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Transnational Processes of Identity in the Tiwanaku State (600 AD-1000 AD): A Biogechemical Study of Omo M10 Individuals and Temple Architecture in the Middle Moquegua Valley of Southern Peru

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Transnational Processes of Identity in the Tiwanaku State (600 AD-1000 AD): A Biogechemical Study of Omo M10 Individuals and Temple Architecture in the Middle Moquegua Valley of Southern Peru

A Thesis submitted in partial satisfaction of the requirements for the degree Master of Arts

in

Anthropology

by

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2018

The Thesis of Julianna Santillan Goode is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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ABSTRACT OF THE THESIS

Transnational Processes of Identity in the Tiwanaku State (600 AD-1000 AD): A Biogechemical, Study of Omo M10 Colonists and Temple Architecture in the Middle Moquegua Valley of Southern Peru

by

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University of California San Diego, 2018

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Despite emphasis placed by transnational theorists on the uniqueness of contemporary connections to homeland, such theories are relevant to the expansion of the ancient Tiwanaku state into the Osmore Drainage of southern Peru. These archaeological connections to homeland were maintained in the broader context of Tiwanaku sociopolitical organization, understanding of which is advanced by recent approaches to inter-regional interaction emphasizing studies of heterogeneous identities in peripheral contexts. The present study employs radiogenic strontium isotope analysis and stable carbon and nitrogen isotope analysis of bone collagen from individuals buried at a Tiwanaku provincial center in comparison with published diet and mobility data to better understand how different communities engaged with their ethnic and broader political identities. Additionally, radiogenic strontium isotope analysis of architectural material from the same provincial center is used to determine its source location and to better

understand how the construction of the provincial center's temple related to colonists' ethnic and/or broader sociopolitical identities. Overall, a lack of difference in diet and mobility practices between different colonial communities and the building material's origin in the Osmore Drainage supports more heterarchical notions of Tiwanaku colonial organization, as well as concepts of Tiwanaku as both a political entity and a deeply held cultural milieu. Moreover, the presence of an anomalous young woman suggests the possible exchange of marriage partners with coastal Huaracane-related populations, an intriguing mechanism for the poorly understood indirect procurement of marine resources by Tiwanaku colonists.

Chapter 1: General Theory

1.1 Introduction

Contemporary transnational approaches to immigration-migration in anthropology emphasize how a context of globalization, including the social, cultural, and identity processes of a "new" immigrant-migrant experience, make borders outmoded. In response, criticisms note (besides recent technological developments making it far easier to communicate with and travel to one's homeland) transnationalism's emphasis on maintaining a cultural connection with a homeland is not something unique to globalization. Instead, it is a phenomenon with a far deeper history (Horevitz 2009). In fact, transnational processes were significant in the expansion of the Tiwanaku state (A.D. 600-1000), with a capital in highland Bolivia, and whose heterogenous influence is evidenced in northern Chile, eastern Bolivia, and southern Peru in the 7th through 11th centuries A.D. (Goldstein 2015; Janusek 2004; Williams 2013).

Transnational theories of immigration-migration with their focus on maintaining substantial, long – term connections with a homeland have been argued to be particularly applicable to the Tiwanaku colonization of the Middle Moquegua Valley (MMV) of southern Peru (Goldstein 2005; Horevitz 2009). For example, Tiwanaku colonists living in the MMV maintained close physical ties with their ancestral homeland through periodic travel to and from it and possible return migration and/or repatriation of physical remains to the homeland after death (Baitzel & Goldstein 2016; Knudson et al 2014). These colonists also maintained a shared Tiwanaku identity via their material culture and ceremonial architecture (Goldstein 2005; Williams 2013). Though this ceremonial architecture can be interpreted as a monumental symbol of highlander identity, it also relates to debates about the degree of centralization in the Tiwanaku state (Goldstein 2005; Goldstein 2015; Janusek 2004). One aspect of this debated sociopolitical organization is the relationship of the homeland to more distant areas of Tiwanaku influence such as the MMV. Contemporary perspectives on inter-regional interaction of ancient states suggest investigation of multi-scalar identities in outlying areas such as the MMV are a promising way to address how ancient states conducted relations with distant areas under their influence (Jennings 2006). Joyce (2015)'s approach to materiality offers a framework for getting at these nested identities and the social relations that informed them. She argues for shifting from viewing the archaeological record as a collection of inert objects to viewing the archaeological record as a collection of material traces. These material traces can be interpreted as mediums of practice. Therefore, Joyce (2015) proposes a complex framework of connections between practices or phenomena and their material extensions. These practices do the work of creating social relations, which are the ultimate object of study (Joyce 2015). Biogeochemical methodologies quantify certain characteristics of material traces at the isotopic level, offering a productive avenue for getting at the practices those material traces are mediums for. Those practices cultivated certain social relationships, such as intra and inter-regional interactions that reflected sociopolitical organization within the Tiwanaku state.

This project utilizes such theoretical developments to ask the following research questions. First, when the paleodiet and paleomobility behaviors of individuals buried at a provincial center and a non-provincial center in the MMV are compared, do people at the provincial center indicate a stronger commitment to affiliation with their homeland? This is investigated using two methodologies. The first methodology is stable carbon and nitrogen isotope analysis of bone collagen from six individuals. The second methodology is radiogenic strontium isotope analysis of bone ash from five individuals to identify travel to and from the homeland during the last several years of life and/or recent arrival from the homeland. Second, how did the construction of ceremonial architecture at the provincial center relate to the ethnic and/or broader sociopolitical identities of colonists? This is investigated through radiogenic strontium isotope analysis of building material from ceremonial architecture to determine the region where the building material was gathered from.

1.2 Politics, Ethnicity, and Culture

A dichotomy between heterarchy and centralization is a prominent theme in debates concerning the nature of Tiwanaku sociopolitical organization. Generally, earlier perspectives argued for a more highly centralized and hierarchically organized state that coordinated the construction of extensive raised-system field systems to produce agricultural surpluses used to fund state projects. More recent investigations throughout the Lake Titicaca Basin have led to revisions of this model as evidence for independent, localized, sociopolitical developments and the continuation of local craft traditions, productive strategies, and ritual practices alongside the adoption of Tiwanaku style material culture and ceremonial practices has mounted. Evidence for varied relationships with areas more distant from the Lake Titicaca Basin ranging from access to fine Tiwanaku wares among a small number of elites to direct demographic colonization have also contributed to these revisions of earlier perspectives (Goldstein 2005; Jennings 2004).

These adjustments reflect broader theoretical shifts in ideas of interregional interaction and developments in world-systems models' notions of a powerful core using extra-economic means to maintain a flow of surplus wealth from a passive periphery (Jennings 2006; Lightfoot & Martinez 1996; Stein 2002). One such area of development has focused on smaller-scale questions of "local agency […] [and] heterogenous identities," especially in more peripheral areas (p. 349, Jennings 2006). Heterarchy is a useful conceptual tool for thinking about these ideas of intentionality and diverse identities in a peripheral context because it emphasizes unranked elements and inclusive decision-making rather than the consistently top-down decision-making that characterizes a hierarchical system (Crumley 2015).

Similarly, Stovel (2013) emphasizes how various aspects of identity (as articulated through multiple lines of evidence) are related to notions of ethnicity. She defines ethnicity as intentional processes that take place in specific economic and political circumstances rather than a static quality that can be assumed a priori. Due to the contextual nature of ethnicity and the variety of situations in which different material assemblages are used, different situations may necessitate demonstrations of distinct types of difference, or no difference, and therefore different material correlates of identity may not communicate complementary messages. Though often conflated with culture, ethnicity is a distinct concept that refers to behaviors stressing intra-group sameness and inter-group difference. In contrast, culture is a deeper set of shared practices and beliefs forming a substrate from which representations of ethnic identity are often drawn (Stovel 2013).

Chapter 2: Regional Background and Local Theory

2.1 Regional Archaeological Background

Tiwanaku was a south-central Andean state with an eponymous type site and core region located in the southeastern Lake Titicaca Basin of Bolivia (see Figure 1). In this steppe-like environment, individuals practiced agro-pastoral subsistence based on a mixture of camelid herding, lacustrine resources, and other wild resources (i.e. water birds, freshwater fish, amphibians, deer, wild camelid species, and small mammals). Agriculture was practiced using a system of more than 120, 000 hectares of raised fields and related canals and watercourses that supported the cultivation of frost-resistant potatoes, other tubers, and chenopod grains (Goldstein 2005). Tiwanaku power and cultural influence can be seen throughout the south-central Andes in the 6th through 11th centuries AD (Goldstein 2015).

Figure 1. Map of the south-central Andean region. (Goldstein & Palacios 2015)

In the mid-valley Moquegua sector of the Osmore Drainage of hyper-arid southern Peru, Goldstein (2005) argued Tiwanaku expansion involved direct demographic colonization and the establishment of insular, multi-generational communities. These communities maintained strong ties with their parental highland communities. In the MMV, river-fed canals made cultivation of temperate and tropical crops possible year-round without the aid of artificial terracing. Evidence of Tiwanaku-affiliated settlement in the MMV is mostly found in four site groups: Omo, Chen Chen/Los Cerrillos, Río Muerto, and Cerro Echenique (See Figure 2). Tiwanaku occupation within these site groups can be divided into three stylistic components: Omo, Chen Chen, and Tumilaca (Goldstein 2005, pg. 134).

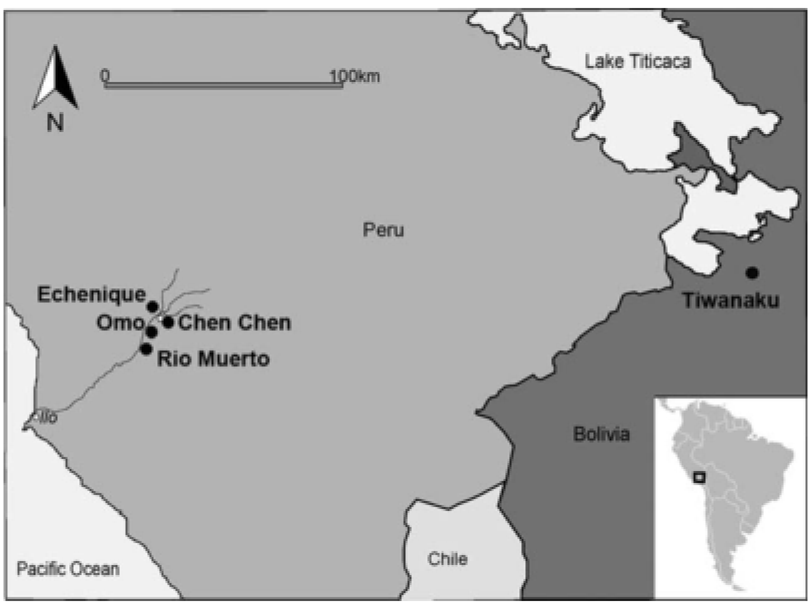


Figure 2. Map of Tiwanaku affiliated site groups in the Middle Moquegua Valley. (Somerville et al 2015)

The Omo style is associated with a pastoralist occupational specialty based on less permanent domestic architecture, a paucity of storage features and material culture associated with maize processing (i.e. large grindstones, stone hoes), a preference for settlement locations near caravan routes indicated by llama geoglyphs rather than closer to agricultural fields, and a higher incidence of periodic paleomobility (Goldstein 2015; Knudson et al 2014). In comparing Omo and Chen style burials, Becker and Goldstein (2018) also found significant age-specific differences in rates of osteoarthritis between the two groups, with patterns of osteoarthritis localization among Omo burials resembling clinical and ethnographic accounts of activities involving walking or running while carrying heavy loads on one's back. This pattern of osteoarthritis could be the result of a more mobile lifeway involving the frequent carrying of personal possessions on one's back as a community moves from place to place and/or produced by the activities of llama caravan traders carrying heaving loads on their backs as they traveled between different elevations.

The Chen Chen style is associated with an agriculturalist occupational specialty based on settlements consistently located closer to agricultural land and canal and spring-fed irrigation systems. These types of settlements also have more permanent domestic architecture, significantly greater concentrations of cist storage features, industrial-size grindstones and stone hoes, and macro-botanical and isotopic evidence pointing to intensive production, consumption, and exportation of maize to the site of Tiwanaku. At the site of Tiwanaku and in the MMV itself, this maize was used to produce chicha, or fermented maize beer. Chicha drinking was a ritually significant, male-oriented activity adopted in all areas of Tiwanaku influence including the MMV. The Tiwanaku corporate ceramic style included a vessel form especially associated with this practice, the *kero*. Keros were constructed of clay, wood, or precious metals (Goldstein 2015; Somerville et al 2015).

Beginning prior to the arrival of Tiwanaku colonists, the MMV was densely occupied by a ceramic phase agrarian people called the Huaracane. Unlike later Tiwanaku associated settlements, Huaracane occupation was restricted to the rim of the valley floodplain and was reliant on simple canal irrigation (Goldstein 2005, pg. 123). Huaracane villages were small and of uniform size, with only rare instances of defensive architecture, public architecture, or elite mortuary components, making it unlikely that any one village constituted a valley-wide power center, although some larger village sites may have constituted more localized centers of power (Goldstein 2005). Botanical and faunal evidence for subsistence practices include lucuma pits, squash seeds, maize and gourds, snail shells, camelid bones, guinea pig bones, and mouse bones (Sandness 1992, pg. 25). Though these lines of evidence provide information about the types of foods comprising the dietary range of Huaracane peoples, they do not shed light on the proportions in which foods were consumed.

Huaracane access to coastal resources is indicated by Goldstein (2000)'s investigations of the Huaracane mortuary tradition in the MMV: excavations of Huaracane pit burials and boot tombs found shell beads and textiles characteristic of the Peruvian Pacific coastal Paracas-Nasca tradition. As noted by Goldstein (2013, pg. 48), "Recent dating of Huaracane contexts at the Los Joyeros, Cerro Trapiche, and Yaway sites (Costion and Green 2009; Green and Goldstein 2009) has extended late elements of the Huaracane tradition into the early Middle Horizon, supporting a continuous occupation by the Huaracane tradition and showing that the mid-valley was occupied contemporaneously with the arrival of Tiwanaku […] colonists […]." Costion (2013) also presents evidence of contemporaneous Huaracane and Tiwanaku occupation of the MMV during the Middle Horizon with his 2-sigma range calibrated radiocarbon dates from the Huaracane settlement of Yahuay Alta. Those dates range from Cal AD 131 – Cal AD 802 (Costion 2013, pg. 566).

Initial occupants of the coastal Osmore Valley are represented by the Algodonal Early Ceramic culture and were indigenous agriculturalists like the Huaracane (Owen 2005).

Components with early Ceramic neckless ollas at the Algorrobal and Algodonal sites have calibrated radiocarbon dates between 100 B.C. and A.D. 675, suggesting these cultures could have been contemporaneous with Tiwanaku occupation of the MMV, at least early in that Tiwanaku occupation (Owen 1993, pgs. 14, 354, 417). Tiwanaku affiliated settlements in the MMV are dated to between the 7^{th} and 11^{th} centuries A.D. (Goldstein 2015, pg. 9204).

2.2 Models of Migration

Though archaeologists have traditionally restricted their explorations of migration to establishing whether people migrated, there has been a shift towards asking why individuals migrated and the consequences of migration for host societies and societies of origin (Dommelen 2014, Horevitz 2009, and Tung 2008). The concept of diaspora as the existence of "transnational communities with strong shared identities, expectation of return, and unwillingness, difficulty, or inability to assimilate in host societies" has proven useful for asking such questions (Goldstein 2000, p. 183). Ethnohistoric and ethnographic accounts demonstrate that in the south-central Andes these characteristics of diaspora are found in lower elevation communities established by individuals and/or households sent by different ethnic groups with primary settlements at higher elevations to exploit resources available only at lower elevations. When this scenario involves more socially complex core populations and the establishment of more distant colonies, such as the Tiwanaku state and their colonization of the MMV, John V. Murra's term "vertical archipelago" can be applied (Goldstein 2000).

Initial studies of migration and residential mobility among the Tiwanaku colonies of the MMV tended to use a single methodology to investigate the narrow question of whether individuals migrated from the Tiwanaku homeland (Knudson et al 2004; Knudson 2008). For example, Knudson et al (2004) used radiogenic strontium isotope analysis of eight individuals from the site of Chen Chen to test this hypothesis. Two individuals with strontium isotope ratios significantly higher than the others sampled were classified as non-local because the narrowness of the MMV local range (defined by analysis of modern guinea pigs) suggested prehistoric inhabitants of Chen Chen obtained their diet from a wider geographic area than modern guinea pigs do. Both individuals designated as non-local had strontium isotope ratios well within the local range of the southeastern Lake Titicaca Basin. Both were females with fronto-occipital cranial modification whose mortuary treatment did not distinguish them from other individuals buried at Chen Chen (Knudson et al 2004). While Knudson et al (2004) does briefly consider how their results relate to information known from other lines of archaeological evidence regarding the nature of Tiwanaku influence at the site, they do this in very general terms without consideration of how their results relate to mortuary or other archaeological information specific to the individuals they analyzed. Similarly, they treat the site of Chen Chen as a uniform entity, and do not discuss intra-site patterning in their data.

Multiple methodologies have also been used in conjunction to investigate this question (Knudson 2007). Knudson (2007) used $\delta^{18}O$ data and radiogenic strontium isotope data from the tooth enamel and bone of twenty-five individuals from the same Tiwanaku-affiliated site of Chen Chen to determine if first-generation immigrants from the Lake Titicaca Basin were present. While no new first-generation immigrants were identified, the $\delta^{18}O$ signatures in the tooth enamel of the first-generation immigrants identified in Knudson et al (2004) were most like published values from coastal sites rather than the southeastern Lake Titicaca Basin, suggesting the need for a better understanding of $\delta^{18}O$ variation in the south-central Andes (Knudson 2007). Knudson (2008) begins to explore migration between the altiplano core and the Moquegua Valley through the life course, though she continues to do this from the perspective of isolated individual migration events and migratory tendencies. She also focuses on the site of Chen Chen and presents radiogenic strontium isotope data from twenty-five individual's tooth enamel. In addition, she considers strontium isotope data from ten bone samples from that larger group of twenty-five. Besides the two individuals previously identified by Knudson et al (2004) as having undergone enamel formation in the southeastern Lake Titicaca Basin, Knudson (2008) finds two individuals present values intermediate between the MMV and the southeastern Lake Titicaca Basin, indicating they may have traveled regularly between the two areas. Additionally, one male with an enamel radiogenic strontium isotope ratio indicative of formation in the MMV and a bone radiogenic strontium isotope ratio indicative of formation in the southeastern Lake Titicaca Basin may have returned to the MMV shortly before death (Knudson 2008).

In contrast to this focus on testing expectations of the colonial diaspora model at the individual level, some scholars have explored it at the level of larger scale sustained population movements, contacts, and or mixing (Blom 1998; Lewis et al 2007). For example, Blom (1998) employs discrete, inherited skeletal and dental traits to measure genetic relatedness between samples drawn from Chen Chen (394), the highland urban sites of Tiwanaku (95), Lukurmata (30), and Chiripa (22), and the highland rural site of Kirawi (15) (See Figure 3).

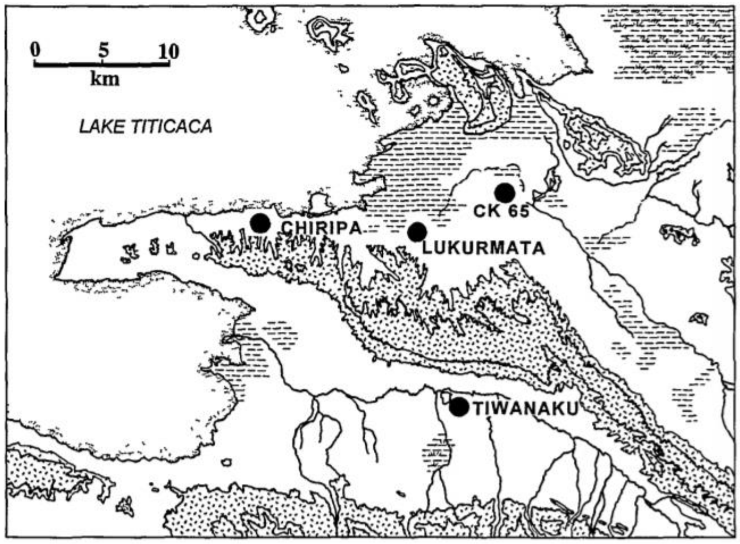


Figure 3. Map of the Tiwanaku highland core region (Blom 1998).

She finds that during the Tiwanaku V period (approximately AD 750 – AD 1000), the MMV population was more closely genetically related to the highland Tiwanaku population than to the earlier MMV Huaracane population, lending support to the idea of consistent migration and genetic mixing between the highlands and the MMV during this time, though the direction of that migration is unclear (Blom 1998). Lewis et al (2007) also explores long-term temporal and spatial genetic relationships at Chen Chen, using mtDNA haplogroup data from Chen Chen skeletal materials and 58 other native South American datasets representing 53 contemporary and five ancient populations. They find they are unable to reject spatial and temporal genetic continuity in the south-central Andes that may pre-date Tiwanaku expansion, except for Aymara speaking groups (Lewis et al 2007).

Besides these investigations of migration as a phenomenon participated in uniformly by all members of society, more recent studies have begun to analyze the social processes structuring migration. Baitzel and Goldstein (2016) seek to understand how return migration was organized and which segments of the population participated. They consider new paleodemographic data from the Omo style M70B cemetery of Río Muerto and published demographic data from the site of Chen Chen. Both groups exhibit small numbers of older individuals when compared with uniformitarian models, suggesting a pattern of return to the homeland among older individuals. Two explanations are proposed: functional reasons aimed at maximizing agricultural productivity of the colony by removing less productive members and more spiritual reasons such as a desire among first-generation immigrants to be buried in the homeland (Baitzel and Goldstein 2016). Similarly, Knudson et al (2014) broadens the scope of migration behavior under archaeological inquiry and considers gender-specific motivations. Specifically, the presence of at least two males who migrated from the Lake Titicaca Basin as juveniles and at least two females who migrated from the eastern highlands as adults of reproductive age could suggest natal family migration from the Lake Titicaca Basin and patrilocal mate exchange with the eastern highlands or the Cochabamba Valley.

Furthermore, four adult males may have practiced transhumance at various times in their lives. Two of these individuals exhibit intermediate non-local $^{87}Sr/^{86}Sr$ values in their early-forming dental elements, but not in their later-forming skeletal elements, suggesting they may have moved to the MMV during enamel formation and resided there during their adult years. The two other individuals, who are only represented post-cranially, also have intermediate $^{87}Sr/^{86}Sr$ values, indicating they may have moved between geologic/environmental zones regularly. All four of these individuals pertain to the M70B cemetery, which is associated with a pastoralist occupational specialty. More generally, when the incidence of non-local origin is compared in all three cemeteries analyzed (M43A, M43B, M70B), M70B has the highest incidence of non-local or intermediate radiogenic strontium isotope values (Knudson et al 2014). The present study complements and furthers such trends by using a comparative approach to paleomigration to better understand inter-regional interactions within the Tiwanaku state and how movement between different areas of Tiwanaku influence was organized.

If there are more paleomigratory behaviors among the Omo M10 individuals analyzed in this study compared to the number of paleomigratory behaviors among individuals analyzed by Knudson et al (2014) from Rio Muerto M43, this suggests individuals analyzed from the site of Omo M10 demonstrate a stronger commitment to physical connection with the homeland than individuals analyzed from the site of Rio Muerto M43. This may be indicative of Omo M10 having a greater number of first-generation immigrants compared to Rio Muerto M43. As suggested by Baitzel (2016), perhaps first-generation immigrants had stronger connections to their homelands than later generations. Though Baitzel (2016) proposes that first-generation immigrants' stronger connections to homeland would motivate them to return to their homeland in old age specifically, perhaps this stronger connection also motivated them to travel back and forth more frequently throughout their lives compared to later generations. In this scenario, the site of Omo M10 could be conceived of as a point of entry that attracted new arrivals to the MMV, a place for immigrants to congregate before deciding whether to settle at the provincial center or elsewhere in the valley. Additionally, this scenario could suggest more centralized control over movement to and from the homeland. Perhaps such centralized control would have been to maximize productive capacity of the agriculturally productive MMV for export of lower elevation crops back to the highlands via demographic manipulation of the colonial population, as Baitzel (2016) suggests.

On the other hand, if there are not more paleomigratory behaviors among individuals analyzed from Omo M10 compared to the frequency of paleomigratory behaviors among those analyzed from Rio Muerto M43, this suggests those at the provincial center did not exhibit greater commitment to physical connection with homeland. This may indicate roughly similar numbers of first generation immigrants living at the site of Omo M10 compared to Rio Muerto M43 if we assume physical connection to homeland waned with passing generations (Baitzel 2016). In this scenario, first generation immigrants to the MMV arrived and settled in an evenly dispersed way among different sites. Furthermore, this possibility supports less centralized control of movement between the highlands and the MMV, and more small-scale, community-oriented connections between higher elevation communities and MMV Tiwanaku populations. Such results would support Janusek (2004)'s argument that "maize [at the site of Tiwanaku] was acquired through local socioeconomic networks" rather than state organized efforts (Janusek 2004; pg. 160).

2.3 Diachronic and Comparative Biogeochemical Approaches to Paleodiet

Sandness (1992) investigated the relative importance of different foods in the diet of Huaracane and Tiwanaku individuals from Omo M10 using stable carbon and nitrogen isotope analysis of bone collagen isolated from the rib bones of five Huaracane individuals and ten Tiwanaku individuals. A linear mixing model was used because of it's potential to provide quantitative estimates for the primary food sources of each group. This quantitative estimation is done by treating the proportions of food sources as linear functions of the isotopic composition of the consumer's tissues. Expectations for the stable isotope values of different possible food categories were determined based on a previous study of marine and terrestrial resources in the Atacama Desert region of northern Chile, which has similar local biota to the Osmore drainage (Sandness 1992, pg.43). Foods believed to comprise the three primary dietary components were grouped into three broad categories: marine resources (plants and animals), terrestrial plants (C_3 and C4), and terrestrial animals (Sandness 1992, pg. 44).

Stable carbon and nitrogen isotope values of Huaracane individuals indicated a diet rich in C_3 plant foods (approximately 50%) and animals consuming C_3 vegetation. Marine resources (fish, shellfish, and perhaps algae) also contributed significantly to the Huaracane diet (23% to 50%), while maize made a limited, or at least less substantial, contribution (3% to 18%) (Sandness 1992, pg. 49). The diets of Omo M10 Tiwanaku individuals differed in statistically significant ways. More positive $\delta^{13}C$ values suggested that maize became the primary food source for the population during this period, with estimated dietary proportions ranging from 46% to 76%. C_3 plants and animals formed most of the remainder of the diet (41% to 61%), with marine resources contributing very little to the diet (zero to 13%) (Sandness 1992, pg. 51).

Somerville et al (2015)'s analysis of 33 human bone samples from the MMV Tiwanaku colonial sites of Rio Muerto M43 and M70 for isotopic ratios of $\delta^{13}C_{apatite}$, $\delta^{13}C_{collagen}$, and $\delta^{15}N_{collagen}$ also supported the importance of C_4 resources, most likely maize, in the diets of MMV Tiwanaku colonists, with an estimation of 54% of total dietary carbon coming from C_4 products based on a linear mixing model using $\delta^{13}C_{apatite}$ values. Besides C_4 resources, there was also consumption of C_3 resources and infrequent consumption of marine resources. Dietary patterns were generally found to be similar at individual sites, though there was a significant difference in $\delta^{15}N_{collagen}$ values between the sites of Chen Chen M1 and Rio Muerto M70 (Somerville et al 2015; pg. 415). This could be due to less consumption of terrestrial protein such as llama meat by Chen Chen style agriculturalists living at the site of Chen Chen M1 compared to Omo style pastoralists living at the site of Rio Muerto M70.

Due to a lack of significant differences in $\delta^{15}N_{collagen}$ values and $\delta^{13}C_{apatite}$ between males and females, they are argued to have broadly similar proportions of C_3 to C_4 resources in their overall diets and to have been feeding at similar trophic levels. However, significant differences in $\delta^{13}C_{collagen}$ values of males and females suggests the dietary protein of males had significantly more carbon atoms coming from C_4 sources compared to females (Somerville et al 2015). Due to the fermentation processes making the protein in maize more bioavailable and the importance of chicha drinking among Tiwanaku-affiliated populations, this suggests significantly more chicha drinking among males than among females (Goldstein 2015; Somerville et al 2015). The present study presents new paleodietary data from Omo M10 and compares it with Somerville et al (2015)'s stable isotope data for Rio Muerto M43, helping to create a fuller picture of lifeways at Omo M10 and how those lifeways compare with those at the ordinary town of Rio Muerto 43.

If individuals from the site of Omo M10 were drinking more chicha than individuals from the site of Rio Muerto M43, this suggests the community of Omo M10 was engaging in more affirmation of their sociopolitical identity than the community of Rio Muerto M43. Furthermore, this indicates that Tiwanaku was perceived in large part as a political phenomenon because those at the provincial center were more motivated to engage in Tiwanaku ritual activity than those away from the provincial center. In other words, residing at the focal point of Tiwanaku presence and power in the MMV was a significant factor in people's notions of being Tiwanaku and engaging in that Tiwanaku identity. Being Tiwanaku was a political act. If individuals from the community of Omo M10 were drinking similar amounts of chicha compared to the community of Rio Muerto M43, this suggests political engagement was not a key factor in affirmation of Tiwanaku identity because those at and away from the provincial seat of Tiwanaku power were engaging in this aspect of Tiwanaku – ness to a similar extent. Instead, Tiwanaku was experienced as a shared cultural repertoire that both communities were equally motivated to participate in (Stovel 2013).

2.4 Provincial Ceremonial Architecture

Recent excavations of the Omo M10 temple demonstrate distinct isolated groups of buildings in the Upper Court, suggesting different social groups may have used distinct groups of buildings and arrived at them via distinct processional pathways (Goldstein & Palacios 2015). Therefore, different social groups particularly associated with distinct groups of buildings may have arranged for the transport of ichu from their respective ancestral highland communities for use in the Omo M10 temple. Besides this evidence for temple use that may have reinforced a multi-ethnic colonial social structure, there is also evidence that temple use may have stressed centralized ritual control. Along the central axis in the Upper Court, there is a room almost entirely filled with skillfully worked blocks forming an altar or throne in the shape of a "U." This room is not accessible via any of the neighboring groups of buildings in the Upper Court and there is no way to leave or enter it besides the entrance along the central axis of the temple (Goldstein & Palacios 2015).

Investigation of the geographical location of the source of ichu grass used in the roof of the Omo M10 temple will help elucidate the relationship between distinct aspects of identity and their importance in temple activities and the role of the temple more generally. If ichu grass was brought down from the altiplano, this suggests a more ritualistic and deliberate transport of the material for the express purpose of temple construction and perhaps more centralized planning in temple construction. On the other hand, if the ichu was not gathered from location (s) within the highland core region and instead from locales closer to the MMV, this suggests that it was treated in a more utilitarian way, perhaps gathered by llama caravaners en route to the MMV primarily as camelid fodder and then used in in the temple when surplus remained.

Chapter 3: Methodological Background

3.1 Radiogenic Strontium Isotope Analysis

Strontium (Sr) is a trace element present in most igneous, metamorphic, and sedimentary rock, as well as in river water, groundwater, seawater, soil, plants, and animals. Strontium has three naturally occurring non-radiogenic isotopes (^{84}Sr, ^{86}Sr, and ^{88}Sr) and one radiogenic isotope: ^{87}Sr. ^{87}Sr is formed by the radioactive decay of ^{87}Rb, which has a half-life of approximately 4.88 x 10^{10} years. The amount of ^{87}Sr in a mineral or rock containing Rb is determined by two things: the age of the rock or mineral and its Rb/Sr ratio (Slovak and Paytan 2011). Radiogenic strontium isotope ratio (^{87}Sr/^{86}Sr) analysis can be used as a tool in paleomobility studies because, due to the large atomic mass of Sr, Sr isotopes are transferred from bedrock to soil into biologically-available solutions without a measurable change in the ratio (Bentley 2006; Makarewicz & Sealy 2015). With regards to the human body, strontium can substitute for calcium in the crystalline lattice of hydroxyapatite in teeth and bone (Knudson et al 2004).

Therefore, ^{87}Sr/^{86}Sr ratios in soil, groundwater, vegetation, and fauna largely reflect the underlying ^{87}Sr/^{86}Sr values in bedrock, with some input from atmospheric sources. Most importantly, the reported ^{87}Sr/^{86}Sr signatures in human tissues, best communicated to five decimal digits, should match the ^{87}Sr/^{86}Sr composition of water, plants, and animals consumed (Bentley 2006; Knudson et al 2004). With regards to the delivery of Sr to a plant, and the utility of this delivery for using radiogenic strontium isotope analysis to determine the location where organic archaeological plant material was grown, soil waters take on the ^{87}Sr/^{86}Sr ratio of the soluble soil component which, in turn, is transferred unchanged to the plant itself. This principle has been successfully used in investigations of where timber used in the construction of Chacoan great houses was grown and where maize cobs found in Pueblo Bonito were grown (Benson et al 2008).

3.2 Stable Isotope Analysis of Carbon and Nitrogen

Animal tissues consist of molecules that have been absorbed or ingested from the environment or synthesized by the organism. Generally, these molecules are labeled with stable isotopes whose relative abundances vary in nature and these isotopes are almost entirely controlled by the diet of the animal. The isotope ratio of $^{12}C/^{13}C$, expressed as $\delta^{13}C$ in the units ‰, varies depending on the photosynthetic pathway of plants consumed by an organism. Most wild and cultivated plants of temperate, tropical and subarctic regions utilize the Calvin cycle, in which the first product of CO_2 uptake of plants is a three-carbon molecule. These C_3 plants have $\delta^{13}C$ values averaging around -25 ‰. The majority of C_4 plants are dry season, arid adapted grasses. Most wild C_4 plants are found in warm, arid to sub-arid regions, though some C_4 grasses exist in temperate regions. C_4 plants utilize the Hatch-Slack cycle, in which the initial product of CO_2 uptake by plants is a four-carbon molecule. All plants that utilize the Crassulacean Acid Metabolism (CAM) pathway are succulents living in hot, arid environments. Carbon fixed by this pathway has $\delta^{13}C$ values intermediate between those of C_3 and C_4 plants although some have values equivalent to C_4 plants (Schwarz & Schoeninger 2012).

The isotope ratio of $^{15}N/^{14}N$, expressed as $\delta^{15}N$, provides information about the trophic level at which an organism is feeding and the degree of marine resource use (Froehle et al 2012; Schoeninger et al 1983; Schoeninger & DeNiro 1984; Schwarz & Schoeninger 2012). Humans typically incorporate nitrogen through dietary plants and animals. Leguminous and non-leguminous plants tend to incorporate nitrogen differently. Leguminous plants often have symbiotic relationships with bacteria capable of fixing nitrogen directly from the atmosphere and are therefore not enriched in nitrogen relative to atmospheric nitrogen gas. On the other hand, those legumes that do not use these types of symbiotic relationships are enriched in ^{15}N relative to the atmosphere, for which the $\delta^{15}N$ value is defined as 0 ‰. Most non-leguminous plants acquire their nitrogen from compounds in the soil and are characterized by $\delta^{15}N$ values greater than 0 ‰ (Froehle et al 2012). Animal $\delta^{15}N$ values are higher than those in consumed plants and animals by 3‰, on average. This "trophic level effect" refers to the offset of $\delta^{15}N$ values between the herbivores and higher trophic level organisms with respect to the diet and enrichment in the heavy isotope. Therefore, terrestrial carnivores have higher $\delta^{15}N$ values, on average, than terrestrial herbivores (Schwarcz and Schoeninger 2012). Nitrate and particulate organic matter in sea-water form the base of the food chain and have generally high $\delta^{15}N$ values. Marine ecosystems also have longer trophic systems relative to terrestrial ones. Therefore, the $\delta^{15}N$ values of organisms feeding on marine resources are higher than those of terrestrial feeders (Schoeninger et al 1983; Schoeninger & DeNiro 1984; Schwarcz & Schoeninger 2012).

Paleodietary analyses of stable carbon and nitrogen isotopes mainly target the organic collagen phase of bone. Specialized cells within Haversian systems are constantly remodeling bones at rates which depend on the skeletal element and age of the individual. On average, C and N atoms reside in bone collagen for about 10 years, though this period can be longer in older individuals (Schwarcz & Schoeninger 2012). Though the $\delta^{13}C$ of collagen is significantly influenced by dietary macronutrients besides dietary protein, dietary protein is the major determinant of $\delta^{13}C_{collagen}$, with dietary protein contributing at least three fifths of the carbon atoms in the $\delta^{13}C_{collagen}$ signal in the form of intact amino acids (Froehle et al 2010). Due to this bias towards dietary protein, stable isotope analysis of carbon and nitrogen isotopes can be used to explore degree of chicha (fermented maize-beer) consumption assuming retention of intact required amino acids (Somerville et al 2015). Chicha production begins with the use of a mortar to produce a corn meal moistened with water and rolled into a ball. Next, the balls are hydrolyzed by either amylase generated during malting (germination) of maize kernels or by salivary amylase incorporated during the chewing/salivation process. Either of these processes convert starch to fermentable sugars. Boiling with water then takes place, followed by cooling and filtration. The final product is then allowed to ferment for some period of days, depending on the temperature (Chavez-López et al 2014). Generally, unfermented maize has a quantitatively and qualitatively poor protein content. Specifically, there are low levels of both tryptophan and lysine (Chavez-López et al 2014; Gernach et al 2011). Gernach et al (2011) investigated the effects of malting and fermentation on various chemical and functional properties of maize grains. They found that, while crude protein composition (%) decreased in fermented maize grains relative to malted maize grains, crude protein (%) in fermented maize grains increased relative to crude protein (%) in un-malted maize grains (Gernach et al 2011). Gernach et al (2011) also recorded some toxins and anti-nutritional factors of unmalted, malted and fermented maize grains. They find a significant ($p<0.05$) reduction in all toxins and anti-nutritional factors, including tannins (g/100 g). As noted by Gerrnach et al (2011), this reduction in tannins is particularly important because Khetarpaul and Chauhan (1989) also reported a decrease in tannins with acid fermentation and tannins inhibit trypsin activity, limiting protein utilization.

Considering these effects of malting and fermentation on the crude protein composition of maize and protein utilization and the bias of $\delta^{13}C_{collagen}$ towards dietary protein inputs, the $\delta^{13}C_{collagen}$ values of an individual consuming significantly more chicha than another individual would be expected to be more positive than that other individual (Somerville et al 2015).

3.3 Diagenesis of Human Bone

The term diagenesis refers to various post-mortem bio-chemical alterations of bones that vary depending on when an element was deposited, taphonomy, and burial environment. Diagenetic processes can involve physical, chemical, histological, and mechanical changes at different scales and involve the incorporation and release of elements. These diagenetic processes are important to assess when reconstructing pre-mortem diet and mobility because they can alter pre-mortem signals (López-Costas et al 2016; Price et al 1992; Szostek et al 2009). One common method of determining the degree of diagenetic alteration in skeletal material is to calculate the Ca/P ratio. Significant changes to the biogenic Ca/P ratio can occur because of deposition in soil, where washout or secondary accumulation of key bone-building macronutrients can take place (Price et al 1992; Szostek et al 2009). The mineral component of bone, which can be isolated by reducing intact bone material to ash, contains 37% Ca, 17% P by weight, and therefore has a Ca/P ratio of approximately two (Price et al 1992). Fresh bones pertaining to modern populations have Ca/P ratios ranging from 1.8 to 2.19 (Szostek et al 2009). Diagenesis of the organic phase of bone is assessed by C:N ratios and percent collagen yield, with acceptable C:N ratios ranging from 2.9-3.6 and acceptable collagen yields being greater than 1% (Somerville et al 2015).

3.4 Contamination of Archaeological Botanical Samples

In their $^{87}Sr/^{86}Sr$ analysis of ponderosa pine (*Pinus ponderosa*) used as building material in three Chacoan great houses (Pueblo Bonito, Chetro Ketl, Pueblo del Arroyo), Reynolds et al (2005) discussed how to assess contamination in archaeological botanical samples. To do this, they compare Sr^{86} concentrations from the architectural wood to those from non-local living specimens because the architectural wood is expected to be non-local. Overlap between the Sr^{86}

concentrations of the architectural samples and the living non-local specimens is interpreted as evidence of little to no Sr^{86} additions from the Chaco Canyon soil water. In addition, Sr^{86} concentrations and $^{87}Sr/^{86}Sr$ ratios of architectural ponderosa pine samples are plotted against each other to see if there is correlation. Very little or no correlation is found, further supporting their determination that diagenetic effects had not had a significant effect on the architectural ponderosa pine samples (Reynolds et al 2005).

Chapter 4: Methods

4.1 Materials

Seven osseous human rib samples underwent radiogenic strontium isotope analysis. Twenty-six botanical samples also underwent radiogenic strontium isotope analysis (4 archaeological *Stipa ichu* samples from the site of Omo M10; five modern *Stipa ichu* samples from the Tiwanaku Valley; seventeen modern botanical samples from the MMV). These individuals were not part of the 2010-2011 excavations conducted as part of Sarah I. Baitzel dissertation work (Baitzel 2016).

4.2 $^{87}Sr/^{86}Sr$ Analysis and Trace Elements Analyses of Botanical Samples – Sample Preparation and Analysis

All botanical samples were prepared for radiogenic strontium isotope analysis and trace elements analysis in the Archaeological Chemistry Laboratory at ASU and were analyzed at ASU's W.M. Keck Foundation Laboratory for Environmental Biogeochemistry. In-house protocols were used and will be described more fully in a future publication (Stanish et al 2018).

4.3 Stable Carbon and Nitrogen Isotope Analysis of Human Bone Samples

Osseous human samples were initially prepared in the Paleodiet Laboratory at the University of California, San Diego. They were cleaned using a diamond point Dremel bit to take off all visible signs of surface contamination and areas of cancellous bone. The samples were cleaned ultrasonically using the following solutions, each for five minutes: twice in ddH_2O and once in acetone. They were then dried overnight in an oven at ~60ºC. For demineralization, approximately 13 mL of .25M HCL (hydrochloric acid) was added to each sample, making sure the level of fluid was above the level of the bone. The HCL solution was changed every other day until the bones had a spongy, transparent appearance (Somerville et al 2015). The remainder of the preparation was conducted in the ACL at ASU. In the ACL at ASU, samples were rinsed and treated with 0.125 M NaOH to prevent contamination by any humic acids. Samples were then rinsed again and solubilized by heating at 70-90ºC in 10^{-3} M HCL. Filtrates were evaporated and re-dissolved in 3.0 ml 10^{-3} M HCL. They were then frozen at -20ºC and lyophilized at -50ºC. Analysis of samples was performed in the W.M. Keck Foundation Laboratory for Environmental Biogeochemistry at ASU, using a Delta Plus Advantage Isotope Ratio Mass Spectrometer equipped with a Costech Elemental Analyzer. Long-term precision for glycine (Aldrich) standards and tomato leaf standard with the instrument is ±2‰ for $\delta^{13}C_{[VPDB]}$ and $\delta^{15}N_{[AIR]}$ (Marsteller et al 2016).

4.4 Trace Elements Analysis – Human Bone Sample Preparation and Analysis

Osseous sample preparation for trace elemental concentration analyses was performed in the Archaeological Chemistry Laboratory at ASU. Ten mg of mechanically and chemically cleaned bone bash were dissolved in 0.64 mL of 5 M HNO_3 and diluted with 9.36 mL of Millipore H_2O. Sample concentrations were analyzed on a Thermo Scientific iCAP Qc quadrupole inductively coupled plasma mass spectrometer (Q-ICP-MS) with a 100 microliter per minute nebulizer and a Peltier cooler in the ASU W.M. Keck Foundation Laboratory for Environmental Biogeochemistry (Knudson & Tomczyk 2017).

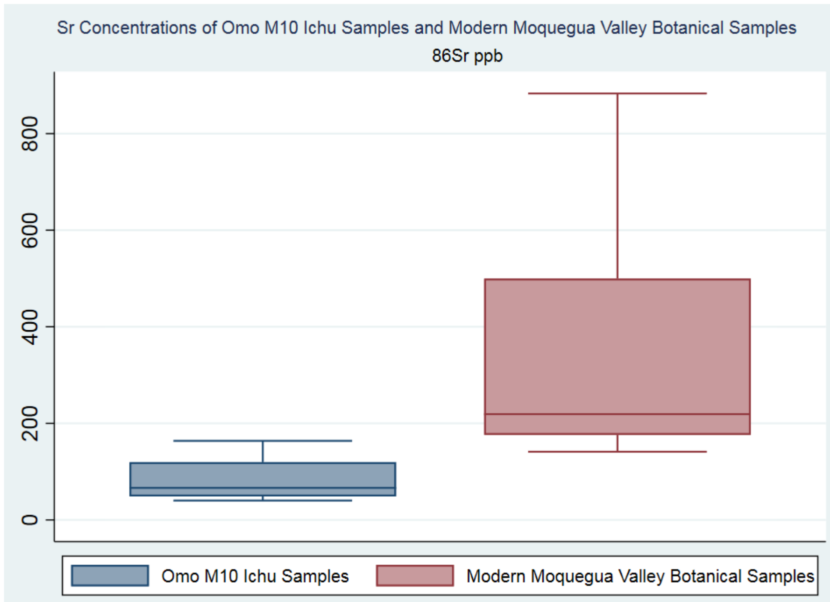
4.5 $^{87}Sr/^{86}Sr$ Analysis of Human Bones - Sample Preparation and Analysis

Preparation of osseous human rib samples was performed in the Archaeological Chemistry Laboratory at Arizona State University (ASU). Osseous samples were mechanically cleaned with a drill equipped with a carbide burr (Marsteller et al 2017). Mechanically and chemically cleaned bone was ashed at 800 ºC for 10 hours, and ground with an agate mortar and pestle. Approximately 10-15 mg of bone ash powder from each sample was dissolved in 0.5 mL of 5 M nitric acid (HNO_3). Samples were evaporated at 50-100 ºC and re-dissolved in 0.25 mL 5 M HNO_3. Each solution was loaded onto EiChrom SrSpec resin (100-150 µm diameter) in fretted glass columns that had been cleaned with distilled and deionized water (18.2 MΩ) and equilibrated with 5 M HNO3. Samples were washed three times with 0.25 mL 5 M nitric acid, and then strontium was separated from the sample matrix via three elutions with 0.5 mL distilled and deionized water (18.2 MΩ). A blank and a sample of NIST 1400 bone ash standard were also prepared for $^{87}Sr/^{86}Sr$ analysis using identical procedures alongside each batch of 15-20 samples. All eluted samples were evaporated at 50-100 ºC, dissolved in 5 M HNO_3, and diluted to a concentration of 0.32 M HNO_3 for analysis. Radiogenic strontium isotope ratios were measured on a Thermo Finnigan Neptune Multi-Collector Inductively-Coupled Plasma Mass Spectrometer (MC-ICP-MS) at ASU's W.M. Keck Foundation Laboratory for Environmental Biogeochemistry. Analyses of strontium carbonate standard SRM-987 for radiogenic strontium isotopes produced mean $^{87}Sr/^{86}Sr$ 0.710251 ± 0.000041 (n = 57, 2σ). Analyses of bone ash standard NIST-1400 produced mean $^{87}Sr/^{86}Sr$ 0.713127 ± 0.000023 (n = 6, 2σ). (Knudson et al 2014; Marsteller et al 2017).

Chapter 5: Results

5.1 Assessment of Contamination in Omo M10 Archaeological Ichu Samples

Graph 1. Comparison of ^{86}Sr Concentrations of Omo M10 Ichu Samples and Modern Moquegua Valley Botanical Samples



As can be seen in Graph 1, there is almost no overlap between Sr concentrations (^{86}Sr ppb) of Omo M10 ichu samples and botanical samples from the modern MMV. This suggests no significant Sr additions from the local burial environment that would have biased ^{86}Sr/^{87}Sr ratios towards local MMV values (Reynolds et al 2005).

Table 1. Correlations of $^{87}Sr/^{86}Sr$ Values With ^{86}Sr Concentrations				
	^{86}Sr Concentrations of Modern MMV Botanical Samples Group 1	^{86}Sr Concentrations of Modern MMV Drainage Botanical Samples Group 2	^{86}Sr Concentrations of Modern MMV Botanical Samples Group 3	^{86}Sr Concentrations of Modern MMV Botanical Samples Group 4
$^{87}Sr/^{86}Sr$ Values of Omo M10 Ichu Samples	-0.4243 0.5757	0.4692 0.5308	-0.7388 0.2612	-0.7388 0.2612
*p < 0.05, **p < 0.01, ***p < 0.001				

To further determine if there was contamination of Omo M10 ichu samples by the local burial environment, Pearson's pair-wise correlations were conducted with ^{87}Sr concentrations of modern MMV botanical samples and $^{87}Sr/^{86}Sr$ values of Omo M10 ichu samples. The ^{86}Sr concentrations of modern MMV botanical samples were broken into four groups for four different Pearson's pair-wise correlation tests of (1) four values of ^{87}Sr concentrations of modern Osmore Drainage botanical samples and (2) the four $^{87}Sr/^{86}Sr$ values of the Omo M10 ichu samples. As shown in Table 1, there were no statistically significant correlations found. This further supports that the local burial environment did not make any significant Sr additions to the Omo M10 ichu samples that systematically shifted the $^{87}Sr/^{86}Sr$ values of the Omo M10 ichu samples towards the MMV local ratios (Reynolds et al 2005).

5.2 Results of $^{87}Sr/^{86}Sr$ *Analysis of Botanical Samples*

Table 2. $^{87}Sr/^{86}Sr$ Values of Modern Osmore Drainage Botanical Samples Collected by Allisen Dahlstedt		
ACL #	Specimen Number	$^{87}Sr/^{86}Sr$
5854	ACD_CON_70_08	0.70676
5857	TOR_73_01	0.70622
5873	ACD_M10_00_02	0.70633
5884	ACD_M10_40_01	0.70622
5889	ACL_MOQ_46_01	0.70629
5897	ACD_M10_57_01	0.70687
5898	ACD_M73_00_01	0.70639
5919	ACD_SCR_00_01	0.70665
5923	ACD_TAG_71_01	0.70622
5989	ACD_TOR_73_01	0.70609
5994	TOR_73_06_palta	0.70581
5997	ACD_TRA_41_01	0.70633
6033	ACD_TRA_72_22	0.70690
6035	ACD_TUM_75_01	0.70641
6038	ACD_TUM_75_04	0.70624
6048	ACD_ZAP_60_04	0.70647
6052	ACD_ZAP_61_04	0.70621

Table 2 shows $^{87}Sr/^{86}Sr$ values of modern botanical samples from the MMV collected by Allisen Dahlstedt ranging from 0.70581 to 0.70690.

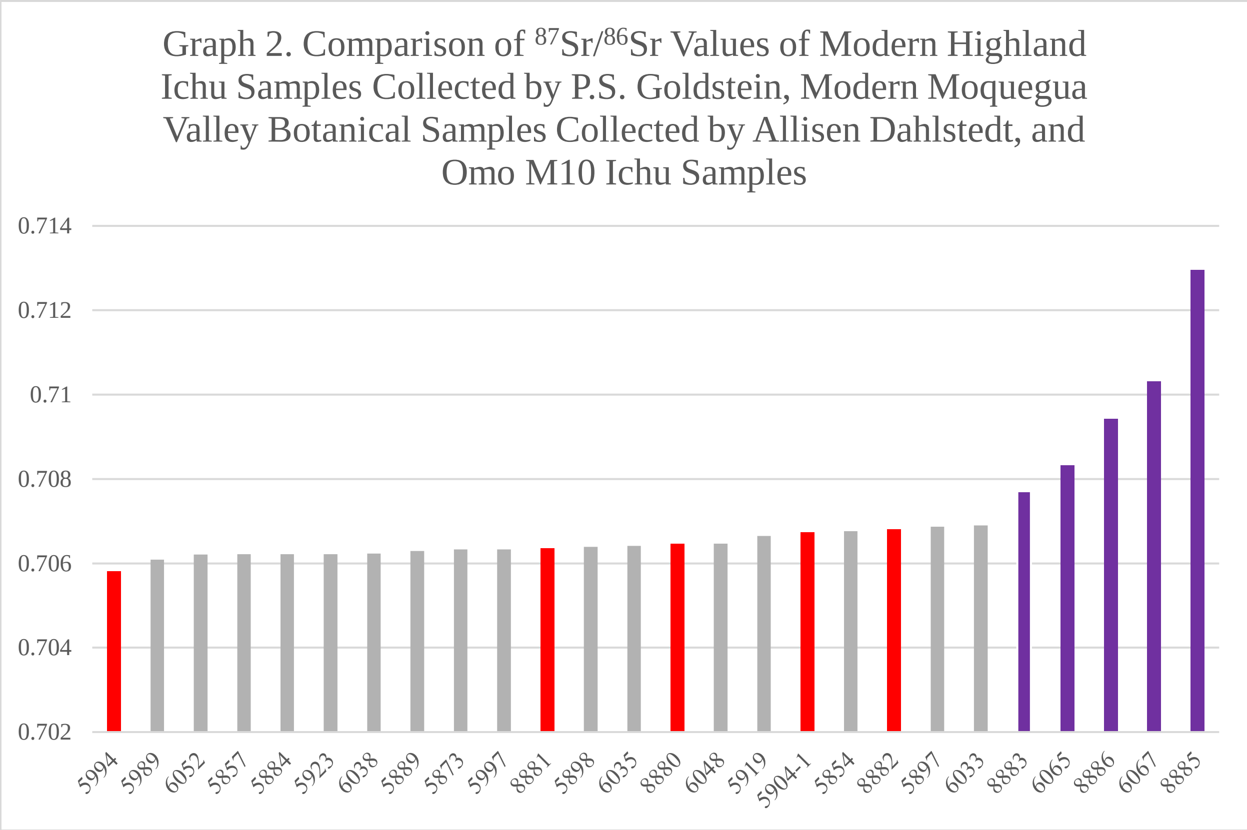
Table 3 shows $^{87}Sr/^{86}Sr$ values of Omo 10 archaeological ichu samples with values ranging from 0.70771 to 0.71295.

Table 3. $^{87}Sr/^{86}Sr$ Values of Omo M10 Archaeological Ichu Samples			
ACL #	Specimen Number	Source Location	87Sr/86Sr
5904-1	OMO_OO_01	Omo M10	0.70673
8880	M10-13469	Omo M10	0.70646
8881	M10-13494	Omo M10	0.70635
8882	M10-3893	Omo M10	0.70680

Table 4 shows $^{87}Sr/^{86}Sr$ values from the four modern ichu samples from the highlands with a range of values between 0.70635-0.70680.

Table 4. $^{87}Sr/^{86}Sr$ Values of Modern Highland Ichu Samples		
ACL #	Specimen #	87Sr/86Sr
6067	TIW_00_02	0.71031
6065	COP_00_02	0.70832
8883	LTB_0001	0.70771
8885	LTB_0003	0.71295
8886	LTB_0003	0.70942

Graph 2. Comparison of ^{87}Sr/^{86}Sr Values of Modern Highland Ichu Samples Collected by P.S. Goldstein, Modern Moquegua Valley Botanical Samples Collected by Allisen Dahlstedt, and Omo M10 Ichu Samples



The range of ^{87}Sr/^{86}Sr values from Omo M10 archaeological ichu samples (0.70635 – 0.70680) falls well within the range for modern botanical samples from the MMV. The range of ^{87}Sr/^{86}Sr values from Omo M10 archaeological ichu samples also falls outside the range of ^{87}Sr/^{86}Sr values for four modern ichu samples from the highlands. This similarity of the Omo M10 ichu samples' ^{87}Sr/^{86}Sr values to the modern MMV botanical samples' ^{87}Sr/^{86}Sr values rather than the modern highlands ichu samples' ^{87}Sr/^{86}Sr values is emphasized in Graph 2 and indicates the Omo M10 archaeological ichu samples have a local origin in the Osmore Drainage.

5.3 Assessment of Diagenesis of Human Bone Samples

Table 5. Diagenesis Assessments for Omo M10 Human Skeletal Samples					
Specimen Number	Sex	Age at Death	Ca/P Ratio	C:N Ratio	% Collagen Yield
M10Q-1=1	Unknown	Adult	2.035760941	Did not produce collagen.	Did not produce collagen.
M10T-3=3	M	40-50	2.079409069	2.9	35.1%
M10T-1=3	Unknown	12-16	1.966724808	3.0	32.3%
M10N-8=1	Unknown	6-10	Data does not meet QA/QC	3.0	8.82%
M10N-5=2	M	Adult	Data does not meet QA/QC	3.0	2.31%
M10A-7=1	F	Young Adult	1.974124604	3.0	16.84%
M10B-12=1	Unknown	12-16	1.944910146	3.0	3.40%

Table 5 shows the results of diagenesis assessments for Omo M10 human individuals analyzed at Arizona State University's Archaeological Chemistry Laboratory. All Ca/P ratios are within the range reported for values from fresh, modern bones, indicating good preservation of bone hydroxyapatite (Szostek et al 2009). For bone collagen samples, C:N ratios range from 2.9-3.0. They are therefore within the acceptable range of 2.9-3.6. Percent collagen yields for collagen samples are also above the 1% minimum, with the average being 16.5%, indicating sufficient preservation of organic collagen (Somerville et al 2015).

5.4 Paleomigration Results and Comparisons

Table 6. Non-Local $^{87}Sr/^{86}Sr$ Values Based on Modern Faunal Values (Knudson et al 2014)	
Lake Titicaca Basin	0.7087-0.7105
Cochabamba Valley (eastern Bolivian highlands)	Mean of 0.72148 $\pm$ 0.00162
Potosi, Bolivia	0.713233 and 0.72053

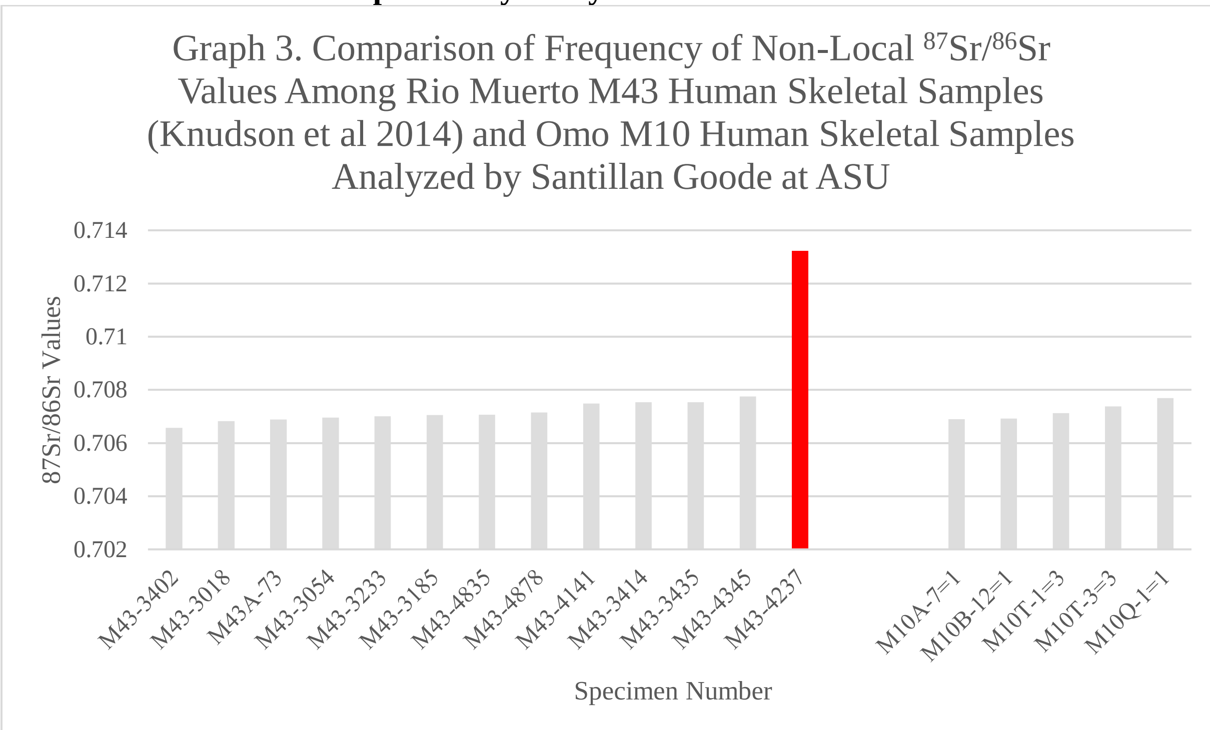
Table 6 shows non-local strontium values based on modern faunal samples for three areas in the highlands: The Lake Titicaca Basin (a range of 0.7087-0.7105), the Cochabamba Valley of eastern Bolivia (an average of 0.72148 ± 0.00162), and Potosí, Bolivia (0.713233 and 0.72053) (Knudson et al 2014). All three of these highland locations were under Tiwanaku influence and therefore provide references for what radiogenic strontium isotope values are to be expected if the human individuals analyzed from Omo M10 were traveling back and forth from the highlands regularly during the last several years of their lives or if those individuals were recent arrivals from the highlands in the last several years before their deaths in the MMV.

Table 7. $^{87}Sr/^{86}Sr$ Values of Omo M10 Human Skeletal Samples

Specimen Number	Sex	Age at Death	87/86Sr
M10Q-1=1	Unknown	Adult	0.70769
M10T-3=3	M	40-50	0.70738
M10T-1=3	Unknown	12-16	0.70713
M10N-8=1	Unknown	6-10	Data does not meet QA/QC
M10N-5=2	M	Adult	Data does not meet QA/QC
M10A-7=1	F	Young Adult	0.70690
M10B-12=1	Unknown	12-16	0.70692

Table 7 shows $^{87}Sr/^{86}Sr$ values for Omo M10 human individuals. The range of $^{87}Sr/^{86}Sr$ values exhibited by Omo M10 human individuals sampled is 0.70690 – 0.70769. This range falls well below the values exhibited by modern faunal material from the Lake Titicaca Basin, Cochabamba Valley, or Potosi, indicating the Omo M10 human individuals lived the last several years of their lives in the MMV (Knudson et al 2014). It also falls almost entirely within a local range for the MMV based on the mean $^{87}Sr/^{86}Sr$ value of modern small mammal samples from the MMV plus or minus two standard deviations, as reported by Knudson et al (2014). To compare the frequency of paleomigratory behaviors among Omo M10 human individuals sampled with the frequency of such behaviors among individuals at the site of Rio Muerto M43, Graph 3 compares the radiogenic strontium isotope values of osseous samples from individuals at these two sites and displays in red those values that were identified as either transhumant or recent arrivals in Knudson et al (2014). This also provides an indication of radiogenic strontium isotope values considered local as a point of comparison for interpreting the human Omo M10 osseous data presented here and shows that all the Omo M10 human individuals sampled had $^{87}Sr/^{86}Sr$ values below those values considered indicative of transhumance or recent arrival status in the literature.

Graph 3. Comparison of Frequency of Non-Local $^{87}Sr/^{86}Sr$ Values Among Rio Muerto M43 Human Skeletal Samples (Knudson et al 2014) and Omo M10 Human Skeletal Samples Analyzed by Santillan Goode at ASU



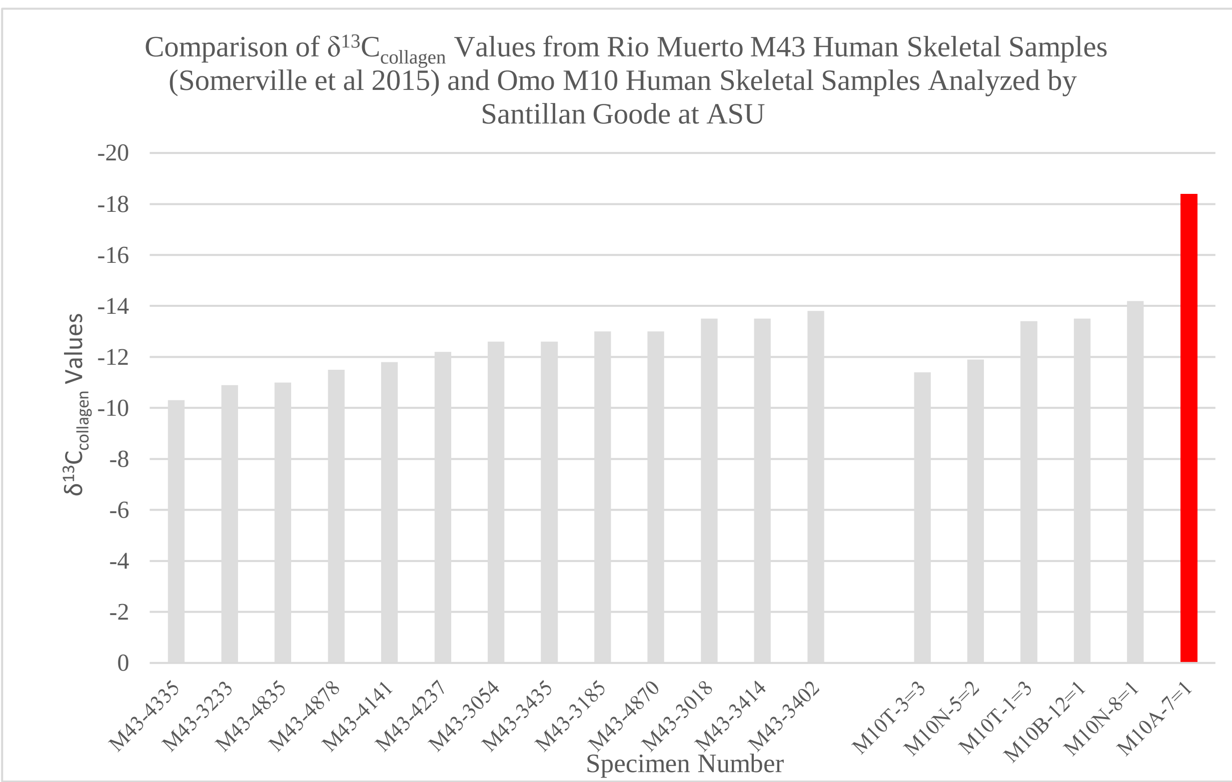
5.5 Paleodiet Results and Comparisons

Table 8. $\delta^{13}C$ Values and $\delta^{15}N$ Values of Omo M10 Human Skeletal Samples				
Specimen Number	Sex	Age at Death	$\delta^{13}C$	$\delta^{15}N$
M10Q-1=1	Unknown	Adult	Did not produce collagen.	Did not produce collagen.
M10T-3=3	M	40-50	-11.4	8.2
M10T-1=3	Unknown	12-16	-13.4	5.1
M10N-8=1	Unknown	6-10	-14.2	6.8
M10N-5=2	M	Adult	-11.9	9.1
M10A-7=1	F	Young Adult	-18.4	13.1
M10B-12=1	Unknown	12-16	-13.5	5.6

Stable isotope ratios of the Omo M10 human individuals analyzed are presented in Table 8 and, except for individual M10A-7 = 1, the Omo M10 individuals analyzed have a dietary profile typical of Tiwanaku colonists: rich in C_4 foods, with minimal inputs from C_3 sources and feeding at a moderate trophic level of largely terrestrial protein (Sandness 1992; Somerville et al 2015). Individual M10A-7=1 is an outlier among the Omo M10 human individuals. She was a young adult woman and has the most negative $\delta^{13}C$ value (-18.4 ‰) and the most positive $\delta^{15}N$ value (13.1 ‰). This suggests that individual M10A-7 = 1 was consuming a diet with a much less substantive contribution of C4 resources and a greater contribution of C3 resources relative to the other individuals analyzed. She was also feeding at a much higher trophic level, which indicates she may have been consuming significantly more marine resources.

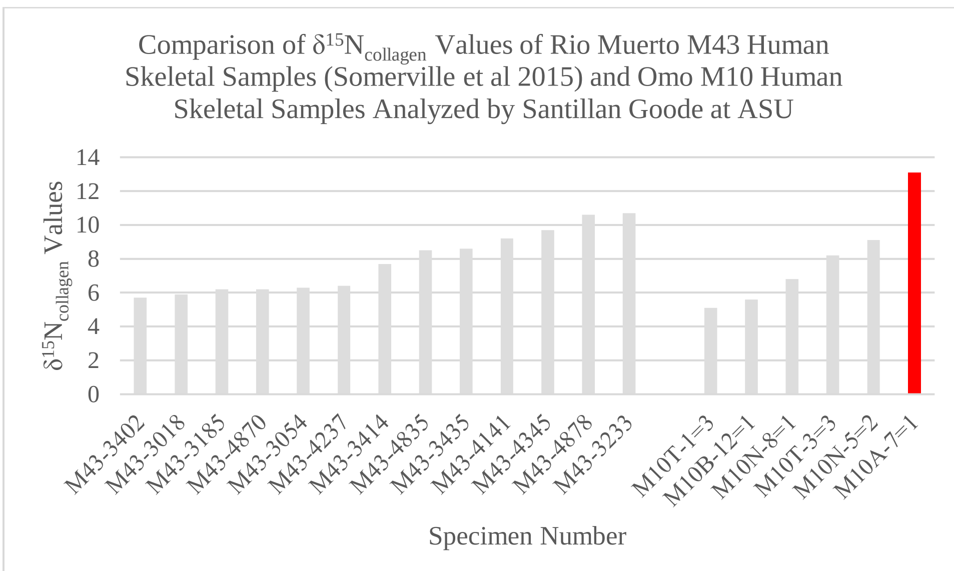
If you do not consider the outlier M10A-7=1, individuals analyzed from Omo M10 and Somerville et al (2014)'s sample from Rio Muerto M43 have a large degree of overlap in both their stable carbon and stable nitrogen ranges (Omo M10 stable carbon isotope range: from -11.4 to - 13.5; Omo M10 stable nitrogen isotope range: 5.6 – 9.1: Rio Muerto M43 stable carbon isotope range: -13.8 – 10.3; Rio Muerto M43 stable nitrogen isotope range: 5.7-10.7). The similarity between the Omo M10 human skeletal data and Somerville et al (2015)'s human skeletal data can be seen in Graph 4 (a comparison of the stable carbon isotope values for each group) and Graph 5 (a comparison of the stable nitrogen isotope values for each group). In both graphs, the outlier M10A-7=1 (ACL – 8877) is displayed in red.

Graph 4. Comparison of $\delta^{13}C_{collagen}$ Values from Rio Muerto M43 Human Skeletal Samples and Omo M10 Human Skeletal Samples



To further compare the stable carbon and nitrogen isotope data from Omo M10 and Rio Muerto M43, R-3.4.3 for Windows (32/64 bit) was used to run a Kruskal-Wallis one-way analysis of variance comparing the stable carbon isotope data from each site and the stable nitrogen isotope data from each site separately. In both cases, the data sets were found not to be significantly statistically different from each other, with P values of 0.7331 and 0.3004 respectively (Somerville et al 2015). This suggests that, besides the outlier in the Omo M10 range, individuals from both sites were feeding at similar trophic levels and had similar proportions of carbon atoms originating from C_4 plant foods contributing inputs to their diets, and to their dietary protein especially.

Graph 5. Comparison of $\delta^{15}N_{collagen}$ Values from Rio Muerto M43 Human Skeletal Samples and Omo M10 Human Skeletal Samples



Chapter 6: Discussion

6.1 Architectural Symbolism

The use of ichu from the Osmore Drainage in the construction of the Omo M10 temple prioritizes cultural continuity rather than functionality in a way that incorporates and sanctifies the local landscape. It maintains a culturally specific aesthetic and refers to a frigid, rainy homeland, keeping the memory of that homeland alive in the hearts and minds of those who visited the Omo M10 temple. Rather than being part of an expression of (ethnic) difference through different source locations particularly associated with different ancestral communities, the use of ichu in an architectural technique more well-suited to the homeland and commonly found there makes use of a cultural repertoire, a deeper set of shared beliefs and practices that Tiwanaku-affiliated colonists of the Omo M10 colony clearly had extensive knowledge of and worked to maintain in many aspects of their lives (Goldstein 2005; Stovel 2013). This further suggests that contexts conducive to displays of difference took place away from the Omo M10 temple. Though Tiwanaku sites in the MMV are largely of either Omo or Chen Chen style, Omo style sites and Chen Chen style sites are often located adjacent to each other, suggesting some form of contact (Goldstein 2005; pg. 134). Considering the previously discussed occupational specializations of the Omo and Chen Chen groups, perhaps such situations of ethnic consciousness and inter-ethnic contact involved exchanges of agricultural products and maritime resources for pastoral products (Stovel 2013).

6.2 Paleodiet Comparisons

The lack of statistically significant differences between the stable carbon and stable nitrogen isotope ratios of the Omo M10 individuals discussed and Somerville et al (2015)'s data on individuals from Rio Muerto M43 suggest those at the provincial center did not engage in significantly more chicha consumption compared to those at the non-provincial center. Considering the sociopolitical salience of chicha drinking in the Tiwanaku state, this does not support comparatively more intentional state-oriented practices of identity among Omo M10 individuals (Goldstein 2015). Furthermore, this suggests that notions of Tiwanaku-ness were not fundamentally tied to political engagement because those who lived at and away from the provincial center were equally engaged in intentional processes of Tiwanaku identity affirmation and felt equally entitled to be engaged in such processes. Therefore, these findings support notions of Tiwanaku as something that, though certainly a political phenomenon, was also a cultural entity comprised of shared beliefs and practices (Stovel 2013). These comparisons also confirm prior findings by Somerville et al (2015) of broad dietary similarity among different Tiwanaku colonial sites of the MMV.

The new paleodietary information from Omo M10 supports additional findings by Somerville et al (2015) and Sandness (1992) that characterized a MMV Tiwanaku dietary profile as being one of predominately C_4 resources, with a lesser contribution of C_3 resources, and minimal contribution of marine resources. Compared to this previous paleodietary research, there are some similarities and differences by sex and age in the new Omo M10 data. First, like Somerville et al (2015)'s finding that across all sites they considered (M10, M43, M70), males had significantly less negative $\delta^{13}C_{collagen}$ values than females (and that there were no significant differences in $\delta^{15}N_{collagen}$ values between the sexes), among the new data from Omo M10 males had the least negative $\delta^{13}C_{collagen}$ values. However, these Omo M10 males also had the highest $\delta^{15}N_{collagen}$ values. It is interesting to note that although Somerville et al (2015) found no significant differences between males and female $\delta^{15}N_{collagen}$ values across all sites considered, males had a higher median $\delta^{15}N_{collagen}$ value than females when Rio Muerto M43 and Omo M10 were considered in isolation. This further supports a model of chicha drinking as being more accessible to males than females (Somerville et al 2015).

With regards to age-based distinctions in the new Omo M10 data, contrary to Somerville et al (2015)'s finding that post-weaning, colonial Tiwanaku children generally had diets like those of adults, the two Omo M10 adults had the least negative $\delta^{13}C_{collagen}$ values and the highest $\delta^{15}N_{collagen}$ values. Among the two sub-adult age cohorts in the new Omo M10 data, the 12-16 years age cohort has the middling $\delta^{13}C_{collagen}$ value and the lowest $\delta^{15}N_{collagen}$ value. The 6-10 years age cohort has the most negative $\delta^{13}C_{collagen}$ value and the middling $\delta^{15}N_{collagen}$ value. Individual M10N-8=1 (6-10 years at death) has a $\delta^{15}N_{collagen}$ value lower than that of the two adults (M10Q-1=1 and M10N-5=2). This fits with Somerville et al (2015)'s observation that juveniles had somewhat lower $\delta^{15}N_{collagen}$ values than adults among all the sites they considered. However, in contrast to Somerville et al (2015)'s observation that among all the sites they considered, the mean $\delta^{13}C_{collagen}$ value of juveniles (defined in their study as between the ages of 2 and 11 years at death) is identical to that of adults, individual M10N-8=1 had a more negative $\delta^{13}C_{collagen}$ value than those who were adults or 12-16 years old at death. This suggests dietary protein consumed by individual M10N-8=1 was richer in C_3 resources than dietary protein consumed by the other two age cohorts in the new Omo M10 data. Individual M10N-8=1 was also eating at a higher trophic level (indicated by a higher $\delta^{15}N_{collagen}$ value) than the 12-16 years age cohort. Nonetheless, individual M10N-8=1 was not eating at as high a trophic level as the adult age cohort.

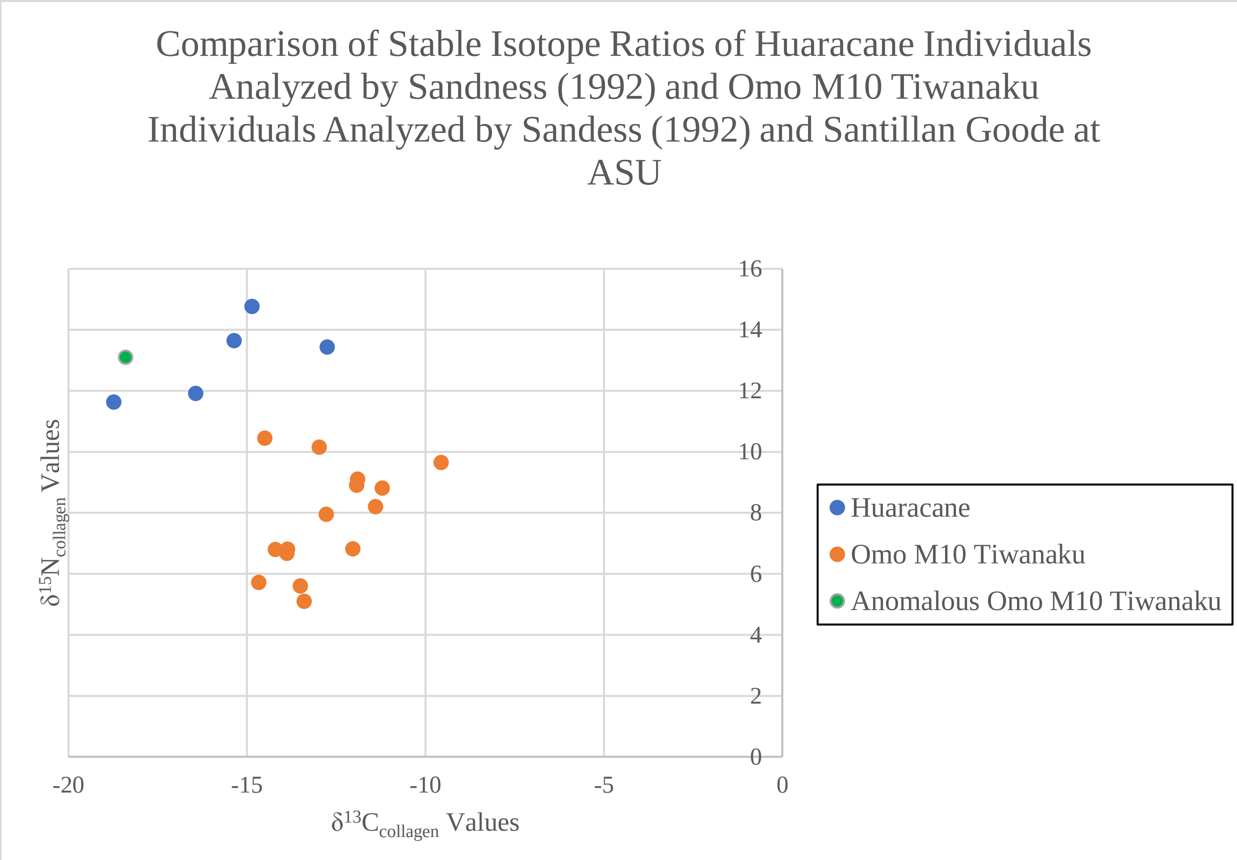
6.3 Paleomigration Comparisons

The classification of the Omo M10 individuals analyzed for this study as local supports characterization of Chen Chen style settlement in the MMV as that of sedentary agriculturalists, as has previously been argued based on published archaeological and osteological research (Becker 2018; Goldstein 2015). Although teeth were not available for the Omo M10 individuals analyzed for this study, the lack of non-local $^{87}Sr/^{86}Sr$ values among the Omo M10 sub-adult osseous samples analyzed (12-16 years age cohort and 6-10 years age cohort) does lend support to a model of Tiwanaku demographic colonization in which first-generation immigrants are a minority at any one time and most population growth and maintenance comes from local births (Goldstein 2005; Knudson et al 2014).

Unlike the homogeneity in inter-site dietary practices, there was a lack of transhumant or recently arrived individuals among the Omo M10 persons analyzed versus one such individual among the Rio Muerto M43 osseous samples analyzed by Knudson et al (2014). This suggests those at the provincial center did not engage in greater commitment to a physical connection with their homeland versus those at Rio Muerto M43, at least in the last several years before death. If one assumes that connection to homeland diminished with passing generations, this also suggests first-generation immigrants to the MMV settled in an evenly dispersed way among the valley's different Tiwanaku sites, rather than being concentrated at Omo M10 (Baitzel 2016). Furthermore, these inter-site differences support movement between the Lake Titicaca Basin and the MMV orchestrated at the community level rather than by a centralized administrative body whose influence was concentrated at the provincial center of Omo M10. Overall, these implications of paleodietary and paleomigration reconstruction support a more decentralized model of Tiwanaku influence in the MMV in which unranked individuals had the power to make decisions about how to engage in Tiwanaku-ness, rather than decision-making flowing downward or outward from a provincial center that regulated access to resources essential for the practice of Tiwanaku culture or mediated physical ties to the homeland (Janusek 2004).

Finally, individual M10A-7=1 is unusual in multiple ways. First, her relatively more negative $\delta^{13}C$ value and her relatively more positive $\delta^{15}N$ value compared to both the other Omo M10 individuals and the Rio Muerto M43 individuals indicate that her diet included a much larger proportion of C_3 resources, and that she was feeding at a higher trophic level. Considering that the $\delta^{15}N$ values of organisms consuming marine resources are higher than those feeding in terrestrial systems, her higher $\delta^{15}N$ value suggests a greater proportion of marine resource consumption (Schoeninger et al 1983; Scheoeninger & DeNiro 1984). In fact, this young woman's $\delta^{13}C$ and $\delta^{15}N$ values and her corresponding dietary profile are much more like that of the indigenous Huaracane population of the Osmore Drainage than the typical dietary profile of Tiwanaku colonists (Goldstein 2003; Sandness 1992; Somerville et al 2015). Her stable carbon and nitrogen isotope values fall within the range of stable carbon and nitrogen values reported by Sandness (1992) for Omo Huaracane individuals in her diachronic study of dietary patterns in the Osmore Drainage. This can be seen in Graph 6. M10A-7=1's female sex also makes her burial's possible inclusion of a kero, a vessel associated with the male-oriented ritual activity of drinking maize-beer, and her high $\delta^{15}N_{collagen}$ value, unusual (Sandness 1992; Somerville et al 2015).

Graph 6. Comparison of Stable Isotope Ratios of Huaracane and Omo M10 Tiwanaku Individuals



Though this could suggest that she originated from a contemporary Huaracane population occupying the MMV and new dates from Huaracane sites do indicate more extended contemporaneity with Tiwanaku colonization than previously thought, this interpretation is rejected because the drastically different settlement patterns of the two groups do not yield evidence of co-existence or antagonistic interaction within sites of either group (Goldstein 2005; Goldstein 2013). There is also no evidence that Huaracane sites were later re-occupied by Tiwanaku colonists or mixed populations of Huaracane individuals and Tiwanaku colonists. Furthermore, there is no evidence of exchange between the two groups in the form of artifacts traded between the two groups (Goldstein 2005). Instead, M10A-7=1 is argued to be a marriage partner originating from a contemporaneous coastal Huaracane related population. Both Chen

Chen and Omo style Tiwanaku colonists made use of marine resources. However, Chen Chen style sites (i.e. Omo M10) had better access to marine resources than Omo style sites, and only Chen Chen style sites seem to have consumed marine resources (edible marine mollusks and crustacea), while Omo style sites used shellfish for ornamental purposes. Nonetheless, Tiwanaku colonists of either style never settled on the coast of the Osmore Drainage, meaning their procurement of marine resources must have been indirect (Goldstein 2005). Therefore, M10A-7=1 may have been a marriage partner sent from a coastal Huaracane-related population to build trade relationships between Tiwanaku and coastal Huaracane related populations. If this is true, she died shortly after arriving in the MMV, before having spent a significant enough amount of time among the Tiwanaku colonists to adopt their dietary practices, and for such dietary practices to be reflected in her bone chemistry.

Chapter 7: Conclusion

Though Omo M10 is a unique Tiwanaku-affiliated site in the MMV and outside of the Tiwanaku homeland more generally, residents of this Chen Chen style site did not demonstrate a different degree of commitment to their homeland or the Tiwanaku state compared to residents of the Chen Chen style site of Rio Muerto M43. Stable carbon and nitrogen isotope data from bone collagen pertaining to six individuals from Omo M10 was not significantly different from published stable carbon and nitrogen isotope values for individuals from Rio Muerto M43, suggesting that the sampled individuals from Omo M10 had a diet typical of Tiwanaku colonists: rich in C_4 resources with minimal contributions from C_3 resources and feeding at a moderate trophic level of largely terrestrial resources, with marine resources making a minimal contribution (Sandness 1992; Somerville et al 2015). The lack of statistically significant difference between the stable carbon and nitrogen values of these two sites also suggests they were engaging in similar amounts of chicha consumption. This similar degree of chicha consumption at and away from the provincial center suggests colonists throughout the MMV considered themselves equally a part of the diasporic Tiwanaku community regardless of whether monumental, ceremonial architecture was a part of their daily lives.

Comparison of $^{87}Sr/^{86}Sr$ values for five individuals from Omo M10 with the frequency of non-local individuals among Rio Muerto M43 suggests a similar lack of greater participation in travel to and from the homeland among individuals from Omo M10 compared to individuals from Rio Muerto M43 (Knudson et al 2014). This supports movement between the MMV and the homeland orchestrated at the community and/or individual level, rather than by a centralized administrative body exerting control from the site of Omo M10 (Janusek 2004). This information regarding diet and mobility at the site of Omo M10 and comparison with published data from

Rio Muerto M43 supports a more heterarchical model of Tiwanaku state influence in the MMV. In this model, decision-making power about how to engage in distinct aspects of Tiwanaku-ness lay in the hands of individuals and communities rather than a centralized administrative body controlling access to resources essential for partaking in Tiwanaku ritual culture or orchestrating physical connections with the homeland.

This emphasis on shared Tiwanaku cultural behaviors is also found in temple construction at Omo M10. Radiogenic strontium isotope analysis of four archaeological ichu grass samples showed that they were all grown in areas within the Osmore Drainage as opposed to the homeland. Rather than symbolizing subsidiary ethnic identities within a monumental, distinctly Tiwanaku context, the use of these ichu samples in a nonfunctional way referred to a shared cultural milieu, or a deeper set of shared beliefs and practices familiar to Tiwanaku colonists and fastidiously maintained in their colonial context (Stovel 2013). This reinforces ideas of Tiwanaku as more than political, or of being in addition a shared worldview and way of doing things captivating enough to be transplanted to vastly different environments (Williams 2013). Furthermore, notions of ethnicity as intentional and situational suggest that circumstances necessitating ethnic differentiation between Omo and Chen Chen people took place away from the Omo M10 temple, perhaps in the context of resource exchanges (Stovel 2013).

Individual M10A-7=1's unique stable carbon and nitrogen isotope values suggest she may have been a bride originating from a coastal Huaracane-related population who became a part of the Omo M10 community as part of efforts to build trade relationships with such Huaracane-related coastal populations. Though both Omo and Chen Chen style sites enjoyed access to maritime resources, Tiwanaku colonists never settled directly on the coastal portion of the Osmore Drainage, meaning they must have obtained those maritime resources indirectly

(Goldstein 2005). The nature of this indirect procurement is still poorly understood and represents a fascinating area of future research. Individual M10A-7=1 is also the first individual from cemetery A of the Omo M10 site to be analyzed for purposes of paleodiet reconstruction or determining local/non-local status, so future work with individuals from that cemetery may reveal additional individuals with coastal affiliations. While supplementation of the previously discussed stable carbon and nitrogen isotope data from bone collagen with stable carbon isotope data from bone hydroxyapatite would have allowed for more quantitative determinations of ancient diet, comparative biogeochemical analyses of ancient populations in conjunction with relevant lines of archaeological and bioarcheological evidence continue to yield insights about individual variation, regional organization, and larger scale inter-regional interaction.

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