantial increase in the consumption of C_4 enriched resources from the Late Formative to Middle Horizon times. On average, C_4 enriched resource constituted 45.5 ± 10% of the diet. The mean $\delta^{13}C_{coll}$ value increased from -18.09 ± 1.15‰ to -14.91 ± 3.02‰ ($z = -4.19$, $p = 0.01$). The greater standard deviation of both the mean $\delta^{13}C_{coll}$ and $\delta^{13}C_{ap}$ indicate greater variation in C_4 resource consumption among Middle Horizon populations. The mean $\delta^{13}C_{ap\text{-}coll}$ of 6.18 ± 1.80‰ remains well above 4.4, indicating that the primary source of C_4 enrichment was a protein depleted food (i.e. maize). However, the Middle Horizon mean $\delta^{13}C_{ap\text{-}coll}$ value is significantly lower than the Late Formative mean (7.57 ± 2.26‰) ($z = -2.16$, $p = 0.03$). This trend is not true for all sites (Lukurmata is a notable exception) and I suspect it is a result of the much larger size of the Tiwanaku Period sample, representing a broader spectrum of society and reflecting the consumption of more fish among certain social groups. The Late Formative sample came primarily from individuals at ceremonial centers that may have had privileged access to maize while the Tiwanaku Period sample is more diverse.

The mean $\delta^{15}N$ value increased slightly from 10.83 ± 0.92‰ in the Late Formative to 11.02 ± 1.28‰ in the Middle Horizon. Although this difference is not statistically significant, it does suggest slight increases in the consumption of C_3 feeding herbivores. The increase in the standard deviation of the mean $\delta^{15}N$ value also indicates greater variation among Middle Horizon populations in access to these protein resources.

In general, altiplano populations during the Middle Horizon remained dependent on local C_3 staples, such as tubers and quinoa, for a carbohydrate source and C_3 feeding herbivores such as camelids as a protein source. Supplementation of the diet with C_4 enriched fish is also apparent at several sites. However, it is also clear that imported maize becomes a much more significant part of the diet for certain individuals at sites with ceremonial architecture (e.g. Tiwanaku, Lukurmata, and Khonkho Wankane) as well as one small rural settlement: Iruihito.

Great disparities in the consumption of maize within and among Middle Horizon sites likely indicate increasing social divisions at these centers. At no site were such disparities attributable to sex-based dietary differences (Table 7.3). However, given the confounding effect of C_4 enriched fish, as well as small sample sizes after dividing by sex (and in the case of Tiwanaku dividing by sector), it is possible that future research with larger Middle Horizon samples may document sex-based differences in diet. Nevertheless, current datasets do not reveal these differences (see Table 7.3).

Having provided this overview of changing altiplano food consumption patterns in the Middle Horizon, I examine inter- and intra-site dietary variation during the Middle Horizon in the following sections.

Table 7.4 Descriptive statistics and Mann-Whitney U test comparisons for Tiwanaku IV-V Period sites

Site	N	Mean	SD	Tiwanaku	Lukurmata	Khonkho Wankane	Kirawi
(a) $\delta^{13}C_{co}$							
Tiwanaku	44	-14.42	3.14				
Lukurmata	10	-16.87	2.3	**z=-2.17 P= 0.03**			
Khonkho Wankane	4	-12.83	2.66	z=-1.19 P= 0.23	**z=-2.27 p= 0.02**		
Kirawi	3	-16.60	0.67	z=-0.65 P= 0.51	z=-0.85 p= 0.40	z=-1.41 p= 0.16	
Iruihito	2	-15.50	0.28	z=-0.35 P= 0.73	z=-1.30 p= 0.20	z=-0.93 p= 0.36	Z=-0.58 P= 0.56
Urikatu Kontu	1	-17.00	-	-	-	-	-
Tilata	1	-18.30	-	-	-	-	-
(b) $\delta^{13}C_{ap}$							
Tiwanaku	44	-8.30	2.70				
Lukurmata	10	-10.03	2.70	z=-1.83 P= 0.07			
Khonkho Wankane	4	-7.00	2.65	z=-0.95 P= 0.34	z=-1.70 p= 0.09		
Kirawi	3	-11.30	0.38	z=-1.87 P= 0.06	z=-0.42 p= 0.67	**z=-1.96 p= 0.05**	
Iruihito	2	-6.65	6.01	z=-0.54 P= 0.59	z=-1.29 p= 0.20	z= 0.00 p= 1.00	Z=-1.16 P= 0.25
Urikatu Kontu	1	-12.40	-	-	-	-	-
Tilata	1	-14.30	-	-	-	-	-
(c) $\delta^{13}C_{co-ap}$							
Tiwanaku	44	6.12	1.67				
Lukurmata	10	6.84	1.23	z=-1.30 P= 0.19			
Khonkho Wankane	4	5.83	0.53	z=-0.37 P= 0.71	z=-1.27 p= 0.20		
Kirawi	3	4.70	0.41	z=-1.70 P= 0.09	**z=-2.38 p= 0.02**	z=-1.77 p= 0.08	
Iruihito	2	8.85	6.29	z=-0.32 P= 0.75	z= 0.00 p= 1.00	z= 0.00 p= 1.00	Z=-0.58 P= 0.56
Urikatu Kontu	1	4.60	-	-	-	-	-
Tilata	1	4.00	-	-	-	-	-
(d) $\delta^{15}N$							
Tiwanaku	44	10.83	1.32				
Lukurmata	10	11.77	1.06	**z=-2.25 P= 0.02**			
Khonkho Wankane	4	10.45	0.26	z=-1.16 P= 0.25	**z=-2.27 p= 0.02**		
Kirawi	3	10.27	0.31	z=-1.11 P= 0.27	**z=-2.03 p= 0.04**	z=-0.36 p= 0.72	

Iruihito	2	13.05	0.21	**z=-2.26** **P= 0.02**	z=-1.72 p= 0.09	z=-1.85 p= 0.06	Z=-1.73 P= 0.08
Urikatu Kontu	1	11.60	-	-	-	-	-
Tilata	1	12.00	-	-	-	-	-

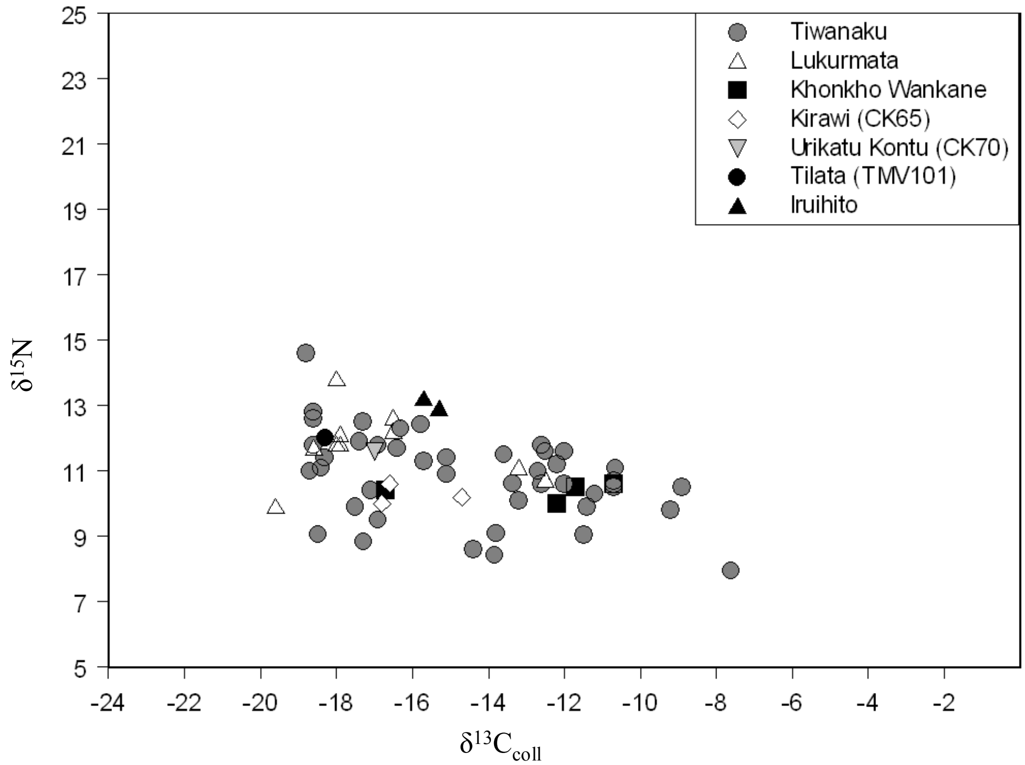

Figure 7.4 Isotopic values for Tiwanaku IV-V sites, $\delta^{15}N$ vs. $\delta^{13}C_{coll}$

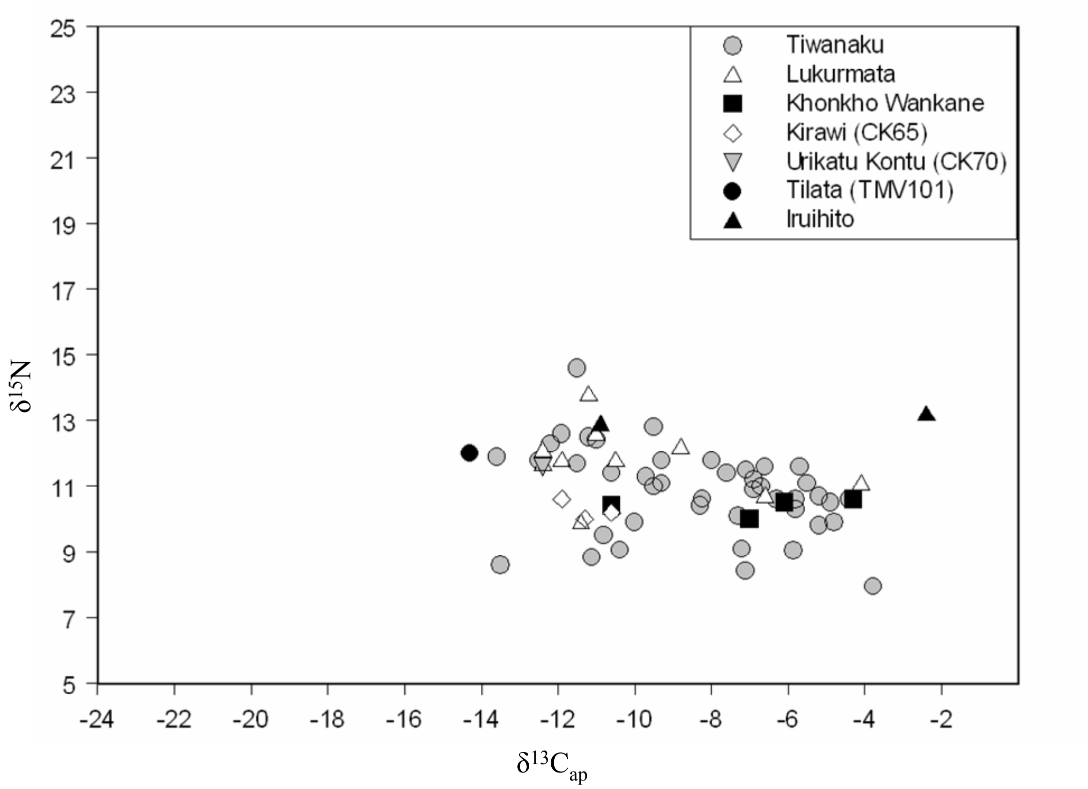

Figure 7.5 Isotopic values for Tiwanaku IV-V sites, $\delta^{15}N$ vs. $\delta^{13}C_{ap}$

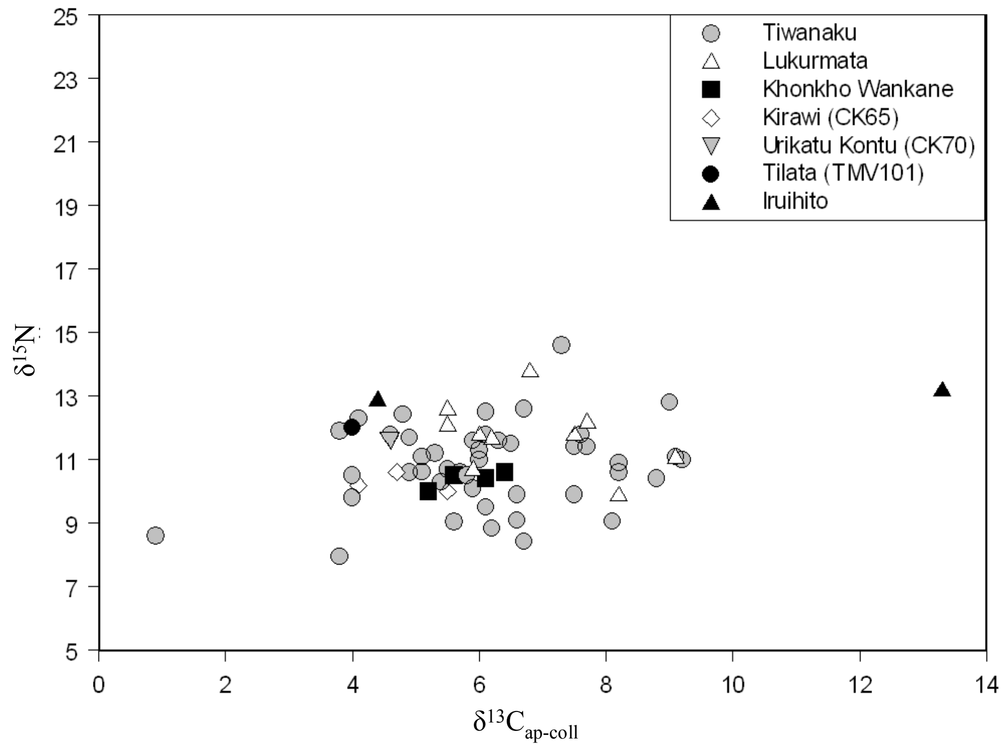

Figure 7.6 Isotopic values for Tiwanaku IV-V sites, $\delta^{15}N$ vs. $\delta^{13}C_{ap\text{-}coll}$

Tiwanaku

A total of 44 adult individuals from the Tiwanaku Period (Middle Horizon) occupation of Tiwanaku were analyzed, including 19 males, 15 females, and 10 individuals of unknown sex. I selected 36 of the samples, which were analyzed by Robert Tykot, and the remaining eight individuals were part of a preliminary study of altiplano diets undertaken by Paula Tomzcak as part of her dissertation (2001). Results for these eight individuals were also presented in a paper co-authored by Tomzcak and Berryman (Berryman et al. 2006). These data, with the permission of Tomzcak, are included in the statistical analyses presented below in order to maximize the sample size and strengthen my conclusions.

The mean $\delta^{13}C_{coll}$ value for Middle Horizon Tiwanaku inhabitants was -14.42 ± 3.14‰. This is significantly higher than Late Formative $\delta^{13}C_{coll}$ values at Tiwanaku. (Mann Whitney U test: z = -2.50, p = 0.01). The mean $\delta^{13}C_{ap}$ value, -8.30 ± 2.70‰, was

$\delta^{13}C$ values based on collagen alone underestimated the contribution of C_4 enriched resources to the overall diet. Values based on collagen estimated that, on average, 36.5 ± 10% of the overall diet during the Tiwanaku Period was composed of C_4 enriched resources while values derived from bone apatite estimated 48.7 ± 10% of the diet was composed of C_4 enriched resources. This discrepancy, in conjunction with the mean $\delta^{13}C_{ap\text{-}coll}$ value of -6.12 ± 1.67‰, is consistent with a diet in which the $\delta^{13}C$ value of dietary protein was more negative than the whole diet. In addition, results of a Spearman's Rho test for correlation revealed a significant negative correlation between $\delta^{15}N$ and $\delta^{13}C_{coll}$ (Rho = -0.30, p = 0.04) as well as $\delta^{15}N$ and $\delta^{13}C_{ap}$ (Rho = -0.34, p = 0.02). These correlations reveal that, in general, protein consumption decreased as C_4 consumption increased, indicating the C_4 resource was depleted in protein. Thus, all lines of evidence indicate that the primary source of C_4 enrichment at Tiwanaku during the Tiwanaku Period was maize.

The mean Tiwanaku Period $\delta^{15}N$ value, 10.83 ± 1.32‰, was only slightly elevated from the Late Formative mean and does not reflect any significant change in protein consumption.

Based on mean stable isotopic values, the average Tiwanaku Period diet at Tiwanaku consisted of carbohydrate resources that fall within both the C_3 (tubers, quinoa, amaranth, etc..) and C_4 (maize) ranges. On average, 48.7 ± 10% of the diet was composed of C_4 enriched resources—primarily maize and to a lesser extent, lake fish.

The diet was not particularly high in protein relative to other Middle Horizon altiplano sites. The primary protein resource appears to have been C_3 feeding herbivores, such as camelids, deer, and guinea pig, as well as some C_4 feeding lake fish. However, the most striking feature of Middle Horizon diets at Tiwanaku is the wide range of dietary variation among its inhabitants. The following section explores the potential source(s) of this variation.

Tiwanaku Intra-site Variation

In order to examine the relationship between diet and status at the site, as well as Kolata's contention that Tiwanaku's urban core was organized in concentric gradients of social status, I compared consumption patterns among adult individuals buried in various sectors of the site—including residential barrios (Akapana East, Chiji Jawira, La Karaña, Mollo Kontu Residential, and Putuni), ceremonial platforms (Akapana and Mollo Kontu Mound), and a probable cemetery (Markapata). Nitrogen and carbon stable isotope values from collagen for each sector are presented in Figure 7.7. Nitrogen and carbon isotope values derived from bone apatite for each sector are presented in Figures 7.8. Nitrogen stable isotopic values and collagen-apatite isotope spacing values are presented in Figure 7.9. Table 7.7 provides descriptive statistics for each sector and results of Mann Whitney U test statistics comparing the various sectors. Sectors that exhibit mean stable isotopic differences significant at the $p < 0.05$ level are highlighted.

Table 7.5 Descriptive statistics for all altiplano sites combined by Temporal Period

Site	$\delta^{13}C_{coll}$ Mean	s.d.	N	$\Delta^{13}C_{ap}$ Mean	s.d.	N	$\delta^{13}C_{coll-ap}$ Mean	s.d.	N	$\delta^{15}N$ Mean	s.d.	N
Late Formative	-18.09	1.15	15	-10.53	2.48	15	7.57	2.26	15	10.83	0.92	15
Tiwanaku IV-V (Mid. Horizon)	-14.91	3.02	65	-8.73	2.93	65	6.18	1.80	65	11.02	1.28	65
Post Tiwanaku (Pacajes)	-17.74	1.22	15	-11.71	2.10	15	6.03	2.21	15	13.15	1.38	15

Table 7.6 Mann-Whitney U test comparisons of Late Formative vs.Tiwanaku IV-V Period isotopic values at each site

Site	$\delta^{13}C_{co}$ LF Mean	TW Mean		$\delta^{13}C_{ap}$ LF Mean	TW Mean		$\Delta^{13}C_{co-ap}$ LF Mean	TW Mean		$\delta^{15}N$ LF Mean	TW Mean	
Tiwanaku N=3/44	-18.47	-14.42	**z=-2.50 p= 0.01**	-10.27	-8.30	z=-1.28 p= 0.20	8.20	6.12	**z=-2.09 p= 0.04**	10.17	10.83	z=-1.11 p= 0.27
Lukurmata N=4/10	-18.80	-16.87	**z=-2.13 p= 0.03**	-13.20	-10.03	**z=-2.83 p= 0.01**	5.60	6.84	z=-1.64 p= 0.10	10.88	11.77	z=-1.27 p= 0.20
Khonkho Wankani N=4/4	-18.05	-12.83	**z=-2.31 p= 0.02**	-9.93	-7.00	z=-1.73 p= 0.08	8.13	5.83	z=-1.73 p= 0.08	11.28	10.45	**z=-2.31 p= 0.02**
Kirawi (CK65) N=2/3	-16.95	-16.60	z=-0.30 p= 0.77	-10.90	-11.30	z=-0.58 p= 0.56	6.05	4.70	z=-0.58 p= 0.56	10.60	10.27	z= 0.01 p= 1.00

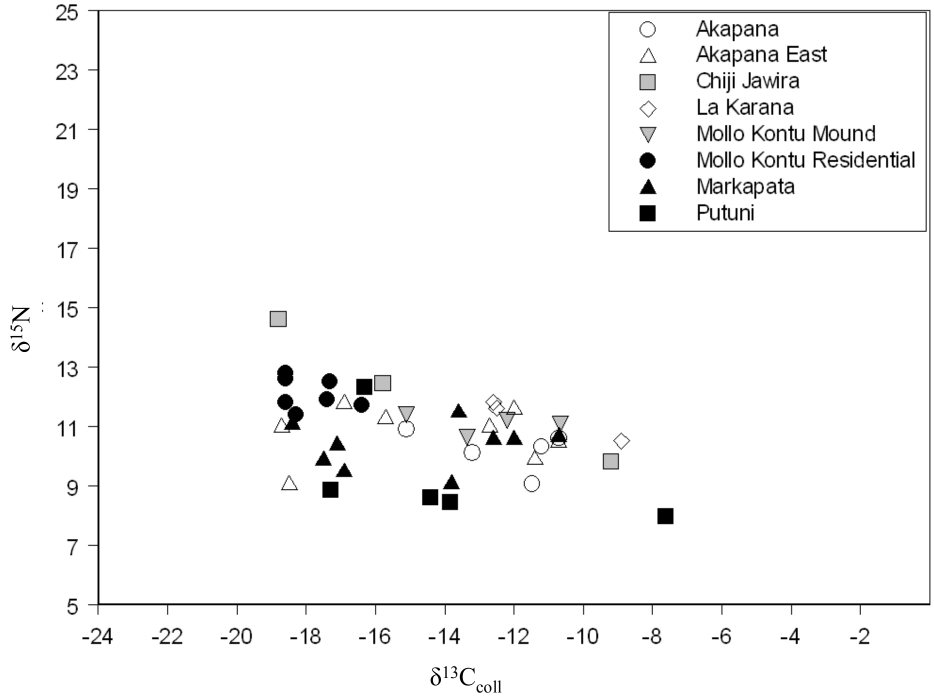

Figure 7.7 Isotopic values for Tiwanaku site sectors, $\delta^{15}N$ vs. $\delta^{13}C_{coll}$

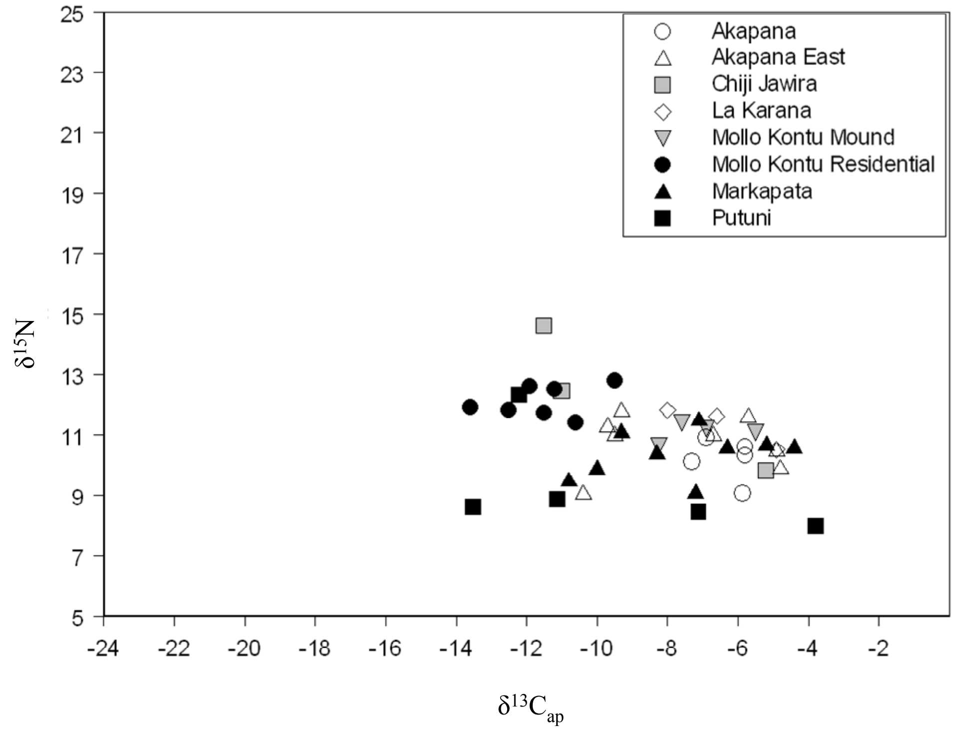

Figure 7.8 Isotopic values for Tiwanaku site sectors, $\delta^{15}N$ vs. $\delta^{13}C_{ap}$

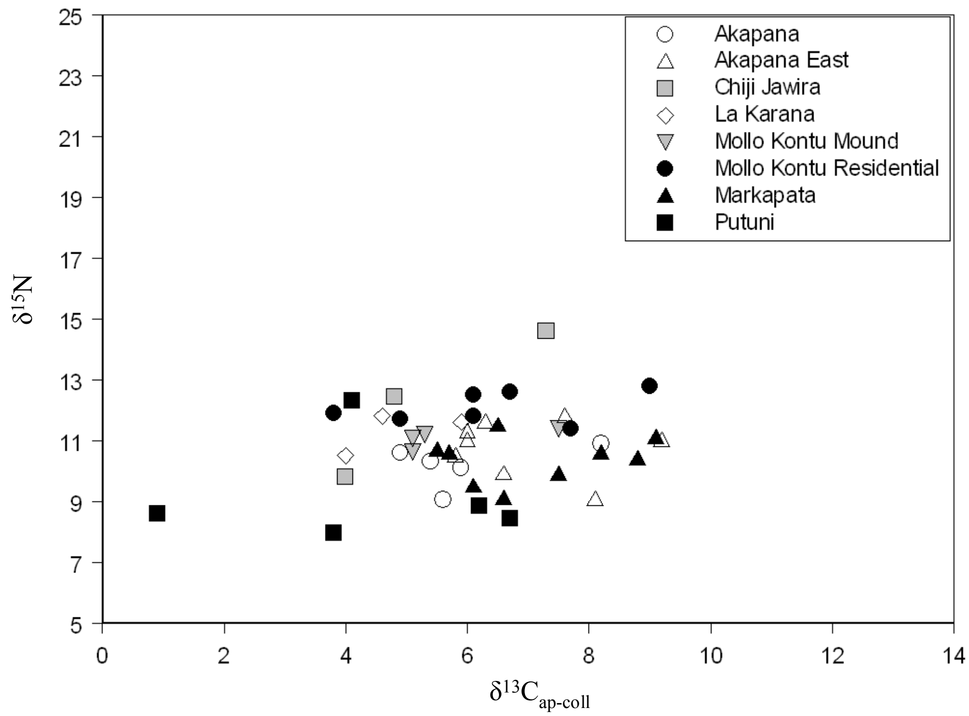

Figure 7.9 Isotopic values for Tiwanaku site sectors, $\delta^{15}N$ vs. $\delta^{13}C_{ap\text{-}coll}$

Table7.7 Descriptive statistics and Mann-Whitney U test comparisons of each sector at Tiwanaku

Site	N	Mean	SD	Akapana	Akapana East	Chiji Jawira	La Karaña	Mollo Kontu Res.	Mollo Kontu Mound	Markapata
(a) $\delta^{13}C_{co}$										
Akapana	5	-12.33	1.80							
Akapana East	8	-14.57	3.26	z=-1.17 P= 0.24						
Chiji Jawira	3	-14.59	4.91	z=-0.24 P= 0.46	z=-0.20 p= 0.84					
La Karaña	3	-11.33	2.11	z=-0.45 P= 0.66	z=-1.22 p= 0.22	z=-1.09 P= 0.28				
Mollo Kontu Res.	7	-17.89	0.86	**z=-2.86** **P= 0.01**	z=-1.86 p= 0.06	z=-0.81 P= 0.42	**z=-2.42** **P= 0.02**			
Mollo Kontu Mound	4	-12.83	1.87	z=-0.37 P= 0.71	z=-0.85 p= 0.40	z=-0.71 P= 0.48	z=-0.71 P= 0.48	**z=-2.67** **p= 0.01**		
Markapata	9	-14.73	2.78	z=-1.60 P= 0.11	z=-0.19 p= 0.85	z=-0.09 P= 0.93	z=-1.67 P= 0.10	**z=-2.39** **p= 0.02**	z=-1.23 p= 0.22	
Putuni	5	-13.89	3.77	z=-1.15 P= 0.25	z=-1.15 p= 0.88	z=-0.45 P= 0.66	z=-1.34 P= 0.18	**z=-2.70** **p= 0.01**	Z=-0.98 p= 0.33	z=-0.07 p= 0.95
(b) $\delta^{13}C_{ap}$										
Akapana	5	-6.33	0.71							
Akapana East	8	-7.62	2.34	z=-0.44 p= 0.66						
Chiji Jawira	3	-9.23	3.50	z=-0.75 p= 0.45	z=-1.23 p= 0.22					
La Karaña	3	-6.50	1.55	z=-0.15 p= 0.88	z=-0.72 p= 0.47	z=-1.09 p= 0.28				
Mollo Kontu Res.	7	-11.54	1.32	**z=-2.85** **p= 0.01**	**z=-2.95** **p= 0.01**	z=-1.14 p= 0.25	**z=-2.39** **p= 0.02**			
Mollo Kontu Mound	4	-7.06	1.17	z=-0.87 p= 0.38	z=-0.34 p= 0.73	z=-0.71 p= 0.48	z=-0.71 p= 0.48	**z=-2.65** **p= 0.01**		
Markapata	9	-7.62	2.16	z=-1.14	z=-0.05	z=-1.11	z=-0.83	**z=-3.02**	z=-0.04	

				p= 0.26	p= 0.96	p= 0.26	p= 0.41	**p= 0.01**	p= 0.64	
Putuni	5	-9.54	4.01	z=-1.36	z=-1.17	z=-0.45	z=-1.04	z=-0.73	z=-0.98	z=-1.13
				p= 0.17	p= 0.24	p= 0.66	p= 0.30	p= 0.47	p= 0.33	p= 0.26
(c) $\delta^{13}C_{co\text{-}ap}$										
Akapana	5	6.00	0.28							
Akapana East	8	6.95	1.22	z=-1.76						
				p= 0.08						
Chiji Jawira	3	5.37	1.72	z=-1.04	z=-1.43					
				p= 0.30	p= 0.15					
La Karaña	3	4.83	0.97	z=-1.20	**z=-2.25**	z=-0.44				
				p= 0.23	**p= 0.02**	p= 0.66				
Mollo Kontu	7	6.30	1.72	z=-0.65	z=-0.46	z=-0.80	z=-1.49			
Res.				p= 0.51	p= 0.64	p= 0.42	p= 0.14			
Mollo Kontu	4	5.75	1.17	z=-0.74	z=-1.88	z=-1.07	z=-1.07	z=-0.57		
Mound				p= 0.46	p= 0.061	p= 0.29	p= 0.29	p= 0.57		
Markapata	9	7.11	1.34	z=-1.74	z=-0.15	z=-1.57	**z=-2.13**	z=-0.80	**z=-1.93**	
				p= 0.08	p= 0.89	p= 0.12	**p= 0.03**	p= 0.43	**p= 0.05**	
Putuni	5	4.34	2.30	z=-0.94	z=-1.76	z=-0.75	z=-0.15	z=-1.22	z=-0.98	**z=-1.93**
				p= 0.35	p= 0.08	p= 0.46	p= 0.88	p= 0.22	p= 0.33	**p= 0.05**
(d) $\delta^{15}N$										
Akapana	5	10.19	0.71							
Akapana East	8	10.77	0.92	z=-1.47						
				p= 0.14						
Chiji Jawira	3	12.28	2.40	z=-1.04	z=-1.02					
				p= 0.30	p= 0.31					
La Karaña	3	11.30	0.70	z=-1.64	z=-0.93	z=-0.66				
				p= 0.10	p= 0.35	p= 0.51				
Mollo Kontu	7	12.10	0.53	**z=-2.84**	**z=-2.84**	z=-0.11	z=-1.60			
Res.				**p= 0.01**	**p= 0.01**	p= 0.91	p= 0.11			
Mollo Kontu	4	11.07	0.34	**z=-2.21**	z=-0.51	z=-0.71	z=-0.71	**z=-2.56**		
Mound				**p= 0.03**	p= 0.61	p= 0.48	p= 0.48	**p= 0.01**		
Markapata	9	10.38	0.76	z=-0.60	z=-1.01	z=-1.20	z=-1.57	**z=-3.23**	z=-1.70	
				p= 0.55	p= 0.31	p= 0.23	p= 0.12	**p= 0.01**	p= 0.09	
Putuni	5	9.22	1.75	z=-1.57	z=-1.76	**z=-1.94**	z=-1.34	**z=-2.19**	z=-1.47	z=-1.80
				p= 0.12	p= 0.08	**p= 0.05**	p= 0.18	**p= 0.03**	p= 0.14	p= 0.07

Table 7.8 Descriptive statistics and Mann-Whitney U test results comparing isotopic values between the sexes at Tiwanaku after separating by sector.

		Male			Female		Mann-Whitney U	
Sample	**N**	**Mean**	**s.d.**	**N**	**Mean**	**s.d.**	**z**	**p**
$\delta^{13}C_{coll}$								
Akapana	3	-13.00	2.21	1	-11.20	-	-0.45	0.66
Akapana East	0	-	-	2	-13.55	3.04	-	-
Chiji Jawira	0	-	-	1	-15.78	-	-	-
La Karana	2	-10.75	2.62	0	-	-	-	-
Mollo Kontu Res.	3	-17.43	1.11	2	-18.45	0.21	-0.89	0.37
Mollo Kontu Mound	0	-	-	2	-12.78	0.82	-	-
Markapata	4	-13.83	3.28	4	-15.88	2.60	-0.58	0.56
Putuni	3	-11.95	3.76	2	-16.80	0.70	-1.73	0.08
$\delta^{13}C_{ap}$								
Akapana	3	-6.67	0.78	1	-5.80	-	-0.94	0.35
Akapana East	0	-	-	2	-7.25	3.46	-	-
Chiji Jawira	0	-	-	1	-10.99	-	-	-
La Karana	2	-6.45	2.19	0	-	-	-	-
Mollo Kontu Res.	3	-11.53	0.35	2	-11.55	1.34	0.01	1.00
Mollo Kontu Mound	0	-	-	2	-7.57	0.95	-	-
Markapata	4	-6.50	2.18	4	-8.85	1.99	-1.44	0.15
Putuni	3	-8.13	4.94	2	-11.66	0.76	-0.58	0.56
$\delta^{13}C_{coll-ap}$								
Akapana	3	6.33	1.69	1	5.40	-	-0.45	0.66
Akapana East	0	-	-	2	6.30	0.42	-	-
Chiji Jawira	0	-	-	1	4.80	-	-	-
La Karana	2	4.30	0.42	0	-	-	-	-
Mollo Kontu Res.	3	5.90	0.92	2	6.90	1.13	-0.89	0.37
Mollo Kontu Mound	0	-	-	2	5.20	0.14	-	-
Markapata	4	7.33	1.63	4	7.03	1.41	-0.29	0.77
Putuni	3	3.80	2.90	2	5.15	1.48	-0.58	0.56
$\delta^{15}N$								
Akapana	3	10.53	0.40	1	10.30	-	-0.45	0.66
Akapana East	0	-	-	2	10.60	0.99	-	-
Chiji Jawira	0	-	-	1	12.43	-	-	-
La Karana	2	11.15	0.91	0	-	-	-	-
Mollo Kontu Res.	3	12.26	0.49	2	11.60	0.28	-1.16	0.28
Mollo Kontu Mound	0	-	-	2	10.91	0.42	-	-
Markapata	4	10.98	0.41	4	10.10	0.50	**-2.18**	**0.03**
Putuni	3	8.33	0.33	2	10.57	2.45	-1.73	0.08

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It is apparent in Figure 7.8 and given the lower standard deviations of the mean $\delta^{13}C_{ap}$ and $\delta^{15}N$ values that the diets of individuals buried in the Akapana, La Karaña, Mollo Kontu mound, and Mollo Kontu residential areas cluster by sector, indicating that individuals buried in these sectors likely came from similar social or ethinc groups. The five individuals buried in the Akapana mound, the most prominent feature of Tiwanaku's ceremonial core, had the highest mean $\delta^{13}C_{ap}$ value of any sector, -6.33 ± 0.71‰, indicating that these individuals, on average, consumed the most C_4 enriched resources (an average 61.8 ± 10% of the overall diet) relative to other Tiwanaku residents. In addition, there is very little variation in $\delta^{13}C_{ap}$ values (s.d. = 0.71). The mean $\delta^{13}C_{coll-ap}$ for Akapana individuals, 6.00 ± 0.28‰, indicates that the primary C_4 enriched resource being consumed was a protein depleted resource such as maize. However, variation in the C_4 source is apparent. Individuals with relatively low $\delta^{13}C_{co-ap}$ values (e.g. AK-21264, $\delta^{13}C_{co-ap}$ = 4.9‰) indicate that fish were a more significant proportion of the C_4 dietary component for some individuals, but overall, maize appears to be the primary source of C_4 enrichment. The mean nitrogen stable isotope value for Akapana individuals, 10.19 ± 0.71‰, was the second to the lowest of any Tiwanaku sector, indicating less consumption of protein resources relative to other residents. When compared to both the Mollo Kontu Mound and Mollo Kontu residential area, this difference is significant ($z = -2.21$, $p = 0.03$ and $z = -2.84$, $p = 0.01$ respectively).

The three residents of La Karaña, a residential compound on the northern edge of the moat defining Tiwanaku's ceremonial core, had $\delta^{13}C_{ap}$ and $\delta^{15}N$ values very similar to those buried in the Akapana. However, these individuals had a low mean $\delta^{13}C_{co-ap}$ spacing value, 4.83 ± 0.97‰, indicating that although a great deal of the diet was composed of C_4 enriched resources (60.7% of the overall diet), those resources included a significant proportion of C_4 enriched fish. However, maize was clearly present, given that the $\delta^{13}C_{co-ap}$ spacing value is slightly greater than 4.4‰, but was not a major component of the diet. This is consistent with the paleobotanical evidence of maize ubiquity and density provided by Wright et al. (2000), which revealed La Karaña had the lowest maize density of any residential compound at Tiwanaku.

The four individuals buried in the Mollo Kontu mound, a small ceremonial mound to the south of the moat defining Tiwanaku's core, also had $\delta^{13}C_{ap}$ and $\delta^{15}N$ values very similar to Akapana and La Karaña individuals. The mean $\delta^{13}C_{ap}$ value was -7.06 ± 1.17‰, indicating that, on average, 56.9 ± 10% of the overall diet was composed of C_4 enriched resources. Similar to Akapana individuals, the mean $\delta^{13}C_{co-ap}$ spacing value, 5.75 ± 1.17‰, was relatively high indicating that the bulk of the C_4 resources being consumed consisted of a protein depleted resource such as maize and to a lesser extent C_4 enriched fish. However, the mean $\delta^{15}N$ value ($\delta^{15}N$ = 11.07 ± 0.34‰) was significantly higher than that of Akapana individuals, which in conjunction with the carbon isotope data, indicate greater consumption of protein resources such as camelids, deer, and guinea pig[40].

The Mollo Kontu residential sector of the site is well outside Tiwanaku's ceremonial core and south of the Mollo Kontu Mound. The seven individuals analyzed from this area of the site had significantly different diets relative to all other sectors. First, the mean $\delta^{13}C_{ap}$ value, -11.54 ± 1.32‰, is by far the lowest of any sector. This difference is significant when compared to all other sectors with the exception of Chiji

[40] If fish consumption were primarily responsible for the inflated $\delta^{15}N$ values, one would expect to see inflated $\delta^{13}C_{ap}$ values and lower $\delta^{13}C_{co-ap}$ spacing values indicative of greater fish consumption.

Jawira and Putuni[41] (see Table 7.7). C_4 resources constituted approximately 27.1 ± 10% of the diet for Mollo Kontu residents, which is not an insignificant proportion of the diet, but is clearly much less than seen in other sectors. $\delta^{13}C_{co-ap}$ spacing values are quite varied (mean $\delta^{13}C_{co-ap}$ = 6.30 ± 1.72‰) and although the bulk of the C_4 enrichment appears to come from a protein depleted resources such as maize, C_4 enriched fish were consumed in more significant quantities by some residents (e.g. MK-890). Second, the mean $\delta^{15}N$ value for Mollo Kontu residents ($\delta^{15}N$ = 12.10 ± 0.53‰) was significantly higher when compared to all other sectors, with the exceptions of Chiji Jawira and La Karaña (see Table 7.7). Thus, relative to residents living in most other sectors of Tiwanaku, individuals buried in the Mollo Kontu residential area had significantly less access to imported resources such as maize and were more heavily dependent on local C_3 crops, such as tubers and quinoa. In addition, Mollo Kontu residents were consuming significantly more meat than most other residents, primarily derived from C_3 feeding terrestrial herbivores such as camelids and to a lesser extent fish.

Only the Chiji Jawira sector of Tiwanaku had isotopic values similar to those of the Mollo Kontu residential area. Chiji Jawira is located on the eastern edge of Tiwanaku and is also well outside the ceremonial core. Only three individuals dating to the Middle Horizon were available for isotopic analysis. The mean $\delta^{13}C_{ap}$ value for Chiji Jawira was -9.23 ± 3.50‰, the third most negative of all Tiwanaku sectors however, given the large range of variation, this value was not statistically significant when compared with other sectors. The large standard deviation is a result of one individual, a probable male (CJ-36980), who was consuming large amounts of C_4 enriched fish, as evidenced by the

[41] The mean Mollo Kontu residential $\delta^{13}C_{ap}$ value is still notably lower than that of Chiji Jawira and Putuni, however, given the large standard of deviation for the $\delta^{13}C_{ap}$ values of these two sectors, the differences are not statistically significant.

much more positive $\delta^{13}C_{ap}$ values ($\delta^{13}C_{ap}$ = -5.2) and very low $\delta^{13}C_{co\text{-}ap}$ spacing value ($\delta^{13}C_{co\text{-}ap}$ = 4.0). These values indicate approximately 69.3 ± 10% of this individual's diet was derived from a C_4 enriched resource. Results for two other individuals, a female and an adult of unknown sex (CJ-33605 and CJ-35250), revealed similar $\delta^{13}C_{ap}$ values averaging -11.20‰. These values are very similar to those obtained for individuals from the Mollo Kontu residential area and indicate approximately 29 ± 10% of the overall diet was derived from a C_4 enriched resource, which, given the variable $\delta^{13}C_{co\text{-}ap}$ spacing values, was a result of both maize and fish consumption.

The mean $\delta^{15}N$ value for Chiji Jawira, 12.28 ± 2.40‰, was the highest of all Tiwanaku sectors, indicating substantial consumption of C_3 feeding herbivores such as camelids and to a lesser extent fish. This difference was statistically significant when compared with the Putuni sector of the site ($z = 1.94$, $p = 0.05$). However, given the large standard deviation, it is difficult to generalize about protein consumption among Chiji Jawira residents.

Like Chiji Jawira, isotopic results for the Akapana East, Markapata and Putuni sectors of Tiwanaku lacked the homogeneity seen within the Akapana, La Karaña, Mollo Kontu residential and Mollo Kontu Mound sectors. The eight individuals analyzed from the Akapana East 1, a group of residential compounds just within the western bounds of the moat defining Tiwanaku's ceremonial core, had a mean $\delta^{13}C_{ap}$ value of -7.62 ± 2.34‰, indicating that, on average, 53.3 ± 10% of the diet was composed of C_4 enriched resources. However, there is a relatively large range of variation among these individuals that can clearly be seen in Figure 7.8. Comparison of the $\delta^{13}C_{ap}$ values and $\delta^{13}C_{co\text{-}ap}$ spacing values for each individual provides some explanation for the large standard deviation in $\delta^{13}C_{ap}$ values. The four individuals with more positive $\delta^{13}C_{ap}$ values are associated with significantly lower $\delta^{13}C_{co\text{-}ap}$ spacing values (averaging 6.20‰) while those with more negative $\delta^{13}C_{ap}$ values are associated with higher $\delta^{13}C_{co\text{-}ap}$ spacing values[42] (averaging 8.30‰). This indicates that the four with more positive $\delta^{13}C_{ap}$ values and lower $\delta^{13}C_{co\text{-}ap}$ spacing values (i.e. closer to 4.4‰), were consuming more fish than the other individuals. However, for each group, $\delta^{13}C_{co\text{-}ap}$ spacing values remain well above 4.4‰, indicating that the primary C_4 enriched resource being consumed was protein depleted---i.e maize. In fact, the mean $\delta^{13}C_{co\text{-}ap}$ spacing value for all Akapana East individuals combined is 6.95 ± 1.22‰, the highest of all Tiwanaku sectors, with the exception of Markapata.

The mean $\delta^{15}N$ value for Akapana East individuals, 10.77 ± 0.92‰, is relatively low and exhibits little variation. It is most similar to results obtained for Mollo Kontu Mound and Markapata, reflecting moderate consumption of C_3 feeding herbivores such as camelids, deer, and guinea pig.

In general, the diet of individuals buried in association with the Akapana East 1 residential sector was based on local C_3 plants, such as tubers and quinoa, as well as consumption of C_3 feeding herbivores (i.e. camelids, guinea pig, deer, etc..) and highly variable amounts of lake fish. However, the data also clearly reflect the consumption of large amounts of a protein depleted C_4 enriched resource---maize. After accounting for the variable consumption of C_4 enriched fish, I estimate that maize accounted for 30-50% of the overall diet among Akapana East residents. These individuals clearly had much more access to maize relative to individuals associated with residential compounds outside the ceremonial core of the site (i.e. Mollo Kontu, Chiji Jawira, and La Karaña).

[42] AKE-20715 is an exception to this pattern.

This observation is consistent with Janusek's assertion that portions of the Akapana East 1 were used for large scale production and storage of *chicha* for elite sponsored ceremonies (Janusek 2003: 292). In addition, Wright and colleagues (2003: 397) reported the Akapana East 1 had the highest maize kernel-to-cob ratio of any Tiwanaku sector, lending support to the idea that maize was imported in large quantities (off the cob) and provisioned to retainers residing in compounds such as the Akapana East, who produced *chicha* for elite patrons.

The Markapata sector of Tiwanaku sits on a hill to the east of the ceremonial core of the site, between the Akapana East 2 and Chiji Jawira. No residential architecture was found in this area however, excavations by Martìn Giesso uncovered more than twenty tombs dating to the Late Formative and Tiwanaku IV-V periods (pers. comm. M. Giesso 2010). Thus, it is believed the area was used as a cemetery during this time. Nine individuals dating to the Middle Horizon were analyzed from this sector. Interestingly, results are almost identical to those obtained for the nearby Akapana East 1 (see Table 7.7). The mean $\delta^{13}C_{ap}$ values, -7.62 ± 2.16‰, indicates that 53.3 ± 10% of the diet was composed of a C_4 enriched resource. As at Akapana East 1, the standard deviation is relatively large, indicating significant variation in C_4 resource consumption ($\delta^{13}C_{ap}$ range: -4.4 to -10.8‰). Unlike Akapana East, no clear relationship between maize vs. fish consumption could account for the variation. However, the mean $\delta^{13}C_{co\text{-}ap}$ spacing value, 7.11 ± 1.33‰, is the highest of all Tiwanaku sectors, indicating that the primary C_4 resource being consumed was protein depleted---i.e. maize. In fact, several individuals (MP-247, MP-41523-2, and MP-230) have $\delta^{13}C_{co\text{-}ap}$ spacing values well above 8‰, indicating that the C_4 resource was almost exclusively maize. MP-247, a 25-

40 year old male, had a $\delta^{13}C_{ap}$ value of -4.4‰ and a high $\delta^{13}C_{co\text{-}ap}$ spacing value of 8.2‰, indicating that a staggering 64-84% of his overall diet was composed of maize.

The mean $\delta^{15}N$ value for Markapata individuals, 10.38 ± 0.76‰, was low relative to most other Tiwanaku sectors and varied little (only Akapana and Putuni are lower), indicating less consumption of protein resources. This value is statistically significant when compared to high $\delta^{15}N$ values of Mollo Kontu residential individuals ($z = 3.23$, $p = 0.01$). Thus, according to both $^{13}C_{ap}$ and ^{15}N data, Markapata individuals appear most similar to those buried in the Akapana East 1 sector. Given the proximity of the two sectors, it is plausible that individuals from the Akapana East 1 were buried in the Markapata mortuary area. Besides the dietary data, the lack of burial offerings, with some exceptions, is consistent in both sectors. However, it is not clear why some individuals would be buried within the residential area while others were buried in a separate mortuary space. Demographics of the two burial populations offer no clues, as each contains a representative cross-section of society. Temporal differences that cannot be separated by ceramic chronologies may explain the variation in burial customs.

Markapata is the only sector of Tiwanaku that revealed a statistically significant difference in male and female diets, with males having a mean $\delta^{15}N$ value of 10.98 ± 0.41‰ and females having a mean $\delta^{15}N$ value of 10.10 ± 0.50‰ (see Table 7.8). This difference is statistically significant ($z = -2.18$, $p = 0.03$) level and indicates that, at least among Markapata individuals, males consumed significantly more protein than females.

Finally, in the heart of the ceremonial center of Tiwanaku, the elite Putuni residential complex (a.k.a. the Putuni Palace) sits adjacent to the western wall of the Kalassasaya. The remains of five adult individuals from this sector were available for isotopic analysis. These burials were interpreted by Couture and Sampeck (2003) to represent dedicatory offerings associated with the razing of earlier Putuni structures late in the Tiwanaku IV period. Many were incomplete burials lying in drainage canals or directly on the exterior surface. The mean $\delta^{13}C_{ap}$ value for Putuni individuals is -9.54 ± 4.01‰, the second lowest of any Tiwanaku sector although, given the large standard deviation (the largest of any sector), this value is not particularly meaningful, as C_4 consumption varied widely among these individuals. $\delta^{13}C_{ap}$ values range from -3.8‰ (PUT-22794) to -13.5‰ (PUT-25940-1). With a mean of 4.34 ± 2.30‰, $\delta^{13}C_{co\text{-}ap}$ spacing values were also the most varied of any sector, indicating that the source of C_4 enrichment varied considerably among individuals.

$\delta^{15}N$ values for Putuni residents are particularly intriguing. The mean $\delta^{15}N$ value, 9.22 ± 1.75‰ is by far the lowest of any Tiwanaku sector and, as Figure 7.8 illustrates, four Putuni individuals with particularly low $\delta^{15}N$ values (PUT-22794, PUT-24106, PUT-25785-1, PUT-25940-1) appear as anomalies within the altiplano sample, indicating either the least protein consumption of all altiplano residents or consumption of non-local protein resources with lower nitrogen values. Recent strontium isotope analysis for some of these individuals by Kelly Knudson confirm the later to be true (Berryman et. al. 2008; results from a smaller study are presented in Knudson et al. 2004). Knudson revealed $^{87}Sr/^{86}Sr$ values for PUT-24106, PUT-25785-1, and PUT-25940-1 that indicate these individuals were not local to the altiplano[43]. Knudson also obtained non-local $^{87}Sr/^{86}Sr$ values for two other Putuni individuals for whom I do not have complimentary ^{13}C and ^{15}N isotope data. In contrast, the $^{87}Sr/^{86}Sr$ signature of PUT-20995, the Putuni individual with the highest $\delta^{15}N$ value (12.3‰), is well within the local range. Thus, in the absence

[43] PUT-22794 was not tested by Knudson.

of $^{87}Sr/^{86}Sr$ isotope data, this research indicates that low $\delta^{15}N$ values can provide some insight into residential mobility within the altiplano. Individuals with $\delta^{15}N$ values less than approximately 9‰ are suspected of being immigrants to the altiplano. Such values are more typical of mid valley inhabitants with little or no access to marine or altiplano resources. This is the situation Tomzcak (2001: 135) describes for Chen Chen however, Chen Chen's mean $\delta^{15}N$ value, 6.9‰, is considerably lower than the mean obtained for the non-local Putuni inhabitants (8.5‰) and the $^{87}Sr/^{86}Sr$ isotope signatures for Chen Chen reported by Knudson and colleagues (2004) are not consistent with values obtained for non-local Putuni individuals.

Interestingly, the non-local Putuni individuals include three males and a child left lying on patio surfaces, in drainage canals, with no burial offerings, and covered by construction fill associated with kitchen construction. The remains of a non-local female were also found but, under the "palace" and with burial offerings. Non-local females and children were also found in the Akapana and Mollo Kontu Mound (Berryman et al. 2008). These data may indicate higher status among non-local females and certain children relative to males and other children. Understanding these discrepancies and determining the geologic source of foreign strontium signatures are the focus of ongoing collaboration with Kelly Knudson.

Lukurmata

Ten adult individuals from the Middle Horizon occupation at Lukurmata were analyzed, including four males, one probable male, and five females. The mean $\delta^{13}C_{ap}$ value increased from the Formative period mean of -13.20 ± 0.67 to -10.03‰ ± 2.74‰, this increase is significant ($z = -2.83$, $p = 0.01$) and indicates that 37.1 ± 10% of the average diet now consisted of C_4 enriched resources. The larger standard deviation of the mean $\delta^{13}C_{ap}$ value also indicates greater variation in access to C_4 enriched resources. In addition, the mean $\delta^{13}C_{ap\text{-}coll}$ value increased from the Formative period mean of 5.60 ± 1.03‰ to 6.84 ± 1.23‰. Although not a statistically significant increase, it does indicate that more of the C_4 enrichment now came from a protein depleted resource such as maize. In fact, with the exception of Iruihito, Lukurmata's mean $\delta^{13}C_{ap\text{-}coll}$ value is higher than any other Middle Horizon site tested. No Middle Horizon Lukurmata individual had a $\delta^{13}C_{ap\text{-}coll}$ value lower than 5.5‰. So, although Lukurmata individuals, on average, were still not consuming C_4 enriched resources as much as inhabitants at Tiwanaku, Khonkho Wankane, or Iruihito, it is clear that maize was now entering the site in substantially larger quantities than was seen in the Late Formative period.

The mean $\delta^{15}N$ value for Lukurmata inhabitants also increased from 10.88 ± 1.51‰ in the Late Formative period to 11.77 ± 1.06‰ in the Middle Horizon. This increase is not statistically significant but does suggest increased meat consumption. Lukurmata's mean $\delta^{15}N$ value is significantly higher than Tiwanaku ($z = -2.25$, $p = 0.02$), Khonkho Wankane ($z = -2.27$, $p = 0.02$), and Kirawi ($z = -2.03$, $p = 0.04$) and, when combined with the decreasing evidence of fish consumption provided by the carbon isotope data, is explained by an increase in consumption of C_3 feeding herbivores. This is surprising given Lukurmata's proximity to the lake but, very consistent with faunal data reported by Bermann (1994; also see Webster and Janusek 2003). Bermann reported a significant decrease in the representation of bird bones in Lukurmata's domestic refuse, primarily lake and shore fowl, and an increase in camelid remains beginning in the

Tiwanaku III period and continuing through the Middle Horizon (1994:117 and Appendix II). Bermann suggests that raised field construction begun during this time may have disrupted lake habitats, resulting in greater competition among Pampa Koani inhabitants for dwindling littoral and lacustrine resources. However, subsequent dating of ancient raised fields by Janusek and Kolata (2004: 420) indicates that large-scale raised field construction did not begin until at least Tiwanaku IV. Bermann (1994) also acknowledges the possibility that lake levels may have dropped during this period, moving the shoreline much further away. Bandy (2005) describes a dramatic lowering of Lake Wiñaymarka during the Late Formative 1b (100-300 A.D.)[44] that would have moved the shoreline several kilometers away from Lukurmata but, this does not explain why exploitation of lacustrine resources did not resume once the lake rose after 300A.D.

Overall, Middle Horizon diets at Lukurmata became more varied with increased access to imported maize, decreased dependence on lacustrine resources, increased consumption of C_3 feeding protein resources (i.e. camelids, deer, guinea pig, etc…), and a continued reliance on local C_3 staples such as tubers and quinoa. Intra-site dietary variation increased, with some individuals consuming substantially more maize than the general population (e.g. LKM-7379, LKM-6625). This variation is not attributable to sex-based differences (see Table 7.8) and seems more likely related to growing social divisions as the site expanded during the early Middle Horizon.

Khonkho Wankane

Four adult individuals from the Middle Horizon occupation of Khonkho Wankane were analyzed, including two females, one probable male, and an adult of unknown sex.

[44] The Formative Period sample from Lukurmata predates this lake level drop.

The mean $\delta^{13}C_{ap}$ value increased from the Late Formative value of -9.93 ± 1.88‰ to -7.00 ± 2.65‰. Although this difference is not statistically significant, it does indicate an increase in the consumption of C_4 enriched resources such that they now composed 57.3 ± 10% of the average diet. This represents an increase of approximately 20% from the Late Formative. This is most similar to the mean $\delta^{13}C_{ap}$ values reported for Tiwanaku and Iruihito during this period, with all three having significantly more positive values than any Katari or Tiwanaku valley rural sites. An additional similarity to Tiwanaku is that although $\delta^{13}C_{ap}$ values increased during the Middle Horizon, $\delta^{13}C_{ap\text{-}coll}$ values decreased to -5.83 ± 0.53‰, indicating an increasing proportion of C_4 enrichment was now coming from a protein rich resource---i.e. fish. In addition, the standard deviation of $\delta^{13}C_{ap\text{-}coll}$ values also dropped, indicating less variation in the proportion of maize vs. fish that constituted the C_4 enriched portion of individual diets. However, as at Tiwanaku, it is clear that maize continued to be the primary source of C_4 enrichment, as the $\delta^{13}C_{ap\text{-}coll}$ value is still well above 4.4‰.

The mean $\delta^{15}N$ value at Khonkho Wankane decreased from the Late Formative mean of 11.28 ± 0.51‰ to10.45 ± 0.26‰. This difference is statistically significant ($z = -2.31$, $p = 0.02$) and may reflect a decreased reliance on C_3 feeding terrestrial herbivores as a protein source. As in the Late Formative, there remains little variation in $\delta^{15}N$ values, indicating that Khonkho Wankane inhabitants had similar access to protein resources. Khonkho's mean $\delta^{15}N$ value is relatively low compared to other Middle Horizon sites; however, this difference is only statistically significant when compared to Lukurmata ($z = -2.03$, $p = 0.02$).

In general, Middle Horizon diets at Khonkho Wankane continued to rely heavily on local C_3 carbohydrate resources, such as tubers and quinoa. However, maize was now entering the site in greater quantities and variation in access to it is apparent in the data. This variation is not attributable to sex-based dietary differences (see Table7.3) and, given the small sample size, it is difficult to ascertain what other factors may have contributed to the variation. Protein resources now included more C_4 enriched fish and/or legumes and fewer terrestrial herbivores. These data may reflect a decreasing emphasis on pastoral pursuits at the site during this period and increased utilization of local marsh resources.

Kirawi (CK65)

Three individuals from the Middle Horizon occupation of Kirawi were analyzed, including one female and two males. No statistically significant changes in diet occurred from the Late Formative to the Middle Horizon. The mean $\delta^{13}C_{ap}$ value increased slightly to -11.30 ± 0.38‰, indicating that, although local C_3 resources composed the bulk of the diet, on average, 28.7 ± 10% of the diet was now composed of C_4 enriched resources. However, this may reflect an increase in fish rather than maize consumption, as the mean $\delta^{13}C_{ap\text{-}coll}$ value dropped to 4.70 ± 0.41‰, indicating that a greater proportion of C_4 enrichment was now derived from a protein rich resource. Overall, consumption of C_4 enriched resources was significantly lower than at Tiwanaku, Lukurmata, Khonkho Wankane, and Iruihito. This difference was statistically significant when compared to Khonkho Wankane ($z = -1.96$, $p = 0.05$).

The mean $\delta^{15}N$ value decreased slightly to 10.27 ± 0.31‰, now the lowest of any site. This may indicate inhabitants were consuming fewer terrestrial herbivores and were more reliant on C_4 enriched fish as a protein resource, a scenario supported by the carbon isotope values.

In general, Kirawi inhabitants had relatively homogenous diets (see the low standard deviations for mean isotopic values in Table 7.4) heavily reliant on local C_3 carbohydrate resources, such as tubers and quinoa, and a mixture of C_4 enriched fish and terrestrial herbivores for a protein resource. The mean $\delta^{13}C_{ap\text{-}coll}$ value is 0.3‰ above 4.4‰, indicating that imported maize was consumed by Kirawi inhabitants, but in very small quantities relative inhabitants at urban centers (i.e. Tiwanaku and Lukurmata) and Desaguadero valley sites. Thus, the diet of rural Katari valley residents did not change significantly following the rise of Tiwanaku (also see similar results for Urikatu Kontu below).

Iruihito

The remains of two adults of unknown sex from the Middle Horizon occupation of Iruihito were available for analysis. Due to the small size of Late Formative and Middle Horizon Iruihito samples, statistical comparison of the temporal periods was not informative. The mean $\delta^{13}C_{ap}$ value, -6.65 ± 6.01‰, was very similar to the Late Formative mean and indicates that an average of 59.3 ± 10% of the overall diet for these two individuals consisted of C_4 enriched resources. This is the highest mean $\delta^{13}C_{ap}$ value for any Middle Horizon site, however, unlike the Late Formative period individuals, the Middle Horizon inhabitants of Iruihito obtained their C_4 enrichment from very different sources. A very high $\delta^{13}C_{ap\text{-}coll}$ value for IR-5.1r6 ($\delta^{13}C_{ap\text{-}coll}$ = 13.3‰) indicates that this individual obtained C_4 enrichment exclusively from a protein depleted resources (i.e. maize) and in fact, an astounding 88 ± 10% of this individual's diet came from maize---the highest of any Middle Horizon individual. This individual consumed very little local C_3 carbohydrate resources. In contrast to all others recovered from Iruihito in either the Late Formative or Middle Horizon Periods, a very low $\delta^{13}C_{ap\text{-}coll}$ value for IR-5.2r5 ($\delta^{13}C_{ap\text{-}coll}$ = 4.4‰) indicates that this individual obtained C_4 enrichment almost exclusively from a protein rich resource (i.e. fish), which constituted 31.3 ± 10% of the individual's diet (notably less C_4 enrichment than other individuals), while the bulk of this individual's carbohydrates came from local C_3 resources.

The mean $\delta^{15}N$ value increased significantly from 11.05 ± 0.07‰ in the Late Formative to 13.05 ± 0.21‰ in the Middle Horizon, now the highest of any altiplano site. This indicates that C_3 feeding terrestrial herbivores (i.e. camelids, deer, guinea pig, etc...) were consumed in increasingly greater quantities among Iruihito individuals relative to other sites and the low standard deviation indicates that access to this type of meat was similar among individuals. This increase in camelid consumption is consistent with the findings of Perez-Arias (2005), who describes a decrease in microfauna at the site from the Late Formative to the Middle Horizon. Similar results have been reported at Lukurmata (Bermann 1994) and Iwawi (Capriles 2003).

The excessive consumption of imported maize among three of the four Iruihito individuals (including both the Late Formative and Middle Horizon individuals), consistently the most maize consumption relative to any other altiplano individual, and the consistently high nitrogen isotope values, which likely indicate greater consumption of camelid meat, seem unusual for a small, rural, riverside settlement such as Iruihito. Given these circumstances, the possibility that these individuals were involved in the organization of llama caravans responsible for maize transportation should be further investigated. The possibility that some of these individuals are migrants into the altiplano must also be considered, however, the high nitrogen isotope values are very consistent with altiplano populations. Individuals from the lower valleys more often have $\delta^{15}N$ values well below 9‰.

Urikatu Kontu (CK70)

Only one adult male from the small rural Katari valley site of Urikatu Kontu was available for analysis. The $\delta^{13}C_{ap}$ value of -12.4‰ is the second to the lowest of any Middle Horizon site and indicates that approximately 21.3 ± 10% of this individual's diet was derived from C_4 enriched resources. The relatively low $\delta^{13}C_{ap\text{-}coll}$ value of 4.6‰ indicates that most C_4 enrichment came from a protein rich resource (i.e. fish). The $\delta^{13}C_{ap\text{-}coll}$ value is 0.2‰ above 4.4‰, indicating a very small amount of maize in the diet. The $\delta^{15}N$ value of 11.6‰ is typical of altiplano diets and, when considered in conjunction with the relatively low $\delta^{13}C_{ap}$ values, is indicative of significant consumption of C_3 feeding terrestrial herbivores. Overall, this individual's diet is typical of an agro-pastoral lifestyle---heavily dependent on local C_3 carbohydrate sources (i.e. tubers, quinoa, etc..) and camelids and some fish as protein sources.

Tilata (TMV101)

One adult female from the small rural Tiwanaku valley site of Tilata was available for analysis. The $\delta^{13}C_{ap,}$ -14.3‰, is the lowest of any site, indicating that 8.7 ± 10% of the diet consisted of C_4 enriched resources. The low $\delta^{13}C_{ap-coll}$ of 4.0‰ indicates that C_4 enrichment came exclusively from a protein resource (i.e. fish). Thus, the carbohydrate component of this individuals' diet consisted entirely of local C_3 resources, such as tubers and quinoa. The $\delta^{15}N$ value of 12.0‰ is the second highest of any Middle Horizon site and indicates significant consumption of C3 feeding terrestrial herbivores (i.e camelids, deer, guinea pig, etc..). Like the individual at Urikatu Kontu, this individual's diet was completely dependent on local altiplano resources and is consistent with an agro-pastoral lifestyle supplemented by fishing.

Post Tiwanaku Period

The isotope data from 15 individuals indicate that the average diet changed dramatically following the demise of Tiwanaku. The Post Tiwanaku samples derive from four sites: Lukurmata, Khonkho Wankane, Urikatu Kontu, and TMV-228. Mean $\delta^{13}C_{coll}$ and $\delta^{13}C_{ap}$ values experienced decreases that were statistically significant (see Table 7.9). The mean $\delta^{13}C_{ap}$ decreased from -8.73 ± 2.93‰ to -11.71 ± 2.10‰ ($z = -3.80$, $p = 0.01$), indicating a substantial reduction in the consumption of C_4 enriched resources such that they constituted 25.9 ± 10% of the average diet. The mean $\delta^{13}C_{coll}$ also decreased from -14.91 ± 3.02‰ to -17.74 ± 1.22‰ ($z = -3.37$, $p = 0.01$). The standard deviation of the mean $\delta^{13}C_{ap}$ and $\delta^{13}C_{coll}$ values also decreased, indicating less variation in the amount of C_4 resources in diets. At 6.03 ± 2.21‰, the mean $\delta^{13}C_{ap-coll}$ value did no change significantly during the Post Tiwanaku period. Still above 4.4‰, the mean $\delta^{13}C_{ap\text{-}coll}$ value indicates that a protein depleted resource (i.e. maize) was the primary source of C_4 enrichment. However, the mean $\delta^{13}C_{ap\text{-}coll}$ value is significantly skewed by an outlier in the Tiwanaku valley (TMV228- 196). Data from all other Desaguadero and Katari valley sites indicate that fish were now a more significantly important source of C_4 enrichment.

The mean $\delta^{15}N$ value increased from 11.02 ± 1.28‰ to13.15 ± 1.38‰---a statistically significant difference ($z = -4.39$, $p = 0.01$), which when taken into account along with the relatively low $\delta^{13}C_{ap}$ values, indicates greater consumption of C_3 feeding terrestrial herbivores such as camelids.

Overall, Post Tiwanaku diets may be characterized by increased reliance on local C_3 resources, such as tubers and quinoa, for a carbohydrate source and much greater consumption of what was probably camelid meat for protein. The influx of lowland maize dramatically decreased, returning to Late Formative levels, and diets in general became more homogenous. These changes are consistent with an increasing emphasis on pastoral pursuits and the breakdown of regional networks. However, it should be noted sampling biases may have influenced results, as the bulk of the Post Tiwanaku sample is from the Katari valley and may not be representative of the entire altiplano. Given the small sample sizes, no statistically significant differences among or within sites were found (Table 7.10). The following sections examine inter- and intra-site variation during the Post Tiwanaku period.

Table 7.9 Mann-Whitney U test comparisons of Tiwanaku IV-V vs. Post Tiwanaku Period isotopic values at each site

	$\delta^{13}C_{co}$			$\delta^{13}C_{ap}$			$\delta^{13}C_{co-ap}$			$\delta^{15}N$		
Site	TW Mean	PTW Mean		TW Mean	PTW Mean		TW Mean	PTW Mean		TW Mean	PTW Mean	
Lukurmata N=10/7	-16.87	-17.29	z=-0.29 p= 0.77	-10.03	-11.64	z=-1.76 p= 0.08	6.84	5.64	**z=-2.35 p= 0.02**	11.77	12.93	Z=-1.66 P= 0.10
Khonkho Wankane N=4/1	-12.83	-17.50	-	-7.00	-12.80	-	5.83	4.70	-	10.45	11.40	-
Urikatu Kontu N=1/5	-17.00	-18.22	-	-12.40	-12.34	-	4.60	5.88	-	11.60	13.66	-

Table 7.10 Descriptive statistics and Mann-Whitney U test comparisons for Post Tiwanaku sites

Site	**N**	**Mean**	**SD**	**Lukurmata**	**Urikatu Kontu**
(a) $\delta^{13}C_{co}$					
Lukurmata	7	-17.29	1.48	-	-
Khonkho Wankane	1	-17.50	-	-	-
Urikatu Kontu	5	-18.22	1.05	z=-0.57 p= 0.57	-
TMV228	2	-18.25	0.49	z=-1.03 p= 0.30	z=-0.40 p= 0.69
(b) $\delta^{13}C_{ap}$					
Lukurmata	7	-11.64	1.46	-	-
Khonkho Wankane	1	-12.80	-	-	-
Urikatu Kontu	5	-12.34	1.49	z=-0.24 p= 0.81	-
TMV228	2	-9.85	5.44	z= 0.00 p= 1.00	z=-0.39 p= 0.70
(c) $\delta^{13}C_{co-ap}$					
Lukurmata	7	5.64	0.7	-	-
Khonkho Wankane	1	4.70	-	-	-
Urikatu Kontu	5	5.88	2.0	z=-0.24 p= 0.81	-
TMV228	2	8.40	5.9	z= 0.00 p= 1.00	z=-0.39 p= 0.70
(d) $\delta^{15}N$					
Lukurmata	7	12.93	1.54	-	-
Khonkho Wankane	1	11.40	-	-	-
Urikatu Kontu	5	13.66	1.35	z=-0.82 p= 0.42	-
TMV228	2	13.55	0.35	z=-0.59 p= 0.56	z=-0.78 p= 0.44

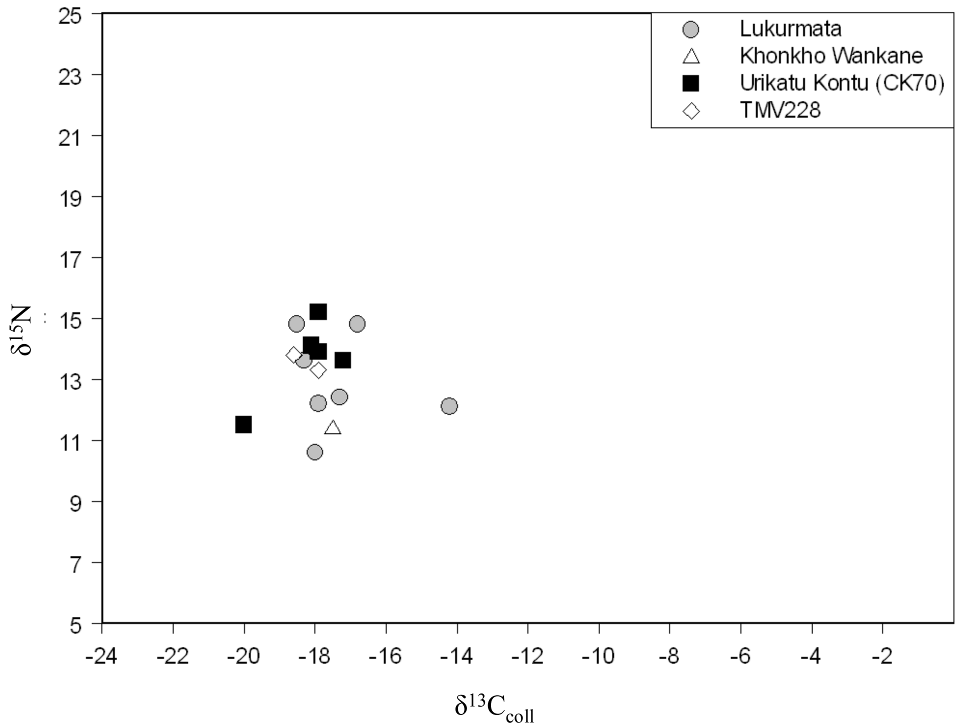

Figure 7.10 Isotopic values for Post Tiwanaku sites, $\delta^{15}N$ vs. $\delta^{13}C_{coll}$

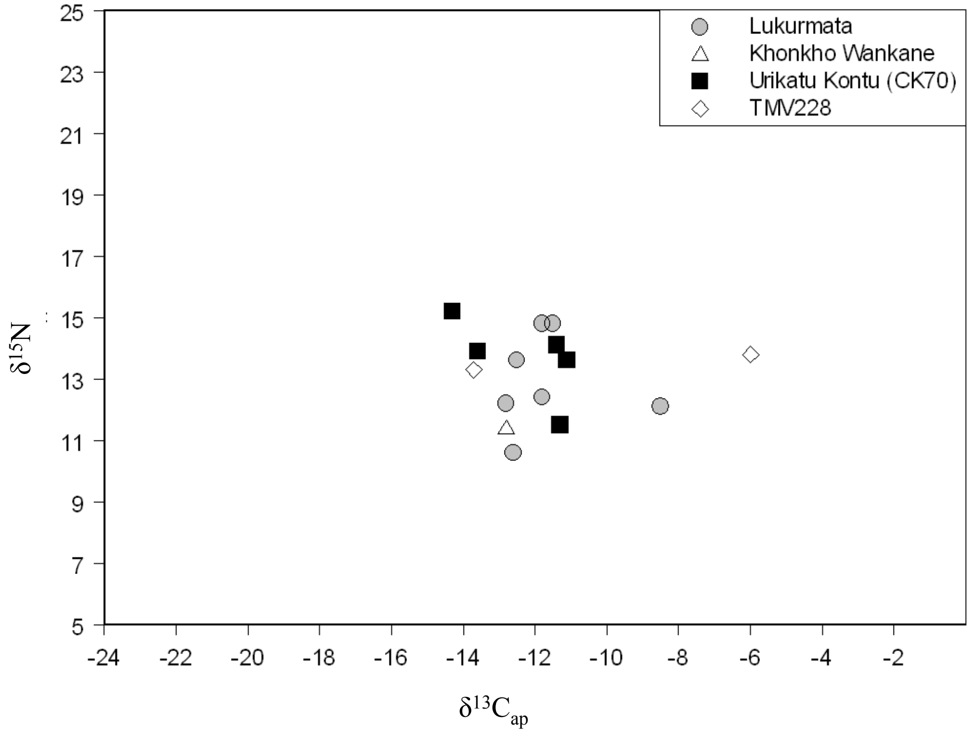

Figure 7.11 Isotopic values for Post Tiwanaku sites, $\delta^{15}N$ vs. $\delta^{13}C_{ap}$

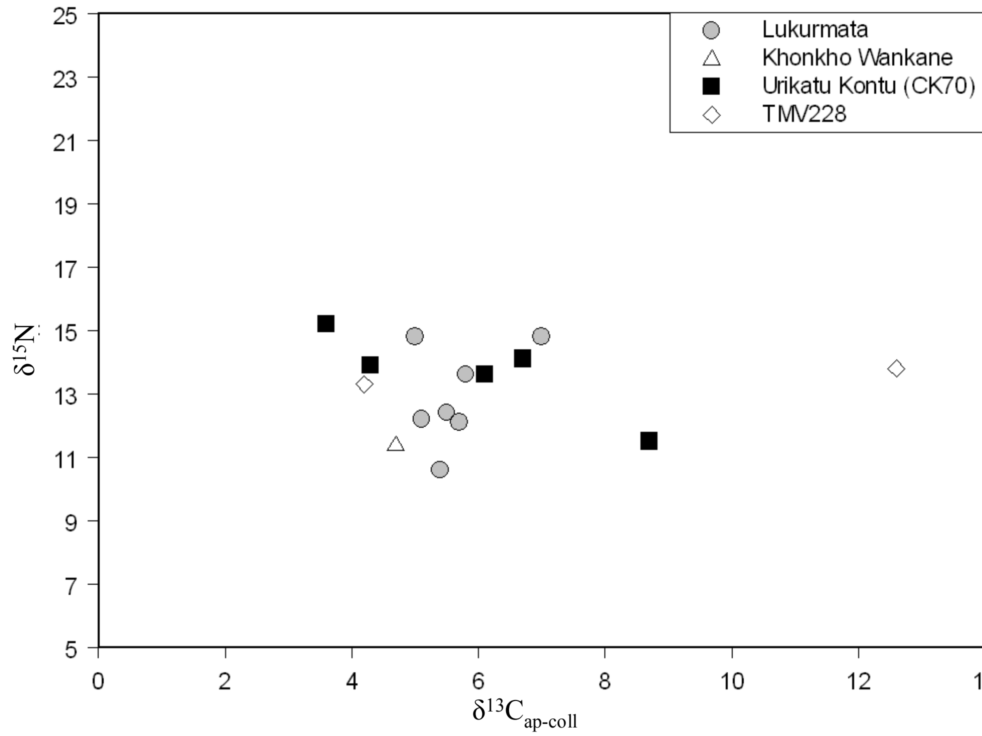

Figure 7.12 Isotopic values for Post Tiwanaku sites, $\delta^{15}N$ vs. $\delta^{13}C_{ap\text{-}coll}$

Lukurmata

Seven adult individuals, including three females, two males, one probable male, and one individual of unknown sex, were analyzed from the Post Tiwanaku occupation of Lukurmata. The mean $\delta^{13}C_{ap}$ value decreased from -10.03 ± 2.74‰ to -11.64 ± 0.54‰, indicating that 26.4 ± 10% of the average diet was now composed of C_4 enriched resources. The standard deviation of $\delta^{13}C_{ap}$ values also decreased substantially, indicating greater homogeneity in the proportion of C_4 and C_3 resources consumed. In addition, a decrease in the mean $\delta^{13}C_{ap\text{-}coll}$ value from 6.84 ± 1.23‰ to 5.64 ± 0.66‰ indicates that an increasing amount of C_4 enrichment now came from a protein resource (i.e. fish); however, lowland maize was still present, as the $\delta^{13}C_{ap\text{-}coll}$ values for all individuals remained above 4.4‰. The standard deviation of $\delta^{13}C_{ap-coll}$ also decreased indicating increasing dietary homogeneity during the Post Tiwanaku period. Although, one individual, LKM-3513, a 35-45 year old male, does stand out as having substantially more maize in his diet relative to other Lukurmata inhabitants.

The mean $\delta^{15}N$ value increased from 11.77 ± 1.06‰ to 12.93 ± 1.54‰, indicating increased consumption of C_3 feeding terrestrial herbivores such as camelids. This trend continued from the Late Formative through the Post Tiwanaku period and most likely reflects an increasing emphasis on pastoralism. In contrast to more homogenous carbohydrate and lake fish consumption, the increased standard deviation of $\delta^{15}N$ values indicates greater variability in camelid consumption during the Post Tiwanaku Period.

In general, Post Tiwanaku diets at Lukurmata reflect increasing homogeneity in the carbohydrate portion of the diet—reflecting a decrease in the amount of imported maize coming into the site and increased reliance on local C_3 resources such as tubers and quinoa. In addition, an increasing portion of the C_4 enriched componenet of the diet came from fish. Dietary protein increased and was primarily derived from Camelids and to a lesser extent fish.

Khonkho Wankane

Only one adult male from the Post Tiwanaku occupation of Khonkho Wankane was available for analysis. The $\delta^{13}C_{ap}$ value of -12.8‰ indicates that 18.7 ± 10% of this individual's diet was derived from C_4 enriched resources. The relatively low $\delta^{13}C_{ap-coll}$ value of 4.7‰ indicates that most C_4 enrichment came from a protein rich resource (i.e. lake fish). The $\delta^{13}C_{ap-coll}$ value is 0.3‰ above 4.4‰, indicating a very small amount of maize in the diet. The $\delta^{15}N$ value of 11.4‰ is relatively typical of altiplano diets, indicating significant consumption of C_3 feeding terrestrial herbivores. Overall, this individual's diet is typical of an agro-pastoral lifestyle---heavily dependent on local C_3 carbohydrate sources (i.e. tubers, quinoa, etc..) and camelids and some fish as protein sources.

Urikatu Kontu (CK70)

Five individuals, including four males and an adult of unknown sex, from the Post Tiwanaku occupation of Urikatu Kontu were available for analysis. The mean $\delta^{13}C_{ap}$ value of -12.34 ± 1.49‰ is relatively low when compared to values for most Middle Horizon sites and indicates that 21.7 ± 10% of the overall diet was composed of C_4 enriched resources. However, given the standard deviation of the mean, variation in C_4 resource consumption is apparent, with three individuals having substantially higher $\delta^{13}C_{ap}$ values. This is explained by the $\delta^{13}C_{ap\text{-}coll}$ values. The mean $\delta^{13}C_{ap\text{-}coll}$ value is 5.88 ± 2.02‰ but, again, there is substantial variation. The three individuals with the highest $\delta^{13}C_{ap}$ values also have the highest $\delta^{13}C_{ap\text{-}coll}$ values (ranging from 6.1- 8.7‰), indicating maize was a primary source of C_4 enrichment. The remaining individuals with very low $\delta^{13}C_{ap}$ values had correspondingly low $\delta^{13}C_{ap\text{-}coll}$ values (4.3‰ and 3.6‰), indicating that C_4 enrichment came almost exclusively from a protein rich resource (i.e. lake fish). Thus, disparities in access to imported maize are responsible for the variation in carbon isotope signatures.

The mean $\delta^{15}N$ value of 13.66 ± 1.35‰ is the highest of any altiplano site during any time period, indicating very heavy consumption of C_3 feeding terrestrial herbivores (i.e. camelids, deer, guinea pig, etc…). In general, Urikatu Kontu diets reflect an agro pastoral lifestyle primarily dependent on local C_3 resources, such as tubers and quinoa, as a carbohydrate source and local C_3 feeding fauna, such as camelids and guinea pig, as a protein source, with some supplementation by fishing. Small quantities of imported maize were consumed by certain individuals. The disparity in maize consumption is very different from the homogeneity seen at Lukurmata during this period. However, unlike Lukurmata, Urikatu Kontu is thought to have been intermittently occupied by rotating field guardians who may have come from different families and communities (Janusek and Kolata 2003:151). Thus, a possible explanation for the dietary variation could be that the men with access to maize came from different communities or families than those without, and perhaps had ties, whether through trade and/or kinship, to lowland areas.

TMV228 (Mollo Kontu site)

Two male individuals from the small Tiwanaku valley site of TMV-228 were available for analysis. The mean $\delta^{13}C_{ap}$ value, -9.85 ± 5.44‰ (38.3%C_4) indicates that an average of 38.3 ± 10% of the overall diet for these two individuals consisted of C_4 enriched resources. However, these two individuals obtained their C_4 enrichment from completely different sources. A very high $\delta^{13}C_{ap\text{-}coll}$ value for TMV-228-196 ($\delta^{13}C_{ap\text{-}coll}$ = 12.6‰) indicating they obtained C_4 enrichment exclusively from a protein depleted resources (i.e. maize) and in fact, 64 ± 10% of this individual's diet came from maize—the highest of any Post Tiwanaku period individual. In fact, this individual is an outlier relative to others from this period. In contrast, a very low $\delta^{13}C_{ap\text{-}coll}$ value for TMV-228-195 ($\delta^{13}C_{ap\text{-}coll}$ = 4.2‰) indicates that this individual obtained C_4 enrichment almost exclusively from a protein rich resource (i.e. fish), which constituted 12.7 ± 10% of the diet, while the bulk of this individual's carbohydrates came from local C_3 resources.

The mean $\delta^{15}N$ value of 13.55 ± 0.35‰ is the second to the highest of any altiplano site during any time period. This indicates that C_3 feeding terrestrial herbivores (i.e. camelids, deer, guinea pig, etc...) were consumed in large quantities among TMV-228 inhabitants relative to other sites and the low standard deviation indicates that access to this type of meat was similar among the two individuals. Nitrogen and carbon isotope values for TMV-228-195 are very typical of other rural altiplano agro-pastoralists from the Late Formative through the Post Tiwanaku period; however, the carbon values for TMV-228-196 are anomalous among Post Tiwanaku communities and among rural altiplano sites in general, with the exception of Iruihito. I suggest this individual may have been involved in the transportation of maize into the altiplano or could be a migrant. Altiplano-like nitrogen values (>9‰) do not support the hypothesis that this individual was a migrant, although future strontium isotope analyses would be necessary to obtain a more definitive answer.

Summary

The isotope data presented here lead to a number of significant conclusions. First, this study provides the first direct evidence for the consumption of significant quantities of maize in the altiplano prior to the Middle Horizon. The average diet of individuals at the Late Formative regional centers of Khonkho Wankane and Tiwanaku was composed of 25-45% maize. Local C_3 crops such as tubers and quinoa were dietary staples but maize was also a substantial carbohydrate resource. The presence of maize at these sites is significant. These sites were the preeminent ceremonial centers in the basin during this Late Formative and archaeological evidence has shown that a central element of ceremonial practice at each involved the use of sunken court complexes as sacred spaces associated with rituals of consumption. Thus, it is likely *chicha* consumption was already a central element of ceremonial practice by the end of the Late Formative.

Interestingly, at the small rural site of Iruihito, a staggering 50-70% of the diet for the two individuals analyzed was maize during the Late Formative[45]. In addition, both Desaguadero valley sites—Khonkho Wankane and Iruihito—have significantly more protein in their diets than Tiwanaku or Katari valley sites (see Table 7.2b), indicating greater consumption of C_3 feeding herbivores such as camelids. This may indicate a greater emphasis on pastoral pursuits in the Desaguadero valley and, given that these communities also had the greatest amount of maize in their diets, I suggest they may have been involved in transporting maize from the western lowlands. Such advantageous trade connections could help explain the rise of Khonkho Wankane to become one of the most important regional ceremonial centers in the Late Formative period, only to be surpassed by Tiwanaku at the end of the Late Formative.

Late Formative Katari Valley inhabitants were significantly more dependent on local C_3 resources, having less access to maize when compared to individuals from the Desaguadero and Tiwanaku valleys. At Lukurmata, between 6-26% of the diet was composed of C_4 enriched resources, which included both maize and a greater amount of fish than seen at Desaguadero and Tiwanaku valley sites.

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[45] Although the consumption of C_4 enriched fish at these sites likely contributed to the elevated $\delta^{13}C_{ap}$ values, the very high $\delta^{13}C_{ap\text{-}coll}$ values (between 8.1 and 10.9‰) make it clear that a protein depleted resource such as maize was the primary source of C_4 enrichment at Khonkho Wankane, Tiwanaku, and Iruihito.

Second, regarding the origins of altiplano maize during the late Formative, I suggest maize was already being imported from the lowlands rather than being grown in significant quantities along the warmer shoreline of Lake Titicaca. Lukurmata was the closest to Lake Tititcaca of any Late Formative site analyzed and its inhabitants consumed the least amount of maize. If maize cultivation occurred around the shoreline of Lake Titicaca, on a scale large enough to supply Khnkho Wankane, Tiwanaku, and Iruihito, there should be more maize in the diets of lakeside communities. Because this is not the case, this study provides tentative support for a lowland source of maize during the Late Formative. Granted, it is possible that maize was produced near the lakeshore and distributed based on something other than proximity to the production zone.

Third, this research documents a statistically significant increase in the importation of lowland[46] maize into the altiplano accompanying the emergence of Tiwanaku political authority at the onset of the Middle Horizon, such that it now constituted 50-70% of the diet for some individuals at regional centers with monumental architecture (i.e. Tiwanaku, Lukurmata, and Khonkho Wankane) as well as the rural Desagaudero valley site of Iruihito.

Fourth, during the Middle Horizon, there is greater variation in maize consumption[47] among inhabitants of sites with ceremonial architecture, including Tiwanaku, Lukurmata, and Khonkho Wankane, which likely reflects increasing social differentiation. It is clear at this point, that within Tiwanaku society, people were not afforded equal access to maize. At Tiwanaku, these developing class divisions as

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[46] A lowland source for maize in the Middle Horizon is supported by paleobotanical data (Hastorf et al. 2006), also see chapter 4.

[47] As demonstrated by the large increase in the standard deviations of the mean $\delta^{13}C_{coll}$ and $\delta^{13}C_{ap}$ values (Table 7.6).

revealed through dietary practices are especially apparent. For example, individuals interred in ceremonial platforms (i.e. Akapana and Mollo Kontu Mound), residential compounds within the marked bounds of the ceremonial core (i.e. Akapana East), and in a cemetery outside the core (i.e. Markapata) had diets composed of approximately 46-66% C_4 enriched resources—primarily maize (see Table 7.7). In contrast, individuals interred in residential areas well outside the ceremonial core of the city, such as the Mollo Kontu, Chiji Jawira, and La Karaña sectors had much less access to maize. For individuals in Mollo Kontu, only 17-37% of the overall diet was composed of a C_4 enriched resources. Estimates for Chiji Jawira and La Karaña are less straightforward due to the greater amount of C_4 enriched fish being consumed however, it is clear they had substantially less access to maize. Similar distinctions were also clear at Khonkho Wankane and Lukurmata. Different segments of society at these sites exhibited an approximate 30% disparity in the proportion of maize in overall diets. No individual associated with a rural settlement in the Katari or Tiwanaku valleys exhibited a maize-intensive diet similar to those at regional centers[48]. These disparities suggest that maize consumption was becoming an important means of marking social boundaries within Tiwanaku society. Valued imports such as maize may have been used as symbolic capital by local leaders who sponsored public feasts as a means of legitimizing growing asymmetries of power.

Fifth, with the exception of individuals interred in the Markapata cemetery of Tiwanaku, no statistically significant sex-based dietary differences were observed at any site during any time period. Among Markapata individuals, males consumed significantly more protein than females (see Table 7.8). However, given the confounding

[48] A single individual at the rural Desaguadero valley site is a notable exception to this pattern.

presence of C_4 enriched fish and small sample sizes when divided by temporal period and site (and in the case of Tiwanaku, sector), I do not discount the possibility that sex-based dietary differences existed but could not be documented with the current sample.

Sixth, during the Middle Horizon, individuals interred at Khonkho Wankane consumed significantly fewer C_3 feeding herbivores, such as camelids (Table 7.9). This corresponds to a time when the construction of monumental architecture at the site ceased and the population abandoned the site's ceremonial core. In contrast, Lukurmata experienced a statistically significant increase in the consumption of C_3 feeding herbivores as well as maize during this time. This period also corresponds to the construction of monumental architecture at Lukurmata and its emergence as the second largest regional center in the southern basin. Although not statistically significant, Tiwanaku also experienced increases in both maize and herbivore consumption during this time. These data support a possible link between pastoralism and status among altiplano sites, a connection tentatively suggested by Webster and Janusek (2003: 345; also see Janusek 2008: 177)

Finally, following the demise of Tiwanaku, Post Tiwanaku altiplano populations experienced a significant shift in subsistence strategies. The mean altiplano $\delta^{13}C_{coll}$ and $\delta^{13}C_{ap}$ values demonstrated a statistically significant decrease and the mean $\delta^{15}N$ value revealed a statistically significant increase (see Table 7.5 and Figures 7.13 and 7.14), indicating a dramatic decrease in maize consumption and an increase in the consumption of C_3 feeding herbivores, most likely camelids and to a lesser extent deer and guinea pig. These data suggest a much greater reliance on local C_3 crop resources, such as tubers and quinoa, (similar to the Late Formative period) and an increased emphasis on pastoral pursuits. However, I caution that much of the Post Tiwananku sample was derived from the Katari valley and may represent a more localized phenomenon.

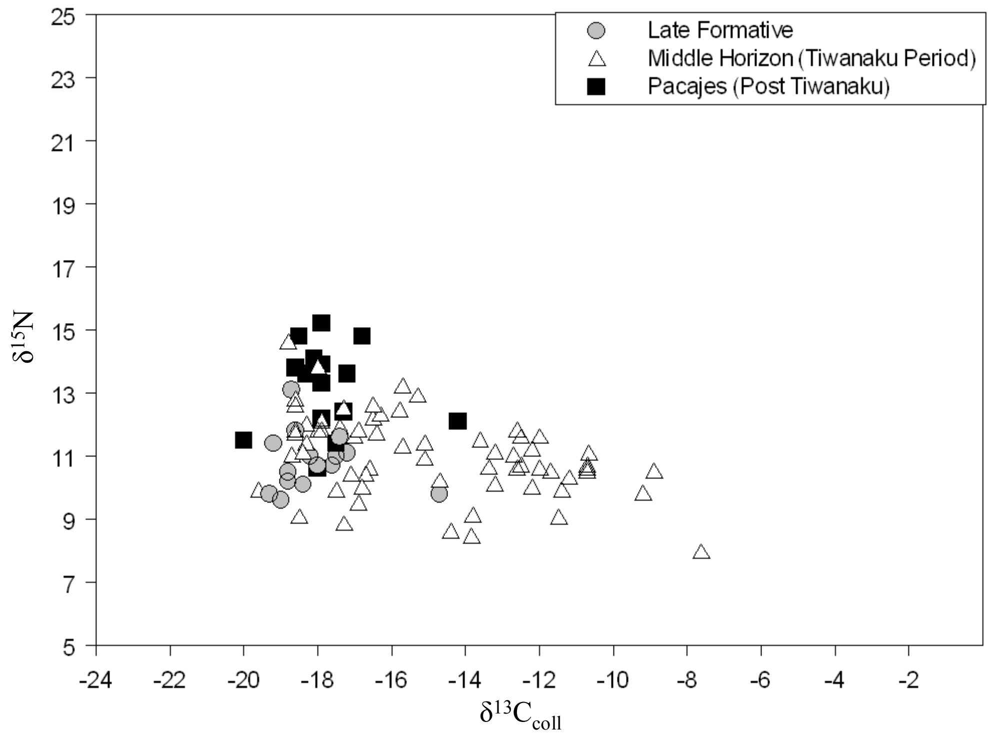

Figure 7.13. Isotopic values for all altiplano by temporal period, $\delta^{15}N$ vs. $\delta^{13}C_{coll}$

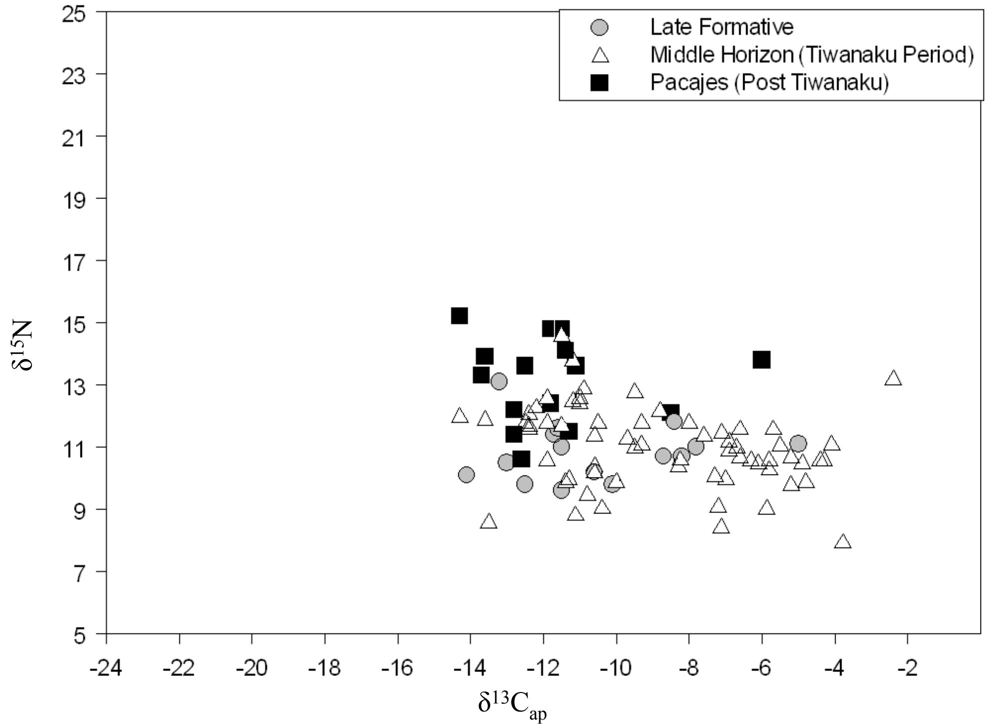

Figure 7.14 Isotopic values for all altiplano by temporal period, $\delta^{15}N$ vs. $\delta^{13}C_{ap}$

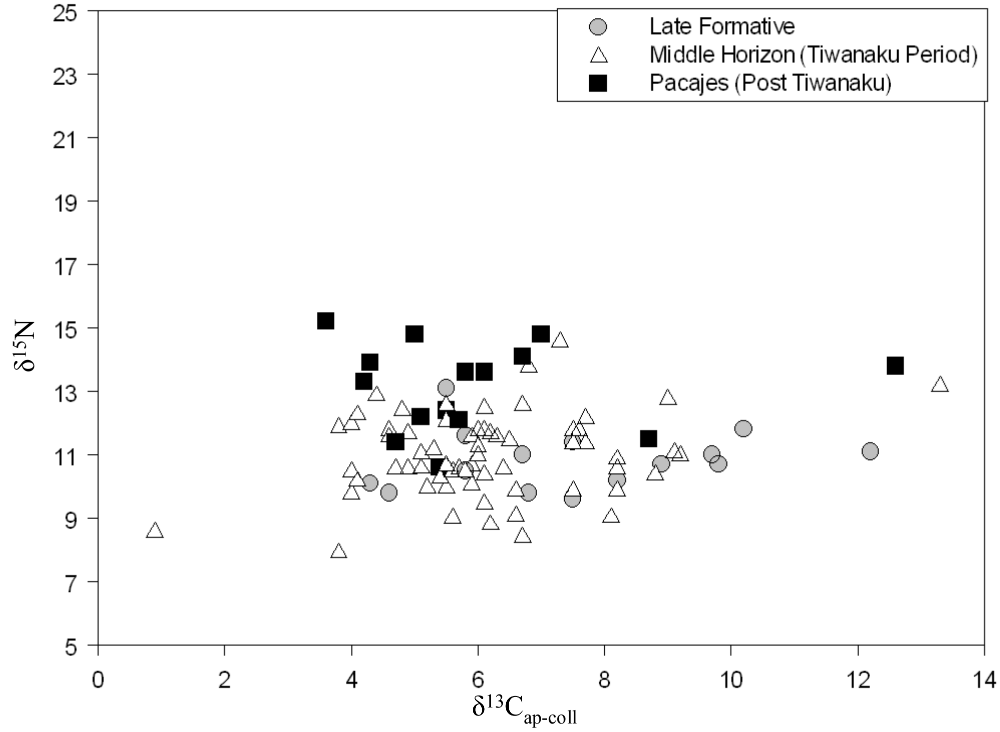

Figure 7.15 Isotopic values for all altiplano by temporal period, $\delta^{15}N$ vs. $\delta^{13}C_{ap-coll}$

CHAPTER VIII

RESULTS: PHYTOLITH AND STARCH GRAIN ANALYSES

Introduction

This chapter reports the results of the plant microfossil portion of this study. Analysis of plant microfossils from human dental calculus allows researchers to identify specific foods in an individual's diet, complimenting dental and isotopic techniques, which offer a broader overview of diet. I first discuss the preservation and recovery of phytoliths and starch grains in the human dental calculus samples. I then report the specific findings of this study and their contexts. And finally, I summarize the significance of these results.

Sample Preservation and Plant Microfossil Yields

Phytolith and starch grain yields from the altiplano dental calculus samples were low. Based on the low yields, 28 of the original 46 samples were subjected to microscopic analysis by Amanda Logan and Deborah Pearsall. In order to maximize phytolith recovery, calculus samples were processed twice. Of these, only 15 of the 28 yielded results (Logan and Pearsall 2007).

Low phytolith recovery was a result of the paucity of appropriate calculus deposits for analysis and the effects of taphonomic processes. Dental analyses revealed that altiplano populations generally lacked large calculus deposits, which is in part, related to the relatively high rate of dental wear among altiplano populations (see chapter

6). Thus, little calculus was available for analysis. In addition, preservation of altiplano skeletal and dental remains was overall poor further contributing to the low recovery of plant microfossils.

Phytoliths

Neither maize, coca, nor psychotropic plant phytoliths were identified. Results for all 28 specimens along with their contextual information are presented in Table 8.1. Phytoliths recovered were primarily derived from wild grasses—panicoid, chloridoid, and festucoid (Logan and Pearsall 2007). Grass phytoliths were recovered in the dental calculus of both males and females in Tiwanaku and Post Tiwanaku Period contexts (MK-876, CK70-3133, PUT-25785, LKM-364, and CK70-3283) and a probable grass phytolith was recovered from an additional Post Tiwanaku Period male (TMV228-196). General indicators of roots and tubers were identified in the dental calculus of three individuals, including both males and females in Late Formative and Tiwanaku Period contexts (KW-5374, MK876, and CK104.1-3433), and fibers associated with fruits and seeds were found in the dental calculus of six individuals, including both males and females from Tiwanaku and Post Tiwanaku Period contexts (MK-874-2, MK-876, KW-5748, CK70-3133, AK-12149, and TLOBS-1). No patterns in terms of temporal period, sex, site, or valley were apparent.

Starch Grains

Recovery of starch grains proved fruitful, recovering maize and potato starches in five specimens (Logan and Pearsall 2007). Maize starch grains were clearly documented in the dental calculus of one Late Formative female from the Katari valley site of Kirawi (CK65-1691), one Tiwanaku Period female from the Mollo Kontu sector of Tiwanaku (MK-874-1), and one Tiwanaku Period individual of unknown sex from the rural Katari valley site of Pokachi Kuntu (CK104.1-3433). A probable maize starch grain was also encountered in the dental calculus of a Post Tiwanaku Period male from a rural Tiwanaku valley site (TMV228-196). A large starch grain likely belonging to a potato was documented in the dental calculus of a Tiwanaku Period female from the site of Tiwanaku (MK-874-2). Damaged and undiagnostic starch grains believed to represent economic plants were encountered in the dental calculus of two Tiwanaku Period individuals, including a male from the site of Kirawi and a female from the site of Tiwanaku (CK65-1086 and MK-874-1).

Summary

Despite the relatively low yields, microfossil analyses were informative, documenting the presence of maize in the dentition of three, possibly four, of the 28 individuals (Logan and Pearsall 2007). Although data derived from plant phytoliths was not informative in regards to maize, starch grain analysis was valuable in recording the presence of maize in human dental calculus dating to the Late Formative, Tiwanaku, and possibly Post Tiwanaku periods—thus, documenting its presence in altiplano diets before and perhaps after state development.

Until recently, there existed little evidence of maize in Formative period contexts within the altiplano. Systematic study of macrobotanical assemblages from Tiwanaku (Wright et al. 2003) and Chiripa (Hastorf et al. 2006) found no evidence of maize during the Formative period. Lee (1997) reported the identification of a single kernel and cupule of maize from a Formative period context on the Copacabana peninsula, which had provided the only macrobotanical evidence of its presence in the region. Recently however, microbotanical studies have documented maize in Formative period contexts both on the Taraco Peninsula (Logan 2007), the Copacabana Peninsula (Chávez and Thompson 2006), and with the addition of this study, the Katari valley. Evidence of Formative period maize on the Taraco Peninsula was primarily restricted to ritual contexts (800-200 B.C.)(Logan 2007: 5). The presence of maize in the diet of an individual at the small rural site of Kirawi is significant in that it demonstrates that some maize was being acquired by members of the general population during the Late Formative, and not just by elites at ceremonial centers such as Khonkho Wankane and Tiwanaku, as suggested by the carbon isotope data.

Significantly, this study also identified maize in the dentition of an adult female associated with the Mollo Kontu sector of Tiwanaku (MK-874-1)—a residential compound well outside Tiwanaku's ceremonial core. This is noteworthy in that, the seven individuals interred in this sector of the site consistently had the lowest $\delta^{13}C$ ratios at Tiwanaku, with $\delta^{13}C$ ratios from bone collagen ranging between -16.4‰ and -18.6‰ and averaging -17.9‰. This indicates that these individuals had very little, if any, access to C_4 plants (i.e. maize). However, the recovery of maize starch in the dentition of one of these individuals suggests that occasional maize consumption was at least possible for these individuals.

Finally, the probable presence of maize in the dentition of a Post Tiwanaku Period male is also significant. Both dental and isotopic lines of data indicate that maize virtually disappeared from altiplano diets following the demise of the state, however, the starch grain data suggests that at least some altiplano individuals were still capable of acquiring maize.

Evidence of tubers, seeds, wild grasses, and economic plants in the dentition of several individuals was unremarkable, as it would be expected in the altiplano context. Given the limitations of the sample size, further comparison of differential consumption of specific food crops based on the phytolith and starch grain data is not possible.

Table 8.1 Specimens analyzed and results of plant microfossil recovery from human dental calculus, in order of temporal period, site, and sex

Specimen	**Valley**	**Site**	**Temporal Period**	**Sex**	**Age**	**Phytoliths**	**Starches**
KW-5374	DS	Khonkho W.	LF	M	45+	4 short stright fibers, 1 blocky Parenchyma	
CK65-1691	KT	Kirawi	LF	F	35-45		2 Zea mays
CK104.1-3433	KT	Pokachi Kuntu	TW	UN	20-35	2 short straight fibers, 2 Raphide	1 Zea mays
KW-5612	DS	Khonkho W.	TW	UN	11-15Y		
CK65-1086	KT	Kirawi	TW	M	45+		1 damaged unidentified economic
CK65-1082	KT	Kirawi	TW	UN	40+		
TLOBS-1	TW	Obsidiana	TW	F	20+	1 Undulating fiber	
MK-29412	TW	Tiwanaku	TW	F	22-24		
MK-39796	TW	Tiwanaku	TW	F	30-40		
MK-874-2	TW	Tiwanaku	TW	F	60+	1 Raphide, 1 undulating fiber	1cf. Solanum sp.
MK-874-1	TW	Tiwanaku	TW	F	50+		1 Zea mays, 1 damaged unidentified economic
MK-876	TW	Tiwanaku	TW	F	20+	1 Festucoid, 2 undulating fibers, 1 short straight fiber, 1 Raphide	
PUT-25785-1	TW	Tiwanaku	TW	F	18-21	1 Panicoid, 1 Chloridoid	
AK-12149	TW	Tiwanaku	TW	M	50-59	3 undulating fibers	
AK-21264-B	TW	Tiwanaku	TW	M	25-35		
MK-985	TW	Tiwanaku	TW	M	20-30		
PUT-25940-1	TW	Tiwanaku	TW	M	40-50		
AK-1777	TW	Tiwanaku	TW	UN	7-11Y		
MK-764	TW	Tiwanaku	TW	UN	20+		
MK-890	TW	Tiwanaku	TW	UN	20+		
CK70-3283	KT	Urikatu Kontu	TW	M	35-45	1 Festucoid	
KW-5748	DS	Khonkho W.	PTW	UN	15-18	1 undulating fiber	

TMV228-196	TW	Mollo Kontu*	PTW	M	35-45	1 Chloridoid	1 cf. Zea mays
CK70-3133	KT	Urikatu Kontu	PTW	M	20-30	1 Chloridoid, 1 undulating fiber	
CK70-3144-3	KT	Urikatu Kontu	PTW	M	25-35		
LKM-364	KT	Lukurmata	NA	F	15-18	1 Panicoid, 1 Festucoid	
LKM-9272	KT	Lukurmata	NA	F	40-50		
LKM-471	KT	Lukurmata	NA	UN	4-10Y		

CHAPTER IX

DISCUSSION AND CONCLUSION

Introduction

This chapter begins by providing a detailed summary of Southern Titicaca Basin diets from the Late Formative through the Post Tiwanaku Period, combining the results of all three data sets discussed in chapters 6, 7, and 8 as well as relevant paleobotanical and archaeological evidence provided by other studies. Using these data, I then address the central research questions of this dissertation presented in chapter 1, including: 1) What role did commensal politics play in the formation and collapse of the Tiwanaku state? 2) How did access to food and food choices reflect and structure social identity within Tiwanaku society? And, 3) what do changes in diet indicate regarding the nature of Tiwanaku's political authority and its impact on the domestic economy?

Summary: Temporal Trends in Ancient Southern Titicaca Basin Diets

Late Formative

Based on stable isotopic data, Late Formative populations in the Southern Titicaca basin relied on local C_3 plants such as tubers and quinoa as their carbohydrate source and local C_3 feeding herbivores such as camelids as their main protein source. Other protein sources may have included deer and guinea pig. Tuber phytoliths in the dental calculus of a Late Formative individual shows the important role this cultigen played in Late

Formative diets. The dental caries frequency (approximately 10.8% of all teeth) is consistent with the isotopic and phytolith data, indicating a mixed agro-pastoral subsistence economy.

Katari valley inhabitants also supplemented their diet with lake fish, while little evidence of fish consumption was found among Desaguadero[49] and Tiwanaku valley populations. Overall, the lack of fish in southern basin diets was surprising given the proximity of most sites to the lake and its abundant resources. However, this is consistent with a growing body of faunal data indicating that fish were increasingly being replaced by camelids as an important source of protein in the Late Formative (Berman 1994; Capriles 2003; Capriles et al. 2008; Pérez-Arias 2005) as agro-pastoralism gradually became the primary productive regime in the basin.

The most notable finding regarding Late Formative diets was the consumption of large quantities of maize by certain individuals at sites with ceremonial architecture (i.e. Khonkho Wankane and Tiwanaku) and at the small rural site of Iruihito. This study provides the first evidence of the consumption of substantial quantities of maize in the altiplano prior to the Middle Horizon. Isotopic data indicate that the average diet at Khonkho Wankane and Tiwanaku during this period was composed of 25-45% maize. As discussed in Chapters 2 and 7, these sites were the preeminent ceremonial centers in the southern basin during the Late Formative. Archaeological evidence indicates that a central component of ceremonial practice at these sites involved sunken court spaces

[49] It is possible that individuals at the riverside site of Iruihito were also consuming significant quantities of fish but that these river fish, in contrast to the lake fish, produce a C_3 stable isotopic signature which would be indistinguishable from terrestrial fauna. However, Pérez-Arias (2005) did find that microfauna (i.e. fish) decreased relative to camelid remains during the Late Formative, indicating an increasing emphasis on patoralism at Iruihito.

associated with rituals of consumption. Thus, this study demonstrates that maize *chicha* was already a central aspect of ceremonial practice by the end of the Late Formative.

In addition, at the site of Iruihito, a small rural site in the Desaguadero valley, isotopic results for two individuals revealed that a staggering 50-70% of the diet was composed of maize[50]. Construction of a ceremonial mound began at the site toward the end of the Late Formative period (Pérez 2004, 2007); thus, it seems likely that rituals of consumption involving maize *chicha* became increasingly important in ceremonial practices at Iruihito during this time. As noted in Chapter 7, the two Desaguadero valley sites of Khonkho Wankane and Iruihito also had significantly more protein in their diets relative to Katari and Tiwanaku valley populations. This likely indicates a greater emphasis on pastoralism in the Desaguadero valley. Given that the Desaguadero valley individuals also consumed the greatest amounts of maize relative to other communities, I suggest that they were involved in the importation of lowland maize during this period. Such advantageous trade connections could explain the rise of Khonkho Wankane as one of the most important regional ceremonial centers during the Late Formative.

In contrast to the predominance of maize in the Desaguadero valley, isotopic data indicate that Katari valley individuals had very little maize in their diets. However, starch grain data indicate that they did have occasional access to it, as maize starch was found in the dental calculus of one 35-45 year old female from Kirawi (CK65-1691).

Given the lack of maize consumption among individuals from lakeside communities such as Lukurmata, I suggest that the large quantities of maize at other sites were derived from a lowland source rather than being grown near the warmer shores of

[50] Analysis of strontium isotopes for these individuals indicates they are most likely local to the altiplano (pers. com. Kelly Knudson 2009).

Lake Titicaca, as some have speculated. Lukurmata is the closest site to the lake of any in this study, and its inhabitants consumed by far the least maize. Study of macrobotanical plant remains by Hastorf and colleagues (2006) has shown that much of the maize entering the altiplano in the Tiwanaku Period was imported from the lowlands. This study indicates that the same was probably true during the Late Formative.

Finally, no significant evidence of sex based differences in diet was found within the Late Formative samples. However, given the small sample sizes for this period, it is possible that such discrepancies existed but could not be documented with the current sample.

Tiwanaku Period (Middle Horizon)

During the Tiwanaku Period, there was a dramatic increase in the consumption of maize in the southern basin, which was statistically significant in both the collagen and apatite stable isotopic data sets. Although local C_3 crops, including quinoa and tubers, remained important carbohydrate sources for much of the population, maize now constituted 50-70% of the diet for some individuals at regional centers with monumental architecture (i.e. Tiwanaku, Lukurmata, and Khonkho Wankane) as well as the rural Desaguadero valley site of Iruihito. Carbon isotope ratios from bone apatite indicate that C_4 resources (maize and fish) constituted 35-55% of the diet for the southern basin population as a whole. The unexpectedly high levels of maize in altiplano diets and its concentration at sites with ceremonial architecture associated with archaeological evidence of commensal consumption[51] indicate that participation in feasts featuring maize *chicha* increased on an unprecedented scale during this period.

It is necessary to point out that these percentages do seem exceptionally high and warrant a few words of caution. First, the Tiwanaku Period sample is primarily composed of individuals from sites with monumental architecture. The smaller sample of individuals from rural sites indicates that these individuals, as well as many living in the periphery of larger urban centers, had considerably less access to maize. Thus, the results likely overestimate the contribution of maize to the diets of the general altiplano population. Second, although collagen-apatite spacing remained well above 4.4‰ for almost all Tiwanaku Period individuals, indicating high consumption of a protein depleted resource (i.e. maize), fish consumption certainly contributed to C_4 enrichment (especially at small rural sites). Third, the formulas used to estimate the percentage of C_4 enriched resources in the diet were based on controlled feeding experiments of mice rather than humans and as such, they may not provide an exact reflection of the percentage in human diets (Ambrose and Norr 1993). Despite these issues, the methods used in this study are identical to those used for Moquegua populations (Tomzcak 2001, 2003), and therefore provided the best means of presenting a broader regional perspective. Even if the percentage of maize in the diet is somewhat less than what has been calculated for altiplano populations, it is still impressive. The same methods determined that maize constituted 40-60% of the diet for contemporaneous maize agriculturalists at Chen Chen in the Moquegua valley (Tomzcak 2001). Those results are identical to those I obtained for the site of Tiwanaku (C_4 resources = 40-60% of the diet).

[51] Although Iruihito was a relatively small rural site, its ceremonial mound was littered with evidence of communal feasting events, including ceramics used for the storage, fermentation, and consumption of *chicha* dating to the Tiwanaku Period (Pérez 2004, 2007).

In fact, some individuals at Tiwanaku consumed significantly more maize than any individual at the lower valley site of Chen Chen. So, despite the potential for overestimating the percentage of maize in altiplano diets, it is clear that significant quantities of maize were being consumed by altiplano populations during the Middle Horizon.

Dental caries rates remained similar to Late Formative levels, which were consistent with an agro-pastoral lifestyle. Thus, despite much evidence of agricultural intensification during this period (Janusek and Kolata 2004), southern basin populations in general never became pure agriculturalists: patoralism remained a significant component of local subsistence strategies. In fact, the isotopic data indicate that consumption of C_3 feeding herbivores, primarily camelids, increased in the Tiwanaku Period, although this increase was not statistically significant.

Isotopic data revealed no sex-based dietary differences at any site, with the exception of individuals buried in the Markapata cemetery sector of Tiwanaku (among these individuals, males consumed significantly more protein than females). However, dental caries data revealed that females now had significantly higher rates of carious lesions relative to males. A number of scenarios could explain this pattern. It could be that males had a more varied diet with perhaps more access to meat, while females were more dependent on cariogenic staple crops. With the exception of the Markapata individuals, the isotopic data do not support this explanation. Lukacs (2008) has recently suggested that increases in women's fertility that often coincide with an agricultural lifestyle may be responsible for higher dental caries rates among women in agricultural societies, as a number of physiological changes that occur during pregnancy are associated with poorer oral health (e.g. hormonal changes and changes in the pH of saliva). Unfortunately, given the small size of the Late Formative skeletal sample from the altiplano, it is not possible to determine if there was a significant increase in fertility during the Tiwanaku Period that might contribute to higher caries rates among females. Thus, this possibility cannot be ruled out. Finally, a sexual division of labor may also explain the discrepancies. As discussed in Chapter 6, scholars working in other Andean regions have reported a sexual division of labor in which females are responsible for masticating maize kernels for *chicha* production, resulting in higher caries rates among women[52]. Given the significant increase in maize consumption in the southern basin during this period, such a scenario does offer a plausible explanation for the differences in caries rates among males and females.

Other dental indicators of diet suggest that foods became more processed and refined during the Tiwanaku Period. There was a statistically significant decrease in the prevalence of dental abscesses and antemortem tooth loss and, although the decrease was not statistically significant, dental wear scores were also lower. As most of the abscesses and resultant antemortem tooth loss in the Late Formative sample were the outcome of extreme dental wear, it is plausible that a decrease in dental wear in the Tiwanaku Period is responsible for the lower rates of abscesses and antemortem tooth loss. This may reflect a change in food preparation techniques or the type of stone used for grinding grains (i.e. selection of a less coarse stone source). However, altiplano diets remained relatively coarse when compared to Moquegua, likely due to the use of grinding stones made of sandstone.

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[52] It should be noted that these differences would not result in differences in male and female stable isotopic ratios, as the women were not necessarily consuming the maize.

Inter-site dietary variation during the Tiwanaku Period was significant. As previously mentioned, sites with monumental architecture (Tiwanaku, Lukurmata, Khonkho Wankane, and Iruihito) had consistently more C_4 enrichment in their diets, averaging 40-60% of the overall diet (primarily maize but varying amounts of fish). The diets of individuals at smaller rural sites (Kirawi, Urikatu Kontu, Tilata) consisted of 9-29% C_4 enriched resources, the bulk of which came from fish. However, the identification of a maize starch grain in the dental calculus of one rural Katari valley individual does indicate that these individuals at least had occasional access to the crop. Consumption of C_3 feeding herbivores (primarily camelids) increased slightly for the basin as a whole during the Tiwanaku Period, but varied significantly among sites. Specific sites are discussed below.

Of the individual sites, Lukurmata underwent the most dramatic change in diet from the Late Formative to the Tiwanaku Period. C_4 resources comprised 6-26% of the diet in the Late Formative (much of which was fish) and now constituted 27-47% of the diet, the bulk of which was now composed of maize. They were also consuming significantly more protein from camelids. These increases in both maize and camelid consumption were statistically significant and correspond to the construction of monumental architecture at Lukurmata and its emergence as the second largest regional center in the southern basin. Similar increases in maize and camelid consumption occurred at Tiwanaku during this period, although the changes were not statistically significant. At the site of Iruihito, some inhabitants continued to have exceedingly high amounts of maize in their diets and there was a statistically significant increase in camelid consumption (these individuals now had the highest nitrogen isotope ratios in the basin), suggesting an increased emphasis on pastoralism. In contrast to these sites (Lukurmata, Tiwanaku, and Iruihito), Khonkho Wankane experienced a statistically significant *decrease* in consumption of camelid meat. Consumption of C_4 resources did increase at Khonkho Wankane; however, although much C_4 enrichment still came from maize, an increasing percentage now came from fish, which may have been replacing camelids as a significant protein source for Khonkho inhabitants. These results suggest a decreasing emphasis on pastoralism at the site, which corresponds to the period when monumental construction ceased and the population abandoned the site's ceremonial core.

Thus, a significant increase in pastoralism is indicated at sites with growing ceremonial centers (Lukurmata, Tiwanaku, and Iruihito[53]), while a significant decrease in pastoralism is associated with sites where monumental construction was in decline (Khonkho Wankane). These data support Janusek's (2008) contention that pastoralism became an increasingly prestigious endeavor from the Formative through the Tiwanaku Period. Maize consumption continued to be highest among sites with monumental architecture, including Khonkho Wankane.

The only site to exhibit statistically significant variation in dental pathologies when compared to all other Tiwanaku Period sites was Kirawi. Adults at this rural Katari valley site had the poorest dental health of any population in the study with a caries rate of 21.6%. Calculus deposits were moderate in contrast to the mild levels seen throughout the rest of the basin. These results are consistent with a population of pure

[53] Although the scale of monumental construction at Iruihito is not comparable to that at Tiwanaku and Lukurmata during this period, inhabitants did complete construction of a 60 x 80m. ceremonial mound standing four meters in height, which was the site of communal feasting events throughout the Tiwanaku Period (Perez 2004, 2007).

agriculturalists, as opposed to agro-pastoralists. This is further supported by the isotopic data indicating they consumed the least camelid meat of any group in the basin. Similar to other contemporary rural sites, the isotopic evidence indicates that these individuals were heavily dependent on local crops, such as tubers and quinoa, as a carbohydrate source and had little access to maize. These data support Janusek and Kolatas' (2003) interpretation of the site as an agricultural outpost for rotating field guardians who oversaw the production of local staples on the Pampa Koani.

This study also documents significant intra-site variation in diet during the Tiwanaku Period, indicating growing social divisions. At Tiwanaku, Lukurmata, and Khonkho Wankane different segments of society exhibited an approximate 30% disparity in the proportion of maize in overall diets. These disparities suggest that maize was becoming an important means of creating and marking social boundaries within Tiwanaku society.

Given its large sample size, Tiwanaku was the only site that provided an opportunity to investigate intra-site variation in great detail. Dental data revealed that women at the site had significantly higher caries rates than men, a pattern which was also observed at the basin-wide level and may be the result of increases in fertility and/or their role in *chicha* production (two scenarios discussed previously). Isotopic data do not indicate that males and females had significantly different diets (with the exception of males from the Markapata sector who consumed significantly more protein than females, which would explain discrepancies in caries data for those individuals).

Diets also varied significantly between people buried in different sectors at Tiwanaku. Individuals interred in ceremonial platforms (Akapana and Mollo Kontu

Mound), a residential compound within the marked bounds of the ceremonial core (Akapana East), and a cemetery outside the core (Markapata) had diets composed of 46-66% C_4 enriched resources—primarily maize. Dental caries rates for these individuals place them within the range of agro-pastoralists, although individuals from the Akapana East and the Mollo Kontu Mound had significantly higher caries rates than those from the Akapana and Markapata. This may be the result of sex- based differences in caries susceptibility, as there are significantly more males in the Akapana and Markapata samples and more females in the Akapana East and Mollo Kontu Mound samples. In addition, the Akapana East has been interpreted as a compound dedicated to the large-scale production of maize *chicha* for elite sponsored feasts (Janusek 2003: 292). Individuals involved in masticating maize for chicha production would be expected to have poor dental health due to the cariogenic nature of maize and in fact, these individuals had relatively high caries rates despite having the lowest mean age-at-death of any sector (25 ± 9 years).

In contrast, individuals interred in residential areas well outside the ceremonial core (Mollo Kontu residential and Chiji Jawira) and in one residential compound on the northern edge of the area defined by the moat (La Karaña) had much less access to maize. Individuals interred in the Mollo Kontu residential sector had diets composed of only 17-37% C_4 resources and consumed significantly more camelid meat than most sectors. However, the identification of a maize starch grain in the dentition of one individual from Mollo Kontu residential confirms they had occasional access to this import. In addition, despite having the oldest mean age-at-death of any sector, their dental caries rate (2%)

was by far the lowest of any, placing them in the range of hunter-gatherer populations[54]. Given these results, I suggest Mollo Kontu residential individuals were more involved with pastoralism than agriculture, and for this reason were consuming more meat relative to other sectors. Results for La Karaña and Chiji Jawira were less straightforward due to the greater amount of C_4 enriched fish being consumed however, it is clear they too had substantially less access to maize.

Finally, the diets of individuals interred as dedications in the Putuni sector were very distinct from others at Tiwanaku. Strontium isotope analyses by Kelly Knudson (Berryman et al. 2008; Knudson et al. 2003) indicate that these individuals (with one exception) are not local to the altiplano, a conclusion supported by the dietary data. These individuals had significantly lower nitrogen isotope values than any other altiplano individual sampled ($\delta^{15}N < 9‰$), indicating consumption of a non-local protein resource with lower nitrogen values. Thus, these results, combined with those of Knudson, demonstrate that within the altiplano, nitrogen isotope values below 9‰ are a good indication of non-local origins. The primary carbohydrate source for these individuals was a C_3 resource. C_4 enrichment in their diets was primarily derived from fish consumption, although some show evidence of maize in the diet. Dental data are consistent with an agro-pastoral lifestyle.

[54] These individuals also had significantly higher rates of dental abscesses and antemortem tooth loss when compared to other sectors and thus, it would be tempting to attribute the low caries rates to missing teeth resulting from advanced caries; however, on closer examination of these individuals, there is clearly a representative sample of dentition from the individuals (including the more caries prone molars) and most tooth loss appeared to be the result of periodontal disease (e.g. loss of lower incisors) and advanced age-related dental wear that resulted in abscesses and ultimately antemortem tooth loss. In addition, the isotopic data indicate that these individuals were consuming a significantly less cariogenic diet that would result in lower rates of carious lesions.

Post Tiwanaku Period

Diets changed dramatically in the Post Tiwanaku Period when C_4 enriched resources constituted only 15-35% of the overall diet—a significant decrease from the Tiwanaku Period. Although maize was still a component of some diets, fish was an increasingly important source of C_4 enrichment, especially for sites in the Katari and Desaguadero valleys. Maize consumption was now less than Late Formative levels and diets were more homogenous. The population was much more dependent on local resources, such as tubers and quinoa as their carbohydrate source. Consumption of camelid meat increased significantly, suggesting a greater dependence on pastoralism. Dental data reveal a statistically significant drop in dental caries rates to levels typical of hunter gatherer populations (1.3%). Taken together, these data indicate that agriculture was no longer a prime subsistence strategy among altiplano populations. Post Tiwanaku populations were primarily pastoralists. However, as noted in chapter 7, much of the Post Tiwanaku sample comes from the Katari valley, and thus, it is possible these changes represent a more localized phenomenon.

There is one significant outlier in the Post Tiwanaku sample. One of the two individuals from the small Tiwanaku valley site of TMV228 revealed that between 54-74% of his diet was composed of maize. A possible maize starch grain was also identified in his dentition. Two other individuals from the site, revealed virtually no maize in their diets. Given these anomalous results and the fact that TMV 228 spanned both the Tiwanaku V and Early Pacajes period and included burials from both, I am somewhat skeptical of the dating of this burial. However, I have no other significant evidence to confirm or refute its temporal assignment and thus, it remains in the Post

Tiwanaku sample. No other significant inter- or intra-site variation was observed in the Post Tiwanaku Period.

Commensal Politics and Political Transformations

A primary goal of this study was to examine how the manipulation of food and beverages, in the context of communal feasting events, actively generated social changes that led to the development of the archaic state. In the following pages I discuss the dietary evidence of feasting in the Southern Titicaca Basin from the Late Formative through the Post Tiwanaku periods provided by this study as well as relevant archaeological and paleobotanical evidence. I argue that taken together these data suggest that feasts featuring maize *chicha* were a central factor in the political transformations that occurred.

This study documented the presence of significant amounts of maize in the diets of Late Formative people from sites with ceremonial architecture that hosted feasting events (Khonkho Wankane, Tiwanaku, and to a lesser extent Iruihito), indicating that maize *chicha* was a central element of commensal politics in the altiplano much earlier than most researchers have assumed. What type of feasting events were these and what might that indicate about Late Formative politics? I argue that the situation Goldstein (2003: 166) has previously described for the Tiwanaku Period best fits the Late Formative data:

> In a setting where political status revolved around the ability to attract followers through the sponsorship of empowering feasts, the introduction of drink would trigger an ever-tightening spiral of factional competition. As each *ayllu* or individual sponsor vied to provide the best drink available, competition would have mandated *chicha* brewed with the uniquely high sugar content of maize…Tiwanaku expansion abroad and political growth at home were both

largely fueled by the accelerated cycle of political feasting that came about with the introduction of maize beer.

Khonkho Wankane and Tiwanaku were two of several ritual-political centers in the basin at this time, each the head of small multicommunity polities. Competition to attract followers necessitated innovation on the part of local leaders and I contend that a large part of Tiwanaku's ultimate success was the ability of its leaders to secure access to a large stable supply of maize through colonization in Moquegua[55] and the establishment of other lowland trade partners during the early part of the Middle Horizon (a strategy that intensified significantly during the Tiwanaku V period). These connections provided Tiwanaku a significant advantage over rival ritual-political centers, allowing its leaders to attract more followers and gain increasing political authority, as evidenced by the decline of other ceremonial centers towards the end of the Late Formative Period.

The major change in commensal politics during the Tiwanaku Period was primarily one of scale. As previously discussed, Tiwanaku's expansion into the lowlands coincided with the introduction of a whole suite of new ceramic forms dedicated to the production, transportation, storage, and serving of maize *chicha*, which quickly spread throughout the South Central Andes. The construction of a massive platform mound, the Akapana, which hosted large-scale feasting events, also began during this period, and specialized compounds, such as the Akapana East, were established for the large-scale production of maize *chicha* (Janusek 2003, 2004). Monoliths were erected in the center of Tiwanaku temples, which depicted mythical ancestors or elite rulers holding a *kero* for

[55] I suggest that during Tiwanaku IV, Omo style settlements likely provided maize to the altiplano and in Tiwanaku V both Omo and Chen Chen style settlements provided a much larger supply of maize (see Goldstein 2005 regarding dates). Separating Tiwanaku IV and Tiwanaku V maize consumption patterns in the altiplano will be an important area of future research.

chicha consumption in one hand and a snuff tablet in the other (Janusek 2008; 138; Torres 1987). Kernel-to-cob ratios from the Akapana East indicate that maize was being transported to Tiwanaku off the cob, suggesting bulk shipment from the lowlands (Wright et al. 2003). And my data reveal that, on average, C_4 enriched resources (the bulk of which were maize) now constituted 35-55% of the overall diet within the southern basin. Taken together, these data clearly indicate that obtaining and redistributing maize, as part of feasting or perhaps work party events, became a key responsibility of the emerging state.

Despite substantial ceramic evidence from feasting middens indicating that *chicha* was a central component of feasts, the apparent prevalence of maize in altiplano diets during this period could be taken to indicate that it had no special or unique place in feasting events. However, as discussed earlier in this chapter, there are a number of reasons to suspect that the percentages calculated by this study (35-55% for the basin as a whole during the Tiwanaku Period) are somewhat inflated due to a sampling bias and do not accurately reflect maize consumption for the general population. That is, individuals from sites with ceremonial architecture are over-represented in the sample and there is reason to suspect that many of these individuals enjoyed priviledged access to maize, perhaps on a daily basis (see the discussion of diacritical feasting below). In contrast, the smaller sample of individuals from rural sites and those living on the outskirts of urban centers indicates that they had very limited access to maize, perhaps only through feasting or work party events.

Given the large percentage of maize in altiplano diets, it also also seems improbable at first glance that it was only being consumed as *chicha*. However, as Dietler

(2001: 81) notes, ethnographic studies reveal that in many societies alcoholic beverages often make a substantial contribution to the overall diet (see Garine 1996; Haggblade 1992; Netting 1964; Richards 1939: 80). Further, according to Goldstein (2003:164) no ceramic forms associated with popping, roasting, or toasting maize are found in Tiwanaku assemblages: therefore, if it was ingested in forms other than *chicha*, it was either boiled or ground and consumed as a type of porridge. Given the symbolic value of this import, the difficulty involved in obtaining it, and the widespread distribution of vessels associated with *chicha* consumption, I doubt it was regularly consumed as a simple porridge. At present, it seems likely that the bulk of maize was consumed as *chicha*[56].

Chicha was vital to the success of Tiwanaku. As a key element in rituals that attracted followers from throughout the South Central Andes, Tiwanaku's leaders recognized the central role this beverage played in the construction and maintenance of political authority and for this reason they went to great lengths to secure a steady supply of it. As Goldstein (2003: 167) states, Tiwanaku's "culinary cachet depended on access to a wide variety of maize types, an efficient and attractive ceramic assemblage for brewing, storing, and serving, and a fully integrated social context for imbibing." Elaborate patron-role feasting events were necessary to fulfill obligations of reciprocity between Tiwanaku's leaders and their followers, and thus, legitimize and naturalize growing asymmetries of power. People were drawn to Tiwanaku because they benefited by participating in its state culture, whether ideologically or economically. For five

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[56] It is important to point out that *chicha*, unlike the light clear beers popular today, is a thick broth-like beverage that is quite filling.

hundred years, Tiwanaku's elaborate ritual ceremonies out-shined all others in the region, gaining the allegiance of diverse ethnic groups who emulated its culinary traditions.

Large-scale patron-role feasts were not the only form of commensal politics carried out at Tiwanaku. Residential compounds throughout the city revealed evidence of hosting periodic (empowering) feasts, including high numbers of elaborate serving wares found in patios and outdoor middens (Janusek 2003: 294). These smaller-scale commensal events likely fostered social solidarity among the various *ayllus* while also providing an arena for their hosts to accrue social prestige. In addition, the evidence of lower status households hosting feasts, which emulated consumption patterns promoted by the state, reveals one means through which the general population embraced and ultimately re-enforced state culture. Paleobotanical data revealed that much of the maize found in residential compounds arrived from the lowlands still on the cob, suggesting smaller-scale provisioning (Wright et al. 2003). It seems likely these residents were able to obtain maize through ethnic or kin ties to other ecological zones and/or exchange rather than through state redistribution. This indicates that the state did not exclusively control access to lowland resources and highlights the choices about food consumption that could be made by people at the local level (i.e. not all food practices were determined by the state).

Finally, the importance of maize *chicha* and feasting to Tiwanaku's political power is underscored by the dramatic changes in consumption that occurred in the Post-Tiwanaku Period. During the Late Intermediate Period, both the Tiwanaku capital and its maize producing colony in Moquegua were abandoned and maize virtually disappeared from altiplano diets. In addition, the large *ollas* and *tinajas* necessary for large-scale feasting events, which were ubiquitous during Tiwanaku times, disappeared. The party was over. Although my data show that small amounts of maize could still be found in the altiplano, the large-scale supply was gone, as were the grand feasts. This suggests that the state had significant control over maize production and distribution which was lost upon (or just prior to) its dissolution.

Interestingly, maize consumption also decreased dramatically in Moquegua (Sandness 1992). As Goldstein (2005: 324) states: "Without Tiwanaku's chicha-fueled ideology, the love affair with maize…seems to have soured." Moquegua populations now had a much more diversified diet; these lower valley populations were more dependent on marine foods and C_3 plants (Sandness 1992). In the altiplano, my data show that consumption of staple carbohydrate resources (including maize, tubers, and quinoa) diminished altogether, while consumption of camelid meat increased significantly. Also, raised field agriculture in the Katari valley ceased and agricultural implements become rare in archaeological assemblages (Janusek and Kolata 2003: 157). It is clear that by the Post Tiwanaku Period, large-scale agriculture in the Southern Titicaca Basin was over; populations were now much more dependent on pastoralism. Taken together, the dramatic dietary changes in both Moquegua and the altiplano provide support for the theory that an extreme drought around 1100 A.D. contributed to the disentegration of the state by exacerbating tensions that were already simmering as a result of increasingly oppressive elite control (Binford and Kolata 1996; Binford et al. 1997; Janusek 2004, 2008; Kolata and Ortloff 1996; Ortloff and Kolata 1993). However, a recent study suggests that although short term droughts did occur near the time of the collapse, a major long term drought did not occur in the region until closer to

1240 A.D. (Arkush 2008; also see Williams 2002). In addition, others caution that environmentally determined collapse hypotheses underestimate the ability of ancient people to adapt to climatic changes (Erickson 1999). In any event, an inability to supply the key element in rituals that legitimated the state's political authority (i.e. *chicha*), either as a result of a climatic catastrophe, political turmoil or the unfortunate historical conjuncture of the two, would have been disastrous for Tiwanaku's leaders. Their authority would have been undermined and the dissolution of the state would soon follow.

Food Consumption and the Construction of Social Identity

This study also sought to elucidate how access to food and food choices may have reflected and structured social identity within Tiwanaku society (see Bourdieu 1984). As discussed in Chapter 3, certain foods often become more symbolically charged than others and thus, their distribution may offer the greatest insight into social dynamics. Within the Andes, both maize and meat have been identified as particularly valued foods that are often reserved for festive occasions and eaten in greater quantities by those of high status (Hastorf 2003a; regarding meat consumption see Cobo1990 [1653]: 198 and Johnsson 1986:40). I considered the distribution of both throughout the periods in question.

Although sample sizes for the Late Formative Period were small, some intra-site distinctions in food consumption were observed. Variation in maize consumption at Khonkho Wankane (n= 4) tentatively suggests that maize may have already been a symbolically charged food, and that access to it (at least in large quantities) may have marked social boundaries. Dietary variation may represent differential consumption based on class or ethnic divisions. However, it is also possible some of these individuals were foreign migrants into the altiplano and thus, reflect the stable isotopic signatures of their homelands. Strontium isotope data for the Late Formative sample is needed to clarify the source of dietary variation at Khonkho Wankane. Meat consumption was relatively homogenous within Late Formative sites.

The large sample size for the Tiwanaku Period provided the best opportunity to evaluate distinctions in food consumption. During this period, there is significant variation in meat and maize consumption within sites, particularly at sites with monumental architecture. As previously discussed, meat consumption increased significantly at sites with growing ceremonial centers (Lukurmata, Tiwanaku, and Iruihito). However, inter- and intra-site variation does not indicate that meat consumption was linked to high status. Individuals at small rural sites, with the exception of Kirawi, consumed a significant amount of meat, likely indicative of pastoral activities. At Tiwanaku, those consuming the most meat lived in low status residential compounds on the outskirts of the city (Mollo Kontu and Chiji Jawira). These sections of the city would have had space to maintain camelid herds. Given this pattern of variation, I suggest greater meat consumption was closely tied to pastoralism, and thus, indicative of occupation rather than high status. The discovery of an increasing emphasis on pastoralism at growing ceremonial centers who were also consuming greater quantities of maize is not surprising, as larger numbers of camelids would be necessary to transport this lowland import to the sites.

Large disparities in maize consumption were found at sites with monumental architecture during the Tiwanaku Period (Tiwanaku, Lukurmata, Khonkho Wankane, and Iruihito). Do these disparities in maize consumption reflect an intensely hierarchical division of society such that social status was a prime determinate of access to it? The well-defined urban barrios of Tiwanaku provided an excellent site for testing such a hypothesis, as well as Kolata's contention that the site was spatially organized in concentric gradients, with elites occupying the ceremonial core. Results reveal that those buried in ceremonial platforms (Akapana and Mollo Kontu mound) as well as a residential compound within the marked bounds of the city's sacred core (Akapana East) and a cemetery outside the core (Markapata) ate the most maize. Individuals interred in residential areas on the outskirts of the city (Mollo Kontu residential and Chiji Jawira) and one low status residential compound on the northern edge of the area defined by the moat (La Karaña) ate significantly less maize. I conclude that these data, along with lesser maize consumption among individuals buried at small rural sites, indicate that access to maize was closely correlated to status and perhaps ethnicity.

Variation in maize consumption was roughly correlated to proximity to the site's core, tentatively supporting Kolata's theory that the site was organized in concentric gradients of social status and that social organization at the site was highly centralized. However, the individuals with greater maize consumption primarily come from ceremonial platforms and a cemetery and therefore assumptions of elite status for these individuals are speculative. A lack of elite burials clearly associated with elite residences remains problematic[57]. Only one residential compound in the ceremonial core (Akapana

[57] Recall that burials from the Putuni palace appear to be low status foreign individuals placed their as dedicatory offerings and not the elite palace residents.

East) had burials available for analysis and these individuals consumed large quantities of maize. Thus, dietary support for Kolata's theory of social organization at the site, although present, remains tentative.

Evidence that dietary variation was also linked to ethnic identity comes from recent collaborative work by Berryman and Blom (Berryman et al. 2009) comparing diet and culturally-modified head shape (a recognized marker of ethnic identity in the region, see Blom 1999, 2005) of individuals buried in the Mollo Kontu residential area and the Mollo Kontu mound (Berryman et al. 2009). Those buried in the residential area had relatively little access to maize, ate substantial quantities of meat, and practiced annular cranial modification. In contrast, those buried in the mound consumed substantial quantities of maize, ate less meat, and practiced fronto-occipital cranial modification[58]. It is important to note that status and ethnicity are often interrelated and I maintain that status and ethnicity were both important factors in the acquisition of dietary resources.

Additional support for a link between status and distinctions in food consumption comes from ceramic analyses, which revealed the use of diverse elaborate serving wares in residential compounds inside the sacred core of the city (Putuni and Akapana East) and simpler more standardized versions used in residential compounds outside the sacred core (Janusek 2003: 293). These data, along with my dietary analyses, indicate that food consumption, particularly the frequent consumption of maize *chicha*, became a diacritical marker of social boundaries in the Tiwanaku Period.

An issue of concern in this study was distinguishing between individual choices about food consumption and imposed dietary restrictions. There is no evidence that elites

[58] Strontium isotope analysis by Kelly Knudson revealed local origins for all Mollo Kontu mound and residential individuals (Berryman et al. 2009).

or other social groups had exclusive access to socially valued resources such as maize or that sumptuary laws ever dictated their distribution. Despite significant disparities, individuals at all levels of society enjoyed occasional access to maize either through participation in state sponsored feasts or through their own provisioning, perhaps involving ethnic ties to other ecological zones. Supporting evidence for this comes from kernel-to-cob ratios, which indicate that maize arrived in many households on the cob: evidence for small-scale provisioning. In contrast, maize primarily arrived in kernel form (i.e. off the cob) in areas associated with *chicha* preparation for state sponsored feasts (i.e. Akapana East), suggesting large-scale provisioning (Wright et. al. 2003: 393). Thus, there is no evidence of imposed dietary restriction; rather, variation was primarily a matter of scale. Individual low status households were capable of obtaining their own maize and often sponsored feasts, but they could not obtain it in comparable quantities to elites.

Distinctions in maize (*chicha*) consumption did not differ among the sexes. Thus, differential access to maize was primarily dictated by class or ethnic divisions rather than gender, a pattern typical of more highly stratified societies (see Dietler 2001: 91). In addition, this indicates that women were participants in commensal politics involving *chicha* consumption.

The poorer dental health of women may indicate that their labor, particularly the mastication of maize for *chicha* production, was valued for staging feasts. Given a larger sample size, future comparison of dental health among high and low status women at Tiwanaku would be particularly informative, as a "shift in the position of women of the elite class from food preparers to commensal partners (with a corresponding development of specialist food preparers and servers)" is often seen in societies with endogamous social classes (Dietler 2001: 91; also see Goody 1982).

In summary, these data indicate that differential access to maize *chicha* (not just maize) likely served to create and maintain social hierarchy within Tiwanaku society. Diacritical modes of consumption are apparent wherein elites naturalized and reified their distinct status through the consumption of large quantities of maize *chicha*, the use of elaborate serving wares (Janusek 2003: 293), and the hosting of smaller more restrictive and exclusive feasting events (Janusek 2003: 262). Their access to and knowledge of such forms of consumption provided elites with cultural capital and distinguished them from lower status individuals.

I find Kirch's description of elite food consumption patterns among Hawaiian chiefdoms particularly relevant for thinking about *chicha* consumption among Tiwanaku elites: "The chiefs…could virtually be found feasting everyday of their lives…feasting was a… mundane, ubiquitous aspect of chiefly *habitus*" (Kirch 2001: 178-179). Similarly, I suggest that *chicha* consumption became a ubiquitous aspect of elite *habitus* within Tiwanaku society. Given the extreme quantities of *chicha* in the diet of some individuals, it is apparent that this socially valued food, which for most was likely reserved for special occasions, was being consumed on a daily basis by certain social groups during the Tiwanaku era.

Throughout the Tiwanaku heartland state culture was embraced through "emulation by those aspiring to higher status" (Dietler 2001: 86). Individual households sponsored small-scale feasts featuring maize *chicha* and consumed other material symbols of Tiwanaku social identity, including ceramic styles associated with *chicha* consumption and other ritual paraphernalia.

Sometime near the end of the Tiwanaku Period, cultural practices and attitudes associated with the state lost their appeal and altiplano populations no longer sought to align themselves with Tiwanaku social identity. The waning appeal of state culture was likely a reaction against increasingly oppressive elite control during the Tiwanaku V period, which may have been exacerbated by prolonged drought. In the Post Tiwanaku Period, maize consumption decreased significantly, while camelid meat consumption increased. I have suggested, based on both stable isotopic and dental indicators, that altiplano populations became very dependent on pastoralism at this time. Diets became homogenous, indicating that with the disintegration of the state, the intense social hierarchy of the Tiwanaku Period was effectively leveled and dietary distinctions no longer marked boundaries among altiplano social groups.

Evaluating the Nature of Tiwanaku Political Authority

A final objective of this study was to provide insight into the nature of Tiwanaku's political authority by examining how state formation affected the domestic economy and thus, impacted daily lives. Specifically, I considered how the Tiwanaku state was politically centralized, particularly as it related to the extent that leaders controlled agricultural production and distribution. In addition, I considered how the activities of individuals helped to undergird state authority and shape policies and strategies.

Dramatic changes in diet throughout the basin during the Tiwanaku Period suggest that the domestic economy was significantly altered by state formation processes.

Large increases in maize consumption, paleobotanical evidence of large-scale (i.e. off the cob) provisioning (Wright et al. 2003), and specialized *chicha* production areas indicate that the state was likely involved in managing the production and distribution of this imported resource. Further support for state management of maize importation is found in the striking decrease in maize consumption that followed the collapse of the state. The selective distribution of maize, favoring certain social groups at sites with monumental architecture during the Tiwanaku Period, also indicates that certain communities and individuals were benefiting more than others from state sponsored activities. However, as previously discussed, there is evidence that altiplano people were able to obtain maize through other means, perhaps involving ethnic or kin ties to other ecological zones. So, although the state likely oversaw large-scale maize importation from lowland colonies and other affiliated trade partners, it apparently could not or did not restrict the rights of others to import it.

It proved difficult to gage the extent to which state formation affected the production of local crops, such as tubers and quinoa. Although maize was now a component of most diets, local crops continued to be the primary staples in the diets of those living in small rural communities as well as many from larger sites with monumental architecture. As discussed previously, I suspect maize consumption is probably over-emphasized in the altiplano sample due to the over-representation of individuals from the ceremonial core of sites. Individuals buried in and near such sacred areas may have belonged to social groups with significantly more access to maize. Certainly archaeological evidence of extensive agricultural intensification in the Koani

Pampa, which coincided with state formation, suggests that the state became significantly involved with the production of local crops as well (Janusek and Kolata 2004).

What then does the dietary data indicate regarding the impact of state formation on the daily lives of individuals living in the Tiwanaku heartland? Although no changes were apparent in the lives of individuals living in small rural communities, who continued to rely on locally produced crops and pastoralism for their livelihood, the evidence does suggest that the lives of those living at sites with monumental architecture were significantly altered. Their diets changed considerably and boundaries between social groups were now marked by significant differences in maize and meat consumption. Changes in diet were most pronounced at the site of Lukurmata, a site thought to have become a second order administrative center charged with overseeing agricultural production on the Koani Pampa during this time (Bermann 1994). Here, both maize and meat consumption increased dramatically, indicating an increasing involvement in pastoralism as well as the introduction of a steady supply of maize. However, given the variation in maize consumption at the site, it is probable that certain individuals at Lukurmata were benefiting from their ties to the state more than others. This is underscored by Bermann's observation that a higher percentage of Tiwanaku style ceramics were found in elite residences at Lukurmata (1994). These changes at Lukurmata and other sites indicate that the state significantly intervened in local domestic economies and impacted daily life, affecting one of the most fundamental household activities—deciding what to eat. No differences in maize consumption were apparent between males and females at any site, suggesting both participated in commensal politics. However, the dental caries data do suggest that the labor of women may have been used by the state to stage its grand feasts. This does not necessarily imply that women were being exploited by the state. It is possible that their role in preparing such a symbolically charged beverage as *chicha* was highly valued by both the patrons who sponsored the feasts and the women themselves (see Gero 1992). A specialized role in the production of such a valued product may have allowed women to acquire status or other opportunities.

Overall, the vision of the Tiwanaku state that emerges from this study is most consistent with the centralized state model proposed by Alan Kolata (1986, 1991, 1993, 2003). Evidence of both diacritical and redistributive patron-role modes of feasting at the site of Tiwanaku is indicative of a society with "institutionalized relations of asymmetrical social power" (Dietler 2001: 82-82). The organization of large patron-role feasting events associated with public architecture that featured the redistribution of maize *chicha* produced by specialists rather than (or in addition to) individual households also suggests a relatively centralized political economy. This is also supported by evidence of Tiwanaku's control over the production and distribution of agricultural resources such as *chicha*. However, the bottom-up perspective offered by this study indicates that Tiwanaku did not exert total control over such resources, as the evidence indicates that many households were allowed to obtain maize independently. It was therefore the scale of *chicha* consumption rather than the presence of *chicha* that differentiated elite and non-elite consumption patterns. And, although Tiwanaku's impact on the domestic economy of communities in the heartland was significant, suggesting its leaders maintained significant political authority within the southern basin, its impact was primarily one of benefits to selective communities and individuals: this suggests integrative rather than coercive strategies of state formation. The state seems to have had little impact on small rural communities, indicating the preservation of local autonomy. There is no evidence that dietary practices within these communities or among individuals living on the outskirts of the urban center were dictated by the state. These individuals were apparently able to develop their own menus; although, their food practices would certainly have been influenced by larger social norms about what was appropriate or desirable to eat. Thus, although Tiwanaku was a centralized state, its leaders exerted their political authority in a selective and flexible manner, which was likely necessary given the diverse beliefs and practices of the regions distinct ethnic groups.

Conclusions

This dissertation demonstrates the valuable insight bioarchaeological study of human diets can provide into social relations and processes of social change in past societies. Further, this study contributes to the growing body of literature suggesting that states and empires around the globe used food and feasting, among other mediums of material culture, to promote political agendas (see Bray 2003; Cook and Glowacki 2003; Dietler 1996, 2001; Goldstein 2003; Kirch 2001; LeCount 2001). Food practices were used by ancient states to simultaneously promote obligations and allegiance while also creating social boundaries, according to class, gender, or ethnic divisions. Thus, as this study of Tiwanaku has shown, food and feasting can be significant elements in the creation and maintenance of political authority.

Dramatic changes in diet that accompanied the rise of the Tiwanaku state in the Middle Horizon, particularly increases in the consumption of imported maize, were likely the culmination of escalating competition among regional ceremonial centers who hosted ritual feasts during the Late Formative period. Maize *chicha* was a central element of commensal politics and other aspects of altiplano ritual life at these centers, and with the establishment of a colony in Moquegua and other lowland trading partners, Tiwanaku's leaders succeeded in obtaining a large steady supply of this socially valued crop, which they transformed into a distinctive and status-enhancing beverage. This advantage, along with the introduction of new ceramic forms for the production, transportation, storage, and consumption of maize *chicha*, the elaboration of public forums for hosting large patron-role feasting events, and the promotion of an appealing state religion, attracted followers from throughout the South Central Andes and was a key element in Tiwanaku's political success. Thus, Tiwanaku's leaders created a social and political climate where maize *chicha,* which they could produce on a grand scale, was vital to the construction and maintenance of political authority.

Study of significant inter- and intra-site variation in maize consumption during the Middle Horizon, provided valuable insight into social dynamics within the Tiwanaku heartland from both a top-down and bottom-up perspective. Diacritical modes of consumption, including the consumption of large amounts of maize *chicha,* became an important means of marking status and ethnic boundaries, and thus, creating and maintaining social hierarchy in Tiwanaku society. Smaller scale emulation of elite feasting events is evident in many homes throughout the site of Tiwanaku, indicating the embracement of state culture by many. Interestingly, no significant differences in diet were observed between males and females, indicating gender was not marked by dietary differences. During the Post Tiwanaku period, diets became much more homogenous, including substantially more camelid meat and significantly less maize or local staple crops. This homogeneity indicates that dietary distinctions no longer marked boundaries among altiplano social groups and that the intense social hierarchy of the Middle Horizon was effectively leveled with the collapse of the state.

Finally, bioarchaeological study of altiplano diets provided insight into the nature of Tiwanaku's political authority. Evidence of patron-role and diacritical modes of feasting within Tiwanaku society indicate the existence of institutionalized asymmetries of social power. Further, dramatic increases in maize consumption that accompanied the rise of the state, large-scale production of maize *chicha* by groups of specialists (e.g. Akapana East), its redistribution at patron-role feasts, and its virtual disappearance following state collapse indicate that the state was involved in managing the production and distribution of maize, and suggest a relatively centralized political economy. However, there is no evidence that the state restricted the rights of independent households to import it through their own means. Together, these data imply that Tiwanaku was an intensely stratified politically centralized state; however, its policies were highly selective and strategic, as many small rural communities in the heartland remained virtually unaffected. Thus, the dietary data indicate that certain communities and individuals certainly benefited more than others from their ties to the Tiwanaku state.

APPENDIX A: PRESERVATION INDICATORVALUES FOR EACH ISOTOPIC SAMPLE

Species	**Site**	**Specimen #**	**C%**	**N%**	**C:N Ratio**	**Collagen % Yeild**	**Apatite % Yield**
H. sapiens	Tiwanaku	AK-11649	36.3	13.9	3.0	3.1	55.9
H. sapiens	Tiwanaku	AK-12149			3.2		77.5
H. sapiens	Tiwanaku	AK-21262	32.9	12.3	3.1	5.0	75.4
H. sapiens	Tiwanaku	AK-21264			3.1		92.5
H. sapiens	Tiwanaku	AK-21266			3.1		82.6
H. sapiens	Tiwanaku	AKE-20042	39.7	15.4	3.0	16.2	71.7
H. sapiens	Tiwanaku	AKE-20715			3.2		69.2
H. sapiens	Tiwanaku	AKE-20727-x	39.4	15.3	3.0	30.7	60.4
H. sapiens	Tiwanaku	AKE-2940	46.2	17.9	3.0	16.2	66.1
H. sapiens	Tiwanaku	AKE-30902					67.4
H. sapiens	Tiwanaku	AKE-6417	38.0	14.7	3.0	21.6	67.7
H. sapiens	Tiwanaku	AKE-8908					45.2
H. sapiens	Tiwanaku	CJ-33605	42.0	16.2	3.0	19.2	48.4
H. sapiens	Tiwanaku	CJ-36980	31.4	11.9	3.1	7.5	60.6
H. sapiens	Tiwanaku	CJ-36995-1	9.3	3.5	3.2	13.2	66.8
H. sapiens	Tiwanaku	CJ-36995-2	42.5	14.4	3.3	6.0	55.2
H. sapiens	Tiwanaku	CJ-36995-3	40.8	15.6	3.1	19.7	76.6
H. sapiens	Kirawi	CK65-1027			3.1		53.4
H. sapiens	Kirawi	CK65-1041			3.2		49.9
H. sapiens	Kirawi	CK65-1086			3.1		65.2
H. sapiens	Kirawi	CK65-1100			3.0		53.7
H. sapiens	Kirawi	CK65-1130			3.1		56.1
H. sapiens	Kirawi	CK65-1691			3.2		74.6
H. sapiens	Urikatu Kontu	CK70-3079	35.8	13.5	3.1	19.1	46.5
H. sapiens	Urikatu Kontu	CK70-3133			3.2		73.3
H. sapiens	Urikatu Kontu	CK70-3144	31.4	12.1	3.0	19.9	60.7

H. sapiens	Urikatu Kontu	CK70-3149			3.3		81.5
H. sapiens	Urikatu Kontu	CK70-3283			3.2		44.4
H. sapiens	Urikatu Kontu	CK70-3324	33.5	12.8	3.1	20.0	58.9
H. sapiens	Iruhuito	IR-4.1R1.1-#2	32.5	12.3	3.1	22.1	71.8
H. sapiens	Iruhuito	IR-4.1R1.1-#3	42.8	16.2	3.1	15.0	67.8
H. sapiens	Iruhuito	IR-5.1r6	39.1	14.7	3.1	14.6	60.9
H. sapiens	Iruhuito	IR-5.2R5	34.6	13.2	3.1	21.9	62.1
H. sapiens	Tiwanaku	KAR-24599	40.8	15.7	3.0	12.7	68.3
H. sapiens	Tiwanaku	KAR-34313	41.3	15.5	3.1	21.2	68.9
H. sapiens	Tiwanaku	KAR-39164-1	39.5	15.0	3.1	14.0	70.6
H. sapiens	Tiwanaku	KAR-39164-2	44.6	17.3	3.0	12.0	60.9
H. sapiens	Khonkho Wankane	KW-0125					58.6
H. sapiens	Khonkho Wankane	KW-12.109	40.0	15.8	3.0	18.5	54.6
H. sapiens	Khonkho Wankane	KW-1205					59.6
H. sapiens	Khonkho Wankane	KW-1285			3.1		55.8
H. sapiens	Khonkho Wankane	KW-14.4R3.2	43.2	16.9	3.0	11.5	46.3
H. sapiens	Khonkho Wankane	KW-1855					54.6
H. sapiens	Khonkho Wankane	KW-2.1.2	40.0	15.4	3.0	22.8	67.5
H. sapiens	Khonkho Wankane	KW-4.19R13.3	42.2	16.3	3.0	21.4	59.8
H. sapiens	Khonkho Wankane	KW-5285			3.2		44.2
H. sapiens	Khonkho Wankane	KW-5374					68.2
H. sapiens	Khonkho Wankane	KW-5612			3.2		63.1
H. sapiens	Khonkho Wankane	KW-5748					73.3
H. sapiens	Khonkho Wankane	KW-7W10-13	39.5	15.2	3.0	19.5	58.8
H. sapiens	Lukurmata	LKM-0043			3.1		80.6
H. sapiens	Lukurmata	LKM-10407			**3.9**		59.2
H. sapiens	Lukurmata	LKM-3036	37.1	14.3	3.0	24.6	52.6
H. sapiens	Lukurmata	LKM-3039	46.1	17.7	3.0	21.8	71.9
H. sapiens	Lukurmata	LKM-3042			3.1		63.7
H. sapiens	Lukurmata	LKM-3043			3.1		80.1
H. sapiens	Lukurmata	LKM-3044	44.3	16.9	3.0	16.5	76.2
H. sapiens	Lukurmata	LKM-3045			3.2		71.1
H. sapiens	Lukurmata	LKM-3048			3.1		53.6

H. sapiens	Lukurmata	LKM-3459			3.2		61.4
H. sapiens	Lukurmata	LKM-3513			3.2		56.9
H. sapiens	Lukurmata	LKM-364			3.2		50.0
H. sapiens	Lukurmata	LKM-4140	35.0	13.6	3.0	19.9	69.3
H. sapiens	Lukurmata	LKM-472			3.2		63.6
H. sapiens	Lukurmata	LKM-6625	39.0	15.0	3.0	16.6	55.5
H. sapiens	Lukurmata	LKM-7022			3.2		69.1
H. sapiens	Lukurmata	LKM-7379			3.1		64.1
H. sapiens	Lukurmata	LKM-8438			3.3		70.5
H. sapiens	Lukurmata	LKM-8444			3.2		55.2
H. sapiens	Lukurmata	LKM-8495			3.1		61.8
H. sapiens	Lukurmata	LKM-9193	40.4	15.5	3.0	11.4	77.8
H. sapiens	Lukurmata	LKM-9271-2	43.9	17.0	3.0	24.1	55.2
H. sapiens	Lukurmata	LKM-9271-3	40.5	15.9	3.0	15.9	70.4
H. sapiens	Lukurmata	LKM-9272			3.3		75.0
H. sapiens	Lukurmata	LKM-9352			3.2		67.4
H. sapiens	Lukurmata	LKM-9620			3.1		75.6
H. sapiens	Tiwanaku	MK-31292	44.8	17.5	3.0	21.8	51.8
H. sapiens	Tiwanaku	MK-39788	42.5	16.5	3.0	17.2	63.8
H. sapiens	Tiwanaku	MK-799			3.1		82.1
H. sapiens	Tiwanaku	MK-833/834					79.0
H. sapiens	Tiwanaku	MK-834			3.0		61.3
H. sapiens	Tiwanaku	MK-841			3.0		72.4
H. sapiens	Tiwanaku	MK-874-1					87.3
H. sapiens	Tiwanaku	MK-874-2					63.5
H. sapiens	Tiwanaku	MK-890			**1.7**		63.5
H. sapiens	Tiwanaku	MK-985					72.4
H. sapiens	Tiwanaku	MP-217	38.8	14.9	3.0	20.7	62.4
H. sapiens	Tiwanaku	MP-225	34.9	13.3	3.0	21.4	75.6
H. sapiens	Tiwanaku	MP-227	42.4	16.5	3.0	21.1	73.3
H. sapiens	Tiwanaku	MP-229	36.9	14.1	3.0	14.8	57.5
H. sapiens	Tiwanaku	MP-230	46.2	17.9	3.0	20.4	62.6
H. sapiens	Tiwanaku	MP-239	35.7	13.8	3.0	17.8	65.8

H. sapiens	Tiwanaku	MP-245	41.6	16.1	3.0	21.7	72.5
H. sapiens	Tiwanaku	MP-247	37.8	14.4	3.1	6.7	74.4
H. sapiens	Tiwanaku	MP-41523-2	36.1	13.9	3.0	20.7	65.2
H. sapiens	Tiwanaku	MP-41728-A	36.2	14.2	3.0	20.2	64.2
H. sapiens	Tiwanaku	PUT-20995			2.9		67.1
H. sapiens	Tiwanaku	PUT-22948	38.7	15.0	3.0	14.5	62.8
H. sapiens	Tiwanaku	PUT-25940-1			2.8		72.4
H. sapiens	TMV228/Mollo Kontu	TMV-228-195			2.9		74.8
H. sapiens	Tilata	TMV-101-468			3.0		70.2
H. sapiens	TMV228/Mollo Kontu	TMV-228-196			2.9		69.7
C. porcellus	Tiwanaku	MK-D-3384	38.1	14.7	3.0	4.6	72.7
Camelid	Khonkho Wankane	KW1.26N2R1	39.9	15.4	3.0	18.8	54.6
Camelid	Khonkho Wankane	KW12.29N3R1	42.6	16.4	3.0	18.0	38.9
Camelid	Khonkho Wankane	KW9.20N6	40.3	15.7	3.0	16.2	58.6
Camelid	Tiwanaku	MK-D-3634	38.9	14.9	3.0	12.4	54.9
Camelid	Tiwanaku	MK-E-3522	37.5	14.5	3.0	18.8	51.4
fish	Tiwanaku	MK-D-3387	40.7	13.6	3.5	**0.5**	67.2

APPENDIX B: CARBON AND NITROGEN ISOTOPE RESULTS FOR EACH SAMPLE[59]

Site	Specimen #	Sex	Age	$\delta^{13}C_{co}$	% C_4 $\delta^{13}C_{co}$	$\delta^{13}C_{ap}$	%C_4 $\delta^{13}C_{ap}$	$\delta^{13}C_{co-ap}$	$\delta^{15}N$
(a) Late Formative									
Iruihito	IR-4.1R1.1-#2	UN	ADULT	-17.2	18.0	-5.0	70.7	12.2	11.1
Iruihito	IR-4.1R1.1-#3	UN	ADULT	-17.5	16.0	-7.8	52.0	9.7	11.0
Khonkho W.	KW-12.109	M	20-40	-18.0	12.7	-8.2	49.3	9.8	10.7
Khonkho W.	KW-4.19R13.3	UN	20+	-17.4	16.7	-11.6	26.7	5.8	11.6
Khonkho W.	KW-5374	M	45+	-18.6	8.7	-8.4	48.0	10.2	11.8
Khonkho W.	KW-7W10-13	F	35-50	-18.2	11.3	-11.5	27.3	6.7	11.0
Kirawi	CK65-1041	F	20-30	-14.7	34.7	-10.1	36.7	4.6	9.8
Kirawi	CK65-1691	F	35-45	-19.2	4.7	-11.7	26.0	7.5	11.4
Lukurmata	LKM-3042	M	15-20	-18.8	7.3	-13.0	17.3	5.8	10.5
Lukurmata	LKM-3043	F	35-45	-19.3	4.0	-12.5	20.7	6.8	9.8
Lukurmata	LKM-3045	M	40-50	-18.4	10.0	-14.1	10.0	4.3	10.1
Lukurmata	LKM-3048	M	50+	-18.7	8.0	-13.2	16.0	5.5	13.1
Tiwanaku	CJ-36995-2	UN	18-35	-18.8	7.3	-10.6	33.3	8.2	10.2
Tiwanaku	CJ-36995-3	UN	18-35	-17.6	15.3	-8.7	46.0	8.9	10.7
Tiwanaku	MP-230	M	25-35	-19.0	6.0	-11.5	27.3	7.5	9.6
(b)Tiwanaku Period									
Iruihito	IR-5.1r6	UN	ADULT	-15.7	28.0	-2.4	88.0	13.3	13.2
Iruihito	IR-5.2R5	UN	ADULT	-15.3	30.7	-10.9	31.3	4.4	12.9
Khonkho W.	KW-1205	F	50+	-10.7	61.3	-4.3	75.3	6.4	10.6
Khonkho W.	KW-125	F	40+	-16.7	21.3	-10.6	33.3	6.1	10.4
Khonkho W.	KW-1285	UN	30+	-12.2	51.3	-7.0	57.3	5.2	10

[59] Note that this list does not include raw data for the eight individuals analyzed by Paula Tomczak, including AK-99412-2, AKE-15628-2, CJ-35250, MK-29412, MK-39787, PUT-22794. PUT-24106, and PUT-25785-1.

Khonkho W.	KW-1855	PM	50-80	-11.7	54.7	-6.1	63.3	5.6	10.5
Kirawi	CK65-1027	F	20-25	-16.8	20.7	-11.3	28.7	5.5	10
Kirawi	CK65-1086	M	45+	-16.6	22.0	-11.9	24.7	4.7	10.6
Kirawi	CK65-1130	M	20-25	-14.7	34.7	-10.6	33.3	4.1	10.2
Lukurmata	LKM-10407	M	35-40	-19.6	2.0	-11.4	28.0	8.2	9.9
Lukurmata	LKM-3459	F	30-40	-18.6	8.7	-12.4	21.3	6.2	11.7
Lukurmata	LKM-6625	M	45+	-12.5	49.3	-6.6	60.0	5.9	10.7
Lukurmata	LKM-7022	M	20-25	-16.5	22.7	-8.8	45.3	7.7	12.2
Lukurmata	LKM-7379	F	50+	-13.2	44.7	-4.1	76.7	9.1	11.1
Lukurmata	LKM-8444	F	45-50	-17.9	13.3	-12.4	21.3	5.5	12.1
Lukurmata	LKM-9271-2	F	20-23	-18.0	12.7	-10.5	34.0	7.5	11.8
Lukurmata	LKM-9271-3	PM	25-45	-18.0	12.7	-11.2	29.3	6.8	13.8
Lukurmata	LKM-9352	M	40-45	-16.5	22.7	-11.0	30.7	5.5	12.6
Lukurmata	LKM-9620	F	45+	-17.9	13.3	-11.9	24.7	6.0	11.8
Tilata	TMV-101-468	F	40-50	-18.3	10.7	-14.3	8.7	4.0	12.0
Tiwanaku	AK-11649	M	50+	-13.2	44.7	-7.3	55.3	5.9	10.1
Tiwanaku	AK-12149	M	50-59	-15.1	32.0	-6.9	58.0	8.2	10.9
Tiwanaku	AK-21264	M	25-35	-10.7	61.3	-5.8	65.3	4.9	10.6
Tiwanaku	AK-21266	F	20-30	-11.2	58.0	-5.8	65.3	5.4	10.3
Tiwanaku	AKE-20042	UN	18-22	-18.7	8.0	-9.5	40.7	9.2	11.0
Tiwanaku	AKE-20715	F	35-50	-15.7	28.0	-9.7	39.3	6.0	11.3
Tiwanaku	AKE-20727-x	UN	ADULT	-12.7	48.0	-6.7	59.3	6.0	11.0
Tiwanaku	AKE-2940	UN	ADULT	-16.9	20.0	-9.3	42.0	7.6	11.8
Tiwanaku	AKE-30902	NA	18-21	-12	52.7	-5.7	66.0	6.3	11.6
Tiwanaku	AKE-6417	F	20-25	-11.4	56.7	-4.8	72.0	6.6	9.9
Tiwanaku	AKE-8908	UN	16-22	-10.7	61.3	-4.9	71.3	5.8	10.5
Tiwanaku	CJ-33605	UN	35-50	-18.8	7.3	-11.5	27.3	7.3	14.6
Tiwanaku	CJ-36980	PM	20-35	-9.2	71.3	-5.2	69.3	4.0	9.8
Tiwanaku	KAR-34313	M	30-35	-8.9	73.3	-4.9	71.3	4.0	10.5
Tiwanaku	KAR-39164-1	PF	17-23	-12.5	49.3	-6.6	60.0	5.9	11.6
Tiwanaku	KAR-39164-2	M	40+	-12.6	48.7	-8.0	50.7	4.6	11.8
Tiwanaku	MK-31292	UN	27-40	-15.1	32.0	-7.6	53.3	7.5	11.4
Tiwanaku	MK-39788	F	40-60	-12.2	51.3	-6.9	58.0	5.3	11.2

Tiwanaku	MK-833	M	35-50	-17.3	17.3	-11.2	29.3	6.1	12.5
Tiwanaku	MK-834	M	25-35	-16.4	23.3	-11.5	27.3	4.9	11.7
Tiwanaku	MK-841	UN	ADULT	-18.6	8.7	-9.5	40.7	9.0	12.8
Tiwanaku	MK-874.1	F	50+	-18.6	8.7	-12.5	20.7	6.1	11.8
Tiwanaku	MK-874.2	F	60+	-18.3	10.7	-10.6	33.3	7.7	11.4
Tiwanaku	MK-890	UN	ADULT	-17.4	16.7	-13.6	13.3	3.8	11.9
Tiwanaku	MK-985	M	20-30	-18.6	8.7	-11.9	24.7	6.7	12.6
Tiwanaku	MP-217	M	25-35	-10.7	61.3	-5.2	69.3	5.5	10.7
Tiwanaku	MP-225	M	20-30	-13.6	42.0	-7.1	56.7	6.5	11.5
Tiwanaku	MP-227	F	30+	-17.5	16.0	-10.0	37.3	7.5	9.9
Tiwanaku	MP-229	M	25-35	-18.4	10.0	-9.3	42.0	9.1	11.1
Tiwanaku	MP-239	PM	18-21	-13.8	40.7	-7.2	56.0	6.6	9.1
Tiwanaku	MP-245	F	50+	-16.9	20.0	-10.8	32.0	6.1	9.5
Tiwanaku	MP-247	M	25-40	-12.6	48.7	-4.4	74.7	8.2	10.6
Tiwanaku	MP-41523-2	F	25-35	-17.1	18.7	-8.3	48.7	8.8	10.4
Tiwanaku	MP-41728-A	F	22-30	-12.0	52.7	-6.3	62.0	5.7	10.6
Tiwanaku	PUT-20995	F	20-24	-16.3	24.0	-12.2	22.7	4.1	12.3
Tiwanaku	PUT-25940-1	M	40-45	-14.4	36.7	-13.5	14.0	0.9	8.6
Urikatu Kontu	CK70-3283	M	35-45	-17	19.3	-12.4	21.3	4.6	11.6
(c) Post Tiwanaku									
Khonkho W.	KW-5285	M	50+	-17.5	16.0	-12.8	18.7	4.7	11.4
Lukurmata	LKM- 0043	F	35-45	-18	12.7	-12.6	20.0	5.4	10.6
Lukurmata	LKM-3036	UN	40+	-17.9	13.3	-12.8	18.7	5.1	12.2
Lukurmata	LKM-3513	M	35-45	-14.2	38.0	-8.5	47.3	5.7	12.1
Lukurmata	LKM-4140	F	50+	-18.5	9.3	-11.5	27.3	7.0	14.8
Lukurmata	LKM-8495	M	35-49	-18.3	10.7	-12.5	20.7	5.8	13.6
Lukurmata	LKM-9193	PM	ADULT	-16.8	20.7	-11.8	25.3	5.0	14.8
Lukurmata	LKM-9272	F	40-50	-17.3	17.3	-11.8	25.3	5.5	12.4
TMV228	TMV 228-195	M	40-45	-17.9	13.3	-13.7	12.7	4.2	13.3
TMV228	TMV 228-196	M	35-45	-18.6	8.7	-6.0	64.0	12.6	13.8
Urikatu Kontu	CK70-3079	M	25-30	-17.2	18.0	-11.1	30.0	6.1	13.6
Urikatu Kontu	CK70-3133	M	20-30	-17.9	13.3	-13.6	13.3	4.3	13.9

Urikatu Kontu	CK70-3144	M	40+	-18.1	12.0	-11.4	28.0	6.7	14.1
Urikatu Kontu	CK70-3144-3	M	25-35	-17.9	13.3	-14.3	8.7	3.6	15.2
Urikatu Kontu	CK70-3324	UN	30-50	-20.0	0.7	-11.3	28.7	8.7	11.5

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