12-17-2019

Residential Mobility in the Late Pre-hispanic Osmore Drainage: Isotopic Analyses of Hair from the Estuquiña

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doi: https://doi.org/10.57709/16014831

RESIDENTIAL MOBILITY IN THE LATE PRE-HISPANIC OSMORE DRAINAGE:

ISOTOPIC ANALYSES OF HAIR FROM ESTUQUIÑA

by

D. ELIZABETH CARMODY

Under the Direction of Bethany L. Turner, PhD

ABSTRACT

I examine, through isotopic analyses, individual and regional interactions in Peru following the collapse of the large polity, Tiwanaku. After its collapse in the 11th century, former territories experienced violent instability, as new communities formed during the Late Intermediate Period, or LIP (1000-1400s AD). I analyze naturally mummified human hair from the later LIP Estuquiña (1250-1470s AD) in the Moquegua Valley of southern Peru to examine patterns of regional mobility in the aftermath of political fragmentation. Reconstructing residential mobility through isotope analyses is methodologically established, and has been instrumental in understanding mobility, exchange, colonization, and regional interactions during Tiwanaku's height. However, less is known about these processes following the disbursement of individuals and groups of people after the early LIP when instability transitioned into a different form of uncertainty, caused by environmental factors. Using heavy isotope analysis, I test the oral tradition and ethnohistoric accounts of the origins of members of the LIP Estuquiña cultural group, which suggested populations moved from around the southern Lake Titicaca region into the middle Moquegua Valley of Southern Peru during the Late LIP.

I analyzed bulk samples of archaeological hair from ten naturally mummified individuals from the site of Estuquiña, located in the middle Moquegua Valley, Peru. I characterized $^{87}Sr/^{86}Sr$ and $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and ^{208}Pb ($^{206,7,8}Pb/^{204}Pb$ for brevity). Additionally, I analyzed ratios of the same isotopes in a subset of individuals (N = 2), using 1cm increments from roughly thirty strands of hair per individual, aligned by the hair follicles. This allowed me to examine incremental variation in isotope ratios during each month or so leading up to death. Hair $^{87}Sr/^{86}Sr$ and $^{206,7,8}Pb/^{204}Pb$ results indicate that only one individual, M6-4203, was distinctly from the altiplano, while two more individuals may have also been from outside, but near to, the region. Most individuals appear to have been locals, isotopically speaking, to the middle Moquegua Valley. These data support recent preliminary work by Sutter and Sharratt (2018) arguing that the Estuquiña inhabitants were a contiguous population extending back to the Middle Horizon, rather than a replacement community from highland Lupaqa cultures or other far-flung regions.

INDEX WORDS: Strontium Isotopes, Lead Isotopes, Mobility, Bioarchaeology, Peru, Tiwanaku

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Arts

in the College of Arts and Sciences

Georgia State University

2019

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December 2019

DEDICATION

I would like to dedicate this thesis to Tangerine and Gravy, the balls of joy who keep me on track to write. As well as the friends that gravitated towards my cats. They have kept me sane during this writing process.

ACKNOWLEDGEMENTS

The process of writing this thesis has been one that I did not anticipate taking as long as it did. During the researching, brainstorming, and writing of the thesis I was supported by a large group of amazing professors and friends. In no significant order, I thank, Dr. Jennie Burnet, for guiding me into the realms of theory which I am still working through. As well as, guidance on how to become a more competent writer. I would also like to thank, Dr. Nicola Sharratt, who took me to work with her in southern Peru. During these trips I gained a deep appreciation for both the practice of archaeology, but also watching and learning the daily interactions that go into making a well-run and sustainable site that is beneficial for both those who live in the region and those who come to excavate. The region of the field visits has grown on me. During these trips I gained a deeper appreciation of all things related to archaeology and bioarchaeology, and the necessity of the two together. Additionally, I would like to thank Dr. Bethany Turner-Livermore, who created engaging undergraduate courses related to bioarchaeology, which led me to fall for the field of bioarchaeology and the study of the past. Were it not for her guidance, and the unique opportunities she provided me in different segments of the discipline throughout my graduate career, I would not have discovered my thesis focus of population movement. I fall short at properly putting to words the amount of information and life lessons provided by these professors, for these I am most grateful to you all. Additionally, I would like to thank Lic. Elva

Torres for her knowledge of all things Moquegua Valley, and the opportunity to discuss her research throughout the valley, specifically at Estuquiña. I would like to thank Dr. Sloan Williams, of the University of Illinois at Chicago, for granting access to the samples that were utilized throughout my thesis. I would also like to thank, Dr. Douglas Dvoracek, of the University of Georgia-Center for Applied Isotopes Studies, for his indispensable contributions to the analyses of the samples. I would also like to thank the Anthropology Department at Georgia State University, which has always had an open environment, no matter our degree, every professor has been amazing. Finally, I would like to acknowledge my friends who have been with me through this process, whether you graduated before or with or after me, I still rely on you strongly, and am so thankful for all your knowledge and kindness. This has been an amazing experience, thanks.

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LIST OF ABBREVIATIONS

Center for Applied Isotopic Studies – CAIS

Georgia State University – GSU

Late Intermediate Period – LIP

Lead – Pb

Meters above sea level – M.A.S.L., masl, m.a.s.l.

Milliliter – mL

Oxygen – O

Strontium – Sr

University of Georgia - UGA

1 INTRODUCTION

The collapse of the Middle Horizon states in Andean South America that began around AD 1000 was followed by widespread socio-political transformation. As noted by scholars including Janusek (2005:176), Torres-Rouff et al. (2015), and Arkush (2008), some of the regions that had a Tiwanaku presence during the Middle Horizon (AD 500-1000) included southern Peru the altiplano of northwest Bolivia, and northern Chile. Within these regions, the following Late Intermediate Period (LIP; AD 1000-1475), witnessed an increase in displacement and relocation of individuals and communities (Arkush 2008:342; Covey 2008). Similarly, some of the regions previously occupied during the Middle Horizon by the contemporaneous Wari Empire saw an increase in the displacement and relocation of communities and individuals to more readily defendable locations (Finucane et al. 2007, Kemp et al. 2009, and Williams 2002) There is evidence for increased violence during the Late LIP (AD 1250) particularly in the altiplano region of the Andes. This is in part due to environmental stress during the LIP, several centuries after the Middle Horizon ended (Arkush 2008:342, 365) (refer to Table 1). Tracking residential movement in the archaeological record has previously been difficult. Material culture can move over long distances without indicating that the person who created it moved with it. Spanish colonial accounts of the Andes are centuries out of date. Oral histories paint broad narratives about interregional mobility but can prove to be partial at times; necessitating that researchers critically analyze the references provided via the oral histories (Covey 2008). Bioarchaeology, specifically multi-isotope analysis, has shown great promise in reconstructing residential mobility in many regions of the world, including the south-central Andes.

1.1 Purpose of the Study

This study tests portions of historical visitas and oral tradition pertaining to population mobility to a site in southern Peru's Moquegua Valley. During the Middle Horizon, Moquegua was incorporated into the Tiwanaku state. The valley's location was an important frontier of not only the Tiwanaku, but also the Wari. This is evident by the Wari outpost, Cerro Baúl, located to the northeast of the Estuquiña site. Although the authority of both states began to wane as early as AD 1000, recent research reveals considerable maintenance of Middle Horizon derived practices, traditions, and populations in Moquegua until AD 1250. These centuries are locally termed the terminal Middle Horizon but correspond with what is called the early Late Intermediate Period elsewhere (Covey 2008). Beginning around AD 1250, or the onset of the later LIP, there is a radical material change in Moquegua's archaeological record with the appearance of Estuquiña style sites and materials. Historical sources suggest that inhabitants of these Estuquiña sites were colonists from the altiplano Lupaqa polity (Murra 1968). After the Middle Horizon and into the LIP, the Lupaqa relied on a non-centralized style political system. Their settlements are smaller than Middle Horizon centers and in easily defendable locations (Graffam 1992:886-887).

By examining mummified hair from ten individuals recovered from the Estuquiña-type site, also called Estuquiña, who were naturally mummified, I test whether the Estuquiña people are local to the region, or migrated to the site from geologically distinct regions, including the Peruvian or Chilean coast or the highland altiplano. This study is part of a larger ongoing investigation into the origins of late pre-Hispanic migration throughout the Osmore Drainage of southern Peru, encompassing the Moquegua and Ilo Valleys (Font et al. 2012, Knudson and Buikstra 2007, Szostek et al 2015, Chau et al. 2016, Knudson 2008, Knudson et al 2012). I characterize isotope ratios of radiogenic strontium and lead in incremental segments of preserved human hair in order to reconstruct interregional individual movement prior to death. This broadens the archaeological understanding of pre-Hispanic Andean paleomobility and how individuals interacted during the rapidly changing social and political environments of the LIP.

Table 1 Periods and Horizons (After Arkush and Tung 2013, Lowman et al. 2019, Sutter 2000)

Time Period	Dominant Polity(ies) in Moquegua	Date
Late Horizon	Inka	AD 1476 – AD 1532
Late LIP Early LIP	Lupaqa/Estuquiña/Chiribaya Tumilaca	AD 1250 – AD 1476 ~AD 950 – AD 1250
Middle Horizon	Wari/Tiwanaku	AD 600 – ~AD 950/1100

1.2 Theorizing Mobility

An arbitrary line marked on a map, separating people from one another, or the actions taken by a group of individuals in a region to 'fit in' to the prominent social organization, contribute to what Horst (2019:56) calls 'uncertainty,' affecting hundreds of thousands of migrants daily. While these barriers exist, there are a myriad of reasons that people migrate between regions, both past and present. For instance, people can go on short extended trips to visit cities that they have not been to previously or visit with family members who do not live nearby. Additionally, there are religious and spiritual reasons for people and groups of people to travel en-masse. While people travel, they can experience epiphanies and hazards, this has not changed from the past to the present (Peters 1994:xxiii).

For instance, Brigden (2016:343) discusses a family who left El Salvador to trek to the United States, passing through Mexico along the way. They started this journey to end suffering afflicted by local gangs in the region they had lived. During their travels, their young boy managed to “speak like a Mexican,” (Brigden 2016:343). This action becomes a point of survival for the migrant family, or what Brigden (2016) calls ‘social camouflage,’ being able to blend into a region as someone who is from that region makes traveling less dangerous. Horst (2019:56) points out that, when one group’s ideology becomes unstable or uncertain due to conflict or displacement, new and different societal changes begin. As seen with the family fleeing from El Salvador, they adopt the mannerisms which are most like those host nations that they are in at the present time, in order to not become targets of crime (Bridgen 2016). As Brigden (2016:347) notes, the social camouflage, made their journey safer, albeit not legal. These mannerisms include speech, walk, as well as iconography. This can often be seen as objects associated with local villages in the region which would identify the family as ‘local’ to a visual inspection. El Salvador is roughly 1600 km away. Along this route the family had to travel roughly 1200 km through Mexico before they arrived at the United States. Adopting the mannerisms of the host nation aided in their survival during travel.

Every year thousands of U.S. citizens visit New York City around December to watch the ‘ball drop.’ This annual visit coincides with the celebration of the U.S. New Year. For the majority of those who travel to New York, the event is one filled with hope for better things to begin the next year. However, some of the people who visited will inevitably have some mishaps occur, such as lost luggage, a missed flight, or an overbooked hotel. These bad experiences do not detract from people returning every year to visit New York to watch the ball drop. As Paolicelli (2019) points out this year’s event is already gearing up, as people who are visiting or living in New York are writing on slips of confetti what they hope for in the New Year. People, if given the opportunity, will move for social gatherings.

A religious annual event, or Hajj, occurs in Saudi Arabia, where 2 million Muslims participate on a journey to Mecca. As Peters (1994) notes there are several reasons to go on this important religious journey. There is the spiritual aspect, but there is also the time set aside for ten days to re-acquaint yourself with old friends and new business partners. Peters (1994) also notes the length of this trip is great for trade and creating new sources of revenue. A large group of like-minded people are moving with a single goal in the end, but along the way smaller interpersonal goals are achieved because of this yearly gathering.

A recent conflict not unlike those that may have occurred during the LIP, involve Hong Kong protesters shoring up at the Chinese University of Hong Kong as they ‘fight’ extradition back to the mainland of China. A crucial piece of information may be that Hong Kong was for a long period, a British colony, having separate regulations than most of China, during this occupation. Although, the reintroduction has been canceled, the new young generation is pushing for a change and shift towards a different form of government (BBC 2019). Horst (2019:54-55) notes conflict and uncertainty often create minority groups, where their survival is based on ‘structural factors’ outside their control. Although the protesters are not able to control what the police do in this situation in Hong Kong, they are able to barricade themselves with like-minded individuals pushing for change, in an extreme way. Contrasting this method of outspoken change, the family who left El Salvador did so peacefully, to hope for a better future. Looking at known examples of archaeological conflict and uncertainty, I note how people survive uncertainty, and how this can be seen in the archaeological record.

With the invention of cars and airplanes, traveling is easy, and somewhat convenient. This allows for people to move from almost any distance to almost any new location within a manner of a few days. While people and communities in prehistoric times did not have access to the modern conveniences of these inventions, groups of people have consistently moved great distances for varied purposes. For instance, polities and empires moved over great distances to secure goods, find new lands, colonize, and religious journeys. However, as these movements were predominantly prior to writing, archaeologists had to rely on what was remaining from these groups of people. The addition of isotopic analyses, carbon dating and other geochemical techniques to the archaeological toolbox has aided in better understanding when and where people moved to, not just that they existed. This is how archaeologists and bioarchaeologists can now infer movement, and date when an individual is from.

Over the span of roughly a century, the Roman empire went from being one of the most prolific expansionist territories in the Old World, to a decentralized region that maintained little to no power. Provinces as far away as Britannia felt the changing nature of the empire's control. Both locals, or those who were from the European continent and who had moved there because of the expanding Roman empire interacted regularly, passing their mannerisms between each other. Through analyzing archaeological Roman citizens (Moreland 2010:146) recovered from a Roman cemetery in Winchester, the story of social camouflage unfolds. While people are social in nature, Brigden (2016) and Horst (2019) point out that people tend to blend into a region to raise their survival rates, especially during times of uncertainty. Moreland (2010) discusses a group of individuals analyzed both archaeologically, as well as bioarchaeologically.

The archaeological data suggested that the individuals were Pannonia, or a migrant group who moved to the Romano-British outpost. The isotopic analysis noted that at least four were from the Winchester site. Additionally, archaeologically identified non-migrants were isotopically analyzed and at least two were from Pannonia (Moreland 2010).

In this case, Moreland (2010:145) points out that the people were potentially second-generation individuals. In another analysis that Moreland discusses, the individuals were mixed between (non)local again, based on the material culture and isotopic signatures. Further still, at other sites, including in North Yorkshire, a similar pattern of heterogeneity was seen in the presence of those who were buried as local vs non-local and their isotopic signatures (Moreland 2010). This is significant, because the sites are from the period that the Roman empire was beginning to lose power. Horst (2019:56) points out how uncertainty is central during our lived experience for new societal changes to occur.

Paleomobility studies in the Andes started with Knudson's (2004) strontium isotope analysis centered on testing models of Tiwanaku rule in hinterland regions such as Chen Chen, namely whether Tiwanaku established influence (via imported material culture and ideologies), or a colony (via imported people). Knudson characterized $^{87}Sr/^{86}Sr$ values in human tooth enamel and bone from human remains at the sites of Tiwanaku in Bolivia and Chen Chen in Peru and compared human values to those characterized in modern cuy (*Cavia porcellus*) fed controlled diets to differentiate geologically local and non-local individuals (Knudson et al. 2004). Her isotopic analyses confirmed that people from Tiwanaku moved into the Moquegua Valley site of Chen Chen during the Middle Horizon (Knudson et al. 2004). In the 15 years following Knudson's study, multi-isotope studies of residential mobility have proliferated in the Central Andes, including Peru's north coast (Slovak et al. 2009, Turner et al. 2013), central highlands (Knudson and Tung 2011), southern highlands (Turner et al. 2009), northeastern cloud forests (Toyne et al. 2016), and southern lowlands (Andrushko et al. 2009; Knudson 2004), as well as the Chilean coast (Knudson and Torres-Rouff 2014) and elsewhere (Knudson and Stojanowski 2008; Durán et al. 2017). This study joins this growing body of work by characterizing strontium and lead isotope ratios in archaeological hair at the Estuquiña site.

1.3 Expected results

The decline of Tiwanaku and Wari political influence across large swathes of the southern Andes began around AD 1000 and was followed in many regions by significant population displacement and migration. Individual and group movement throughout the Southern Andes begins to reflect a time of uncertainty and what Brigden (2016) terms "social camouflage." For instance, there are polities within the Moquegua Valley following the collapse of the Tiwanaku and Wari during the early LIP (AD 950 – AD 1250) that established settlements in secure locations, such as Tumilaca la Chimba. Throughout the Moquegua Valley, artefacts no longer display the 'Staff God,' an important iconographic image associated with both the Tiwanaku and Wari. However, the ceramic style is still very influenced by the Tiwanaku and is produced in a similar manner to the Tiwanaku style (Goldstein 1989).

Many former Tiwanaku-influenced regions appear to have more or less stabilized, during the later LIP. They became small organized communities that jockeyed for status. During the late LIP the Moquegua Valley was a place of communications between the coastal region of southern Peru and the altiplano of Chile. However, it was also a time characterized by minor conflicts and shows of defense and force between groups, with limited interregional conflict between neighboring polities but no full-scale warfare (Covey 2008:313-314, 320-321). The middle valley of the Moquegua Valley is an ideal location for cultivating crops because of the climate and soil (Stanish 1989).

During the later LIP, some valleys such as the Moquegua Valley, were used as conduits for trade and agricultural gains between the altiplano and the southern Peruvian and northern Chilean coasts. This was reflected in the movement of individuals to the middle valley proper from both the coastal region and the altiplano (Williams 1990). Following the cultural and biological continuity with Tiwanaku at early LIP Tumilaca sites in Moquegua, the later LIP (AD 1250 - AD 1476) is distinguished by significant changes in material culture, with the appearance of Estuquiña sites and materials. While the origins of the Estuquiña remain the subject of ongoing bioarchaeological work, an ethnohistoric account from a 1568 visita has been interpreted as evidence that the Estuquiña were migrants from the Lupaqa, one of the LIP altiplano kingdoms or senorios (Murra 1968). The records suggest that the Lupaqa claimed the region of the middle valley and the site of Estuquiña during a census recorded by a Spanish censor visiting the Southern Andes. The reason they claimed the site of Estuquiña during this census was the Lupaqa had previous records showing they had sent emissaries to the middle Moquegua Valley to obtain crops such as maize and aji (Murra 1968). It is possible during the later LIP, instead of an outside polity colonizing the valley, following the withdrawal of Tiwanaku and Wari, the middle Moquegua Valley may have been independently populated by the remaining individuals (Covey 2008). It is also possible that the individuals at Estuquiña are from the coastal regions to the south and southwest. In this thesis project, I generate isotopic data to test that claim. If the ethnohistoric description is substantiated, the individuals from the site of Estuquiña should have isotopic signatures like those of the altiplano Lupaqa and should be geologically distinct from both the Moquegua Valley individual’s isotopic signatures, as well as the coastal regions individuals of the southern Andes (Fig. 1).

Figure 1 Southern Andes during the Middle Horizon and LIP, Estuquiña is marked by a circle and Cutimbo is a Lupaqa site. Modified from Turner et al. (2009)

2 CULTURAL CONTEXT: PREHISPANIC SOUTHERN PERU

Max Uhle, a German archaeologist who did extensive research in the Andes in the early twentieth century, established the basis for the chronological framework still used by scholars today (Moseley 1992). Specifically, noting stylistic differences he defined three ‘great periods’ before the Inka. Expanding on Uhle’s work, Rowe (1945) and Kroeber et al. (1924) established a chronology for these earlier phases using alternating “horizons” and “intermediate periods”. Horizons are characterized by the widespread distribution of shared material styles which has been understood as reflective of political and cultural unity. Intermediate periods are characterized by regional stylistic variation which has been associated with periods of political fragmentation and cultural difference (Covey 2008). For example, the Middle Horizon (AD 500-1000) is identified by the extensive distribution of Wari and Tiwanaku material styles, which is interpreted as the political hegemony of those two states. During the subsequent Late Intermediate Period (AD 1000-1400s), there is significant regional stylistic variation across the Andes which is interpreted as evidence for the absence of imperial political authority. With Inka imperial expansion in the Late Horizon (AD 1400s-1532), Inka political control is accompanied by the presence of Inka material styles across the empire. These stylistic and political shifts are well documented for the Moquegua Valley (Chacaltana-Cortez 2015; Goldstein 2005; Stanish 1991; Williams 2001).

The Moquegua Valley, or Osmore Drainage, is located in the modern political Department of Moquegua, in southern Peru between 70° 27’ and 71°20’ west longitude, and 16° 52’ and 17° 42’ south latitude. The Tambo river borders the northern limit and the Locumba Valley demarcates the southern limit of the Osmore Drainage. The drainage empties into the

Pacific Ocean (Rice 1989). Within these natural limits, the drainage is split into three distinct valley regions, the upper, middle, and lower valley (Rice 1989).

The lower valley region is from around sea level to about 1000 meters above sea level (masl). The inhabited region of this valley section is predominantly around the coastal area as the region beyond the coast includes a large swath of land where the river goes underground (Rice 1989). Further up valley is the middle valley region, which ranges from 1000 – 1500 masl. As the rivers Tumilaca, Torata, and Huaracane meander across the upper valley floor, they join in the middle valley, creating a broad basin becoming the Moquegua river. The middle valley is surrounded by gentle hills and receives 20 mm - 100 mm of rain, necessitating the use of irrigation. Further along the valley, from 1500 - 3500 masl, the Upper Valley, is a narrow, steep region (Fig. 2; Rice 1989; Torres 1990).

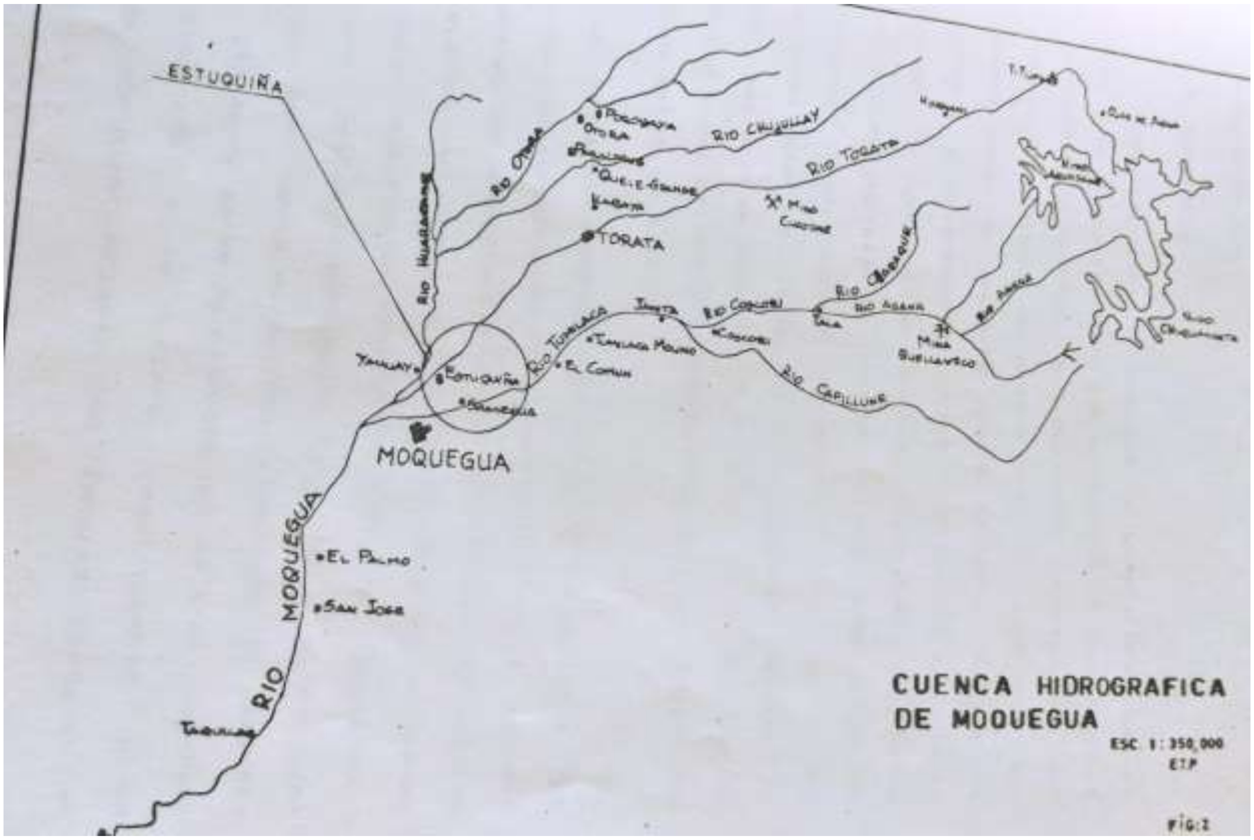

Figure 2 Map of the Osmore Drainage, the circle shows some of the known extent of the Estuquiña (Torres 1990:5)

Within the middle valley local flora and fauna included; cacti, *challachay*, *caña brava* (*Gynerium sp.*), *chilca amarga* (*Baccharis salicifolia*), *chilca gateadora* (*Baccharis buxifolia*), *molle* (*Schinus molle*, or pink peppercorn), *pacay* (*Inga feuillei*), *calabaza* (*Cucurbita moschata*, or pumpkin), *cuy* (*Cavia porcellus*, or guinea pig), and llama (*Lama glama*); as Torres (1990) points out, some of these no longer exist in the region. The middle valley cultivated plants that could withstand the weather, such as cotton (*Gossypium sp.*) and corn (*Zea mays*) (Torres 1990). Torres (1990:9) notes that the cotton was cultivated at Estuquiña, and further investigation should confirm this. The current city of Moquegua, located in the middle valley, continues to produce crops such as, maize, pepper (*aji*) grapes, and cotton. The upper valley is at 1500-3900 masl and has less arable land (Rice 1989; Torres 1990).

Southern Peru is within the Andean Mountains and has two distinct geological regions, the Cordillera Occidental and the Cordillera Oriental (Knudson et al. 2013). The Cordillera Oriental has geological formations from the Paleozoic, with higher radiogenic strontium levels, while the Cordillera Occidental has Cenozoic rocks, e.g., andesites, meaning there are lower levels of strontium toward the northern Andes (Knudson et al. 2013) (see Chapter 3). Both Cordilleras have complex geology that affects $^{87}Sr/^{86}Sr$ and $^{206,7,8}Pb/^{204}Pb$ within the Moquegua Valley. For instance, there are both igneous rock, such as andesites and basalt which are overlain by fluvial and lacustrine sediments. For the Moquegua Valley, there are six distinct soil formations within both Cordilleras which enable the use of strontium isotope values for mobility studies. The types of soils include Quaternary, Cretaceous, and Cretaceous-Tertiary volcanics, Tertiary, Mesozoic-Cenozoic intrusives, and Jurassic-Cretaceous (see Knudson et al. 2014, Fig.1). Additionally, as Knudson et al. (2013) point out, individuals who traded with or are from the coast, have an associated strontium level to the ocean, because of salt spray. As will be discussed in Chapter 3, older rocks have higher $^{87}Sr/^{86}Sr$ ratios than younger rocks, which creates some predictability in interpreting the range of expected values in human tissues.

2.1 Mobility in the Pre-Hispanic Andes

Over the past forty years, intensive and extensive archaeological research conducted in collaboration between Peruvian and foreign scholars has explored Moquegua's pre-Hispanic and early colonial past (see Table 1). (Goldstein 2000; Stanish and Rice 1989). Further south, during the Middle Horizon, the archaeological site of Larache, Chile has a mixture of both Tiwanaku and regional San Pedro de Atacama oasis individuals interred at the site. Torres-Rouff et al.

(2015) note that Larache may have been a Tiwanaku trade post, which had a few non-locals identified using radiogenic strontium isotope data to identify them. In death, these individuals were not treated vastly different from those who lived at the site. This assessment is based on the Tiwanaku artifacts at the site, that were likely traded from Cochabamba to the oases (Torres-Rouff et al. 2015:11). While most of the individuals at the site were buried in a similar manner, a select few were buried with distinct burial goods, that were found throughout the oases during the Middle Horizon. For this reason, Torres-Rouff et al. (2015:12) note that the uncommon burials are likely a social order rather than a distinction between local and non-local. The Middle Horizon site of Larache is significant, because there is evidence for trade with the altiplano polity Tiwanaku. Additionally, using isotopic analyses to further understand the relations between the Chilean and Bolivian sites would be interesting.

At the site of Caspana, just north of San Pedro de Atacama, Knudson and Torres-Rouff (2009) analyzed the grave goods, architecture and isotopic signature of those interred at the cemetery to understand the relationship between the altiplano and the southern Andean region. Archaeological and ethnohistoric documents suggested that after the Tiwanaku collapse in the Middle Horizon, large groups of migrants moved into the region (Knudson and Torres-Rouff 2009). Strontium and Oxygen isotopic analyses conducted on teeth noted that most individuals were from the region, while the greatest distinction was in burial artefacts (Knudson and Torres-Rouff 2009).

By using multiple methods to understand the archaeological relations of the people at the site at Caspana, Knudson and Torres-Rouff (2009) demonstrated that at least one individual buried there had migrated to the site.

2.2 LIP Moquegua

The Late Intermediate Period (LIP) can be broken down into the early and later LIP (Covey 2008). In the middle and upper Moquegua Valleys, the early LIP (AD 950-1250) is associated with Tumilaca sites and materials (Sharratt 2019). The later LIP (AD 1250-1476) is primarily associated with Estuquiña materials and sites (Sharratt 2019). Other local LIP cultures include Chiribaya. Although not the subject of this thesis, it is important to note that, unlike the Tumilaca, who are predominantly found throughout the middle Moquegua Valley, the Chiribaya, are often found along the coastal regions of the Moquegua Valley, and arise after the Tiwanaku collapse (AD 1000 – AD. 1300), although they have been found in the middle valley regions as well (Tomczak 2003:3).

2.2.1 The early LIP: Tumilaca

The Tumilaca communities that lived in the middle and upper Moquegua Valley during the early LIP (AD 950-1250) were descendants of Tiwanaku migrants who had arrived in the valley during the Middle Horizon. Those earlier Tiwanaku populations are associated with a local variant of Tiwanaku styles called Chen Chen and were concentrated in towns of several thousand in the middle valley. When Tiwanaku state authority was rejected in Moquegua (see Williams 2002, Goldstein 2005, Sharratt 2019 for debates about the causes of Tiwanaku political collapse), Chen Chen populations dispersed to the coast and the upper valley where they established small village sites in defensive locations. Biodistance data confirm an ancestor descendant relationship between Chen Chen and Tumilaca populations (Sutter and Sharratt 2010). Excavation and materials analyses demonstrate considerable cultural continuity with Tiwanaku at Tumilaca sites (Parker and Sharratt 2017; Sharratt 2010, 2011, 2016, 2016b, 2017, 2019; Sharratt et al. 2012, 2015). Because of this continuity, these centuries are also referred to in the literature as the terminal Middle Horizon (Sharratt 2019) but they correspond with what is more broadly called the early LIP.

2.2.2 The later LIP: Estuquiña

The second half of the LIP in the middle and upper Moquegua valleys is associated with Estuquiña sites (Burgi 1989; Chacaltana Cortez 2014; Conrad 1993). Some earlier Tumilaca sites also have Estuquiña occupations (Lowman et al 2019; Parker and Sharratt 2017; Sharratt 2017, 2019; Sims 2006). Estuquiña materials are stylistically very different from Tiwanaku and Tumilaca.

Typical ceramics associated with the Estuquiña include bowls, bootpots, jarras, and ollas (Lozada Cerna 1987). The ceramics are red-slipped, with little decoration. However, some ceramics have molded nubs on the rim of bowls and jarras. The ceramics are also thicker than the previous ceramic styles found within the Osmore Drainage (Stanish 1991).

Estuquiña sites are built in locations that are easily defendable (Burgi et al. 1989). Estuquiña style buildings can have up to 22 rooms, though the more common Estuquiña style buildings had two rooms. Conrad (1993) points out that these grander buildings were found at the site of Estuquiña proper, with the range of room numbers varying from 6 – 22 (Fig. 3). Some of the rooms were subdivided using cane (tortora/quincha) an organic material that does not preserve well in archaeological contexts (Fig 4).

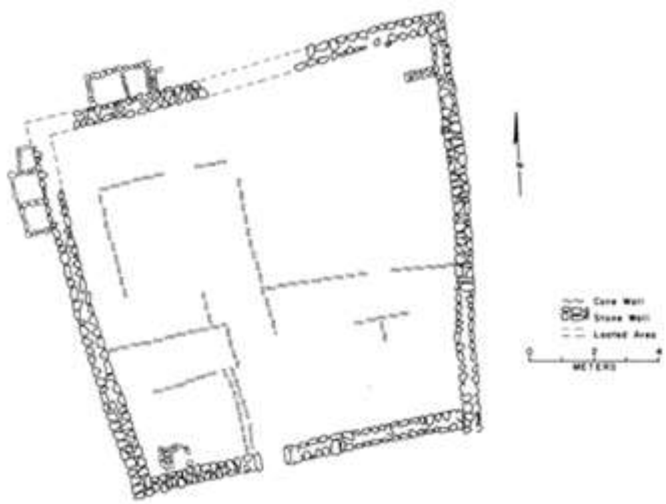

Figure 3 Standard building at Estuquiña (Conrad 1993)

The origins of Estuquiña remain debated. Ethnohistoric accounts suggest the Lupaqa sent emissaries to regions such as the Osmore Drainage, which may have developed into what is now the Estuquiña. Additionally, the Estuquiña could have originated from the Wari, as the Estuquiñian style agriculture is like the Wari style. In the middle Moquegua Valley, recent research has suggested that the Tumilaca could have been the ancestors of Estuquiña (Sharratt and Sutter 2018).

3 ISOTOPE ANALYSIS AND PALEOMOBILITY

Stark altitudinal changes result in rapid and significant ecological variation and therefore resource availability across the Andean landscape. For millennia, Andean people have developed social systems that facilitate both movements around distinct ecological zones and access to a varied resource base. John Murra proposed the concept of verticality to explain these social mechanisms (Sutter 2000) which enable Andean communities to obtain diverse resources across several ecological zones. Beyond this interzonal exchange within regions, there is also indirect (archaeological) and direct (isotopic) evidence of migration between regions, as noted in Chapter 1.

In bioarchaeological studies of mobility, isotope ratios are used almost like homing devices, geolocating or ecolocating individuals to candidate regions of origin. Isotopes are chemical variants of a given element that differ in the number of neutrons in the nucleus, and therefore in atomic weight. While carbon, nitrogen, and sulfur isotope ratios are commonly used to reconstruct aspects of diet in archaeological human remains, isotope ratios of strontium, oxygen, and (less commonly) lead are used to reconstruct residential origin and movement between geologically and/or ecologically distinct regions.

The use of both heavy ($^{87}Sr/^{86}Sr$, $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$, or $^{206,7,8}Pb/^{204}Pb$ for brevity) and light ($\delta^{18}O$) isotopic analyses to identify the origin of both archaeological individuals and of the more recently deceased has increased dramatically within the last 30 years (Chau et al. 2017, Font et al. 2012, Knudson and Buikstra 2007, Knudson and Price 2007, Price and Burton 2012). In the Andes, heavy isotope studies conducted over the past fifteen years have significantly improved our understanding of paleomobility related to several cultural factors, including pilgrimage, conflict, and imperialism. While this study presents analyses of $^{87}Sr/^{86}Sr$ and $^{206,7,8}Pb/^{204}Pb$ isotope analyses from the site of Estuquiña, I plan to characterize hair keratin $\delta^{18}O$ in the future and therefore discuss $\delta^{18}O$ characterization here as well.

3.1 Strontium Isotope Analysis

Radiogenic strontium is used to geolocate individuals who lived in the past (Chau et al 2016, Font et al. 2012, Knudson et al. 2012). Radiogenic strontium (^{87}Sr) is the product of radioactive rubidium (^{87}Rb) decay, and ^{87}Sr has an isotopic abundance of 7.04% (Knudson and Tung 2011, Szostek et al. 2015, Price et al. 2002). The radiogenic isotope is commonly compared to a non-radiogenic strontium isotope, ^{86}Sr, with an isotopic abundance of 9.87%. Comparing the heavier isotope with the lighter ($^{87}Sr/^{86}Sr$) generates values for bedrock geology that usually fall between 0.700-0.750. The difference in size, though relatively small, is still meaningful, because the atomic mass of each isotope is nearly identical, and there are no discernible fractionation effects when strontium isotopes cycle through ecological systems (Chau et al. 2017, Knudson et al. 2012, Price et al. 2002). Certain rock sources have a predictable amount of strontium. In rocks 100 mya or older, Price et al. notes (2002:118) the $^{87}Sr/^{86}Sr$ ratio falls between 0.700-0.750, whereas younger rocks have less rubidium decay, and are around 0.706. Rock types that are older have more ^{87}Sr, because there is a greater amount of time for ^{87}Rb to decay over its half-life of 48.8 billion years.

Strontium isotope ratios are found in soils, reflecting the $^{87}Sr/^{86}Sr$ of the underlying bedrock, and these ratios are taken up by plants, entering foodwebs. Strontium is metabolized into tissues, and the $^{87}Sr/^{86}Sr$ ratios in human tissues thus reflect the values in the food that individuals consume. Assuming those foods are locally sourced, $^{87}Sr/^{86}Sr$ values in human tissues thus reflect the underlying geology where an individual lives. There is a higher concentration of strontium overall in whole grains, seafood and root vegetables, meaning that those foods disproportionately contribute to tissue $^{87}Sr/^{86}Sr$ values. These ratios can be analyzed to assess if an individual was from the region or moved throughout the region prior to death, by comparing values in preserved tissues to those from local bedrock (Knudson 2008, Knudson et al. 2012, Chau 2016, Knudson and Buikstra 2007), or to the "bioavailable" values in local, small-ranging animal tissues (Price et al. 2002). However, this also means that individuals who consumed non-local foods via trade or exchange could appear to be non-local to a given region, so it is important to interpret Sr isotope values with this in mind.

Most $^{87}Sr/^{86}Sr$ isotope studies focus on tooth enamel or bone, given that those tissues are much more likely to preserve in archaeological contexts, but recent research has characterized isotope ratios in the keratin protein of preserved hair. For example, Font et al. (2012) used archaeological hair samples recovered from the Netherlands (~AD 1750-1850) to determine individual mobility up to time of death via strontium and lead isotope comparisons. This and other studies caution that the consumption of food may not be the sole way $^{87}Sr/^{86}Sr$ values were incorporated into archaeological hair keratin; instead, it gets complicated. When samples are exposed for long periods to pollutants, such as dust or water, strontium isotopic signatures may include those deposited, in addition to those metabolized, into the hair shaft (Font et al. 2012, Price et al. 2002, Vautour et al. 2014:63-64).

3.2 Lead Isotope Analysis

Lead is a xenotoxin, and any significant amount in human tissues can lead to significant physical and cognitive damage. However, trace amounts of lead are found in the skeletal tissues of humans and other animals; lead is deposited in bone and tooth enamel after ingestion and/or inhalation of dust and soil particulates, therefore $^{206,7,8}Pb/^{204}Pb$ ratios in preserved human tissues reflect local Pb ore geology. Similar to Sr, Pb isotope ratios in local geology vary depending on the ore's geological age, mineral content, rate of weathering, and its original U/Pb and Th/Pb ratios (Faure, 1986; Gulson, 1986). There is little to no fractionation among these isotopic ratios and are great to pair with isotopes such as Sr and O in order to create a complex movement pattern. This is because the ratios from Pb reflect the soil source (Turner et al. 2009:320; Kamenov and Gulson 2014). As Pb enters the body through accidental consumption, it is found in lower amounts in blood, bone and soft tissues. Once deposited into the skeleton, Pb can be metabolized and if a person becomes pregnant, they can transfer their Pb to the newborn through lactation.

3.3 Oxygen Isotope Analysis

Stable Oxygen isotopes are used to identify individual mobility between ecologically and/or climatically distinct regions. The isotope ratio of interest in this analysis is that between ^{16}O, which has an isotopic abundance of 99.762%, and ^{18}O, which has an isotopic abundance of 0.200%. Because the differences in atomic mass between the two isotopes is extremely small, the ratio of ^{18}O:^{16}O is expressed in delta notation (δ) relative to the established Vienna standard of mean ocean water, or vSMOW (Gat 2010). In obligate drinkers including humans, oxygen isotopes are metabolized into tissues from consumed water (Longinelli 1984), and the relative proportion of ^{18}O increases in a stepwise fashion (known as fractionation) as it undergoes physical and chemical changes related to metabolism and excretion. The $\delta^{18}O$ of consumed water is affected by temperature, latitude, humidity/aridity, elevation, and distance from the ocean. It is also affected by cultural factors such as breastfeeding, open-air storage, and boiling for soups or brewed beverages (Knudson and Torres-Rouff 2007, Gagnon et al. 2015). In the Andes, $\delta^{18}O$ values are difficult to interpret in some regions because of environmental complexity and shifts related to El Nino cycles (Knudson 2009). Indeed, as Chau et al. (2017) note, oxygen isotopes may be very similar, even along great distances. Because of this, $\delta^{18}O$ values are commonly analyzed along with strontium and/or lead isotope ratios to improve accuracy.

4 MATERIALS AND METHODS

Ongoing research in the Moquegua Valley is attempting to answer the origins of the LIP Estuquiña. At the site of Estuquiña in the middle Moquegua Valley, during 1985, archaeologists excavated 245 burials, creating the most extensive Estuquiña skeletal collection in the Moquegua Valley. 430 individuals were recovered during these excavations. Of the 430 individuals that were recovered from the site of Estuquiña, I am working with individuals (N= 10) who were naturally mummified and have preserved hair. Building off the work of Knudson (2004) and others in the region, I am characterizing and analyzing heavy isotopes ($^{87}Sr/^{86}Sr$, $^{206,7,8}Pb/^{204}Pb$) to answer whether the oral and ethnohistoric accounts regarding the origins of the Estuquiña are accurate, i.e. that Estuquiña represent a cultural offshoot of the highland Lupaqa, if they represent a contiguous, isotopically local, population from earlier in the Middle Horizon, as Sutter and Sharratt (2018) argue in a recent conference paper.

In order to do this, I use published baseline strontium data from the Moquegua Valley (0.70580-0.70630) from Knudson et al. (2007) and De France et al. (2016) and compare it with surrounding strontium values. I expect that if this is Lupaqa colonialism, as ethnohistoric data suggests, then the individual hair strontium isotopic values should be between 0.70696-0.71191. If, instead, there is in-migration from elsewhere such as the southern Peruvian and northern Chilean coast, then the individual hair samples isotopic values should be around 0.70671-0.70668, per Knudson et al. (2014). Finally, if individuals commonly moved between regions, I expect shifts in isotopic values between the incremental samples from a subset of the study sample (N=2).

4.1 The site of Estuquiña

The Estuquiña site is located in the middle Moquegua Valley, close to the modern village of Estuquiña. It is the type site for the Estuquiña archaeological culture.

The site lies along the foothills of Cerro Los Angeles, near the modern city of Moquegua (Burgi et al. 1989; Williams 1990). The remains of a domestic sector and three cemeteries sit atop a natural bluff (Fig. 5). Williams (1990) notes that a portion of one of the cemeteries (Cemetery 3) may once have been part of the original domestic sector of the site. As Williams (1990) points out, this suggests the domestic sector of the site of Estuquiña may have extended to the western edge of the bluff.

In AD 1600, Huaynaputina, a local volcano erupted, creating a layer of ash. Archaeologists use this layer as a reference throughout the Osmore Drainage. At the site of Estuquiña, this layer made it evident that huaqueros looted the more obvious burials and left skeletal remains behind in shallow pits, and that looting occurred after AD 1600 (Williams 1990).

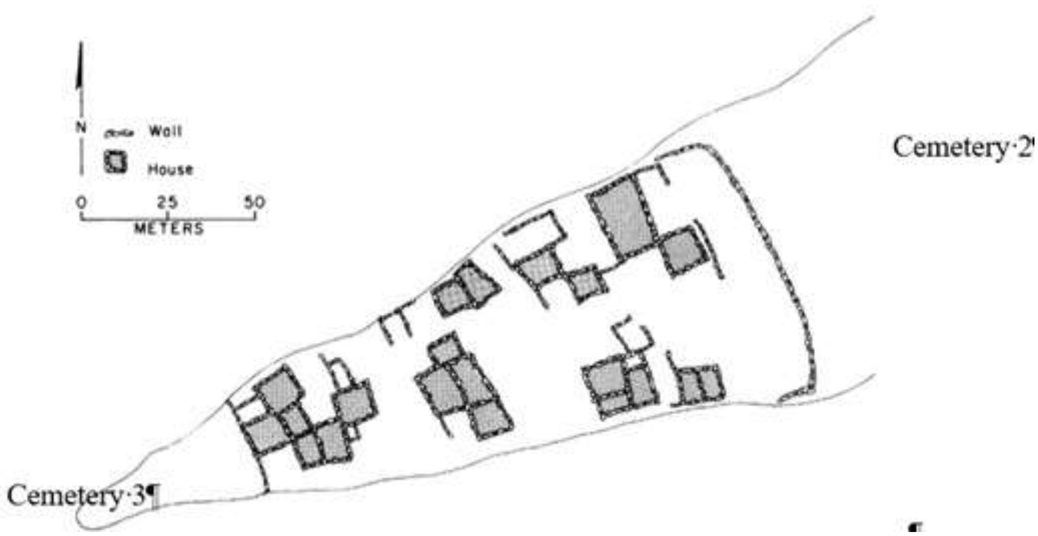

Figure 4 Map of cemetery 3, domestic region and a part of cemetery 2 at Estuquiña, cemetery 1 is to the right of cemetery 2 (Conrad 1993)

4.2 Excavations of Mortuary Contexts at Estuquiña

The largest excavated sample of Estuquiña style burials is that excavated at the site of Estuquiña in 1985 by Sloan Williams and Nikki Clark as part of a larger research project at the site directed by Don Rice, Geoff Conrad and Lucho Watanabe. During this work, archaeologists excavated 60 intact burials and 185 disturbed burials. They documented the mortuary practices at the site.

Tomb Types:

At the site of Estuquiña several different types of tombs were excavated. The styles include cist tombs, large collared tombs satellite tombs, above ground collared tombs, ring tombs and subterranean structures. Of the six different tombs found at the site, the two most common are the cist and collared tombs (Torres 1990; Williams 1990:57-58).

During the excavations in 1985 the tomb types were better understood. For instance, cist tombs are bell-shaped and roughly one-half meter in diameter, with a depth of one meter. They have also been discovered under collared tombs, with a layer of soil between them. The large collared tombs, which are the second most common burial type, consist of a ring of large rectangular stones against a wall of dirt. Additionally, when compared to cist tombs, they are nearly twice their size. The excavators determined that smaller cist tombs surrounding large collared tombs were separate tomb features, and usually only have a single ring of stones with no opening (Williams 1990:56).

Above ground collared tombs, or proto-*chullpas*, are visually distinct. Additionally, they are found in cemeteries 1 and 2 only. Williams (1990) notes that during their excavations they were only able to excavate one of these due to time constraints. As the name proto-chullpa implies, there may be some lingering ties with the Altiplano *chullpas* associated with these burials (Williams 1990:57).

Ring tombs are an alternate version of the collared tomb. The surface of these burials are seen with a single ring of rocks. Finally, there are subterranean structures found in both cemetery 3 and the domestic sector. These burials are old storage regions that have been converted to hold bodies, or depositos (Williams 1990:58). Additionally, several of the younger individuals were found in these burials. (Table 2).

Table 2 Burials type and count at Estuquiña (Williams 1990)

	Tombs Excavated	Intact	Disturbed
	245	60	185
Cemetery 1		11	
Cemetery 2		12	
Cemetery 3		3	
Domestic		34	

Cultural Grave Offerings:

In addition to a variety of burials and tomb types, the grave goods associated with the burials at Estuquiña were numerous. The items included ollas, which have two lugs, jarras, which have one, cuencos (bowls), kerros, tupus, and cuchara cestas. There were food offerings of, textiles, spindle whorls, needles of copper and cactus, wooden spoons, bootpots, and gourds (Fig. 6; Williams et al. 1989; Torres 1990). These burials were associated with an assortment of food offerings as well. The people at Estuquiña were buried with many different articles of the living.

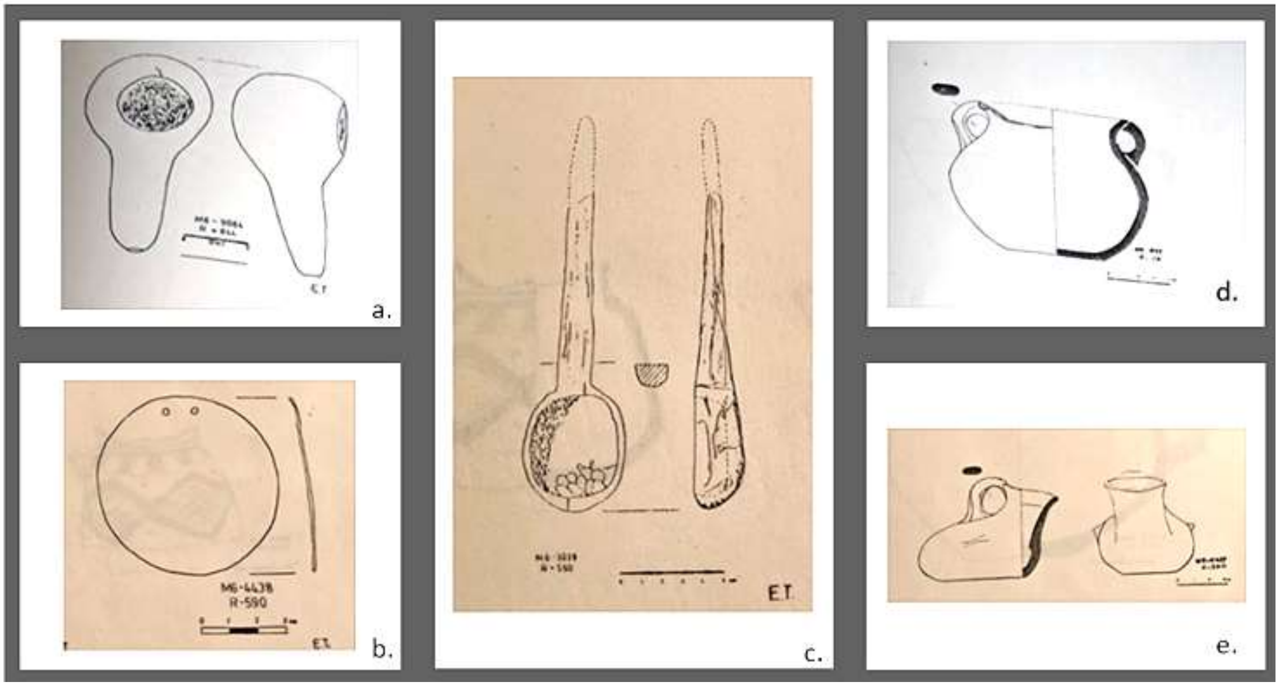

Figure 5 a. Modified gourd, common burial item found at Estuquiña. b. Tupu, a metal grave good, often recovered in burials of sexed female individuals. c. Cuchara, wooden spoon a common Estuquiña burial good. d. Estuquiña style pottery e. Bootpot (Torres 1990:85-88,91).

Additionally, specialized tools were associated with some individuals that were sexed female, such as the spindle whorls and tupus (Figure 6). The textiles found in the burials were woven from camelid fiber and to a lesser extent cotton. The types of cloth used for burials range from cloth and garment wrappings, to more layered tunics and loincloths with the addition of a garment wrapping to the individuals. In order to secure the layers of cloth together, cords were wound around the individual. Most of the textiles were used before interment, as the textiles were mended along wear locations. In addition to the many types of fabric found with the interred, the textiles had distinct patterns as well. Some of the designs included balance/tabby, plainweave and twill weaves (Clark 1993). Cotton was consistently woven using a warp-faced plainweave (Clark 1993). The bags were the most vibrant cloth, with a varying bright red, gold, blue and green dyed yarn weave. The cloth bags were usually used for carrying coca (Clark 1988; Williams 1990; Williams et al. 1989; Torres 1990).

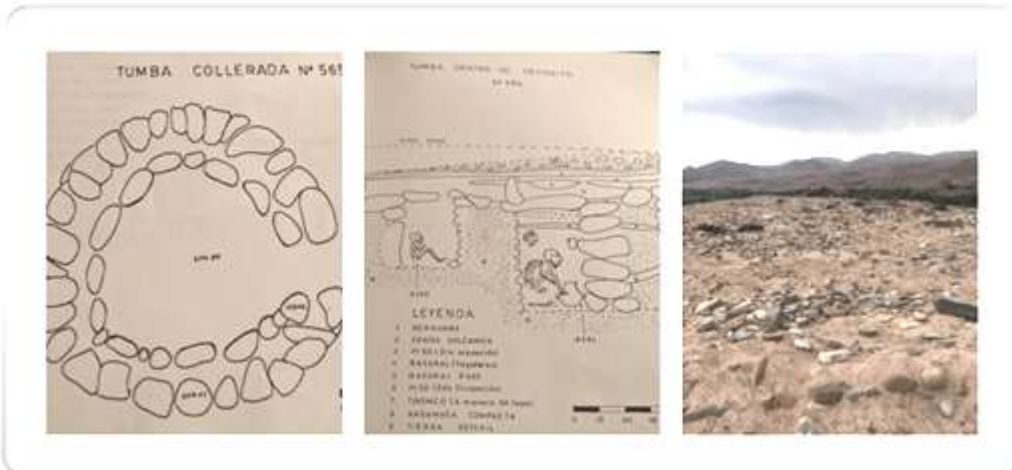

Figure 6 from left to right: Sketch of a large-collared tomb. Deposito, #2 is the ash layer from Huaynaputina. Photograph is a westward view of the Domestic cemetery. (drawings from Torres 1990:82-83)

4.3 The Human Remains from Estuquiña

During the 1985 excavation at Estuquiña in the Moquegua Valley four cemeteries were identified. The cemeteries were recorded as Cemetery 1, Cemetery 2, Domestic, and Cemetery 3 (Williams 1990). Cemetery 3 is on the western edge of the site and is potentially part of an older domestic occupation at Estuquiña, that was later converted to only burials (Williams 1990). The Domestic section that has burials is termed this way because it is bound by Cemetery 3 and Cemetery 2, more importantly though the burials are found in subfloor contexts in residential structures at Estuquiña. This meant when the archaeologists excavated this burial section, the tombs were predominantly intact, because they were masked by the buildings that were over them. Cemetery 2 is directly to the east of the Domestic sector and contains some of the only above ground collared tombs. The only other cemetery to contain this type of burial is Cemetery

1, which is on the eastern most edge of the site, boasting fourteen of the twenty above ground collared tombs (Williams 1990).

While excavating the six different tomb types; cist tombs, large collared tombs satellite tombs, above ground collared tombs, ring tombs and subterranean structures, archaeologists recovered 430 individuals. These individuals were recovered from 245 tombs, with 60 that were considered intact (see table 2 and table 3; Williams 1990). The age at death of individuals excavated at the site ranges from 0-45 years old with a few who are 55 years and over. However, when Williams (1990) was conducting her analysis of the mortuary remains at the site, she noted roughly 40% are under the age of 15 but also that there is a lower rate of infant mortality than would be expected at a site during this period.

Table 3 Individuals included in the study sample, along with estimated age-at-death and biological sex (estimates from Williams 1990).

Individual	GSU Lab Code	Age at Death (years)	Estimated Sex
M6-4203	DC_GSU 1b	Adult	Female
M6-4179	DC_GSU 2b	52-59	Female
M6-3635	DC_GSU 3b	30-35	Female
M6-8839	DC_GSU 4b	10-15	Female
M6-3615	DC_GSU 5b	30-35	Female
M6-5454	DC_GSU 6b	9-11	Male
M6-986	DC_GSU 7b	0.5	Indeterminate
M6-5839	DC_GSU 10b	18-19	Male
M6-4203	DC_GSU 11b	10-12	Indeterminate
M6-4179	DC_GSU 12b	25-26	Male

4.3.1 Mummified individuals of Estuquiña

Mummified individuals were recovered from the site of Estuquiña during the 1985 excavation. In the summer of 2016, colleagues collected hair samples from twelve individuals in the collection which is currently curated in the Museo de Contisuyo. Of the twelve individuals examined, three were identified as male, three are of indeterminate sex, and six were identified as female and recovered as *fardos*, or mummy bundles. The tomb type they were recovered from were variants of the cist tomb (Torres 1990:60-63; Schaefer et al. 2018). I am working with samples from ten of the twelve individuals, because two individuals lacked sufficient hair for isotopic analyses. The analyzed individuals are from across all the cemeteries at the site of Estuquiña. During the 1985 excavations they were given distinct burial numbers; when the samples arrived at Georgia State University for analysis, I assigned them a unique lab code (Table 3).

4.4 Isotope Analysis of Archaeological Hair

Large scale migrations have been identified in regions of southern Peru, through heavy and light isotopic analysis of bone and dentition (Knudson and Buikstra 2007, Knudson and Price 2007). However, the results from bone and dentition samples provide a large scale of time, when discussing where the person was located (Bartelink et al. 2014). Analyzing soft tissues, such as skin, muscle, fingernails, or hair, for isotopic values may provide a more intricate movement model. Moreover, using segments of hair, which grows on average at 1cm per month, in isotopic analyses provides a detailed time-series to infer personal mobility, for the months before death. When this analysis is compared with long-term bone isotopic values and the early-life time series provided by isotopic values in dentition, an in-depth example of population movement becomes evident (Chau et al. 2016, Font et al. 2012).

Font et al. (2012) and Chau et al. (2017) note, a sample of hair can be analyzed to account for time and a moment in time. They refer to these variations of time as bulk versus temporal samples. There are different requirements in collecting the amount of hair required for each. For instance, bulk hair requires roughly 120-60 mg, while temporal variation analysis requires ~ 30 strands, or 29-8 mg (Font et al. 2012).

Recent focus of isotopic analyses for soft tissues, such as hair, has aided in the identification of unknown murder victims in forensic cases. The identification was accomplished through δ18O values derived from hair strands (Bartelink et al. 2014; Chau et al. 2017; Font et al. 2012; Kennedy et al. 2011). Hair is keratin, forming as it grows from the dermis through the epidermis at a rate of 1 cm per month. In healthy individuals, a hair strand on the scalp may not be contemporaneous with other hair strands. The average hair strand is active between 85-90% of the time and is inactive for roughly 10-15% of the time (Williams et al. 2011).

In addition to the varying rates of hair growth, there is also a cycle of birth and rebirth, for hair. During this cycle, there are three phases of hair growth. Anagen, during which the structural units of hair follicles and fibers grow. Then catagen, in which the hair bulb constricts and becomes keratinized. After this, the telogen phase begins, and the bulb releases, becoming inert, restarting the process (Fig. 8).

Figure 7 The process of hair follicle growth (NHL 2019)

During this growth period, hair exchanges strontium at a rate of ~0.0002mg per day, from the daily intake of strontium (~2 mg) in the average human diet. Additionally, the consumption of water is read, by the value of $\delta^{18}O$ left on the hair strands, and in the hair structure (Bartelink et al. 2014, Chau et al. 2017, Font et al. 2012, Vautour et al. 2014). A recent study conducted by Williams et al. (2011) notes three distinct phases of hair growth and within these phases the potential for 'non-standard' results to occur in individuals experiencing acute wasting diseases, pregnancy, or other conditions. Active growth is known as the anagen phase when oxygen and strontium isotope ratios are metabolized into hair keratin while slowing and stoppage of growth occur during the catagen phase. Once a hair follicle enters the telogen phase, it becomes metabolically inert, and keratin isotope values are set (Williams et al. 2011). For instance, during the analysis of 10 individuals from Egypt, Williams et al. (2011) noted that each phase, telogen, anagen and catagen, relied on the amount of nutrition and health of the individual sampled, to have the predicted "normal" rate. They cut their samples into 1 cm segments, accounting for roughly a month, and documented which end was towards the scalp. Williams et al. (2011) followed established procedures. They found that during the telogen phase, of the ten tested individuals, there were five who fell outside the range of what is considered a healthy telogen phase. Williams et al. (2011) note that when conducting isotopic analyses, it will be essential to find not only the age of the hair, but the potential health of the individual sampled, if possible.

4.5 Study Design

Because hair is unlikely to preserve in the archaeological record, the mummified individuals from Estuquiña present an important opportunity to study incremental isotope values related to mobility in this region of the Central Andes. In this study, I characterize $^{87}Sr/^{86}Sr$ and $^{206,7,8}Pb/^{204}Pb$ values in the keratin of archaeological human hair samples to infer individual mobility in the months prior to death for the individuals within the collection. In doing so, I test several hypotheses: I use baseline strontium data from the Moquegua Valley (0.70580-0.70670) and compare it with surrounding strontium values. If the Lupaqa are colonists to the Moquegua Valley, as ethnohistoric data suggests, then I expect people to exhibit hair $^{87}Sr/^{86}Sr$ values to be between (0.70696-0.71191). However, if there is a connection with the coast, then the individual hair $^{87}Sr/^{86}Sr$ values should be around (0.70671-0.70668). Similarly, if they are from further away, like Chile, the values may be even more distinct (Fig 9) (Knudson et al. 2013). Finally, if the individuals moved more frequently than in a single direction, I expect shifts in isotopic values between the incremental samples to be variable within the same samples (N=2).

Lead isotope analysis is relatively uncommon worldwide, and especially in the Andes; research by Turner et al. (2009) is among the only existing bioarchaeological studies with Pb isotope data from archaeological human and faunal remains. Recent work by Mamani et al. (2008) provides baseline Pb isotope ranges for regions of the Central and Southern Andes that are useful here, though there is some overlap in values between far-flung regions and including significant overlap in values between Estuquiña and Tiwanaku (see Figure 9). Therefore, I do not advance specific hypotheses regarding $^{206,7,8}Pb/^{204}Pb$ results as I do with $^{87}Sr/^{86}Sr$. Instead, I interpret these values together with associated Sr isotope values to attempt to more accurately geolocate the individuals in the Estuquiña study sample.

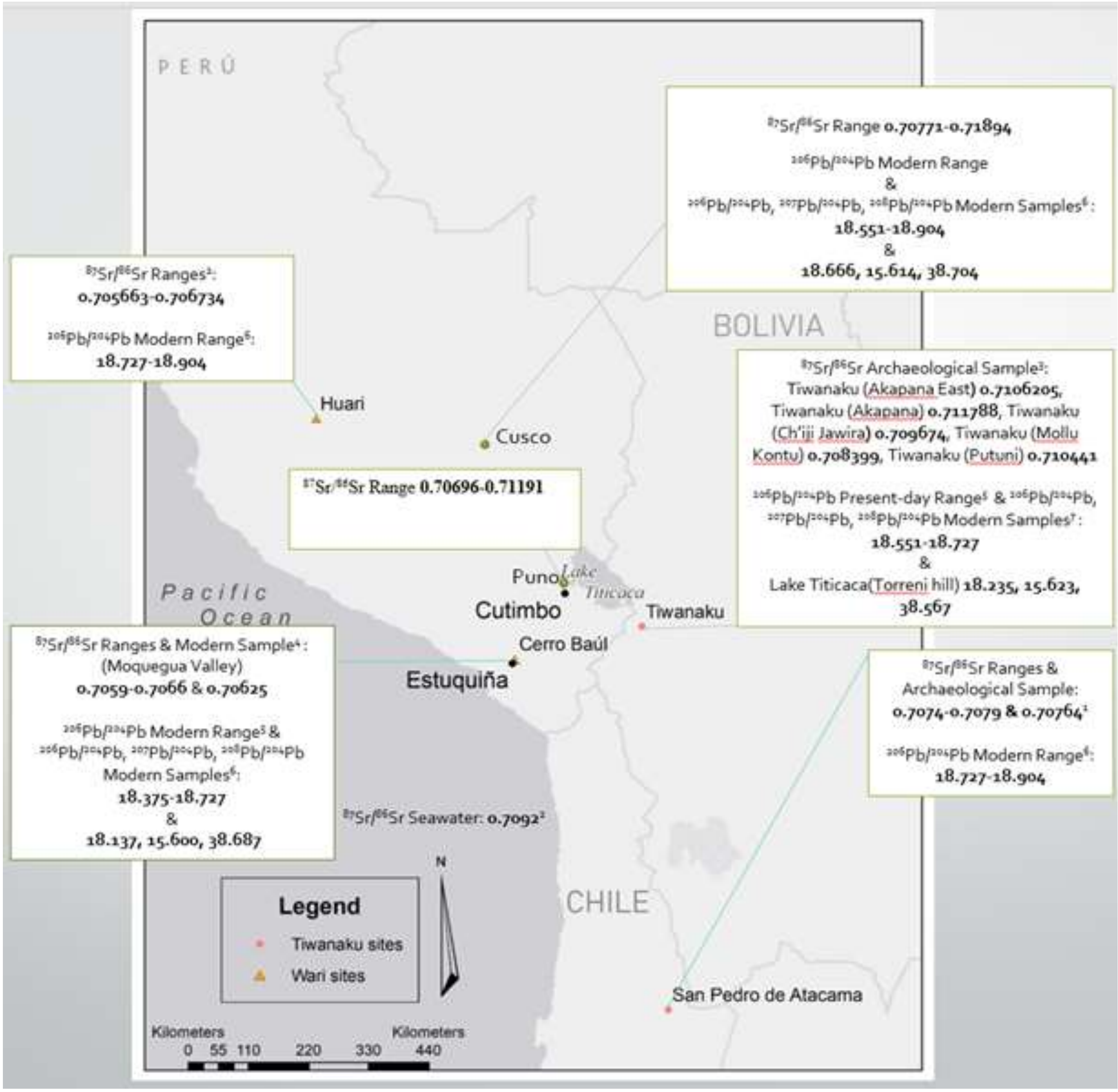

Figure 8 Isotopic Studies throughout the Southern Andes (Slovak et al. 2008; Knudson and Torres-Rouff 2009; Knudson and Price 2007; and Knudson et al. 2014; Turner et al. 2009; Turner et al. 2013; Kamenov and Gulson 2013; Gulson 1986)

4.6 Methods

Lead and Strontium Isotope preparation samples were divided into both bulk and temporal groups. The bulk group contained ten samples of hair from 6.23-84.81mg. All of the samples were examined under a Leitz DM RB 10x1.22 microscope. They were examined for follicles, which are used to identify the end that is attached to the scalp. During this process, five samples were determined to have follicles, *DC_1, DC_3, DC_5, DC_6, and DC_12*.

From these five samples, two were randomly selected to serve as temporal samples, *DC_1* and *DC_5*. Then, all the samples were sonicated in a Branson Ultrasonic Cleaner, with 18Ω ultrapure water for two minutes at a time, to remove any surface adherents or contaminants. After letting the samples dry, all the samples were placed into glass tubes and transported to the Center for Applied Isotope Studies (CAIS) at the University of Georgia (UGA) in Athens, GA for analysis in the class 100 and class 10000 cleanrooms. *DC_1* and *DC_5* hair samples were lain out on a clean workspace and cut into 1cm segments using stainless steel utensils, each sample starting from the scalp end going toward the free end of the hair. The samples were labeled as *DC_1* H#; H0 is the 1cm segment closest to the scalp, and each incremental number represents 1cm further from the scalp. Under the direction of CAIS research scientist Dr. Doug Dvoracek, I finished preparing the samples by dissolving them in ultrapure HBr and letting the solutions dry down in Savilex beakers inside an oven for roughly eight hours.

Once the dissolved samples dried completely, I capped the Savilex beakers and brought them to a class 10000 clean room to carry out column chemistry. For Pb columns, I added two rounds of 1mL 6N HCl to the Dowex Pb resin columns, then loaded the sample aliquot is loaded, with 100-200 microliters 1N HBr. I then collected and culled the following three rinses with 1mL 1N HBr and saved them for Sr separation before collecting the Pb in 1mL of 20% (4.5N)

HNO_3. I then used the saved Sr solutions to perform column chemistry for Sr collection. I placed 3-5mL 8N HCl and let it filter through Dowex Sr resin columns twice, after which I placed 5 mL 8N HCl into the column and set the flow rate. Once this was completed, the dissolved sample was loaded. Then, 3 mL ultrapure 8N HCl was introduced and let run down, after which I added 4 mL of 18Ω ultrapure water and collected 3mL of Sr solution into acid-cleaned plastic sample vials.

After the column chemistry, I collected the samples in ultrapure-acid cleaned Savilex beakers, with around 1.5mL of 14M HNO3 and 0.5 mL of 8M HCl sealed and placed on a hot plate at 110 degrees for 24 hrs. This fully digested the samples, after which I evaporated them to dryness at 105 degrees Celsius for 24 hours, using 1 mL 14M HNO_3 to retrieve the residue. I then dissolved the dried sample pellet in 100mL 14M HNO_3 and 100mL 31% H_2O_2, aggregated the mix and left them to rotate on a hotplate for 10 minutes at 105 degrees Celsius, then dried them completely; the remaining solution was free of organics. I then introduced the dry sample to 2 mL of 3M HNO_3, and took an aliquot of 30%.

Sr and Pb aliquots were characterized for $^{87}Sr/^{86}Sr$ and $^{206,7,8}Pb/^{204}Pb$ on a nu-Plasma II high resolution multi-collector mass spectrometer (MC-ICP-MS) at the Center for Applied Isotope Studies on campus at the University of Georgia by Dr. Doug Dvoracek. The MC-ICP-MS is fitted with faraday collectors and ion counters, coupled to a dry desolvating system which allows for increased sensitivity for measuring very dilute solutions, such as mummified hair samples (UGA Center for Applied Isotope Studies 2019). In order to ensure that the machine is acting optimally, CAIS performs several different checks before, during and after the analysis. For strontium isotope measurements, the $^{87}Sr/^{86}Sr$ is checked for isobaric krypton impurities in the argon gas, the presence of rubidium and corrected for mass bias. Additionally, CAIS uses

NBS 987 throughout the entire sample set as a reference (UGA Center for Applied Isotope Studies 2019b). Like the checks conducted on strontium when operating the MC-ICP-MS, CAIS uses mass 205 and 203 titanium to correct mass discrimination and improve ratios run within a sample set analyzing for lead. Additionally, they run NBS 981 during every operation to calibrate the machine while using it (UGA Center for Applied Isotope Studies 2019c).

The amount of each sample required to run a sample excluded samples *DC_8* and *DC_9*. However, *DC_1* and *DC_5* were run for both temporal and bulk samples. This means that the sample total is fifteen. *DC_1* is from *DC_1 H0-DC_1 H2*, with the bulk sample at *DC_1 H2*. *DC_5* is from *DC_5 H0 - DC_5 H3*, with the bulk sample at *DC_5 H2* and *DC_5 H3* (Fig 7, See Appendix A Table 4 for Strontium values throughout the Andes). For *DC_5 H3*, the sample was used to assist in calibrating the machinery for the individuals from the site of Estuquiña. For archival and future research purposes, each of the samples, where permitted were divided into three sections, sample A (*DC_#A*), sample B (*DC_#B*) and sample C (*DC_#C*). For simplicity, when discussing the samples throughout the document I only refer to them as *DC_#*. Sample A was divided for oxygen isotopic analysis from sample B. Sample B was separated for lead and strontium isotopic analysis, and sample C was half the original weight of hair and is currently stored at GSU for future research. Therefore, all results presented in the next chapter are from sample group DC_#B.

5 RESULTS

The isotopic results for the site of Estuquiña are predominantly consistent with individuals who are from the Moquegua Valley. The results of the analyses will be discussed in greater detail in Chapter 6.

Hair keratin $^{87}Sr/^{86}Sr$ values range between 0.70672 and 0.71017, with a mean of 0.70768 ± 0.00107. Hair keratin $^{206,7,8}Pb/^{204}Pb$ range between 18.357 and 18.772, with a mean of 18.480 ± 0.133; 15.639 and 15.694, with a mean of 15.664 ± 0.021; and 38.630 and 38.802, with a mean of 38.703 ± 0.065. Values are summarized in Table 4.

Table 4 Summarized values of Hair keratin $^{87}Sr/^{86}Sr$ values and Hair keratin $^{206,7,8}Pb/^{204}Pb$ for the site of Estuquiña.

Burial	GSU Lab Code	Segment	$^{87}Sr/^{86}Sr$	±SD	$^{208}Pb/^{204}Pb$	±SD	$^{207}Pb/^{204}Pb$	±SD	$^{206}Pb/^{204}Pb$	±SD
M6-4203	DC_1	H2	0.71083	0.0000235	38.630	0.00299	15.694	0.00	18.586	0.000935
	DC_1	H1	0.71005	0.0000149						
	DC_1	H0	0.70961	0.0000119						
M6-4179	DC_2	bulk	0.70875	0.0000153	38.795	0.00286	15.692	0.00	18.520	0.000971
M6-3635	DC_3	bulk	0.70791	0.0000129	38.654	0.0023	15.648	0.00	18.398	0.000894
M6-8839	DC_4	bulk	0.70672	0.0000134	38.676	0.00238	15.657	0.00	18.357	0.000882
M6-3615	DC_5	H3	0.70633	0.0000114	38.701	0.00202	15.650	0.00	18.407	0.000639
	DC_5	H2	0.70677	0.0000116	38.682	0.00296	15.656	0.00	18.427	0.00102
	DC_5	H1	0.70686	0.00000972						
	DC_5	H0	0.70861	0.0000158						
M6-5454	DC_6	bulk	0.70746	0.0000144	38.672	0.00191	15.641	0.00	18.395	0.000657
M6-986	DC_7	bulk	0.70675	0.0000135	38.802	0.00234	15.680	0.00	18.772	0.000657
M6-3299	DC_10	bulk	0.70774	0.0000153						
M6-4091	DC_11	bulk	0.70701	0.0000148	38.647	0.002	15.639	0.00	18.376	0.000657
M6-5839	DC_12	bulk	0.70711	0.0000147	38.759	0.00316	15.673	0.00	18.498	0.000657

Figure 10 shows the individual hair keratin strontium isotope values for the samples with the large dashed box showing Ilo Valley strontium values, and the smaller dotted box showing Moquegua Valley strontium values. Figure 11 shows the relationship between $^{206,7,8}Pb/^{204}Pb$ in hair keratin from the sample of ten individuals at the site of Estuquiña. Figure 12 compares the relationship between strontium and lead in hair keratin from the individuals sampled at the site.

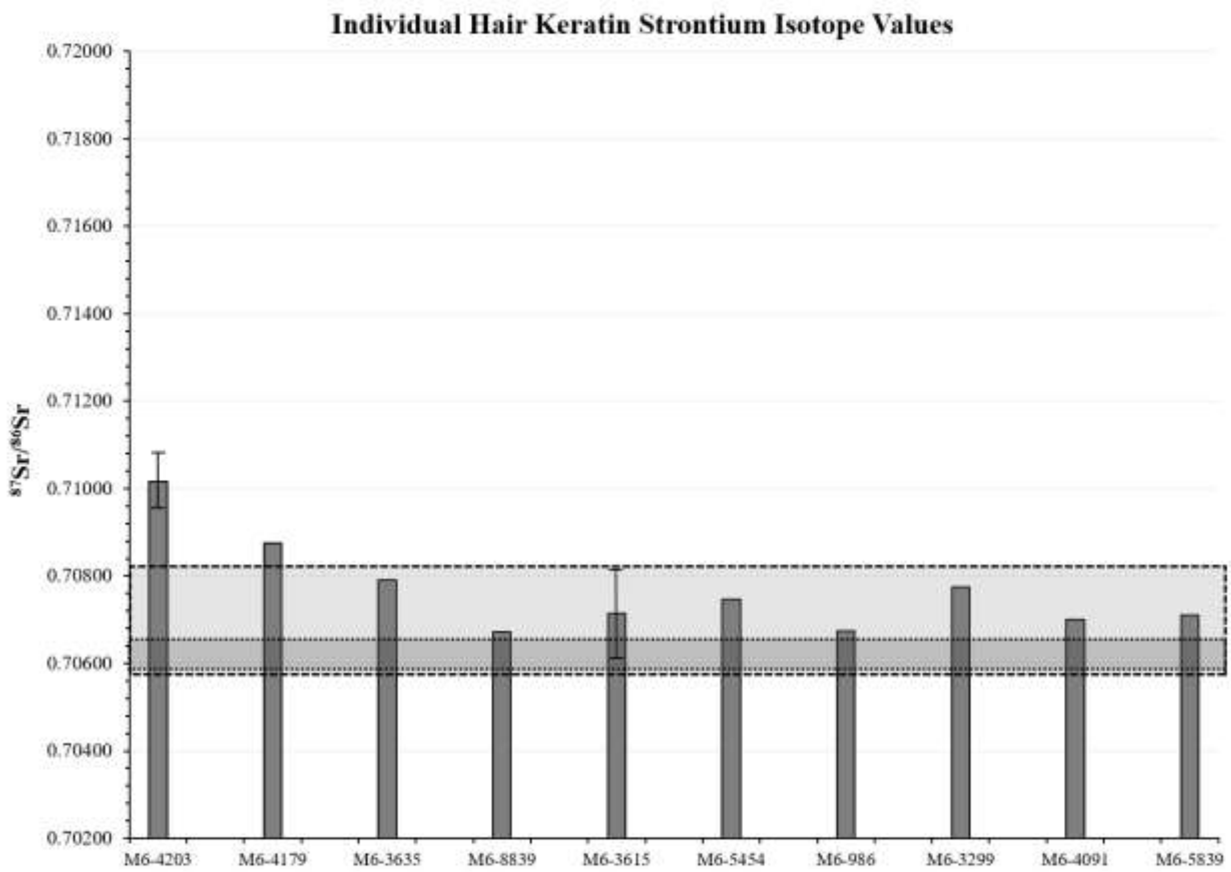

Figure 9 Individual Hair Keratin Strontium Isotope Values, N=10, Estuquiña.

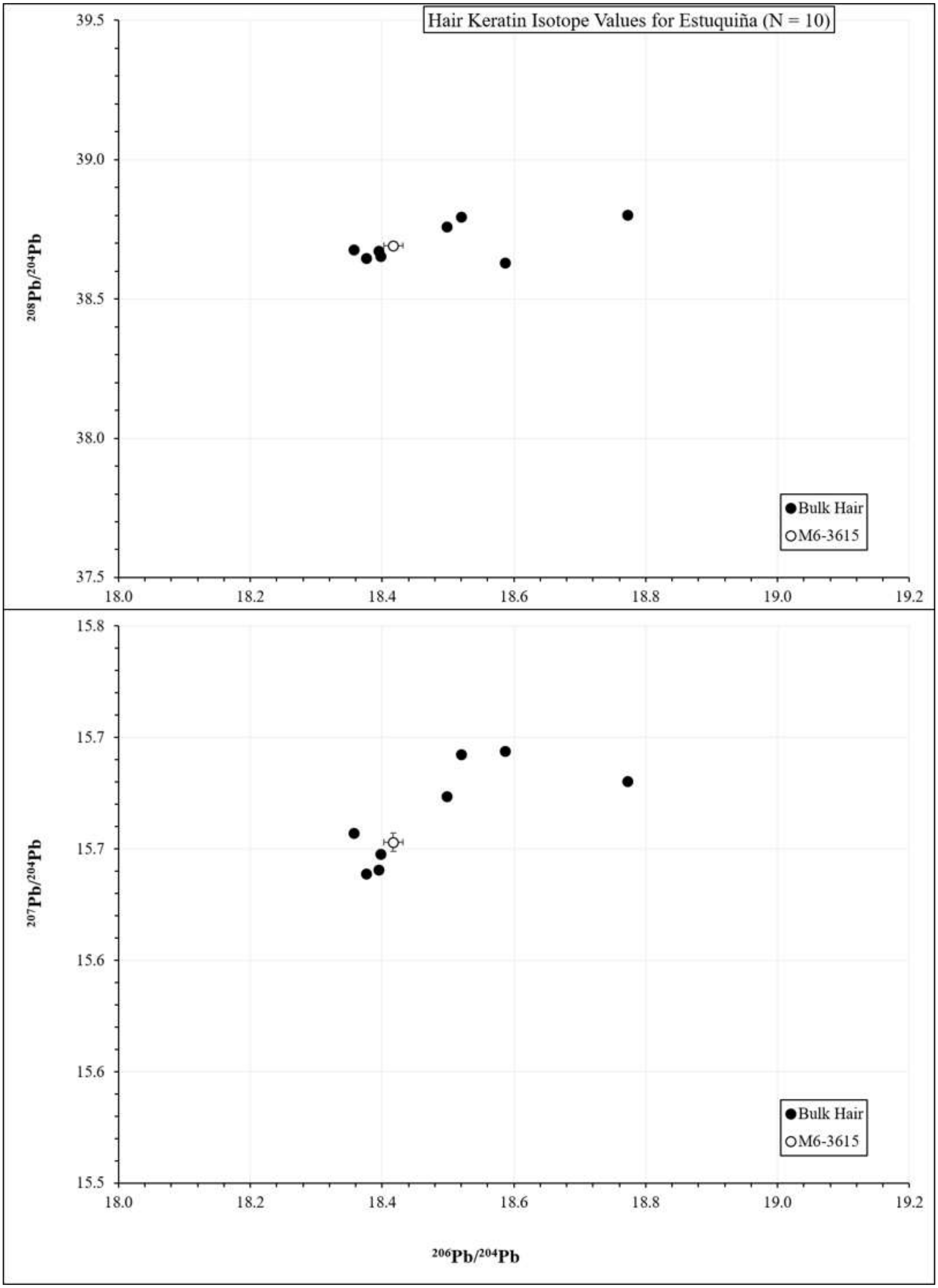

Figure 10 Hair Keratin $^{206,7,8}Pb/^{204}Pb$ Isotope Values for Estuquiña (N=10)

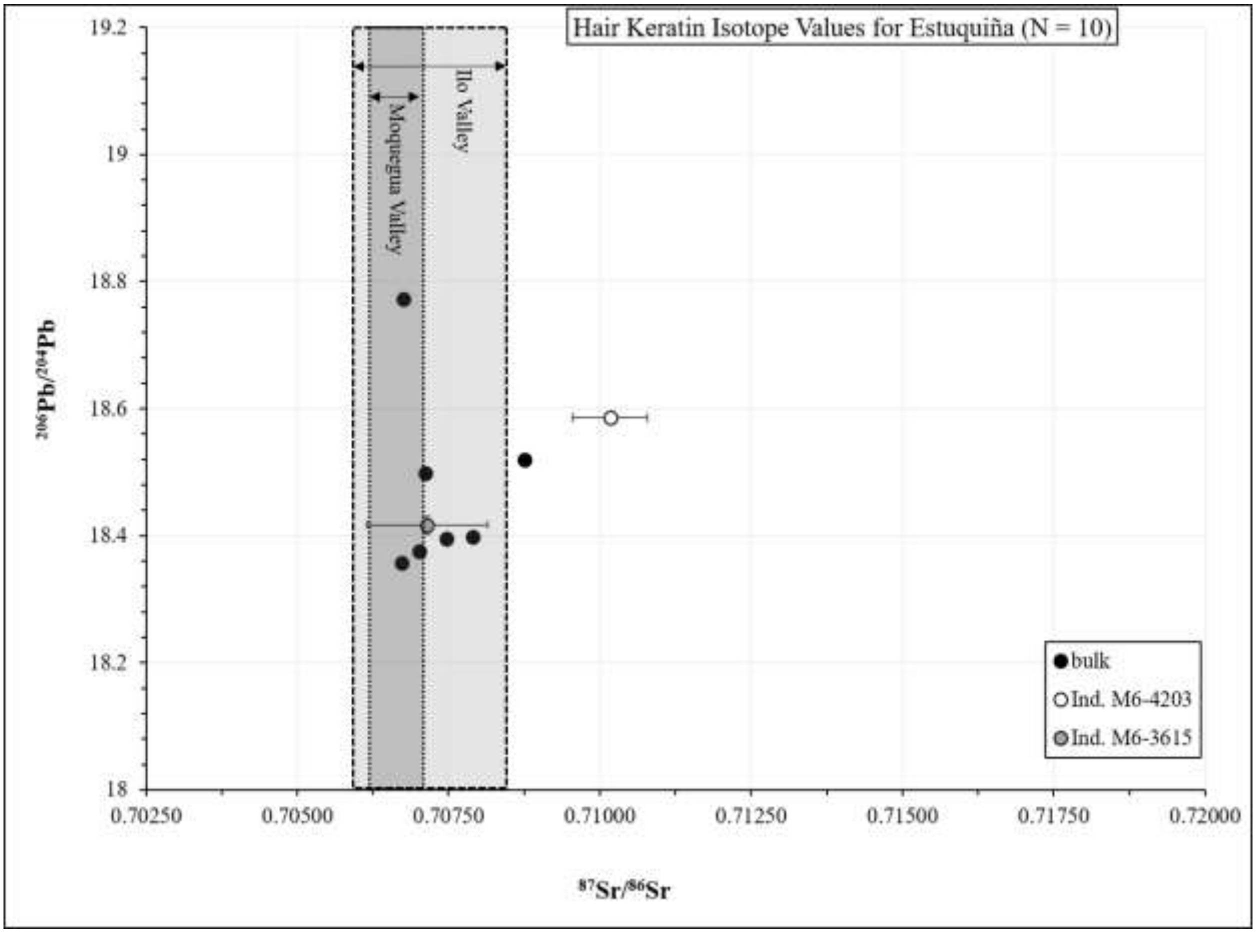

Figure 11. Strontium and Lead isotope comparison based on hair keratin samples from Estuquiña.

Of the two individuals with incremental hair isotope data, M6-3615 appears to be moving within the Moquegua and Ilo Valley. H3 the furthest segment from the scalp, and well within the Moquegua Valley isotope ratio range. As they approach their death, they appear to move away from Estuquiña. For M6-3615, hair keratin $^{87}Sr/^{86}Sr$ values range between 0.706334 and 0.70861, with a mean of 0.70714 ± 0.00100. The potential reasons for the elevated strontium level in their final month will be discussed in Chapter 6.

In contrast to *M6-3615,* individual *M6-4203* appears to not only be non-local to the Moquegua and Ilo Valley, but they also appear to be moving towards the valley as opposed to away from the valley like *M6-3615* was. For M6-4203, hair keratin $^{87}Sr/^{86}Sr$ values range between 0.70961 and 0.71083, with a mean of 0.71017 ± 0.00062. As with *M6-3615, M6-4203* will be discussed in greater detail in Chapter 6(Fig. 13).

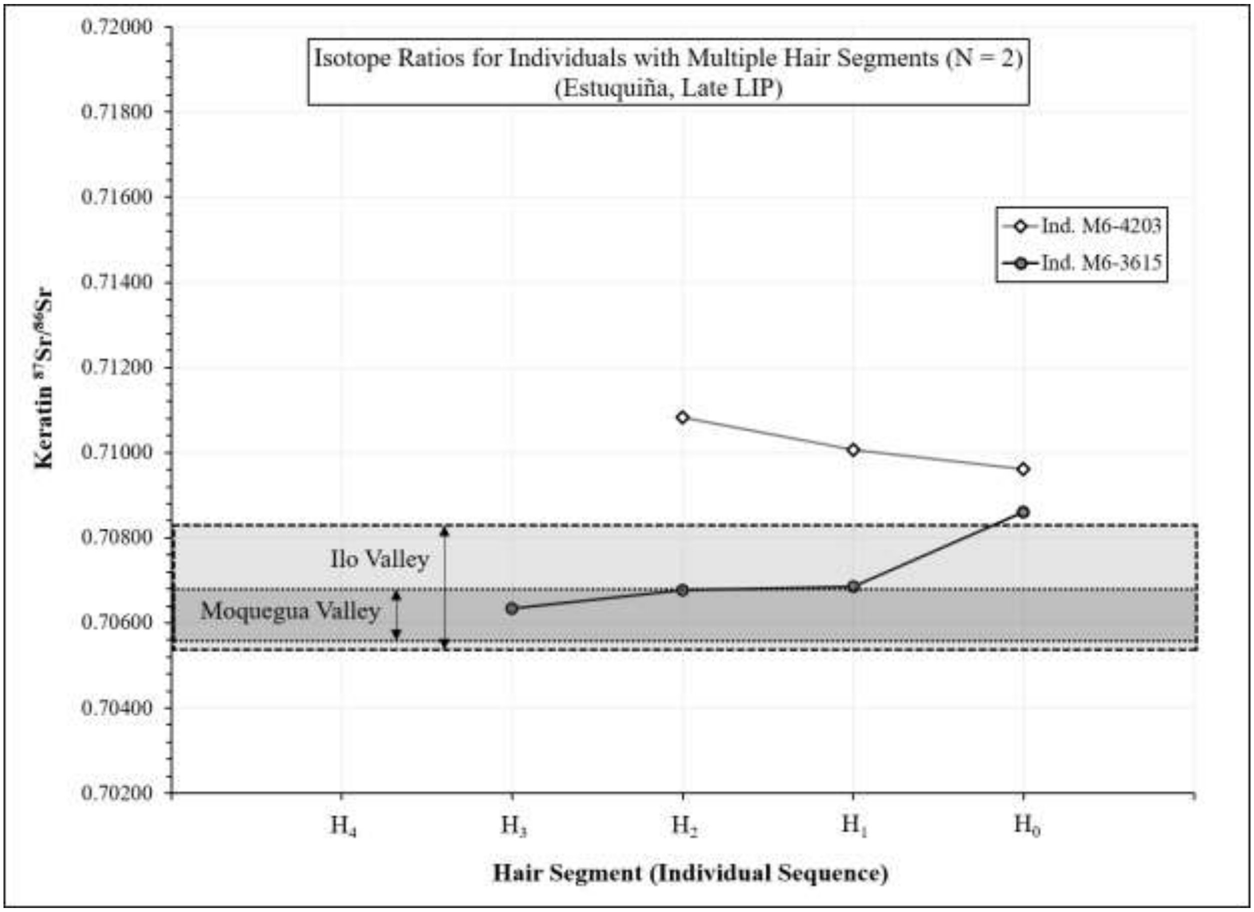

Figure 12. Individual Keratin strontium samples from Estuquiña sample.

In comparison with published isotope values for the region, *M6-3615* appears to be local to the Moquegua Valley and *M6-4203* appears to be from around the Lake Titicaca region (See fig 9).

6 DISCUSSION AND CONCLUSIONS

The Estuquiña appeared in the middle Moquegua Valley during the late LIP (~AD1250). Previous ethnohistoric data suggested the Estuquiña were colonists from the altiplano, specifically from the Lupaqa polity. However, debate about the origins of the Estuquiña is ongoing. For instance, based on preliminary findings from a biological distance analysis, Sharratt and Sutter (2018) argue that the Estuquiña are more likely the descendants of the terminal Middle Horizon occupants in the middle and upper Moquegua Valley who were themselves descended from earlier (Middle Horizon) Tiwanaku affiliated populations.

Based on my heavy isotope analysis of ten individuals from the site of Estuquiña in the middle Moquegua Valley, I argue that only one individual appears to have arrived in Moquegua from the altiplano, *DC_ 1* (Fig. 13). It is essential to point out that *DC_2,* a fifty-year-old female, had strontium isotope values just outside the strontium isotope values provided by Knudson et al. (2007) and reported in DeFrance et al. (2016). An additional individual (*DC_7*) with local $^{87}Sr/^{86}Sr$ values exhibited Pb isotope values suggesting arrival in Moquegua from outside the region; however, Pb isotope analysis in the Andes is still in its infancy, and much more systematic research is needed before this result can be firmly interpreted. Overall, however, the majority of the study sample exhibit isotope values placing them within the Moquegua Valley, or neighboring Ilo Valley some 60km southeast (Fig. 12). More specific interpretations of the possibly-nonlocal individual results are as follows.

6.1 Inferring Individual Histories

DC_1 is an adult female whose strontium isotopic signature correlates with the altiplano regions of Lake Titicaca or Puno. What is of particular interest for this individual is that they are one of the temporal samples and show a pattern of movement from around Puno towards the site of Estuquiña (Fig. 13 and 9). The individual was possibly making a journey towards Estuquiña because of family ties, or the prospect of a new spouse. When the oxygen isotopes signatures are processed, it will be interesting to see if they narrow down where *DC_1* traveled from.

DC_2 is another unique individual. Their strontium isotopic value is 0.70875. The baseline strontium data from the Moquegua Valley is (0.70580-0.70670), and the altiplano is from (0.70696-0.71191). This suggests that *DC_2*, a fifty-year-old sexed female, could have been from the Altiplano or a region with intermediate $^{87}Sr/^{86}Sr$ values, or consumed nonlocal food sources from outside of the Moquegua/Ilo region.

Finally, *DC_7* may not be from the Moquegua Valley either. *DC_7*'s strontium isotopic signature is 0.706754, which is on the edge of the Moquegua Valley, though within the Ilo Valley range for tested values of strontium. The San Pedro de Atacama strontium value is also just out of this range, from 0.7074-0.7079. However, if the Huari strontium isotopic values are considered for *DC_7* at 0.705663-0.706734, it is possible they are from this location.

However, bulk hair $^{206}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ values for *DC_7* are 18.7722 and 38.8016, respectively. At both San Pedro de Atacama and Huari, the $^{206}Pb/^{204}Pb$ range is 18.727-18.904. These data suggest that individual *DC_ 7* could be from the region that surrounds the site of Huari in central highland Peru, but also from San Pedro de Atacama in coastal Chile, hundreds of kilometers to the south. A significant detail about *DC_7* is they are around six months of age. As an infant, they possibly obtained their lead isotopic values from drinking contaminated breast milk (Ettinger et al. 2004). If this is the case, *DC_7* is an example of not one but two individuals who may not be from the site of Estuquiña, or at least spent considerable time outside of the Moquegua Valley.

DC_5's $^{87}Sr/^{86}Sr$ isotope results suggest origins in a wide array of regions including Cusco in the southern Peruvian highlands, Puno and the Lake Titicaca region more broadly, Huari, and San Pedro de Atacama. However, by comparing *DC_5*'s lead isotope values, the region narrows to three candidate regions: Cusco, the Lake Titicaca region and the Moquegua Valley. Although $^{207}Pb/^{204}Pb$ was higher than the Moquegua Valley region, most of the values align for this region. Additionally, this individual was one of the two individuals with incremental isotope data from multiple hair samples; it is not until the final month that the $^{87}Sr/^{86}Sr$ isotope results appear to leave the Moquegua Valley, suggesting that individual *DC_ 5* was local to the Moquegua Valley throughout their life.

Based on these results, it appears that the Estuquiña stayed predominantly within the middle Moquegua Valley, and possibly closer to the coast near the modern city of Ilo, though some individuals may have moved between a number of highland and/or coastal regions, for reasons that are beyond the scope of this analysis. This in situ presence potentially extends as far back as the Middle Horizon and runs counter to the argument that Estuquiña was colonized by an outside group during the LIP. However, one individual's isotopic signature fits within the established range for the altiplano, suggesting that there may have nonetheless been sustained interaction between the regions.

Moreland's (2010) example of the migrant burials during the Roman Empire's decline, discussed in Chapter 1, could provide some interpretive insights into individual DC_ *1*. When the Wari and Tiwanaku withdrew from the Moquegua Valley, they would not have forgotten about it. Additionally, whether due to familial ties or due to the highly productive soils of the valley, people may have maintained cultural ties with the Moquegua Valley, even after the two main polities withdrew during the end of the Middle Horizon.

6.2 Future Directions

While conducting the isotopic analyses on the ten individuals from the site of Estuquiña in the Moquegua Valley, I wanted to examine whether the individuals were from the altiplano, as oral and ethnohistoric records suggested. Upon completion of the analysis, minus the ongoing oxygen testing, only one of the ten samples appears confidently to be from the altiplano, *DC__ 1*. With the oxygen analysis completed, I will be able to more definitively determine the origins of this individual, as well as the two other individuals with more isotopically ambiguous values. For now, it is reasonable to conclude that the people buried at Estuquiña do not appear to be from the region of Lupaqa, as oral and ethnohistoric data suggested.

The site of Estuquiña has an extensive bioarchaeological sample size. The small number of individuals within this thesis sampled (N=10) already shows the potential to answer important questions regarding the origins of the Estuquiña throughout the upper and middle Moquegua Valley. The importance of employing isotopic and bioarchaeological perspectives to investigate the origins of a population during the late LIP is significant (Sharratt and Sutter 2018). Additional light and heavy isotopic data should be characterized in other tissues such as enamel and bone from a larger sample of the remaining 400+ individuals recovered from the site of

Estuquiña. If it is possible to obtain AMS dates for each of the four burial locations at the site, those data will add an essential chronology of Estuquiña occupation and improve interpretations of mobility and migration patterns within and outside of the middle and upper Moquegua Valleys. As Sharratt and Sutter (2018) suggested, investigating the genetics of who is present at the site may also assist in knowing from whom the population of Estuquiña arose, which can aid in understanding the LIP diasporas more broadly. If the Estuquiña are not from the Lupaqa, who are they descended from, are they from the early Tiwanaku colonists roughly 250 years ago in the valley or another coastal group? Further research as suggested above will help explore these questions.

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APPENDICES

Appendix A

Table 5 Strontium Values throughout the Southern Andes (Slovak et al. 2008; Knudson and Torres-Rouff 2009; Knudson and Price 2007; and Knudson et al. 2014)a- from Chen Chen onwards the $^{87}Sr/^{86}Sr$ value is the mean of individuals from each site.

Site	$^{87}Sr/^{86}Sr$ Bioavailable - Archaeological
Ancón-faunal	0.70638
Ayacucho-(Conchopata)-human	0.705663-0.706734
Caspana-human, mean and range	0.70765, 0.70706-0.70964
San Pedro de Atacama	0.707511
Lake Titicaca Basin	0.7083-0.7112
Tiwanaku Valley-*modern, bone	0.709545
Machu Picchu	0.71407
Middle Nazca Valley- faunal	0.70559-0.70727
Chen Chen[a]	0.7078235
Chiribaya Baja	0.707299
Chiribaya Alta	0.7084391
Coyo-3	0.7075708
Coyo Oriental	0.7077248
Iwawe	0.70885
Kirawi	0.710213
San Geronimo	0.7072822
Solcor-3	0.7082172
Tilata	0.7089535
Tiwanaku (Akapana east)	0.7106205
Tiwanaku (Akapana)	0.711788
Tiwanaku (Ch'iji Jawira)	0.709674
Tiwanaku (Mollu Kontu)	0.708399
Tiwanaku (Putuni)	0.710441
La Yaral	0.708436

Appendix B

Figure 13 UGA's CAIS lab used for strontium and lead analysis.
Top left – right: Strontium column set up. Lead column set up
Bottom left – right : Savilex hotplate used to gelatinize samples. AirClean 600 – where

the columns were setup.

Figure 14 GSU's Bioarchaeology Lab where samples were prepped for isotopic analyses. Top left – right : Microscopes. Weigh scale. *Bottom left – right: stainless steel material used to cut hair, drying. Sonicator.*

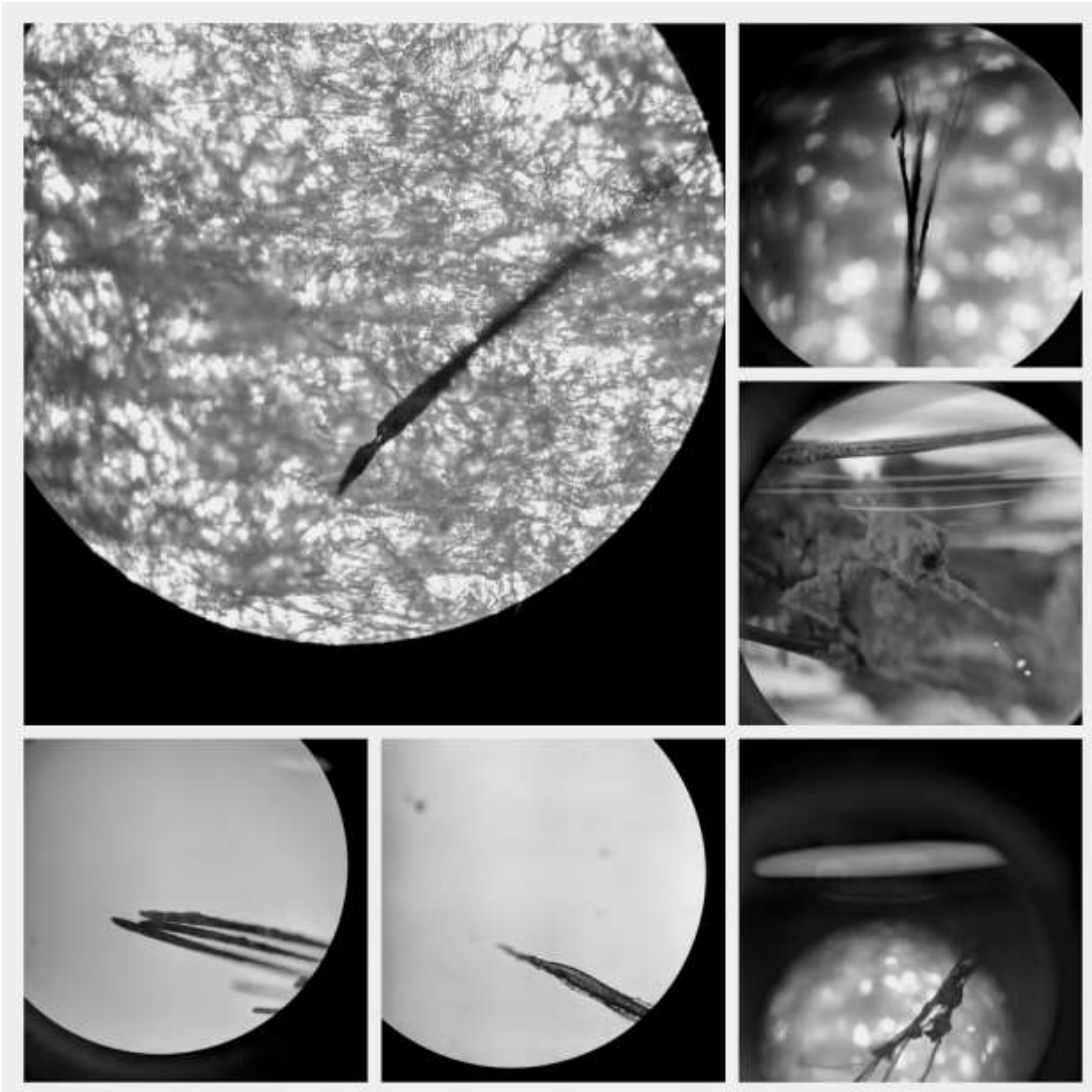

Figure 15 Hair at different stages of cleanliness from the Estuquiña group.