

**THE BIOARCHAEOLOGY OF INKA RESETTLEMENT PRACTICES:
INSIGHT FROM BIOLOGICAL DISTANCE ANALYSIS**

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DEDICATION

This work is dedicated the memory of two extraordinarily influential biological anthropologists whose desire to impact the world beyond the walls of the ivory tower was abundantly obvious, and both of whom I had the good fortune to meet:

Professor Phillip Vallentine Tobias

and

Dr. Karen Ramey Burns.

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ABSTRACT

The Inka Empire, known as *Tawantinsuyu* to those who lived there, achieved an imperial scale in less than one century. Since the Spanish Conquest, a tremendous corpus of literature has been published on the Inka by scholars representing multiple disciplines; these include relatively recent contributions from Andean bioarchaeologists.

This study contributes to Inka scholarship and an overarching bioarchaeology of empire through the bioarchaeological investigation of phenotypic variability of individuals recovered from locales which had been incorporated by the Inka. Few imperial edicts altered the Andean settlement landscape more than the Inka's diverse resettlement strategies. Archaeological and ethnohistorical evidence suggests that some communities incorporated by the Inka were populated with individuals relocated by imperial resettlement policies while other communities were not incorporated into the Inka's complex resettlement network at all.

To examine the biological effects of Inka resettlement on population structure, craniometric data of 552 individuals from nine archaeological sites in Peru were examined. These sites include four non-Inka samples (n=237) which were used to examine pre-Inka population variation. Five Inka samples include three coastal locales (Huaquerones, 57AS03, and Pachacamac) and two sites from the sierra (Colmay and Machu Picchu) (n=315). A model-bound biological

distance analysis was conducted using craniometric variables. Data were fit to an unbiased **R** Matrix (after Relethford and Blangero [1990]) to examine population heterogeneity, the amount of among-group variation, and estimates biological distances between groups.

Results indicate several apparent patterns regarding the population structure of the sample. Demarcation between coastal and highland groups is noted; however, the Inka sites Colmay and Machu Picchu appear to deviate from the expected highland cluster. In addition, genetic heterogeneity is present at the sites of Ancón, Machu Picchu, Colmay, and Pachacamac while all remaining sites appear more homogeneous. Individuals from the Inka sites of Huaquerones and 57AS03 do not appear to have been resettled while the populations from Machu Picchu, Colmay, and Pachacamac appear to have been moved by the Inka. Overall, results from the biological distance analysis suggest that the Inka employed a nuanced approach to population resettlement which altered pre-existing population structure patterned along an altitudinal gradient.

TABLE OF CONTENTS

Chapter 1 – Introduction	1
Study Focus	2
The Bioarchaeological Approach	6
Structure of the study	8
Chapter 2 – Empire: Definitions, Characteristics, and Theory	11
Definitions of Empire	11
Stages of Empire	14
Identification of Empire in the Archaeological Record	17
Theoretical Approaches to the Study of Empire	26
Bioarchaeology of Empire	33
Migration, Movement, and Relocation	36
Nutritional Health and Disease Loads	41
Warfare, Violent Conflict, and Human Sacrifice	44
Chapter Summary	48
Chapter 3 – The Inka Empire	50
Ethnohistorical Accounts from the Chronicles	57
Inka Resettlement Policies	73
Chapter Summary	79
Chapter 4 – Biological Distance	81
Bioarchaeology and Biological Distance	81
Biodistance Datasets	84
Heritability and Biological Distance	87
Distance Measures for Metric and Non-metric Datasets	90
Discriminant Function or Canonical Variates Analysis	91
Mahalanobis Distance	92
Mean Measure of Divergence (MMD)	93
Wright's F_{st}	94
Methodological Approaches to Biological Distance	94
R Matrix Methods in Biodistance Analysis	96
Artificial Cranial Vault Modification	100
Ecogeographic Variation and Andean Population Structure	106
Biological Distance Studies on the Inka	109
Chapter Summary	112
Chapter 5 – Materials and Methods	118
Late Horizon Site Descriptions	120
Machu Picchu	120
Colmay	122
Puruchuco-Huaquerones (Huaquerones and 57AS03)	123
Pachacamac	126

Non-Inka Coastal and Highland Samples	130
Sex and Age Estimates.....	132
Craniometric Data Collection Methods	135
Data Screening and Selection of Variables.....	140
R Matrix	144
Mantel Test	144
Chapter 6 – Results	149
Summary Statistics.....	149
R Matrix Results	160
Chapter 7 – Discussion, Summary, and Future Directions	178
Site-specific use	183
Empire Theory	187
Bioarchaeology of Empire	189
Future Directions	190
References Cited	194
Vita.....	225

LIST OF TABLES

Table 1. Archaeological Model for Identification of Empires.....	18
Table 2. Andean Chronology.....	56
Table 3. Succession of Inka Emperors.....	62
Table 4. Explanatory model for Relethford-Blangero residual interpretation in an Inka mortuary context.....	115
Table 5. Non-Inka Coastal and Highland Samples.....	131
Table 6. Sex estimates of the Inka skeletal assemblage.....	133
Table 7. Sex distribution by age cohort of the Inka samples.....	134
Table 8. Craniometric landmarks registered via Microscribe digitizer	136
Table 9. Craniometric distances utilized by Verano (2003)	141
Table 10. Intraclass correlations of twelve craniometric variables.....	143
Table 11. Geographic distances between sites in kilometers.....	147
Table 12. Vector means of the twelve craniometric variables by site	150
Table 13. Variance-covariance matrix of craniometric variables for 57AS03 ...	151
Table 14. Variance-covariance matrix of craniometric variables for Huaquerones	152
Table 15. Variance-covariance matrix of craniometric variables for Colmay.....	153
Table 16. Variance-covariance matrix of craniometric variables for Machu Picchu.....	154
Table 17. Variance-covariance matrix of craniometric variables for Pachacamac.....	155
Table 18. Variance-covariance matrix of craniometric variables for Yauyos	156
Table 19. Variance-covariance matrix of craniometric variables for Ancón.....	157
Table 20. Variance-covariance matrix of craniometric variables for Cajamarca	158
Table 21. Variance-covariance matrix of craniometric variables for Makatampu	159
Table 22. F_{st} estimates for sites utilized in this study and other South American samples.....	161
Table 23. Minimum F_{st} estimates for other New World archaeological samples.....	162
Table 24. Biological distances between all groups.....	164
Table 25. Biological distances between Inka groups.....	167
Table 26. Matrix correlation analysis between biological and geographic distance	170

Table 27. Relethford-Blangero residuals for all sites.	172
Table 28. Relethford-Blangero Analysis for Inka Sites.....	174
Table 29. Future Inka sites for potential study	192

LIST OF FIGURES

Figure 1. Model of strontium isotope ratios.....	39
Figure 2. Extent of the Inka Empire.....	51
Figure 3. The Four Parts of the Inka Empire	53
Figure 4. Cross-section of Andean geography.....	54
Figure 5. Plate from Guaman Poma depicting a <i>mamacona</i>	58
Figure 6. Plate from Guaman Poma depicting <i>mit'a</i>	59
Figure 7. Illustration of <i>aryballoid</i> pottery style.....	69
Figure 8. Plate from Guaman Poma depicting a <i>kipu kamayuq</i>	71
Figure 9. Khipu example.....	72
Figure 10. Figure 2 from Ross et al. (2008:164) depicting differentiation between coastal and highland populations.....	108
Figure 11. Map of Inka sites sampled.....	119
Figure 12. Location of Huaquerones and 57AS03.....	124
Figure 13. Photograph of mummified remains from Pachacamac before and after processing	129
Figure 14. Lateral View of Craniometric Landmarks Registered with Microscribe (from the left side)	137
Figure 15. Anterior View of Craniometric Landmarks Registered with Microscribe.	138
Figure 16. Position of each cranium as it is digitized with the Microscribe.....	139
Figure 17. General Map of the Inka Road System.....	146

Figure 18. Principal Coordinate Plot of First and Second Eigenvectors of Biological Distances for All Sitees	165
Figure 20. Principal Coordinate Plot of First and Second Eigenvectors of Biological Distances for Inka Sites.....	169
Figure 21. Plot of genetic distance to the centroid against observed within-group phenotypic variance for all sites.....	175
Figure 22. Plot of genetic distance to the centroid against observed within-group phenotypic variance for Inka sites	176

Chapter 1 – Introduction

“Archaeology can provide a check on the accounts of writers who did not fully understand what they were encountering, or who had reason to embellish and invent for audiences in Europe and the Americas.” (Pillsbury 2007: viii)

“The Inca legacy is alive.” (D’Altroy 2002: 324)

On November 16, 1532 Francisco Pizarro captured the Inka¹ emperor Atawallpa. Within a few years of this date, Pizarro and the other Spanish conquistadors conquered all indigenous resistance and formally solidified a colonial presence throughout the Andes. After the Conquest, Spanish colonists set about documenting the territory and people now under their domain. In the ensuing five centuries, scholars from multiple disciplines have published an increasing corpus of literature on the Inka and their ancestors, including contributions integrating analyses of human skeletal remains recovered from Inka mortuary contexts.

Recent excavations and subsequent analyses are beginning to offer insight on those who administered and lived under imperial Inka rule. Bioarchaeological scholars have addressed questions regarding paleodemography, health and disease, diet and subsistence, residential mobility, and biological distance from sites located throughout the empire (e.g., Verano 2003; Murphy 2004; Williams 2005;

¹ Throughout this study, I adopt a spelling of Inka instead of the hispanicized Inca, though the Inka did not have written language themselves. In doing so, I follow recent shifts in Inka scholarship (i.e., Burger et al. 2007; Malpass and Alconini 2010).

Andrushko and Verano 2008; Murphy et al. 2010ab; Andrushko and Torres 2011; Salter-Pedersen 2011; Turner and Armelagos 2012).

Until recently, however, relatively few Late Horizon or Inka burials (AD 1450 – 1532) have been investigated, making population-based bioarchaeological studies and inter-site comparisons data difficult. This research contributes to a bioarchaeology of empire by coupling an understanding of Inka resettlement strategies with a model-bound population genetic model capable of deciphering phenotypic variability among and between individuals analyzed from five Inka mortuary contexts. These findings will be interpreted in the context of the Inka's socio-political imperial organization and will add to a growing body of literature on bioarchaeology of pre-colonial imperial societies (Tung 2003; Knudson et al. 2004; Andrushko 2007; Boza 2010; Salter-Pedersen 2011; Tung 2012; Pink 2013).

Study Focus

In this study, I rely on human skeletal remains to investigate a particular aspect of the Inka's strategy of imperial administration: forced resettlement. As numerous scholars have discussed, few other imperial edicts of the Inka altered the Andean landscape more so than the Inka's diverse resettlement policies (Murra 1982; Wachtel 1982; Ogburn 2001; D'Altroy 2002; Haun and Cock Carrasco 2010). Moreover, archaeological and historical evidence suggest that individuals who were forcibly resettled may never have returned to their homelands, and therefore lived out the remainder of their lives in new locales

(Cornejo 2004). In some instances, it is clear that new communities, populated by individuals from distant spans of geography, were artificially created by imperial relocation policies. Conversely, the Inka were also known to have relocated entire communities *en masse* to new locales. In some instances, groups were not relocated at all (Salazar 2001; Andrushko et al. 2009; Turner et al. 2009; Turner et al. 2010; Turner and Armelagos 2012).

Occasionally, communities of relocated individuals became incorporated into the archaeological record through mortuary practices and burial customs. Given the degree and nature of the Inka's ability to manipulate the structure of populations, I argue that the application of bioarchaeological methods in the form of biological distance analysis of craniometric measurements might very well offer a perspective on Inka resettlement that other forms of archaeological data have not. Traditionally, Inka scholars have utilized forms of archaeological material culture (i.e., ceramics and textiles) to analyze the degree of Inka influence throughout the empire (Malpass 1993; Malpass and Alconini 2010). However, archaeologists have also highlighted the limitations of material culture in the interpretation of colonial contexts (Croucher and Wynne-Jones 2006; Cruz 2011). As Cruz (2011:336) noted, "pots are pots, not people." Though analysis of material culture has informed Inka archaeology with respect to administration of provincial localities (Malpass 1993; Malpass and Alconini 2010), the physical

remains of those who lived in and saw the empire for themselves can also provide a rich dataset for those interested in Inka studies.

In describing a recent bioarchaeological publication by Haun and Cock Carrasco (2010) that attempted to document Inka resettlement on the central coast of Peru, Malpass and Alconini (2010:193) assert that the study “marks a milestone in Inka studies by the authors’ analysis of a skeletal population to evaluate imperial practices.” Despite centuries of scholarship on the sphere of Inka resettlement practices, few scholars have utilized human remains from Late Horizon burial contexts to investigate the widely described practice of state-controlled population movement. The work presented here is a novel contribution to Inka scholarship and contributes an equally fresh perspective to what is known about the diverse ways in which the Inka utilized population movement as an imperial tool of administration. Moreover, this work will suggest that contrary to widespread documentation of ubiquitous population resettlement, some regions were little affected by the practice. In other words, some populations incorporated into the empire were not affected by resettlement. This fact underscores that the Inka utilized numerous strategies in administering the empire.

A central goal of this study is to investigate Inka resettlement practices from two regions of empire: the imperial heartland around Cuzco and the central coast of what is now Peru. Though Menzel’s (1959) influential work has encouraged adopting a regional perspective for over fifty years, few

bioarchaeological contributions have approached the study of Inka resettlement in this way. Admittedly, the paucity of Inka-era mortuary samples presents an obvious challenge to bioarchaeologists seeking resettlement dynamics, as does a comprehensive understanding of site-specific population structure prior to Inka incorporation. It is my expectation that this work will lay a foundation for future bioarchaeological projects that investigate Inka population resettlement. Given that this study examines phenotypic variation in a modest sample (four non-Inka sites provide baseline data and five are from Late Horizon mortuary contexts), additional research is warranted, particularly in contexts outside of Cuzco region, the heartland of the Inka Empire.

Inka archaeologists agree that Cuzco-centered sites like Machu Picchu were staffed by a diverse community of relocated workers; however, they are much less certain with regard to the degree that resettlement took place in other regions of the empire. For example, it stands to reason that administrative centers like Quito, Ecuador or Paria, Bolivia would be primary areas of imperially driven population movement given the strong Inka presence in each of these peripheral capitals. Unfortunately, sites from these locales have yielded few burials and cannot be currently tested. Other provincial complexes, such as Puruchucho-Huaquerones located on the central coast of Peru, might demonstrate entirely different patterns, as archaeological data currently suggest that this site was an important site of specialized craft (i.e., textile) production (Haun and Cock

Carrasco 2010). In other words, locales that were known to produce certain types of goods prior to the arrival of Inka conquerors may very well have been left out of the extensive labor tribute network. Among other reasons, those populations may have been left intact so that the Inka could exploit a pre-existing enclave of production.

The Bioarchaeological Approach

Though the systematic study of human skeletal remains is a relatively recent addition to Inka archaeology, interest in this class of archaeological mortuary material has persisted for well over two centuries (see Buikstra and Beck 2006 [Chapter 1] for a review). For example, in the United States numerous 19th and early 20th-century contributions explicitly examined skeletal assemblages to investigate the origins of American Indians (Beck 2006). Indeed, the human skeleton has been utilized since the 18th century to answer questions related to variation found among *Homo sapiens* (Blumenbach 1775). It is quite clear that specialists of the human skeleton have offered complementary/novel insights into the history of the human condition through their diverse analyses, particularly over the course of the last century. Indeed, the human skeleton has been utilized in contexts ranging from understanding the evolution of our species, to documenting contemporary crimes against humanity (White et al. 2012).

As biological anthropology emerged as a discipline, numerous specialties were developed as investigators began utilizing skeletal material to answer

questions related to health and disease (Moodie 1917; 1923a; 1923b; 1931), paleodemography (Hooton 1930), and biological distance (Neumann 1941; Martin et al. 1947; Long 1966; Lane and Sublett 1972). Intense interest in archaeological skeletal collections persisted throughout the 20th-century and the specialty of bioarchaeology was formally defined by Jane E. Buikstra in 1977 (Buikstra 1977). That same year, Peebles penned the now often-cited observation: “a human burial contains more anthropological information per cubic meter of deposit than any other type of archaeological feature” (1977:124). Since these influential comments in the late 1970s, scholarship has been produced by bioarchaeologists of diverse specialties, and the discipline has emerged as a central field within a broader anthropological discourse (e.g., Larsen 1997; Buikstra and Beck 2006; Gowland and Knüsel 2006; Lewis 2007; Knudson and Stojanowski 2009; Fitzpatrick and Ross 2010; Agarwal and Glencross 2011; Baadsgaard et al. 2011; Bonogofsky 2011; Robbins Schug 2011; Stodder and Palkovich 2012; Tung 2012).

Regardless of a specific regional or temporal focus, bioarchaeology couples osteological data with contextual information derived from archaeological excavations. However, as Larsen (2006) observes, synthesis of the archaeological context has not always occurred. He asserts “previous generations of bioarchaeologists typically studied archaeological skeletons without ever having seen the context of recovery... [t]hus, collaborative research was limited to the

interaction between the individual who excavated the skeleton and the individual who studied them” (Larsen 2006:359). Larsen (2006) notes that while the disconnect between archaeological context and bioarchaeological analysis remains a frequent practice, the presence of skeletal specialists on archaeological projects is increasingly routine. Moreover, as Larsen (2006) observes, bioarchaeology relies on diverse inter-disciplinary teams whose members represent a wide range of expertise and specialties. cursory searches through contemporary bioarchaeological literature sources confirm this trend as scholars seek to blend the most recent advances from the numerous biological and social sciences. Indeed, recent examples of work from regions such as the Andes indicate a true synthesis of approaches, all of which enhance present understanding of the ancient Andean world (Andrushko et al. 2009; Turner et al. 200; Murphy et al. 2010ab; Andrushko et al. 2011; Gaither and Murphy 2012; Turner and Armelagos 2012; Pink 2013).

Structure of the study

To examine the phenomenon of Inka population resettlement, it is first necessary to consider general characteristics of archaeological empires. In Chapter 2, I define and describe the most important features of empire, and in particular, the archaeological signatures of imperial dynamics. In addition, I discuss two theoretical paradigms that have been used to conceptualize archaeological empires: world systems theory and the territorial-hegemonic power

continuum. Lastly, I discuss the growing literature related to the bioarchaeology of empires. In addition to describing the effects of imperialism on the human skeleton (as described by Tung [2003, 2012]), I summarize examples of recent bioarchaeological work that have examined various aspects of imperial organization.

Chapter 3 presents an introduction to the history of the Inka Empire and provides a description of its most salient characteristics. In addition, a hallmark of the Inka's imperial strategy, population resettlement, is presented and various types of resettlement practices are discussed along with particular classes of resettled individuals.

Chapter 4 introduces biological distance analysis and describes its importance to research questions regarding population structure. Datasets utilized to derive biological distances are described, as are various statistical distance measures. Heritability of odontoskeletal features is introduced as are model-free and model-bound types of analyses. The **R** Matrix introduced by Relethford and Blangero (1990) and used for generated estimates of gene flow, biological distance between group, and estimates of among-group variation (F_{st}) is presented in this chapter. The influence of cranial vault modification on biological distance analysis is discussed in this chapter. Additionally, Andean population variation and its relationship to high-altitude adaptation is described along with a discussion of what the few previous biological distance studies on the Inka.

Chapter 5 describes the five Inka-period sites from which the study sample was drawn. In addition, the comparative dataset used for investigating pre-Inka population structure is described, as are methods related to data craniometric data collection with a Microscribe digitizer. Methods for variable screening and selection are described in this chapter. The software package RMET 5.0 (Relethford 2003), used for generating a Relethford-Blangero analysis, is presented and the Mantel test utilized for performing matrix correlation analysis is discussed.

Chapter 6 presents summary statistics of the craniometric variables along with results from the biological distance analysis.

Chapter 7, I discuss the implications of this research on Inka scholarship and bioarchaeology of empire, generate overall conclusions of this project, and present ideas for future work on the bioarchaeological analysis of Inka resettlement practices.

Chapter 2 – Empire: Definitions, Characteristics, and Theory

“Empires mess with people’s minds.” (Alcock 2002: 36)

“Ancient empires were large and complex entities, and archaeological fieldwork can only illuminate bits and pieces of them.” (Smith and Montiel 2001:271-272)

Definitions of Empire

To understand the complex way in which the Inka Empire came to dominate western South America during the 15th and 16th centuries, it is necessary to first define, describe, and understand the characteristics of imperial states. In an influential synthesis on archaeological empires, Sinopoli (1994) notes that simply mentioning the names of early empires (e.g., Rome, Babylon, Aztec, Inka) conjures up notions of political ambition, infrastructural splendor, and decline. Moreover, she notes that empires are geographically and politically expansive and composed of numerous heterogeneous communities. Clearly, the diversity and scale of empires present challenges for archaeological anthropologists who seek to understand prehistoric imperial dynamics. As Sinopoli (1994) and others have suggested (i.e., Schreiber 1992), interpreting prehistoric empires is best done by a nuanced synthesis of numerous sources, namely historic accounts, external interpretations by conquerors or witnesses, and analyses of material remains derived through archaeological excavations.

In a recent volume describing archaeological and early modern empires, Morrison (2001) suggests that interest in empires is as old as empires themselves. In other words, she reiterates that scholarly interest in imperial societies is not a

new phenomenon and that centuries of scholarship have contributed to contemporary understandings of imperial dynamics. Even the origin of the word “empire,” which is derived from the Latin root *imperium* [*control*], implies a type of political achievement reminiscent of Roman hegemony (Pagden 1995; Morrison 2001). Moreover, Pagden (1995) notes that scholarship on the Roman Empire shaped generations of European scholarly thinking on the subject. As Pagden (1995) explains, European scholarship has considered Roman imperial organization as the model to which numerous other empires are compared and contrasted; and, even popular media accounts utilize Roman analogies. For example, in describing the rapid territorial expansion of the Inka Empire, a recent National Geographic film entitled *Great Inca Rebellion* (2007) explicitly describes the Inka as the ‘Romans’ of the New World.

Turning now to definitions of empire, it is clear that numerous scholars have broadly defined empires as sovereign polities that incorporate multiple states (Finley 1978; Adams 1979; Conrad and Demarest 1984; Doyle 1986; D’Altroy 1992; Sinopoli 1994; Morrison 2001; D’Altroy 2002). Schreiber (2001:71) corroborates this definition and argues that all empires also maintain standing armies and military fortifications. D’Altroy (2002) defines empires as heterogeneous, expansionist states that maintain political, economic, and coercive control over a wide geographic territory. Malpass and Alconini (2010) describe empires as multiethnic, plurilinguistic, and multinational states which have

expanded over large expanses of territory. As Sinopoli (1994) asserts, despite subtle differences in semantics that might emphasize particular imperial dynamics over others (i.e., geographic, economic, political, or ideological dimensions), these definitions “share in common a view of empire as a territorially expansive and incorporative kind of state, involving relationships in which one state exercises control over other sociopolitical entities” (1994:160).

A closer look at each of these definitions reveals a few central ideas regarding empire. First, it is clear that empires are a specific type of state-level society (Carneiro 1970; Wright and Johnson 1975). In this anthropological framework, a state is described as a society possessing an institutionalized hierarchy of administrative control. In other words, states are centralized polities that control decision-making and ultimately govern the populace located within its domain (Wright and Johnson 1975). While empires are states, the inverse is not always true. As Sinopoli (1994, 1995) notes, a primary difference between a state and an empire has to do with the level of control that one polity exercises over another. Sinopoli (1994:160) observes, “[t]he incorporated entities can be states, chiefdoms, or non-hierarchical societies.” Second, these contemporary definitions imply that empires are capable of expansion, sometimes rapidly, through a number of different diplomatic and/or coercive strategies. Lastly, the tendency of empires to maintain a military presence further separates them from non-imperial states, though some states, such as the Moche of Peru’s north coast

were known to maintain a military presence (Swenson 2003). Admittedly, the degree to which a group must meet all components of the definition is debated in the literature. For example, Andean polities such as the Wari are not unanimously classified as an empire, while on the other hand, the Inka are unequivocally recognized as an imperial power (D'Atroy 2002; Covey 2006, 2008).

Stages of Empire

Turning now to stages of empire, Sinopoli (1994) argues that all empires share three sequential temporal characteristics: (1) expansion, (2) consolidation, and (3) collapse. Despite these shared characteristics, Taagepera (1978) notes that ancient empires vary significantly in their longevity. For example, the Timurid of Central Asia and the Ch'in empire of China did not survive the rule of their first emperor and empires such as the Aztec and Mongol persisted for less than one century, while others such as the Gupta and Vijayanagara (both located in present-day India) lasted for almost two centuries (Bodde 1967; Berdan 1982; Allsen 1987; Palat 1987; Manz 1989; Sharma 1989; Liverani 1993). Still other empires, exemplified by Rome and the Han Dynasty, lasted for many centuries (Duncan-Jones 1990; Steinhardt 1990).

While understanding geographic expansion is necessary for scholars interested in ancient and modern empires, attention must also be paid to how empires initiate consolidation or the process by which subjugated territories are unified under common political, economic, and ideological systems (Eisenstadt

1963; Morrison and Sinopoli 1992; Brumfiel 1994; Sinopoli 1994). Clearly, effective consolidation of imperial territory is compulsory in order for empires to maintain themselves, and scholars have paid a great deal of attention to this particular topic (Ogburn 2004; Schreiber 2005). Lastly, the subject of imperial decline and collapse has also been investigated, as scholars have recognized a multitude of agents responsible for fragmentation and collapse ranging from foreign invaders, environmental factors, over-centralization, communication problems over large distances, and regional conflict (Bronson 1988; Brumfiel 1992; Postgate 1992; Weiss and Courtney 1993).

Regardless of the temporal component of an empire's longevity, all empires share the common characteristic of rapid territorial growth or expansion during their initial stages. As Sinopli (1994) suggests, territorial expansion through either diplomatic or coercive means is a hallmark of imperial propagation. Clearly, the mechanisms of initial imperial expansion are complex and diverse and can range from localized tensions related to regional disintegration to complete breakdown of political systems (Finley 1978; Brumfiel 1992; Sinopli 1994). In both these cases, the fundamental assertion is that imperial powers sometimes seize opportunities of political upheaval in order to conquer and subsume new tracts of territory.

Moreover, the growth of an empire during its nascent stages has been attributed to a multitude of factors including protection from outside threats, a

desire for procurement of economic resources, and the spread of imperial ideology (Earle and D'Altroy 1989; Conrad 1992; Conrad and Demarest 1984; Liverani 1993). Sometimes, as numerous scholars have asserted, imperial centers of power have relied on military prowess for territorial expansion (Luttwak 1976; Mann 1986; Hassig 1988; Hassig 1992). In other contexts, however, diplomatic processes have been utilized for more peaceful integration of new territory (Schreiber 1992). Regardless, as Sinopoli (1994), Hodge (1991), and more recently Liebmann and Murphy (2010) reiterate, conquest is hardly ever a single event and territorial expansion is often met with resistance, often in the form of violent rebellion.

For an empire to survive multiple generations of power transfer, a totalitarian system of imperial governance must be established by those individuals occupying the most senior levels of authority (Morrison 2001). As Sinopoli (1994) and Streusand (1989) maintain, this involves establishing new bureaucratic institutions, building administrative infrastructure, spreading imperial ideology across newly acquired territory, and sometimes coopting local elites to serve as representatives of the imperial state.

In sum, different empires accomplish each of these objectives in numerous and diverse ways. Moreover, particular socio-political practices such as forced resettlement were more common strategies among certain imperial groups than in others. In the case of the Inka, for example, resettlement was a cornerstone of the

imperial agenda and reshaped the Andean landscape in a way that had never been seen previously (see Chapter 3).

Identification of Empire in the Archaeological Record

In a useful model based on empires of pre-Columbian Mesoamerica, Smith and Montiel (2001) summarize the work of political scientist Michael Doyle (1986) in an effort to understand the political nature of empire by identifying several social and economic components extrapolated from archaeological remains (Table 1). These authors extend Doyle's emphasis on political variables to define and classify empires of pre-Columbian Mexico, which Doyle himself characterizes as, "[f]our intersecting sources account for the imperial relationship: the metropolitan regime, its capacities and interests; the peripheral political society, its interests and weakness; the transnational system and its needs; and the international context and the incentives it creates" (1986:46).

Smith and Montiel (2001) argue that Doyle's "metropolitan regime" refers to the dynamics of the imperial capital, a characteristic shared by all empires. The authors maintain that the capital city must be large enough to administer the far reaches of the imperial territory and that it present material evidence of imperial ideology through its infrastructure (i.e., its architecture). Even today, some imperial capitals have survived into the 21st century. Cities as Cuzco, Athens, and Rome are indeed some of the most remarkable archaeological locales in the world

Table 1. Archaeological Model for Identification of Empires²

Features	Examples
1. The imperial capital A. Large, complex urban center B. Proclamations of imperial ideology	1. Militarism 2. Glorification of king or state
2. Domination of a territory A. Economic exchange between capital and provinces B. Political control of provinces	1. Provincial goods found at capital 2. Imperial goods found in provinces 1. Military conquest 2. Construction of imperial infrastructure 3. Imposition of tribute or taxes 4. Reorganization of settlement systems 5. Imperial coopting of local elites
3. Projection of influence in a larger international context A. Economic influence B. Political influence C. Cultural influence	1. Trade with extra-imperial regions 1. Military engagement along enemy borders 2. Centralization or militarization of extra-imperial polities 1. Adoption of imperial gods or rituals by distant peoples 2. Emulation of imperial styles and traits by distant peoples

² After Smith and Montiel (2001:247)

and provide a direct line of evidence for imperial complexity (Smith and Montiel 2001). Interestingly, in the case of some empires such as that of the Inka, multiple capitals were utilized which served as important regional centers of administration (Pärssinen et al. 2010). Moreover, each of these capitals functioned as a microcosm of the empire, as they were characterized by numerous social strata, diverse craft specialists, and were teeming with inhabitants who represented diverse ethnic groups and cultures (Fritz et al. 1984; Hyslop 1990; Owens 1991; Smith and Montiel 2001).

In addition to their role as centers of imperial power, capital cities played a vital role proclaiming the ideology of the state. Though few overarching statements can be articulated when comparing empires across time and geography, Smith and Montiel (2001) argue that the capital was the central locus for dissemination of imperial ideology, particularly in regards to military activity and adoration of the emperor. A military theater was often centered in and around the capital and numerous examples of public military showmanship have been documented (Larsen 1979; Cotterell 1981; Cook 1983). Examples of military power have also been achieved around capital cities through the construction of impressive military fortifications. The well-known monumental fortress of Saqsaywaman in Cuzco is one such example, though numerous others have been described (Hyslop 1990; Stienhart 1990; Julien 2004). Lastly, numerous scholars have recognized that imperial centers were often filled with municipal monuments

and shrines designed to venerate the empire and to sometimes link it with the cosmos (Fritz et al. 1984; Bauer 1998; Smith and Montiel 2001).

According to Smith and Montiel (2001), Doyle's "peripheral political society" refers to those provincial areas outside the capital that are incorporated into the imperial state. Smith and Montiel (2001: 246) indicate that peripheral societies take many forms and can range in size from small, non-hierarchical groups to other empires. Regardless of size, a common thread among all incorporated peripheral polities is that they are located outside of a defined socio-political, as well as geographic core. Smith and Montiel (2001) assert that while understanding an empire's role in the provinces is of paramount importance, particular characteristics of peripheral territories are not useful for identifying the presence of imperialism.

In other words, *identification* of empire is concerned with recognizing the presence of imperial control in peripheral territory while additional fine-scaled analyses are typically concerned with elucidating the "mosaic of control" levied by the empire (Schreiber 1992:69). As will be discussed in Chapter 3, Inka expansion throughout the Andes incorporated a diverse array of provincial localities, many of which have only recently been described by archaeologists (Malpass 1993; Malpass and Alconini 2010).

Smith and Montiel's (2001) characterization of Doyle's (1986) "transnational system" requires an analysis of the relationship between the capital

city and the imperial provinces. Using the label “domination of a territory,” Smith and Montiel (2001:248) split transnational processes into two distinct categories: economic exchange and political control. In considering economic exchange between the capital city and the provinces, Smith and Montiel (2001) assert that both written documentation and archaeological data have potential for elucidating this relationship. For example, in the case of Tenochtitlan highlighted in their paper, Smith and Montiel demonstrate the sphere of imperial influence by describing an elaborate network of portable material culture, evidenced by the ubiquitous presence of imperial black-on-orange ceramics throughout the empire. Moreover, Smith and Montiel (2001) emphasize that all empires, regardless of temporal or geographic context, engaged in widespread exchange. They clarify that it is not necessary to determine if goods or commodities were acquired through state-sanctioned coercion or free-market exchange and emphasize that the presence of imperial goods in the provinces simply indicates socio-economic interaction, a fundamentally important criterion for identifying empire.

Considering the political aspects related to domination of territory, Smith and Montiel (2001) summarize the variable mechanisms that archaeological empires utilized in maintaining control. As has been mentioned by some authors regarding the definition of empire (i.e., Schreiber 2001), military conquest is synonymous with imperialism. Numerous scholars indicate that despite often widespread and rapid military expansion, cities and towns were rarely razed

during conquest (Smith and Montiel 2001; Schrieber 2001). They argue that damage to buildings or structures was probably quickly repaired; therefore, archaeological evidence of this type is most likely irrecoverable. As Schrieber (2001:71) points out, “the presence of military garrisons provides direct evidence of the existence of standing armies. Permanent garrisons are to be found in strategic locations, often located apart from population centers, and often associated with roads. They may have limited access from the outside, and may be fortified.” While garrisons are perhaps the most direct evidence for militaristic expansion, other classes of archaeological data might also indicate military activity. In the case of the Inka for example, numerous types of weaponry have been recovered through archaeological excavations (D’Altroy 2002; Alconini 2004).

To maintain a dominant position throughout an empire, construction of appropriate infrastructure is necessary. As numerous authors have suggested, substantial amounts of both human resources and material wealth were often earmarked for such construction projects (Hyslop 1984, Jennings and Craig 2001; Bauer 2006). Smith and Montiel (2001) assert that examples of infrastructure are sometimes the most obvious and elaborate evidence of heavy-handed territorial imperial strategies. In other contexts, where imperial presence was at a minimum, scant archaeological remains require that archaeologists utilize more indirect lines of evidence. In the case of the southeastern Inka frontier, Alconini (2008) argues

that the imperial elites relied almost exclusively on cultivating alliances with local lords by offering protection from external invasions.

Turning to other forms of political control, Smith and Montiel (2001) argue that the collection of tribute or taxes was nearly a universal characteristic of empires. They maintain that many examples of taxes (i.e., foodstuffs, portable objects) can be recovered archaeologically and provide direct lines of evidence for elaborate taxation schemes. Given that taxes were often tied to crop production, members of the provincial populace might have had to increase their personal or house yields, resulting in an intense increase in the number of acres dedicated to crop production or the expansion of novel horticultural or agricultural practices such as terracing. In describing changes related to crop production in the Roman Empire, numerous scholars argue that methods of terracing and irrigation are visible across the landscape (Hopkins 1978; Redmond 1983; Morrison 1995). Smith and Montiel (2001) maintain that imperial taxation might also lead to lowered living standards. Though they do not explicitly define how lowered standards are defined archaeologically, this argument is linked to the biological consequences of imperialism that will be discussed later in this chapter and have recently been elaborated upon by bioarchaeologists (e.g., Tung 2003, 2012).

According to Smith and Montiel (2001), reorganization of local settlement systems is another important component related to political control. Imperial

powers typically relocate individuals for a number of reasons, ranging from increasing state-sponsored control, to decreasing the chance of rebellion, or realizing a specific economic goal. Though many empires practiced forced resettlement, few are said to have engaged in the practice to the degree of the Inka (D'Altroy 1992, 2002). D'Altroy (2002) asserts that Inka resettlement plans were initiated for two distinct reasons: 1) to scatter those groups that threatened Inka security and 2) to assemble economic specialists in concentrated numbers so that their products could be produced in bulk. According to D'Altroy (2002:248) "no state policy affected the Andean social landscape more than resettlement." This particular policy will be discussed more in the subsequent chapters of this study.

A final characteristic describing political control underscores the economic relationship between imperial authorities and local elites. As Smith and Montiel (2001) maintain, this practice is initiated so that local individuals cooperate in the administration of the provinces. Numerous researchers have demonstrated that on the fringes of imperial borders, cooption is oftentimes minimal and loosely controlled 'client states' are maintained (Isaac 1990; Postgate 1992). In some cases, such as with client states in the Roman Empire, taxes were not collected (Isaac 1990). Kuhrt (2001) maintains that incorporation of local elites into an imperial framework can be identified in the archaeological record by documenting the presence of extra-local prestige goods in provincial contexts.

Finally, turning now to Doyle's (1986) "international context," Smith and Montiel (2001) maintain that empires are part of a larger geopolitical setting involving other sovereign polities. The authors apply a world systems framework (discussed below) to document the interaction and influence of empires on their neighbors. In this context, Smith and Montiel (2001) investigate various economic, political, and cultural spheres of influence. In terms of economic influence, the authors assert that most empires engaged in economic trade with their outside neighbors, as evidenced by the presence of Roman objects recovered from worldwide contexts (Whittaker 1983, 1994). Regarding political influence, it was quite common for empires to strengthen their borderlands, evidenced by the presence of archaeologically known fortifications punctuated across the imperial frontier (Hyslop 1990).

In addition, Edens (1992) suggests that political centralization of neighboring polities is a common effect of imperialism in border regions. As Edens (1992) suggests, political centralization is often initiated to deal with the threat of a looming neighboring empire. Lastly, cultural influences can be elucidating by examining patterns of cultural mimicry along frontier regions. As Whittaker (1994) has documented along the Roman frontier, imitation of imperial styles was commonplace.

Theoretical Approaches to the Study of Empire

Perhaps no body of theory has been applied to the study of archaeological empires more than Immanuel Wallerstein's influential body of work commonly referred to as world systems theory (WST). WST was originally published in 1974 to explain the success of modern capitalist economies, although Sinopoli (1994) suggests Wallerstein calls for extension of WST to prehistoric economies as well. Archaeologists have certainly applied particular aspects of WST to archaeological empires, particularly to the core-periphery sphere of interaction (Malpass and Alconini 2010; Tung 2012).

It is critical to note that the world system is defined as a type of social structure comprised of numerous inter-societal networks (Kuznar 1996). These networks are conceptualized in terms of their position as a core, periphery, or semi-periphery. When applied to archaeological contexts, a core is best described as large, urban center from which the central leadership of a single individual or group of administrators promulgates their ideology. The periphery is generally described as the territory that lies geographically outside of the core area but remains under its control. Peripheries are often rich in resources and viewed as exceptionally beneficial by the core. Semi-peripheries are conceptualized as dynamic zones of interaction that oftentimes mediate relations between the core and periphery. In sum, Kuznar (1996:3) provided the following criteria for the imperial world system:

- The empire should encompass a large and bounded area, and be centralized
- The empire should be economically self-contained
- The empire should contain core, periphery, and semi-periphery polities
- There should be a net economic flow of raw materials and wealth from periphery to core

Models applying WST to interaction and exchange between the core, periphery, and semi-periphery have been characterized as using a top-down approach. In other words, those individual agents who are classified as part of the elite core class dictate the type and amount of heavy-handed governance that occurs. In economic terms, for example, the core controls the flow of highly valued prestige goods that are produced in peripheral areas. These prestige goods take the form of tribute payment that Kuznar (1996) argues is a key component of the imperial world system. As is well known in the case of the Inka Empire, tribute payment has taken many diverse forms and was not solely limited to raw materials or prestige goods. For example, a primary form of tribute that was extracted by the Inka was in the form of human labor (Murra 1982; Wachtel 1982; D'Altroy 2002).

Kuznar (1996) documents how the Inka empire conformed to the world systems model. Citing the work of LaLone (1991, 1994), Kuznar asserted that Inka elites, with their core centered in Cuzco, imposed control on numerous

conquered peripheral regions and completely converted a kin-based economy to one almost exclusively centered on tribute. Kuzar (1996:5) expounds upon LaLone and LaLone's (1987) characterization of the Inka as a world system because, as he argues, they were an entirely autonomous empire with the ability to incorporate "any polity that possessed raw materials they desired....The empire had a distinct geographical core that can be contrasted with more peripheral regions, and also had semi-peripheral states." Without doubt, the central core (i.e., Cuzco) dominated the Inka's worldview and it is well known that they believed the city to be the center of the entire universe.

In the Inka context Kunzar (1996) defines peripheral societies as those that had little ability to resist Inka occupation, or those where local people had no chance to resist Inka desire for resource extraction. Using an example from the province of Chupachos in central Peru, Kuznar maintains that individuals from this region had virtually no choice to avoid the state-sanctioned resettlement policy (discussed further in Chapter 3) that relocated approximately 89% of the population. In the case of Chupacos, entire households were relocated for a diverse array of political, economic, and military purposes (Julien 1993; Kuznar 1996). In describing the semi-periphery, Kunzar (1996) uses the Aymara polity from Bolivia and the Chimú kingdom from Peru's north coast to illustrate somewhat autonomous semi-peripheries. By absorbing pre-existing political

structures into an Inka managerial framework, administrators were able to capitalize on local leaders well versed in local policies and customs.

Van Buren and Presta's (2010) recent contribution on Inka silver production provide an example of core-periphery relations from the imperial provinces. The authors describe administrative policies instituted at silver mines near Porco, Bolivia. In this case study both documentary and archaeological evidence were used to demonstrate imperial strategies implemented for the single purpose of economic extraction. Inka nobility realized that the area was a poor producer of agricultural commodities; however, they realized that silver ore was plentiful. As a result, labor tribute was organized to extract silver ore for many years by relocating at least two populations of workers (Van Buren and Presta 2010). The mined ore was then smelted into numerous classes of objects, including high status prestige wares utilized by Inka nobility in Cuzco. As Van Buren and Presta (2010:191) write "the data from Porco thus support...that goods were highly valued, required skill to manufacture, and circulated among a restricted number of individuals – such as metal ritual and sumptuary objects."

Anecdotal, silver metallurgy was so valued during Inka times that it was utilized as ransom to free the captured Inka emperor Atahualpa. As part of Conquistador Pizarro's demands, he ordered that an entire room be filled with gold objects and another with silver. The Inka, anxious to have their divine

emperor released, complied with the request. Pizarro ultimately did not live up to his end of the bargain and Atawallpa was hanged (D'Altroy 2002).

While WST has been used to conceptualize imperial organization of the Inka, as well as other archaeologically known empires, numerous scholars have recognized the inadequacies of applying a strict core-periphery world systems approach to ancient empires, particularly when cultural contact between the core and periphery is considered (Stein 1998). As Stein (2005:9) has argued, archaeologists have recently emphasized the role of interregional interaction in terms of “long-distance trade, colonial situations, and military expansion.” Moreover, Stein (2005) argues that in numerous examples of colonial encounters, interaction between the core and periphery occurs on an equal footing.

As Schreiber (2005) notes, the role of the core has often been overemphasized with regard to the type of control levied on the periphery. Furthermore, she describes the inadequacies in assuming that peripheral groups represent traditional societies who passively comply with core directives without resistance. Resistance to imperial domination is a relatively new area of inquiry and is currently being investigated (Liebmann and Murphy 2010). Likewise, Tung (2012) calls for a fundamental shift in thinking regarding the top-down approach and calls for investigating archaeological empires from the bottom up; however, she also maintains that critical analyses of core-periphery relationships still allows

researchers to analyze fundamentally important aspects of institutionalized imperial hierarchies.

In addition to the world systems approach, numerous archaeologists have focused their attention on differentiating the types of military, economic, political, and ideological power exercised by archaeological empires (Mann 1986). Conceptualized as a continuum of power, two contrasting types of control are noted: the direct *territorial* approach and the indirect *hegemonic* approach (Luttwak 1976; Hassig 1985; D'Altroy 1992).

On one end of the continuum, a *territorial* strategy utilizes a direct, administratively-heavy method of control where costs in both human capital and natural resources are high. As Ogburn (2001) notes, territorial empires invest heavily in administration and military in order to keep rebellion at a minimum. In addition to maintaining order, military conquest is simultaneously utilized to expand territorial advances.

On the other end, a *hegemonic* strategy exercises loose, indirect rule through diplomacy and/or conquest. A hegemonic empire is ruled by a core state that controls other polities through loose, low cost administration. In hegemonic empires, pre-existing political systems are exploited and local elites are often left in positions of power (Ogburn 2001).

While the territorial and hegemonic strategies are opposing approaches to imperial domination, Malpass and Alconini (2010) and Alconini (2008) note that

neither of the approaches were fixed forms of administration. They argue that in the case of the Inka Empire, for example, variable and diverse strategies of military force, political involvement, and economic extraction took place. Ogburn (2001:7) reiterates this notion clearly: “this model allows us to conceive of empires as making decisions and choosing strategies suited to each region according to the particular circumstances in time and space.” Though the territorial-hegemonic model is a relatively recent addition to the study of archaeological empires, as previously discussed, Menzel’s (1959) influential work on the Inka’s administration of the south coast of Peru is reminiscent of this approach.

Schreiber’s (1992:69) influential contribution which conceptualizes imperial organization as a “mosaic of control” underscores the necessity of nuanced interpretations of local conditions. The mosaic analogy, as described by Jennings and Craig (2001), reiterates that imperial strategies employed in one region of an empire might drastically differ from those utilized in another. In their analysis of the Wari Empire³ (AD 600-1000) from the Central Andes, the authors examine imperial organization in peripheral provincial locales. Through their use of Geographic Information Systems (GIS), Jennings and Craig (2001) conclude that variability of site placement (i.e., establishing administrative centers) depended on the level of preexisting sociopolitical complexity.

³ Jennings and Craig (2001) clearly define the Wari as an empire. See Isbell (2008) for a discussion of the debate on the use of the term “empire” in reference to Wari.

In sum, it is clear that an archaeological study of empire draws on several theoretical perspectives. Though perspectives vary, it is clear that archaeologists interested in examining imperial interactions benefit from an interface between WST and the power continuum models. Indeed, all empires were governed from a central, administrative core; however, the approaches to domination were oftentimes nuanced and tailored to specific regions for explicit purposes. For the purposes of this study, I argue that bioarchaeologists interested in examining imperial dynamics must keep both perspectives in mind as they work to understand skeletal data in their archaeological context. Indeed, bioarchaeologists must recognize that the physical remains recovered from imperial contexts embody a diverse range of biologically significant skeletal indicators. Moreover, it is clear that bioarchaeologists interested in interpreting biocultural histories must attempt to recognize imperial strategies of administration and its subsequent biological effects. These are discussed in the section to follow.

Bioarchaeology of Empire

Though archaeologists have spent decades studying the effects of imperial administration on individuals and communities, greater emphasis has been placed on generating interpretations through specific types of portable material culture (i.e., ceramics, metal objects, textiles) than on others (i.e., human skeletal remains). Though bioarchaeologists have been methodically investigating similar questions across diverse regional and temporal contexts, a

“bioarchaeology of imperialism” is an relatively recent addition to the field by (e.g., Tung 2003, 2012). As Tung (2012) has recently articulated, bioarchaeologists are uniquely positioned to examine the direct effects of imperialism on skeletal remains of individuals derived from contexts found within imperial borders.

Bioarchaeologists routinely investigate questions including those surrounding demography, health and disease, residential mobility, and violence. As Buikstra (1991) noted, teasing social phenomena from the bony records of deceased individuals is best accomplished when skeletal data are coupled with their archaeological context. In regards to imperial expansion and its relationship with bioarchaeology, Tung (2003: 60-61) lists five distinct themes that scholars of the human skeleton might choose to emphasize:

1. Imperial policies can relocate populations or segments of populations, thereby creating distinct population profiles among various communities within the empire.
2. Imperialism can affect nutritional health and disease loads of subject peoples by controlling access to the means of agricultural production of food resources, or by levying heavy tribute demands on conquered communities.
3. Imperialism and conquest can create or exacerbate violent conflict, leading to injury or death for particular segments of the population.
4. Imperialism may alter ritual practices that involve human mutilation and sacrifice, particularly as a means to indoctrinate and subjugate new populations.

5. During periods of imperial expansion, individuals may migrate to the imperial center as a result of new economic opportunities, post-marital residence rules, or forced relocation.

Recent contributions to the bioarchaeology of empire have emphasized each of the above themes in a diverse ways and have utilized a wide variety of methods drawn from human skeletal biology (Tung 2003; Andrusko 2007; Pink 2013). Moreover, numerous recent examples have contextualized human skeletal biology within an explicit framework of empire (Andruskho and Torres 2011; Gaither and Murphy 2012; Turner and Armelagos 2012). Following the examples of Tung (2003, 2012), numerous bioarchaeologists appear to fully embrace an approach that relies on the archaeological context to tease apart nuanced variations of imperialism.

Turning now to specific examples of bioarchaeological data, several apparent trends have emerged in regards to the specific types of questions that Tung (2003) described in her implementation of a bioarchaeology of empire. I will now describe specific types of bioarchaeological datasets that Tung (2003, 2012) and others (i.e., Knudson et al. 2004; Knudson et al. 2005; Andrushko et al. 2009; Turner et al. 2009; Andrushko et al. 2011; Turner and Armelagos 2012) have utilized to describe ancient expressions of imperialism.

Migration, Movement, and Relocation

Though Tung (2003) differentiates two themes related to mobility, I elect to combine those two foci under a single heading, as scholars have employed similar methodologies to investigate numerous causal mechanisms of population movement. In describing the imperial effects of forced migration, resettlement, and relocation, numerous authors have utilized three distinct lines of evidence to elucidate the degree to which imperial polities influenced population movement: (1) strontium isotope analysis, (2) measures of biological distance, and (3) ancient DNA (aDNA). The principles of strontium isotope analysis are discussed below while a more thorough discussion of biological distance analysis is presented in Chapter 4. Stone (2008) and Cabana et al. (2013) provide an introduction to the literature on molecular anthropology and Kemp et al. (2009) demonstrate an application of mitochondrial DNA (mtDNA) analysis on populations controlled by the Ware Empire.

Isotopic analysis

Without doubt, the most common technique utilized by scholars interested in population movement and migration of ancient empires has been the analysis of stable isotopes from human bones and teeth. Of the numerous isotopes often investigated by anthropologists, strontium has been most widely utilized by those bioarchaeologists interested in tracking ancient migration (Katzenberg 2008; Bethard 2013).

To briefly summarize, Ericson (1985) published the first example of the anthropological use of strontium isotope ratios, or $^{87}\text{Sr}/^{86}\text{Sr}$. In this seminal paper, Ericson (1985) asserted that strontium isotope abundances found in human bone and tooth enamel reflect the concentration of strontium in geological bedrock. The concentration or abundance of strontium in geological substrates is variable and depends on the type of bedrock present. Numerous authors (see Bentley 2006 for a review) have discussed the way in which strontium is transferred throughout an ecosystem. In essence, the geological composition of bedrock subsequently influences the concentrations of strontium in groundwater and soil, which are taken up or absorbed by local flora and fauna. In other words, local flora and fauna mimic the underlying strontium concentration contained in local bedrock (Bentley 2006; Andrushko et al. 2009).

Strontium becomes incorporated into the body's skeletal and dental tissues through the consumption of water, plants, and animals because it substitutes for calcium in the hydroxyapatite in bones and teeth (Ericson 1985; Sealy et al. 1991; Knudson et al. 2004; Knudson et al. 2005; Andrushko et al. 2009; Turner et al. 2009; Turner et al. 2010 Andrushko et al. 2011; Turner and Armelagos 2012). Unlike other isotopes, such as nitrogen, no change or fractionation occurs as the isotopes move from water, plants, and animals to humans. Skeletal and dental tissues mirror concentrations of strontium in the geological bedrock of the area

where an individual lived while their teeth were mineralizing, predominately during the first 12 years of life.

Due to the use of strontium isotopes as a proxy for birthplace, researchers typically compare an individual skeleton's strontium ratio to the strontium signature of the locale from where the skeleton was excavated. Differences between these two signatures are used to detect residential mobility or migration in the archaeological record, as those individuals who are migrants oftentimes present strontium ratios that are outside of the expected local level. Local "baseline" levels are traditionally calculated by comparing values reported in the geological literature with data generated by analyzing archaeological fauna, or by taking modern examples from wherever the local area might be (Knudson et al. 2004; Knudson et al. 2005; Andrushko et al. 2009; Turner et al. 2009; Andrushko et al. 2011; Turner and Armelagos 2012). The heuristic adapted from Turner and colleagues (2009:319) (Figure 1) presents a visual representation of the way in which population structure is interpreted strontium isotope ratios. In this model, three scenarios are presented which explain potential archaeological populations: 1) an entirely local group, 2) distinct outside populations from the local group, and 3) a heterogeneous population representing both locals and outsiders.

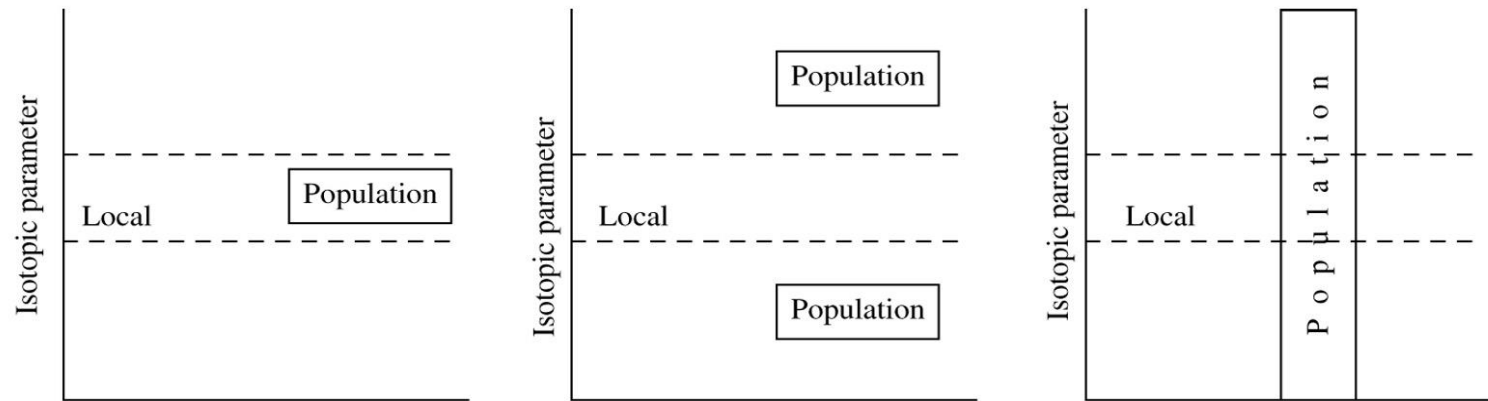


Figure 1. Model of strontium isotope ratios⁴

⁴ After Turner et al. (2009:319)

In the corpus of work from the Andes, scholars have tended to rely on guinea pigs (*cuy*) to serve as baseline data for their respective areas of study. *Cuy* are ubiquitous throughout the Andes and are an excellent example of a locally raised species, both from prehistory and the present day (Knudson et al. 2004; Knudson et al. 2005; Andrushko et al. 2009; Turner et al. 2009; Andrushko et al. 2011; Tung 2012; Turner and Armelagos 2012). Once these samples are obtained, the local signature is calculated by adding and subtracting two standard deviations to the mean value of the pooled faunal sample (Price et al. 2002). Any human sample that falls outside of this local range is considered a migrant or non-local individual.

An example that illustrates the role of strontium isotopes in identifying non-local individuals comes from the work of Knudson and colleagues (2005). In this paper, Knudson et al. describe an assemblage of naturally mummified human remains recovered from a cave in southern Bolivia. These individuals were recovered with artifacts in the Tiwanaku style, which is centered some 600 km away from the cave site in northern Bolivia. The presence of extra-local artifacts suggested non-local individuals; however, $^{87}\text{Sr}/^{86}\text{Sr}$ analyses demonstrated that these individuals were in fact from the local area in southern Bolivia. Such findings led Knudson et al. (2005) to question the sphere of influence of the Tiwanaku polity in southern Bolivia.

Likewise, Andrushko and colleagues (2009) utilized strontium isotopes to examine imperially driven mobility at the site of Chokepukio, Peru. Through their analysis of strontium isotopes from 59 individuals, Andrushko et al. (2009) determined that a marked shift in migration occurred after the emergence of the Inka Empire occurred in the Cuzco region. They argue, “the timing of these migrations coincides with the development of the Inca tribute system featuring state-directed migration” (Andrushko et al. 2009: 67). Moreover, these scholars utilize an analogy of a “melting pot” to describe types of populations that were created by the Inka’s imperial policies. In the case of Chokepukio, strontium isotopes confirmed the melting pot phenomena. Lastly, Andrushko et al. (2009) maintain that strontium isotope analyses indicate more diversity among female individuals and cautiously link this heterogeneity to exogamy-dictated marriage patterns.

Nutritional Health and Disease Loads

A mainstay of typical bioarchaeological investigations includes research related to health and disease in antiquity. Oftentimes, these studies are interpreted in context of social phenomena such as agricultural production or socio-political shifts, such as those seen with the rise of empires (Cohen and Armelagos 1984; Walker 1986; Larsen 1997; Steckel and Rose 2002). Skeletal indicators such as cribra orbitalia, porotic hyperostosis, Harris lines, periostitis, and linear enamel hypoplasia have traditionally been used to indicate physiological stressful periods

of time and have been linked to nutritional deficiencies and/or various types of infections (Cohen and Armelagos 1984; Larsen 1997; Walker et al. 2009).

In cases where bioarchaeologists examine skeletal markers of stress, typically investigators examine frequencies of skeletal lesions across their given study samples. The frequency of lesions is usually interpreted within the context of both child and adult health. In the case of Andrushko's study (2007) on Cuzco burials, she found that 4.6% of the skeletal sample presented linear enamel hypoplasias, 5.2% presented either porotic hyperostosis or cribra orbitalia, and 3.7% presented indicators of stunted growth. Like other bioarchaeologists who utilize these indicators, Andrushko (2007) interpreted these data to indicate that populations in the Cuzco region were relatively unstressed. She notes, however, that the frequency of periostitis increased to 11.1% and she maintains that this stress indicator might provide evidence of a negative consequence of urban population aggregation. Numerous scholars have observed that densely populated living environments, poor supplies of potable water, and improper sanitation infrastructure can lead to increased levels of periosteal bone infections (Weston 2008). Ultimately, as Andrushko (2007) concludes, overall health status was not affected negatively by the rise of the Inka Empire.

Another line of skeletal evidence that reflects health is arthritis. Typically, manifestations of arthritis affect bony joints and can be characterized by both proliferation and resorption of bone. As numerous scholars indicate, over a dozen

types of arthritis have been documented; however, osteoarthritis is by far the most common (Bridges 1991; Salter-Pedersen 2011). Sometimes termed degenerative joint disease or enthesal change, osteoarthritis is typically considered to indicate levels of physical activity, occupation, or age (Jurmain 1977, 1980; Listi and Manhein 2012).

Recent examples investigating osteoarthritis postulate that gendered divisions of labor can be inferred by comparing frequencies of osteoarthritis between males and females (Lieverse et al. 2007; Schrader 2012). In examples related to the Inka Empire, both Andrushko (2007) and Salter-Pedersen (2011) note that osteoarthritis was more common in individuals outside of the Cuzco heartland and that those individuals who were assigned to physical tasks most likely had higher rates of degenerative joint disease.

Regardless of the types of question that bioarchaeologists seek to answer from skeletal indicators of health and disease, the work of Wood and colleagues (1992) transformed the way in which paleopathologists approach their research questions. The well-known *osteological paradox* presented by Wood et al. (1992) raised important issues that confound interpretations of health from skeletal remains. These include 1) demographic nonstationarity, 2) selective mortality, and 3) hidden heterogeneity. As summarized by Wright and Yoder (2003) and Smith (2013), the first issue of demographic nonstationarity considers the age-at-death distribution of the skeletal population and reminds skeletal biologists that

age distributions emphasize fertility rather than mortality. In other words, rather than depicting mortality rates, age-at-death distributions of skeletal assemblages are indicators of fertility.

Regarding selective mortality, Wood et al. (1992) point out the paradox of attempting to interpret health from a series of *dead* (i.e., unhealthy) individuals. Wright and Yoder (2003) further explain by pointing out idiosyncratic variations in response to disease loads are commonplace in skeletal samples. They pose the question “does a skeleton without evident lesions represent a healthy person or a weak individual who perished at the first exposure to a pathogen?” (Wright and Yoder 2003: 45).

Finally, in regards to hidden heterogeneity, Wood et al. (1992) remind skeletal biologists that skeletal assemblages represent a diverse population of individuals who differed according to their level of susceptibility to disease (i.e., frailty). Ultimately, the heterogeneous risk of dying obstructs aggregate interpretations of a skeletal population’s health (Wood et al. 1992; Wright and Yoder 2003; Smith 2013).

Warfare, Violent Conflict, and Human Sacrifice

Similar to the earlier topic of resettlement and migration, I elect to combine several of Tung’s (2003) foci under a single heading. In this case, I combine warfare, violence, and human sacrifice, as bioarchaeologists specializing in these subjects utilize similar methodologies to investigate the social context of

skeletal trauma. It is well known that bioarchaeologists document frequencies of antemortem, perimortem, and postmortem skeletal trauma in order to understand our species' often violent past (Martin and Frayer 1997; Walker 2001). In doing so, bioarchaeologists offer a perspective on inter-personal violence that often resulted from increased levels of stress, and in some cases, marked imperial expansion.

In the case of the Inka Empire, numerous sources have documented various manifestations of Inka warfare, and as a result, bioarchaeological analyses of perimortem insults can be used to substantiate such accounts (Arkush and Stanish 2005; Andrushko 2007). Drawing on similar types of data from the Wari Empire, Tung (2012) systematically documents perimortem injuries from three distinct archaeological contexts and maintains that many of the injuries she documented were the result of battle-related conflict.

An additional line of skeletal evidence that has been used to document violence and warfare among ancient empires is cranial trepanation. Traditionally it is thought that trepanations were performed to relieve one of the following conditions: cranial trauma, epilepsy, non-epileptic seizure disorders, or mastoiditis (Clower and Finger 2001; Andrushko and Verano 2008). Through the analysis of trepanations across eleven different sites, Andrushko and Verano (2008) maintain that in the case of the Inka Empire, trepanations were most likely

initiated to relieve infra-cranial pressure associated with traumatic injury sustained through violent conflict.

Another example of bioarchaeological research on imperially driven patterns of violence comes from the recently discovered cemetery at Puruchucho-Huaquerones (see Chapter 4). The large number of interments coupled with exceptional preservation makes this cemetery the largest ever Inka mortuary complex discovered. Though work is still underway on this unique burial assemblage, Murphy et al. (2010ab) and Gaither and Murphy (2011) have published two descriptions of trauma patterns, the former concerning adult members of the population and the latter documenting frequencies of traumatic injuries in children. When coupled together, these contributions indicate that levels of violence intensified as the empire waned after the arrival of the Spanish and that a dramatic social upheaval was marked by intra-indigenous conflict.

In an interesting shift away from inter-personal violence related to conflict, scholars have documented the presence of staged, ritualized violence in the Andes (Allen 1988; Parsons et al. 1997; Bolin 1998). Termed *tinku*, two neighboring communities met to engage in physical combat. Typically initiated at the start of a maize harvest or to gain prestige, the fundamental idea behind *tinku* is the release of blood as an offering. As Bolin (1998:95) observes, *tinku* “is not done in the mood of hostility.” Regardless, numerous injuries are often sustained and evidence demonstrates that the practice dates back to the time before Spanish

contact. As a result, both Andrushko (2007) and Tung (2012) observe that *tinku* might potentially represent a reason for observing skeletal trauma in bioarchaeological populations.

Lastly, numerous empires were known to participate in the practice of human sacrifice (Reinhard 1996, 1997, 1999, 2005; Andrushko et al. 2011). In the case of the Inka, numerous well-preserved mummies of children have provided physical evidence for the Inka ceremony referred to as *capacocha* (Reinhard 1996, 1997, 1999, 2005; Andrushko et al. 2011). In the case of the Inka, the mummies of children have been recovered from exceptional contexts, including archaeological sites from some of the highest altitudes in the world (Reinhard 1996, 1997, 1999, 2005). Typically, *capacocha* were selected from the populace who were thought to represent the most pronounced examples of physical beauty (Verano 2008; Andrushko et al. 2011).

Though many of these interments have been recovered from high-altitude contexts, recent discoveries from lower elevations have also been recorded. Andrushko and colleagues (2011) report a burial context from which seven children (aged 3-12 years) were buried together at the site of Chokepukio, Peru. Along with high status burial goods, two of these individuals had non-local strontium isotope signatures, a trait consistent with the practice of utilizing children from all realms of the empire (Andrushko et al. 2011).

Chapter Summary

In this chapter I have sketched out how anthropologists define and describe the characteristics of ancient empires. Moreover, I have demonstrated that two theoretical approaches have typically been applied to the study of archaeological empires: WST originally published by Wallerstein (1974) and the power continuum or territorial-hegemonic model originally introduced by Mann (1986). From these descriptions, it is clear that scholars have moved towards a nuanced interpretation of archaeological empires, particularly regarding notions of administration and control. Schreiber's (1992) model depicting imperial organization as a 'mosaic of control' aptly illustrates this approach.

I have also outlined how bioarchaeologists have developed a 'bioarchaeology of empire' and the various research topics they have addressed. I have attempted to demonstrate that contemporary bioarchaeologists draw on numerous analytical approaches to answer specific questions related to imperial organization and administration. While the study of the bioarchaeology of empire is in its infancy, it is clear that the themes outlined by Tung (2003) have provided a starting point for a more thematic and theoretically-grounded specialization within a broader bioarchaeology. As described in this chapter, scholars working in the Andes have contributed new information pertaining to both the Wari and Inka Empires. Moreover, the examples described in this chapter (i.e., *tinku* and *capacocha*) demonstrate that bioarchaeologists have supplemented the existing

literature on these imperial practices with bioarchaeological datasets. Without doubt, as more bioarchaeologists continue to investigate archaeological empires those themes outlined by Tung (2003) will continue to be examined. In the next chapter I will discuss key concepts related to the Inka, particularly regarding their social organization and resettlement policies.

Chapter 3 – The Inka Empire

“The great metropolis was first sighted by a cavalry vanguard. By all accounts it was unbelievable – it was alien – and it was magnificent.” (Michael E. Moseley 2001:7)

In this chapter, I describe the most salient characteristics of the largest civilization ever to emerge in the New World. Recent archaeological contributions (i.e., Wernke 2006; Burger et al. 2007; Malpass and Alconini 2010) have added fresh perspectives to Inka scholarship and have confirmed longstanding assumptions regarding the scope of Inka imperialism. While this new work has clarified the nuanced role of Inka administration, several fundamental characteristics of the Inka empire require further treatment in this chapter.

It is well understood that Inka elite consolidated their authority by around AD 1400 and began a campaign of territorial expansion shortly thereafter (Covey 2006; Covey 2008). By the time of the Spanish conquest in 1532, *Tawantinsuyu* or ‘the four parts together’ as it was known to the Inka, stretched for some 4,000 km across western South America and contained between 10-12 million people who represented countless numbers of distinct ethnic groups (Figure 2). As Moseley (2001:10) notes, “[t]he rugged Andean Cordillera housed a myriad large and small populations with distinct identities and strong separatist tendencies. This rich diversity played for an against empire building. Ethnic separatism made

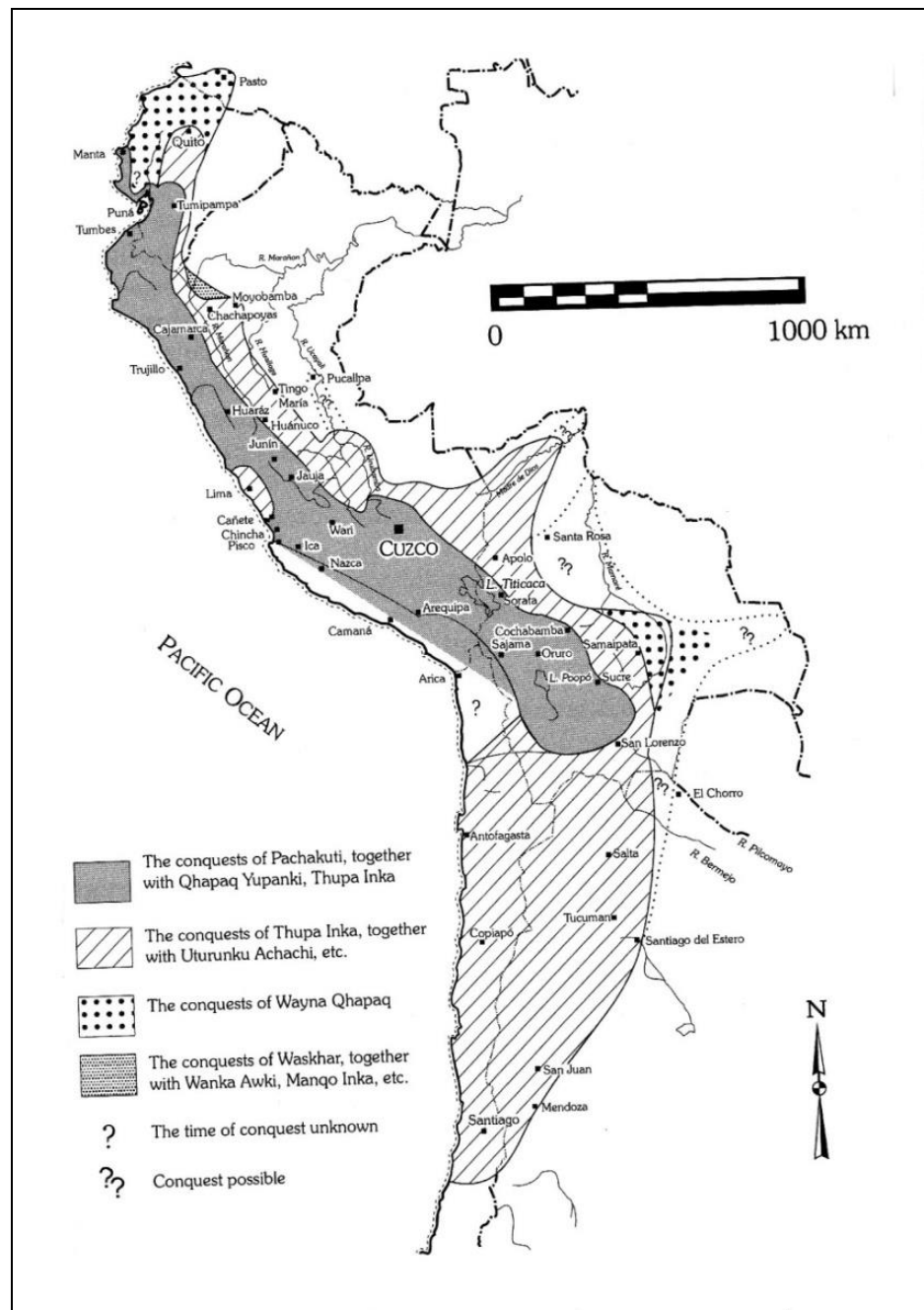


Figure 2. Extent of the Inka Empire⁵

⁵ After Pässinen (1992) and D'Altroy (2002:66)

conquest relatively easy, but consolidation extremely difficult.”

The four parts of the Inka Empire were known as Collasuyu, Antisuyu, Cuntisuyu, and Chinchaysuyu and were linked together through the centralized capital at Cuzco, located at the geographical and spiritual heart of the empire, in what is now Peru (Figure 3). Of these, the province of Chinchasuyu was most populous and Cuntisuyu was home to the least number of inhabitants. At its zenith, the four provinces were comprised of diverse ecological zones and contained countless natural resources (Hyslop 1990; Pärssinen 1992; D’Altroy 2002). Even today, each of these regions is characterized by remarkably diverse swaths of geography that stretch from the Pacific coast to the forests overlooking the Amazon (Moseley 2001). In between the Amazon Basin and the Pacific Ocean span two distinct ranges of the Andean Cordillera, along with a narrow strip of some of the driest desert in the world, the Atacama (Figure 4). Moreover, when the Inka rose to power in the 15th century, geography did little to stop their rapid pace of expansion and they were able to successfully extract resources from the wide diversity of ecological zones throughout their territory.

Though the Inka achieved a scale of complexity that was unrivaled in the Americas, scholars understand that the cultural developments in the Andes were millennia in the making. Social complexity in the Andes has often been characterized by large-scale periods of stylistic continuity (termed horizons)

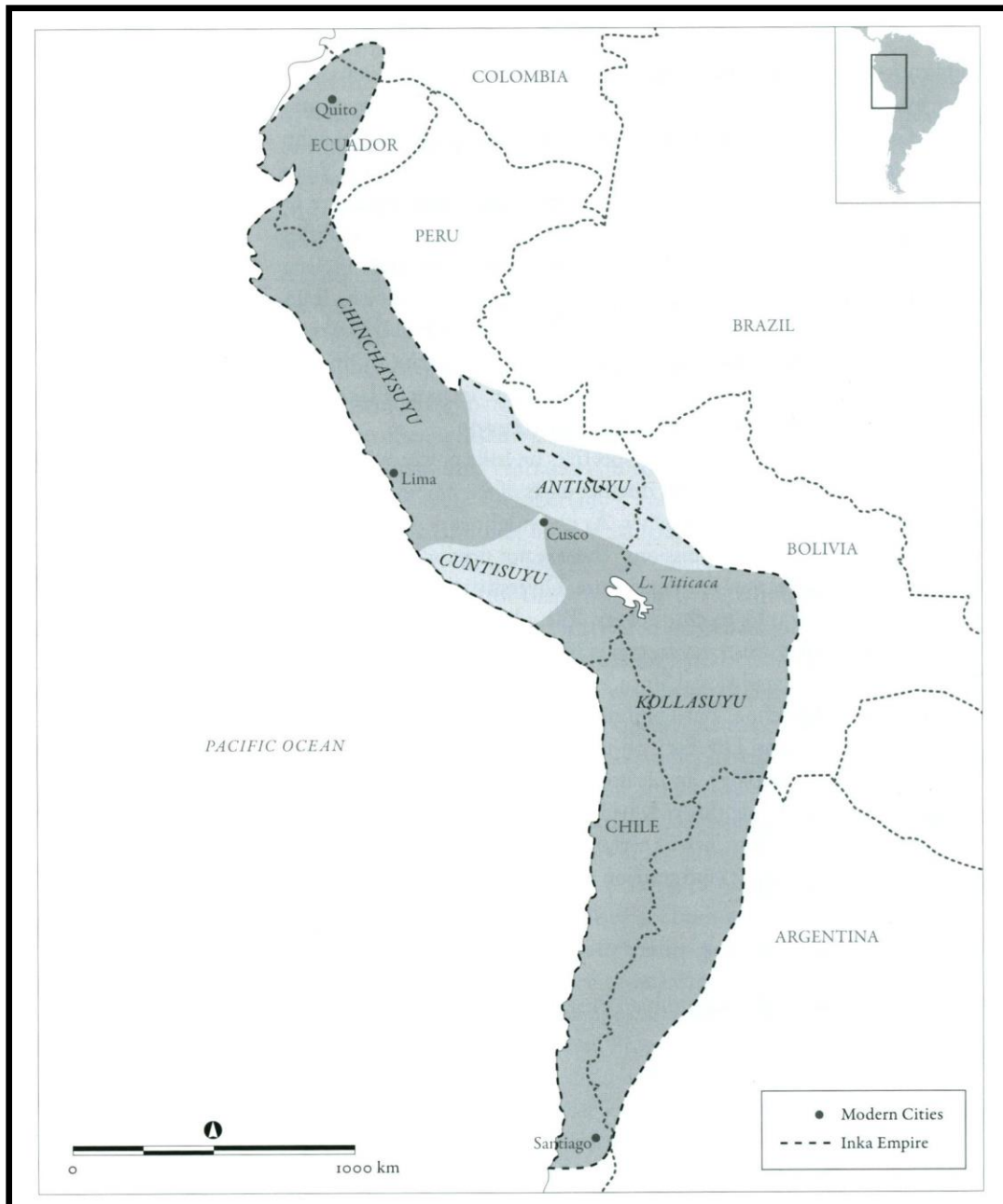


Figure 3. The Four Parts of the Inka Empire⁶

⁶ After Pillsbury (2007:x)

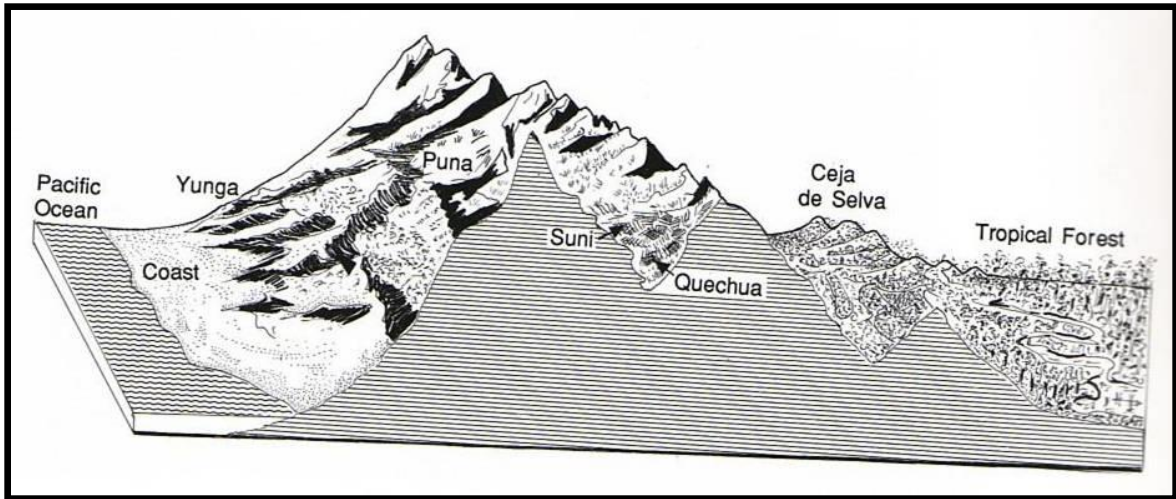


Figure 4. Cross-section of Andean geography⁷

⁷ Adapted from Burger (1992:21)

punctuated by intermediate periods of regional variation (Rowe 1960; Rowe 1962; Rowe and Menzel 1967; Lanning 1967; Moseley 2001) (Table 2). Accordingly, the Early, Middle, and Late Horizons parallel the widespread cultural influences of the Chavin (800 BC – AD 1), Wari (AD 600 – 1000/1100) and Tiwanaku (AD 600 – 1000/1100), and Inka (AD 1450 – 1532) polities. The horizons indicate widespread similarities across geography in terms of material cultural and socio-political organization while the intermediate periods were times of less far-reaching political influence and better reflect insular regional development in diverse localities. While these chronologies do provide a basic framework for cultural interpretations, several scholars have indicated that rigid temporal frameworks are not always universally accepted by Andean archaeologists (D’Altroy 2002; Conlee and Ogbun 2004; Silverman 2004). Silverman (2004) outlines numerous debates regarding the construction of Andean chronologies and competing frameworks for conceptualizing time.

While debate exists among archaeologists about how to conceptualize chronology, scholars agree that the Late Horizon is synonymous with the Inka and that it was a “short-lived phenomenon that lasted about a century” (D’Altroy 2002: 45). Given recent evidence derived from archaeological survey of the Cuzco region, researchers agree the Inka consolidated power sometime during the Late Intermediate Period, around AD 1400. The beginning of the Late Horizon is said to have begun in 1476 when the Inka occupied the Ica valley on Peru’s south

Table 2. Andean Chronology⁸

Time Period	Dominant polities	Dates
Late Horizon	Inka	AD 1450 – 1532
Late Intermediate Period	Regional polities	AD 1000/1100 – 1450
Middle Horizon	Wari and Tiwanaku	AD 600 – 1000/1100
Early Intermediate Period	Regional polities	AD 1 – 550/600
Early Horizon	Chavín	800 BC – AD 1

⁸ (See Willey 1991; Tung 2012)

coast (Rowe 1962; D'Altroy 2002; Andruskho 2007; Covey 2008). Given that the Spanish Conquest occurred a mere 56 years after this defining period, the relatively brief time during which the Inka flourished serves to further complicate our understanding of the Inka's influence across their empire.

Ethnohistorical Accounts from the Chronicles

Scholarship on the Inka Empire is extensive and comprises a rich literature from ethnohistorical sources. The first group of these written accounts can be traced to the 16th century with documented Spanish colonial recordings of Inka socio-political organization (D'Altroy 2002; Covey 2008). As Covey (2008) notes, the first 350 years of Inka scholarship almost exclusively relied on documents written by both Spanish and Andean authors. These sources were invaluable contributions as they gave descriptions of countless aspects of Inka culture, ranging from origin myths to descriptions of many imperial policies. For example, in the case of Felipe Guaman Poma de Ayala's work *El primer nueva corónica y buen gobierno* ["The First New Chronicle and Good Government"] (1615), the author produced hundreds of fine line drawings that offer ephemeral glimpses of life throughout the empire (Figures 5 and 6). Structured as a letter of more than 1000 pages written to King Felipe III of Spain, Guaman Poma's primary objective was to document and describe the invasion and conquest of Peru (Adorno 1986).

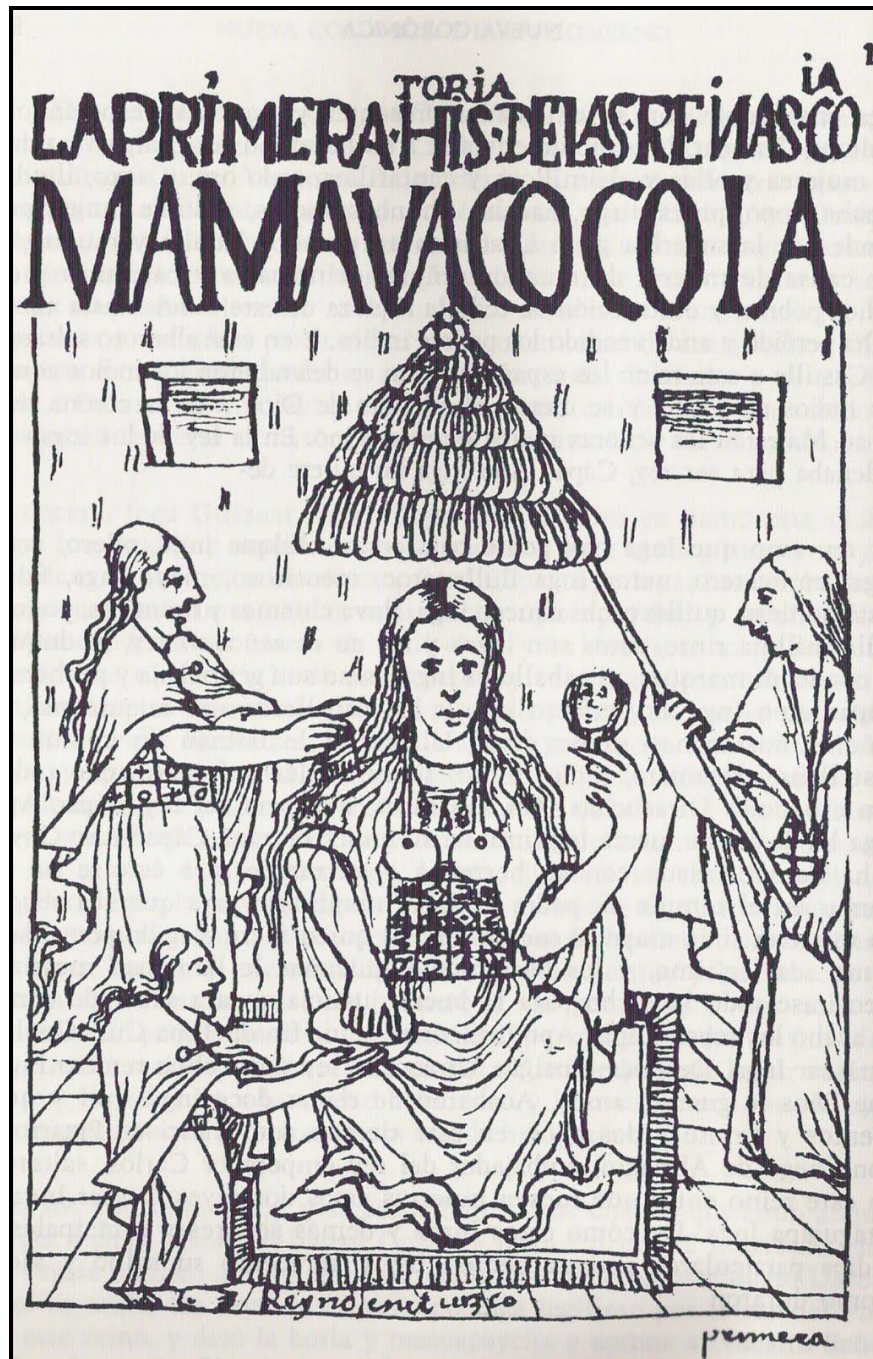


Figure 5. Plate from Guaman Poma depicting a *mamacona*

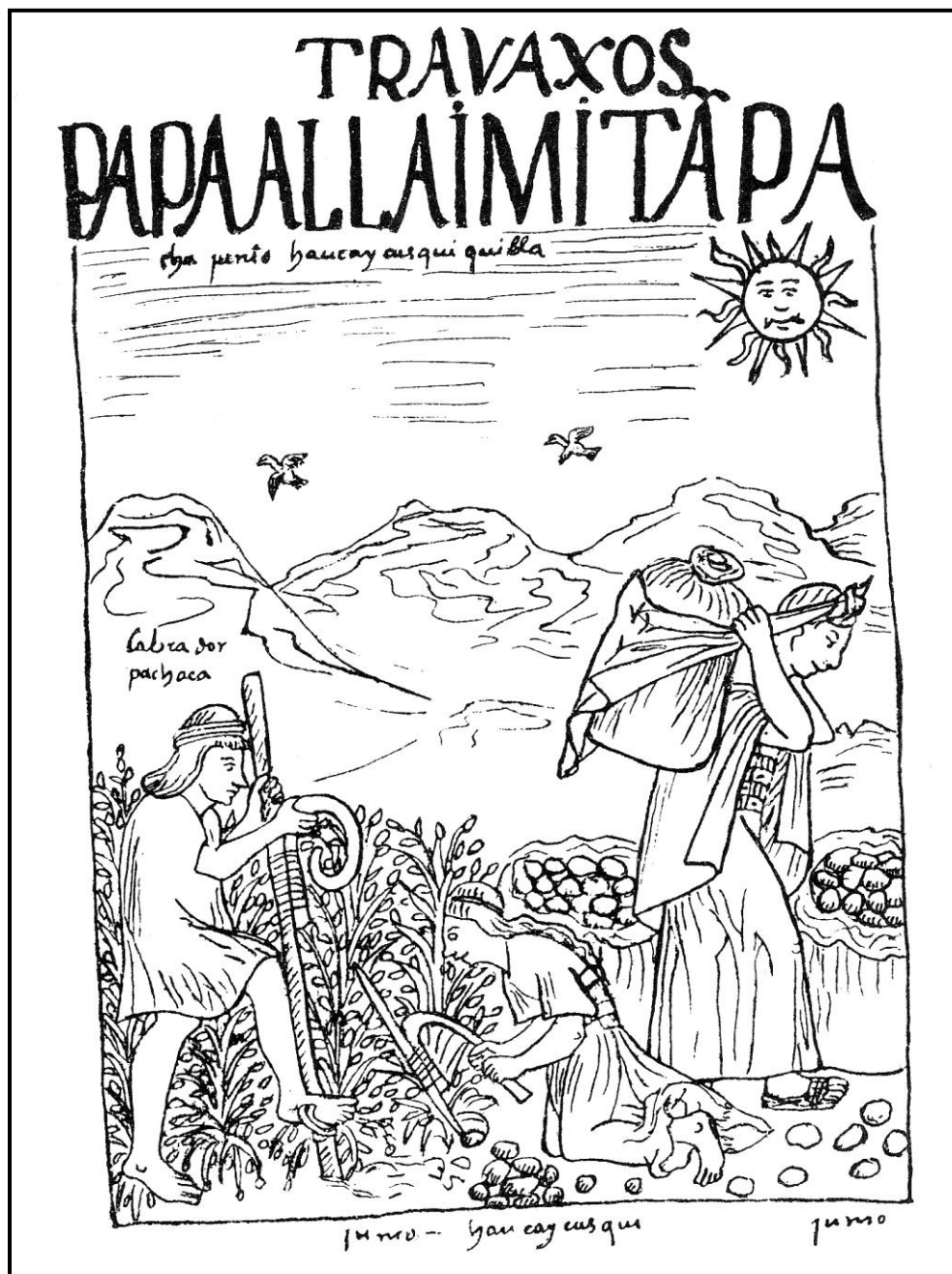


Figure 6. Plate from Guaman Poma depicting *mit'a*

[“The Chronicle of Peru ”] (1553) provides a detailed description penned during a three year journey across the north realm of the empire. In this four-volume work, Cieza documents numerous aspects of Inka culture (D’Altroy 2002). Other examples of the early chronicles include the royal accounts described in Juan de Batanzos’ *Suma y narración de los Inca* [“Summary and Narration of the Inca ”] (1557), Garcilaso de la Vega’s *Comentarios reales de los Incas* [“Royal Commentaries on the Incas”] (1609), Sarmiento de Gamboa’s *Historia de los Incas* [“History of the Incas”] (1572), Cristóbal de Molina’s *Relación de la fábulas y ritos de la Incas* [“Account of the Fables and Rites of the Incas”] (nd), and Bernabe Cobo’s *Historia del nuevo mundo* [“History of the New World”] (1653). Still as D’Altroy (2002) notes, other chroniclers contributed to the historiography of the Inka. These individuals include but are certainly not limited to Bartolomé de las Casas, José Arriaga, José de Acosta, Francisco de Avila, Domingo de Santo Tomás, and Diego González Holguín. Regardless of the author, it is important to note that analyses of the chronicles by anthropologists and historians have highlighted their limitations (Hiltunen and McEwan 2004). Nevertheless, the ethnohistorical record remains an important contribution to Inka scholarship.

While colonial accounts have been useful for contemporary archaeologists who utilize the information to test specific assumptions about the Inka against archaeologically-derived data, “modern historians of the Incas view these Spanish

accounts with some distrust. The consensus is that whatever the Spanish historians of the Incas said must be interpreted with much circumspection” (MacCormick 2001: 331). In other words, archaeologists understand the limitations of colonial-era documents and contemporary scholars no longer exclusively rely on the historical record. Turning to the mid-20th century onward, the contributions of four scholars have been recognized as vital to the development of Inka scholarship over the last six decades. These scholars, John Howland Rowe, John Murra, María Rostworowski, and Tom Zuidema are well known for their contributions that have shaped both ethnohistorical and archaeological interpretations. Recently, Morris (2007) summarized the contributions of each of these scholars in an influential volume that synthesized the diverse expressions of Inka power.

Turning now to other aspects of the empire, the entire realm of the Inka was governed by a heredity king who was believed to be part of an unbroken lineage divinely sired by the Sun God, *Inti* (D’Altroy 2002). In total, thirteen different emperors were claimed to be part of this lineage, though specific dates have not been ascribed to the first seven rulers (Table 3). The monarch, known as the *Sapa Inka*, while all powerful, did not rule alone. In fact, the Inka were known to intentionally transform the deceased body of each emperor into mummies (D’Altroy 2002). The mummified remains of each emperor (as well as

Table 3. Succession of Inka Emperors⁹

Emperor	Moeity	Panaqa (royal kin group)	Possible Dates of Reign
Manqo Qhapaq	Hurin Cuzco	Chima panaqa ayllu	Specific dates remain unknown
Zinci Roq'a	Hurin Cuzco	Rawra panaqa ayllu	
Lloq'e Yupanki	Hurin Cuzco	Awayni panaqa ayllu	
Mayta Yupanki	Hurin Cuzco	Uska Mayta panaqa ayllu	
Qhapaq Yupanki	Hurin Cuzco	Apu Mayta panaqa ayllu	
Inka Roq'a	Hanan Cuzco	Wika K'iraw panaqa ayllu	
Yawar Wapaq	Hanan Cuzco	Awqaylli panaqa ayllu	
Wiraqocha Inka	Hanan Cuzco	Zukzu panaqa ayllu	Deposed AD1438
Pachukuti Inka Yupanki	Hanan Cuzco	Hatun ayllu	AD 1438 - 1471
Thupa Inka Yupanki	Hanan Cuzco	Qhapaq ayllu	AD 1471 - 1493
Wayna Qhapaq	Hanan Cuzco	Qhapaq ayllu	AD 1493 - 1527
Waskhar	Hanan Cuzco	Tumipampa panaqa ayllu	AD 1527 - 1532
Atawallpa	Hanan Cuzco	--	AD 1532 - 1533

⁹ (Adapted from Rowe 1945, 1946; D'Altroy 2001, 2002; Andruskho 2007).

bodies of the emperor's wives) were then maintained by specialized attendants.

At specific times of year, such as around the June solstice (at a festival called *Inti Raymi*), the mummies were brought out and paraded in grand fashion.

MacCormick's (2001: 329-300) translation of Miguel de Este's chronicles summarizes the moments of the final enactment of this festival in 1534:

“... and so they brought them down, singing ballads and giving thanks to the Sun for having allowed them to expel their enemies from the land. . . . Accompanied by countless people they reached the main square, with Manco Inca in his litter at the head, and by his side the body of his father Guayna Capac. Behind came all the other Inca rulers in litters, embalmed and with diadems on their heads. In the square, stalls had been prepared for each one of the dead, where they were placed in order of rank, each seated on a stool, surrounded by pages and ladies holding fly wisks, who showed them the same respect as when they were alive.”

Centered in Cuzco, the Inka emperor proclaimed his imperial ideology through a mixed strategy that relied on direct force, as well as diplomatic coercion. In some instances provincial territories were assumed quickly into the empire while others, like the Chimor kingdom from the north coast of Peru, offered fierce resistance to Inka domination and were not conquered until a few decades before the arrival of the Spanish (Mackey 2010). Incorporation and control of diverse groups of people required an extensive infrastructure for communication and extraction of resources. As a result, the Inka are known for having built approximately 40,000 km of roadways to transport both people and goods throughout the empire (Hyslop 1984). Known as the *qhapaq ñan*, the Inka road

system represents a hallmark of their engineering achievements in less than 100 years' time. In addition, Bauer (2006) describes an elaborate system of suspension bridges that Inka engineers incorporated into this vast transportation network. As Covey (2008) notes, the rapid expansion of the empire required an immense infrastructure for moving caravans, military personnel, and facilitating an astounding transportation network.

The Inka were adept at managing their imperial affairs through a network of provincial installations situated along the roadway (Hyslop 1984; D'Altroy 2002; Covey 2008). Known as *tampu* (or sometimes *tambo* in Spanish), these structures were most likely lodgings that provided travelers with easily accessible stopping points along the roadway. Hyslop (1984; 1990) estimated that as many as 2,000 *tampu* were constructed and Morris (1972) notes that they were typically located at strategic points of long distance movement. Ultimately, these installations provided numerous kinds of services such as housing for travelers, while others have yielded data suggesting that they were used for craft production and/or administrative activity. As Covey (2008) asserts, *tampu* often reflected local variations in road construction and the implementation of construction projects was diverse and variable. Though no archaeological excavations have taken place at the Late Horizon site of Colmay (which forms part of this study sample) Andrushko (2007) suggests that it perhaps functioned as a *tampu* due to its proximity to a known portion of the Inka road system, as well as having

hallmarks of imperial architecture that it retains today (see Chapter 5). Few bioarchaeological studies have examined skeletal remains from *tampu* contexts; therefore, no comparative datasets exists to which this assemblage can be compared.

Other examples of Inka infrastructure include those related to intense economic production, such as sites that functioned as either state farms or food storage facilities. Regarding state-controlled farms, these agro-production zones tended to be located in the most fertile ecological regions such as the coastal or Amazonian piedmont, both of which were conducive for growing maize, coca, and cotton (Spurling 1982; D'Altroy 1992; Covey 2008). Moreover, these areas were often transformed into irrigated terraces to increase production, though many of these were never put into use due to the arrival of the Spaniards (Albeck and Scattolin 1991; Nielsen 1996). State-run storehouses were engineered by the Inka for the purpose of storing agricultural surpluses generated from imperially administered agricultural fields (Wachtel 1982; LaLone and LaLone 1987; Gyarmati and Varga 1999). Examples of food storage facilities have been described throughout the empire, particularly in areas well-known for agricultural production like Cochabamba, Bolivia and the Upper Mantaro Valley, Peru (D'Altroy 1992). As Covey (2008) notes, administrative centers typically had somewhere between 200-500 structures, while less-regulated locales tended to have fewer.

Defensive fortifications, a necessary feature of empire described by Schreiber (2002), illustrate an additional example of the complexity of Inka infrastructure, though they are not present in great numbers throughout the empire (D'Altroy 2002). Those fortifications that have been documented in the Inka empire are spatially closer to frontier regions (Hyslop 1988; Bray 1992; Alconini 2004). Other examples of monumental Inka architecture, such as the well-known sites of Ollantaytambo and Sachsawaman (each centered around the Cuzco heartland), demonstrate striking examples of Inka infrastructure. However, scholars still debate the military functions of each of these sites, as they may have served to limit the flow of traffic into Cuzco, rather than having an explicitly militaristic function (Rawls 1979; D'Altroy 2002; Stanish and Bauer 2007). Moreover, Salomon (1986) asserts that military fortifications located around present-day Quito, Ecuador were most likely staffed with colonists relocated from numerous locations. The southern frontier was also heavily fortified, clearly indicating an intense interest on behalf of the Inka to secure and stabilize their rather nebulous border regions (D'Altroy 2002; Alconini 2004; Acuto 2008).

When considering the Inka's success at incorporating new territory and the populace therein, numerous scholars have pointed to the Inka's use of ideology as a primary means of control. Perhaps of all ideological tools of control, none was more utilized than the pan-Andean concept of ancestor veneration (Urton 1999; D'Altroy 2002). Ancestor veneration provided a common link between all

members of kinship groups, typically referred to as an *ayllu*. The *ayllu* is of fundamental importance in the Andes, as it is the basis for economic production. Moreover, the *ayllu* serves to unite distant members of kin groups by linking them together to a common ancestor (Moseley 2001). Many *ayllu* could trace their lineages to the physical remains of the long-deceased relatives, sometimes intentionally preserved as mummies called *mallki* or occasionally represented by less complete sets of human remains (Carmichael 1995; Moseley 2001; Gaither et al. 2009). As mentioned previously, the importance of these ancestors reached the zenith of Inka social hierarchy, as the *Sapa Inka* relied on the mummified remains of his predecessors for advice and collaboration and were attended to regularly, as was described by Pedro Pizarro (1986:89-90) (as cited by D'Altroy 2002:97):

“...(m)ost of the people [of Cuzco] served the dead, I have heard it said, who they daily brought out to the main square, setting them down in a ring, each one according to his age, and there the male and female attendants ate and drank. The attendants made fires for each of the dead in front of them with firewood that they worked and cut until it was quite even, very dry, and lighting [them], burned everything they had put before them so that the dead should eat of everything that the living ate, which was what was burned in these fires. The attendants also placed before these dead certain large pitchers...and here they poured out the chicha¹⁰ that they gave the mummies to drink, showing it to him, [and] the mummies toasted each other and the living, and the living toasted the dead.”

Turning now to archaeological indicators of Inka influence, perhaps no type of material culture signals Inka presence more so than pottery. As D'Altroy

¹⁰ *Chicha* is a type of beer fermented from maize.

(2002: 304) notes, “Cuzco-style polychrome pottery is the archaeological hallmark of Inca presence throughout the Andes.” According to scholars, while imperial ceramics were produced in Cuzco and dispatched throughout the imperial core, they can also be found at sites from all over the empire (Rowe 1946; Bauer 2004; Covey 2008). Imperial polychrome styles were often imitated in the provincial regions and archaeologists have long-recognized the presence of regional variants that are hybrids of imperial and local forms. Additionally, a hallmark of Inka influence on pottery styles is the physical form of the vessel. Perhaps the most ubiquitous Inka pottery form is the *aríbalo* style, or the form typified by flared-rim jars with constricted necks (Figure 7).

According to D’Altroy (2002), despite the archaeological significance of Inka pottery, ceramic production comprised just a small part of the Inka economy. He notes that while pottery-manufacturing was an important task related to production, it was considered to be of less importance than those tasks associated with textile production, feather work, and metallurgy. D’Altroy (2002:307) illustrates this point by describing the number of laborers dedicated to both ceramic and textile production and the sites of Huánuco and Milliraya – in both cases there were ten times the number of weavers as potters. Incidentally, numerous authors also describe the common frequency of non-Inka pottery styles found at locales throughout the empire, the presence of which may indicate relocated individuals (Lorandi 1984; Williams and Lorandi 1986; Williams 1996).



Figure 7. Illustration of *aryballoids* pottery style¹¹

¹¹ Bingham (1930)

In examining examples of the Inka's use of metallurgy, it becomes clear that Inka craft specialists achieved a level of sophistication that rivals even the most modern 21st-century technology. Unfortunately, as Lechtman (2007:313) reminds us, the majority of Inka metal objects were melted down as part of Atawallpa's ransom: "if it were not for eyewitness accounts of the first invaders...who saw the gold- and silver-clad palace and temple walls of Cusco....we would have no idea of the vast quantities of gold and silver mined, processed, and made into objects for use by the state." Lechtman (2007) further describes the three-component metallurgical system developed throughout the Andes which relied heavily on copper, silver, and gold. Clearly, as Lechtman asserts, by the time the Inka rose to power in the 15th and 16th centuries, Andean metal smiths were well versed in generating objects that fulfilled numerous roles for the state and exemplified elaborate social hierarchies. Moreover, Van Buren and Presta (2010) reiterate the importance of state-sponsored resource extraction through the way in which controlled labor was used to mine silver ore throughout the provinces.

Despite the complex number of bureaucratic tasks associated with administering an empire, the Inka were not known for having utilized a written alphabet to record or transmit information. To the contrary, they developed a well-known system of record keeping on a knotted string instrument called a *quipu* (Asher and Asher 1981; Urton 1997; D'Altroy 2002) (Figures 8 and 9).



Figure 8. Plate from Guaman Poma depicting a *khipu kamayuq*



Figure 9. Khipu example¹²

¹² From the collections of the Musee Quai Branly, Paris, France.
http://khipukamayuq.fas.harvard.edu/images/KhipuGallery/MiscAlbum/images/Musee%20Quai%20Branly_jpg.jpg

Though the *kipu* is most often associated with the Inka, it is clear that the tool dates back for almost 1000 years prior to the rise of the Inka Empire and several hundred artifact examples still exist today (Salomon 2004). *Khipu* consist of a series of pendant cords that are suspended from a top cord. Pendant cords can be dyed a number of different colors and present varying numbers of tied knots that are spaced at variable intervals. The direction of the knot records information, as do the number of knots on each pendant cord. According to D'Altroy (2002:18), *kipu* "were used to record a wide range of numerical data, from census records, to warehouse contents, counts of the royal flocks, tax obligations, land measurements, military organization, and calendrical information." Each *kipu*, regardless of the type of information it recorded, was maintained by an administrative specialist called a *kipu kamayuq* and this position was passed hereditarily down male lineages (D'Altroy 2002; Urton and Brezine 2007). Though the 'code' of the *kipu* has yet to be definitively deciphered, numerous scholars are contributing to the analysis of this recording instrument via the ongoing Khipu Database Project: <http://kipukamayuq.fas.harvard.edu/>.

Inka Resettlement Policies

In an in-depth treatment of imperial relocation policies, Ogburn (2001) asserts that all ancient empires engaged in the practice of resettlement in some form or another. He argues that while many of these population movements were intentionally short-term, other forms were more permanent. Ogburn (2001) also

contrasts resettlement that occurred over short distances with those that were more long-distance in nature. In other words, some empires relocated individuals on an intra-local level while others intentionally moved individuals across tremendous spans of geography. In the case of the Inka, it is clear that their relocation policies were unmatched in the Americas: “no ancient state altered the ethnic landscape within its territory as drastically as did the Inca Empire, where many thousands of people were relocated over hundreds of kilometers across the expanse of the imperial domain” (Ogburn 2001: 10).

It is well known from the written record of Spanish chroniclers that Inka administrators relocated individuals throughout the empire and utilized a diverse system of relocation strategies (Garcilaso de la Vega 1966 [1653]; Cobo 1979 [1653]; Cieza de León 1984 [1553]). Under this system, individuals and sometimes entire communities were called on to perform variable and diverse tasks for the state. As D’Altroy (2002) notes, the Inka oftentimes relocated people to ecologically-similar zones or exchanged groups from two comparable locales with one another. Individuals who were resettled throughout the empire were referred to as *mitmaqkuna* (written *mitmaq* in the singular form, or *mitima* in the hispanicized singular) and scholars generally agree that the term *mitmaq* can be interpreted to mean “colonist” or “foreigner” (Rowe 1982; Ogburn 2001; D’Altroy 2002). As Rowe (1982:96) notes, regardless of context, *mitmaqkuna* is a term that implies an individual lived outside of their place of ethnic origin.

As D'Altroy (2002:248) observes, the purpose of Inka resettlement was threefold: 1) to disperse potentially rebellious groups that posed a threat to Inka security; 2) to aggregate economic specialists into highly profitable production enclaves; and 3) to claim a "divine mandate" over the Andean corridor. In some cases, colonists were relocated to staff garrisons and other fortifications. Those who specialized in economic production were often moved to economic zones rich in raw materials, and still others were moved to work on agricultural projects near state farms (Wachtel 1982; D'Altroy 2002; Van Buren and Presta 2010). Though exact numbers of *mitmaqkuna* are both regionally and site-specific, it is clear that the number of affected individuals in any one place could be tremendously high. In describing the number of affected individuals, Rowe (1982: 107) remarked, "an impressionistic estimate is that the proportion of *mitimas* in the population of different provinces varied between about 10% and about 80%." Such a diverse estimate suggests that the Inka's approach to resettlement was tailored to particular regions and that their use of *mitmaqkuna* was not unified across the empire. This underscores previously described work of Menzel (1959) who was the first person to reach this conclusion through the use of archaeologically-derived data.

Regardless of the context, *mitmaqkuna* were continually reminded of imperial politics, as they were required to maintain their traditional customs (i.e., language and dress) (D'Altroy 2002). Though the arrival of *mitmaqkuna* signaled

Inka presence for one reason or another, it is clear that local individuals who came into contact with resettled people had a diverse array of reactions. As D'Altroy (2002) observes, sometimes bitter resentment persisted as *mitmaqkuna* were awarded the most valuable parcels of land while in other instances, positive relationships were sometimes cultivated.

In contrast to *mitmaqkuna* who were typically relocated for long periods of time, and in many cases, permanently resettled for the duration of their lives, short-term resettlement was also utilized by the Inka. This system was entirely based within the scope of the Inka's political economy and involved a type of rotating labor service called *mit'a* (Rowe 1982; Murra 1982; 1983; Moseley 2001; D'Altroy 2001; 2002). Under this system, various products and services required by the Inka state were procured through the *mit'a system* and LeVine (1987) asserts that this system was critically necessary for the Inka state to fund its activities.

As D'Altroy (2002) summarizes, the Inka made this system of labor extraction work by carefully analyzing data related to the taxpaying population. Often described as a system of *supply on command*, the rotating labor tribute system was designed to maximize yield for the Inka state (LaLone 1982, 1994). The Inka knew what goods were produced in local areas, the skillsets of the individuals who produced those resources, and the maximum number of individuals who could be removed at once from any given location. Workers

were separated based on their abilities and it appears that the Inka differentiated between various classes of artisans based on the types of wares they produced (Murra 1986). Julien (1982) summarizes an example of Inka administration from the Huánuco province in the the Lake Titicaca region and presents data which suggests that a diverse array of craft specialists and other workers had been settled there.

Through the analysis of ethnohistorical sources, it is clear that *mit'a* obligations were typically paid by male heads of households aged anywhere from 25-50 years (D'Altroy 2002). Specific types of *mit'a* obligations were diverse and variable, as were the recipients of the *mit'a* labor tax. As Murra (1982:238) notes, "in each ethnic territory the Inka carved out estates that henceforth produced food, cotton, maize, or wool for the crown, the several state cults, and the royal lineages." Though ubiquitous throughout the empire, *mit'a* tribute obligations were not applied equally in all locales. As numerous scholars point out, in many instances local elites in various regions of the empire were charged with the task of deciding how many individuals would be relocated at a time (Polo 1916; Moore 1958; D'Altroy 2002).

An additional characteristic of the Inka's labor tribute system was further specialized labor classes (Covey 2009; Quave 2012). Unskilled laborers were often replaced with craftspeople further broken down into distinct classes: *kamayukuna* or labor specialists, *yanakuna* or lifelong retainers, and *aqllakuna*

or chosen women. *Kamayuqkuna* were often relocated to perform specific tasks such as military service or construction projects. *Yanakuna* are often described as those individuals who staffed elite residences or palaces. Verano (2003) and Turner et al. (2009) suggest, for example, that *yanakuna* staffed the elite residential palace of Machu Picchu. Moreover, in describing *yanakuna* the Spanish chronicler Santillán penned the following description in (1879:39[1563]):

“The Inca [ruler] took from each valley or province the number of yanaconas he wanted and assigned them to himself. These were chosen from the best people, most of them sons of curacas¹³ and people of strength and good disposition. As his ‘criados’ he made them exempt from the authority of the curacas, who had no responsibility for them; rather, the Inca governor kept them occupied in affairs relating to his service. Some [the ruler] took to Cuzco and retained in his own service, and these he sometimes made curacas in their provinces. Others he assigned to the houses of the dead rulers.”

Aqllakuna were females who were removed from their homes around 10 years of age, sequestered in special housing called *aqllawasi* and taught specific skills such as weaving and chicha-making. Perhaps the best well-known example of an *aqllawasi* comes from the ritual center of Pachacamac located near Peru’s capital city Lima and excavated in 1896 by Max Uhle (see Chapter 5). It is from this site that 46 crania (likely representing the *aqllakuna* themselves) were taken from Peru to the University of Pennsylvania. Unfortunately, during the mid-20th century, the collection was donated to the University of Pennsylvania medical

¹³ Curacas (Kurakas) were individuals who were incorporated into the Inka’s system of administration. They were not ethnically Inka and typically represented a class of local elites (Rowe 1982; D’Altroy 2002; Wernke 2006).

school and subsequently misplaced for many decades. In August 2009, a subset of the crania was rediscovered in a closet of the University's medical school and is included in this sample (see Chapter 5). Recently, Carol Mackey (2010) describes what she considers an *aqllawasi* from Peru's north coast site of Farfán; however, bioarchaeological analyses of the mortuary sample are preliminary.

Though many questions remain regarding the Inka's use of population resettlement, it is clear that potentially tens of thousands of individuals and/or households were moved throughout the empire as part of an elaborate labor tribute system. Such a notion is supported by recent bioarchaeological studies of Inka mortuary contexts, though many regions from the Inka Empire are conspicuously absent in these analyses. Despite the tremendous amount of scholarship that has described the Inka Empire in detail, very few studies have examined Inka imperialism from a bioarchaeological perspective. This reason is due in part to the relatively few number of Late Horizon or Inka sites that have yielded undisturbed mortuary contexts. The work described in the remainder of this study attempts to contribute to that discussion.

Chapter Summary

In this chapter, I have outlined the most salient characteristics of the Inka Empire. While summarizing every aspect of the Inka and their complexity is beyond the scope of this study, I have nevertheless attempted to demonstrate that both ethnohistorical sources and archaeological research have influenced current

interpretations about the Inka. Moreover, I have documented that the Inka were known for devising a labor tribute system that drastically changed the composition of the populace. Individuals were moved around the territory of the empire to levels that had never previously been seen prior to the imperial Inka state. In the next chapter I will discuss the fundamental concepts related to biological distance analysis and how this method of bioarchaeological inquiry can help elucidate information regarding population resettlement orchestrated by the Inka state.

Chapter 4 – Biological Distance

“The ongoing bioarchaeological study of large Inca mortuary populations should yield unprecedented insights into ethnicity and migration, advancing Inca studies in areas where the chronicles are completely silent.” (Covey 2008: 825)

Bioarchaeology and Biological Distance

Though labor tribute has been described in both the ethnohistorical and archaeological literature, few bioarchaeological studies have attempted to quantify the result of these practices on individuals living under Inka imperial rule. It is hypothesized here that bioarchaeological approaches that utilize **R** Matrix analyses of craniometric data may offer some insight into phenotypic variation resulting from the Inka’s socio-political practices related to intentional population resettlement. Given that individuals from diverse locales throughout the Andean Cordillera and Pacific Coast were often moved to live out the duration of their lives in new areas, some Inka cemetery contexts might appear exceptionally heterogeneous. On the other hand, locales that were not affected by resettlement policies may have been buffered from an infiltration of outsiders and maintained a more homogenous composition. Regardless of the scenario, biological distance analysis offers a unique approach to the study of Inka cemetery structure that may in turn offer some insight into the extraordinarily complex labor tribute system.

Interest in biological distance analysis has a long history within the field of biological anthropology and bioarchaeology. In fact, attention to population

structure and characterization of groups can be traced back to times that predate biological anthropology as a discipline. Examples illustrating this early interest have been described by Cook (2006) and include works such as Johann Friedrich Blumenbach's (1775) *De generis humani varietate native* ["*On the Natural Varieties of Mankind*"] and Samuel George Morton's (1839) *Crania Americana: or A Comparative View of the Skulls of Various Aboriginal Nations of North and South America*. In these early treatments, the authors utilized human skeletal remains, particularly measurements of the cranium, to examine similarities and differences between groups.

Konigsberg (2006) traces trends in biological distance analyses after the 1960s and reiterates that scholars interested in bioarchaeological questions began using biological distance analyses to answer questions related to the role of external migration in shaping population structure. Recently, Stojanowski and Schillaci (2006) synthesize over 400 sources that trace both the methodological and theoretical histories of biological distance analysis. In addition to describing the overarching foci of biological distance studies, Stojanowski and Schillaci (2006) examine numerous approaches to the study of intracemetery biological variation and provide a thorough overview of five distinct lines of inquiry (i.e., kinship, postmarital residence, cemetery variance, temporal microchronology, and age-structured phenotypic variation). Clearly, biodistance analyses have offered a

great deal of insight to numerous anthropological contexts, as scholars have long-recognized the importance of examining population structure.

The goal of this chapter is to define biological distance analysis and to introduce the methodological and theoretical concerns related to estimating population structure from human skeletal remains. Moreover, the vexing issue of cranial vault modification will be discussed, as will the paucity of studies that have utilized biological distance analysis to investigate Inka population structure.

According to Buikstra et al. (1990:1), “biological distance or ‘biodistance’ refers to a measurement of population divergence based on polygenic traits.” Similarly, Stojanowski and Schillaci (2006) maintain that biodistance analysis attempts to assess genetic similarities and differences of populations through the analysis of various kinds of phenotypic traits. Stojanowski and Schillaci (2006:49) assert that biodistance analyses enable researchers to examine patterns of gene flow and genetic drift, population origins, and long-distance migration. In other words, as discussed by Relethford and Lees (1982), biodistance analysis supports the notion that the interaction between both biological and cultural factors shape both human micro and macroevolution. Ultimately, as Buikstra et al. (1990:4) succinctly note, patterns of “biological variation can often be interpreted in terms of population history.” It should also be noted that in terms of scale, biodistance analyses range from large global studies which investigate continental or large-scale regional diversity (i.e., Ousley 1995; Relethford 2001, 2002, 2004) to those

studies interested in examining intra-site population variation (i.e., Alt and Vach 1998; Doran 2002; Schillaci and Stojanowski 2002; Stojanowski and Schillaci 2006).

Biodistance Datasets

Both metric and nonmetric datasets can be used to conduct biodistance analysis and both classes of data have been used extensively in biological anthropology and bioarchaeology. Typically in metric analyses, investigators utilize standard osteometric tools to record linear distance measures between specific osseous or dental landmarks. These linear distance measures can be taken from the cranium, dentition, or post cranial skeletal elements (Buikstra and Ubelaker 1994). Moreover, recent approaches involving three-dimensional data have been published and some researchers have elected to capture data in this way (Richtsmeier et al. 1992; McKeown 2000; Ousley and McKeown 2001; Richtsmeier et al. 2002; McKeown and Schmidt 2013). While post-cranial measurements have been used, they are not utilized as frequently as cranial or dental metrics, as some researchers maintain that environmental influences blur underlying genetic information (Stojanowski and Schillaci 2006).

As the discipline of physical anthropology emerged during the 20th century, metric approaches to quantifying variation have dominated the discipline. As mentioned previously, Konigsberg's (2006) historical review of biological distance studies highlights Long's (1966) role in legitimizing craniometric

approaches to biodistance analyses. Certainly, the influential works of Jantz (1973) and Howells (Howells 1973, 1989, 1995) served to spur interest in craniometric approaches to biodistance analysis during the latter part of the 20th century. The exceptionally influential work of Relethford and Blangero (1990) and subsequent applications of the **R** Matrix demonstrate the utility of odontoskeletal metrics for applying a population genetic approach to biological distance. Moreover, forensic anthropologists commonly rely on craniometric data in their attempts to classify, group, and identify unknown individuals from forensic contexts. For example, the software packages *FORDISC 3.0* (Jantz and Ousley 2005) and *CRANID 6* (Wright 2012) require users to input craniometric information before classifying unknown crania against known reference populations. Recently, Slice and Ross (2009) introduced an additional software package called *3D-ID* for classifying crania via geometric morphometric approaches. Ultimately, metric variables of the cranium have been more heavily utilized than any other portion of the skeletal system in biological distance analysis.

During the late 1960s and early 1970s, other approaches to biological distance analysis entered the discipline. These studies began utilizing an entirely new type of data in the form of non-metric traits to address questions related to population structure and biological distance. Non-metric traits, sometimes called discrete or discontinuous traits, can be observed but they cannot be measured in

the same way as metric distances and they are understood to have a “polygenic mode of inheritance” (Stojanowski and Schillaci 2006:53). As a result, non-metric traits are only observable (i.e., present) when numerous genes act concurrently along with environmental influences to push trait past a threshold of expression (Cheverud and Buikstra 1981; Hauser and DeStefano 1989). Typically, non-metric traits take the form of ossicles, varying numbers of foramina, or hyper/hypostatic bony variants (see Buikstra and Ubelaker 1994).

Other applications of non-metric trait analysis were initiated in the 1970s by Lane and Sublett (1972), who attempted to reconstruct post-marital residence patterns of the Allegheny Seneca. In this analysis, the authors argued that comparing biological distances between males and females across sites might be represented by greater heterogeneity in non-metric trait values of one sex or another. Konigsberg (1987, 1988) elaborates on this methodology by incorporating the work of Sewall Wright to further define parameters of post-marital residence. Stojanowski and Schillaci (2006) discuss the significance of Konigsberg’s contribution and further highlight ways in which non-metric traits are utilized in biological distance analyses. Finally, Hefner (2009) presents findings related to the use of non-metric traits for the determination of ancestry in forensic anthropological contexts.

In cases where cranial remains are too fragmentary for traditional craniometric analyses, researchers have sometimes also relied on non-metric traits

of the dentition. In these studies, workers apply the Arizona State University Dental Anthropology System published by Turner and colleagues (1991) to score a host of non-metric dental characters. For example, Sutter and Verano (2007) scored dentitions of 559 individuals to investigate biological distances from a Moche-era sacrificial context on the north coast of Peru. In this study, Sutter and Verano (2007) concluded that individuals identified as sacrifice victims were most likely nonlocal combatants who had been captured by a competing polity.

Heritability and Biological Distance

To understand the role of both metric and non-metric traits in biological distance analysis, it is necessary to explicitly state how biological data enable anthropologists' understanding of quantitative variation. In other words, any study in biological distance assumes that the variables chosen actually reflect genetic relationships among and between populations (Šlaus et al. 2004; Stojanowski and Schillaci 2006). Early studies examining heritabilities of cranial dimensions utilized animal models (i.e., Deol et al. 1957; Leamy 1974), while early applications concerning humans typically involved twin studies (Dahlberg 1926; Vandenberg 1962). Recent treatments of craniometric heritability include the work of Carson (2006) and Martínez-Abadías et al. (2009), though numerous other examples have been published (Vandenberg 1962; Nakata et al. 1974; Sjøvold 1984; Devor et al. 1986; Konigsberg and Ousley 1995; Sparks and Jantz 2002).

In any study of heritability, it is conventionally held that estimates of h^2 can range from 0.0 (no genetic heritability of trait expression) to 1.0 (complete genetic control of trait expression)¹⁴. Given that studies of heritability rely on known samples of related individuals, bioanthropologists have utilized pedigreed skeletal samples to calculate heritability estimates. Of these, a sample of decorated crania derived from an ossuary of Hallstatt, Austria have been widely studied by a variety of researchers (Sjøvold 1984; Carson 2006). In Carson's (2006) recent study, she found that heritabilities of cranial length and height measurements ranged from 0.102–0.729. Martínez-Abadías et al.'s (2009) work on the same collection from Hallstatt generated heritability estimates from 0.00–0.43 and these authors concluded that there are no statistically significant differences between heritabilities derived from the facial skeleton, neurocranium, or cranial base. In another recent study utilizing metric data collected in Franz Boas' classic study of European immigrants in New York, Sparks and Jantz (2002) generated heritabilities that ranged from 0.49–0.61 for various dimensions of the cranial vault and face. Ultimately, as Carson (2006:170) notes (as will be discussed later), the most common practice is to utilize an average estimate of $h^2 = 0.55$ or assume a complete phenotypic-genotypic correlation $h^2 = 1.0$.

While the notion of heritability has been accepted by the bioanthropological community, it is necessary to discuss several key factors

¹⁴ See Vitzthum 2003:553 for a discussion of the common misinterpretation of high h^2 estimates.

related to the degree to which biological traits are under genetic control.

Typically, the expression of phenotypic traits is understood to result from a combination of both genetic and environmental factors. This is often represented through the variance component equation as follows

$$V_P = V_G + V_E$$

where V_P represents total phenotypic variation and V_G and V_E represent genetic and environmental variance, respectively (Konigsberg 2000). Extending this model to a multivariate framework, scholars often utilize the following equation

$$P = G + E$$

where P represents the total phenotypic covariance matrix, and G and E represent the genetic and environmental covariance matrices. In a seminal study examining the covariation between genetic and phenotypic correlations of 41 genetic- and phenotypic correlation matrices, Cheverud (1988:958) reported that “phenotypic correlations are likely to be fair estimates of their genetic counterparts,” especially in samples greater than 40 individuals. In a similar study that utilized 12 anthropometric traits drawn from the Boas dataset, Konigsberg and Ousley (1995) found that the genetic variance/covariance matrix is proportional to the phenotypic variance/covariance matrix.

As discussed by Mielke and colleagues (2006), another key idea to understand when discussing phenotypic variance is heritability, as both metric and non-metric traits must have a heritable component in order for biodistance

analysis to have meaning. In a recent treatment on the topic, Vitzhum (2003) traces the history of the heritability concept and discusses various methods for estimating and interpreting heritability. Moreover Vitzhum (2003) and Mielke et al. (2006) elaborate on the important concept of *narrow sense heritability*, or the degree to which any phenotypic trait is transmitted from parent to offspring. Typically, *narrow sense heritability* is depicted by the notation h^2 and is expressed by the following equation

$$h^2 = V_A / V_P$$

where V_A represents *additive genetic variance* and V_P represents *phenotypic variance*. As Vitzhum (2003:541) notes, h^2 reflects “only the additive (transmissible and amenable to selection) component of nonenvironmental variance.”

Distance Measures for Metric and Non-metric Datasets

In a recent synthesis by Pietrusewsky (2000), the author outlined numerous approaches that have historically been applied to the analysis of craniometric data for the purposes of analyzing biodistance. As Pietrusewsky (2000) states, the analysis of craniometric data has a long history in biological anthropology, particularly before the development of robust multivariate methods. Though these approaches have been dismissed as typological exercises of classification by some (Armelagos and Van Gerven 2003), other scholars have demonstrated that current applications of biological distance analysis are firmly

grounded in population genetic models which seek to answer questions related to gene flow and among-group variation (Stojanowski and Buikstra 2004).

As the 20th century advanced, multivariate statistical methods began to become commonplace in biological anthropology and bioarchaeology.

Multivariate procedures enabled researchers to deal with numerous variables while simultaneously analyzing multiple groups or populations. According to Howells (1973:3-4),

methods of multivariate analysis...allow a skull to be treated as a unit, i.e., as a configuration of the information contained in all its measurements. Next, they allow populations to be treated as configurations of such units, taking account of their variation in shape because they in turn are handled as whole configurations of individual dimensions.

In the following section, I outline several multivariate methods and their application to biodistance analysis.

Discriminant Function or Canonical Variates Analysis

According to Pietrusewsky (2000), the purpose of discriminant function analysis (DFA) is to characterize differences between two or more groups through the combination of two or more discriminating variables. In cases where more than two groups are analyzed, the procedure is called canonical variates analysis (CVA). In a classic study of Arikara crania, Jantz (1973:18) summarizes the statistical procedures that are utilized in any DFA: “simply put, the original variables are transformed to a set of axes which maximize the separation among populations under analysis. The populations may be visualized as existing in a

multivariate space with as many dimensions as there are variables.” Ultimately, at the conclusion of any DFA, an individual specimen is classified into a reference population and the probability of group memberships is evaluated through the analysis of posterior and typicality probabilities (Jantz and Ousley 2005).

Posterior probabilities are related to overall group classification while typicality probabilities inform the investigator of how representative that specimen is of the group. Classic examples of DFA that have been used in biological anthropology were published by Giles and Elliot and were used to classify unknown crania by ancestry (1962) and sex (1963). Forensic anthropologists commonly utilize DFA when utilizing the software packages *FORDISC 3.0* (Jantz and Ousley 2005) or *CRANID 6* (Wright 2009) in the analysis of unknown forensic cases. In a recent example, Ousley and Jantz (2012) discuss the specific components of DFA as it relates to forensic analyses and underscore the role of DFA as a classificatory tool. As will be discussed later, DFA has also been applied to biodistance questions related to Inka contexts from Peru.

Mahalanobis Distance

As numerous scholars have discussed, another common biodistance measure that is calculated from metric traits is the Mahalanobis distance (D^2) (Bedrick et al. 2000; Konigsberg 2006; Pietrusewsky 2008; Ousley and Jantz 2012). Originally defined by Mahalanobis (1930, 1936), D^2 is a Euclidean distance measurement that accounts for “univariate variation in all measurements,

the relationship among measurements within reference groups, and the mean measurements in each group, to objectively represent differences among groups” (Ousley and Jantz 2012: 313). Ultimately, according to Keita and Boyce (2008), D^2 can be considered a measure of dissimilarity, because larger values indicate less affinity between groups (for an example see Pietrusewsky 2000). Moreover, in many statistical packages Mahalanobis distances are calculated along with canonical variates and represent differences between group centroids (Keita and Boyce 2008; Pietrusewsky 2008).

Mean Measure of Divergence (MMD)

While both DFA and Mahalanobis Distance have been utilized for metric datasets, CAB Smith’s Mean Measure of Divergence (MMD) has been typically applied to datasets of both cranial and dental non-metric traits. Originally published by Grewal (1962) to estimate biological divergence in mice, Berry and Berry (1967) first utilized MMD to examine biological relationships on a large world-wide sample of human crania. Irish (2010:378) summarizes interpretation of MMD in that “low values indicate similitude and high ones imply greater inter-sample phonetic distance.” It should be noted that while non-metric data are not utilized in this project, numerous studies have employed the MMD statistic (Edgar 2004; Harris and Sjøvold 2004; Irish 2006; Harris 2008). Lastly, in discussing MMD, it should be noted that researchers have generated some debate

on the utility of the statistic, including abandoning it altogether (Konigsberg 2006; Irish 2010) and replacing it with an analog for the Mahalanobis distance.

Wright's F_{st}

The population geneticist Sewall Wright (1951, 1969, 1978) is credited with deriving several population structure F-statistics, F_{is} , F_{it} , and F_{st} . These statistics are inbreeding coefficients where F_{is} is the coefficient of an individual relative to its subpopulation and F_{it} is the coefficient of an individual relative to the total population (Falconer 1996). F_{st} provides a measure of subpopulation differentiation, or as others have described, a measure of among-group variation (Relethford 1994; Steadman 2001; Nystrom 2006; Scherer 2007). In biological distance analysis, measures of F_{st} have been used in studies ranging from comparisons of diversity across world-wide regions (Ousley 1995) to those that examine subtle changes in migration on interregional levels (Steadman 1998; 2001). In a comprehensive review of the literature, Steadman (2001) reports F_{st} estimates that range from quite small (i.e., 0.0016) in regionally isolated populations from the Central Illinois River Valley to those that are exceptionally high (0.33-0.39) among South American Indians.

Methodological Approaches to Biological Distance

Research focused on questions related to biodistance of quantitative traits derived from bioarchaeological contexts can typically be classified as either model-free or model-bound approaches. Differences between the two approaches

were clearly defined by Relethford and Lees (1982) and recently revisited by Frankenberg and Konigsberg (2011). According to Relethford and Lees (1982:116), model-free analyses involve “the indirect application of models of population structure in the assessment of biological differences between populations.” Frankenberg and Konigsberg (2011) add that model-free methods investigate relationships between biological traits and various factors such as geography, language, time, or cultural distance. As both Relethford and Lees (1982) and Frankenberg and Konigsberg (2001) have pointed out, model-free methods are influenced by population genetic parameters but do not estimate genetic parameters of those models. As Herrmann (2002) notes, typical examples of model-free analyses include those studies that utilize discriminant function analysis to classify individuals relative to reference populations and a shared covariance matrix and typically generate various distance matrices.

Frankenberg and Konigsberg (2011) indicate that model-bound methods are preferable to model-free methods because population variation can be explained through mathematical processes. To demonstrate their point, Frankenberg and Konigsberg (2011) present a series of model-bound simulations to demonstrate the effects of migration on population structure. Their simulation results demonstrate that migration events can have small effects on quantitative trait values when population sizes are small and when genetic drift has a long time (i.e., 50 generations) to operate (Frankenberg and Konigsberg 2011).

R Matrix Methods in Biodistance Analysis

According to Konigsberg (2006), the work of Relethford and Lees (1982) influenced a transition towards model-bound approaches in biodistance analysis. In the same year, Harpending and Ward (1982) developed a population genetic model for comparing heterozygosity of allele frequencies within populations of a local region. Several years later, Relethford and Blangero (1990) extended the model of Harpending and Ward (1982) to polygenic continuous quantitative traits. Relethford and Blangero (1990) applied the model to two distinct continuous datasets: dermatoglyphic ridge counts of 503 adults from eastern Nepal and anthropometric data on 259 adults from western Ireland. In each case, Relethford and Blangero (1990) were interested in examining heterozygosity among populations as well as levels of gene flow between populations.

The Relethford-Blangero (1990) model uses a relationship or **R** matrix to examine levels of gene flow. Their model is adopted in this study and applied to craniometric data discussed in Chapter 5. The model states that when populations within a given region exchange migrants with an external population at equal frequencies, the relationship between the average within-group variation and genetic distance to the regional centroid (r_{ii}) should be linear (Relethford and Blangero 1990; Relethford et al. 1997; Powell and Neves 1999; Stojanowski 2004; Nystrom 2006; Scherer 2007; Steadman 1998, 2001) and monotonically decreasing. In the contrasting situation, populations that are not isolates should

have greater within-group variation and will be nearer to the regional centroid. Finally, in addition to estimating levels of gene flow, the **R** Matrix also calculates estimates of genetic distance (d^2) and among-group variation (F_{st}) (Steadman 2001; Nystrom 2006; Scherer 2007).

A unique aspect of the model-bound **R** matrix approach is the capability to include estimates of effective population size (N_e). These are “drift effective” population sizes and are the sizes of idealized populations that would provide the same amount of drift as actually observed (Relethford et al. 1997). Typically, the drift effective size is approximately one-third of the census size, so that for example a village with a census size of 90 individuals would have a drift effective size of 30 individuals once one adjusted for all the factors that decrease the effective size. These include the age structure of the village, variance in family size, imbalance in the sex ratio, and fluctuations in census size over time. As numerous authors have suggested, scaling the **R** matrix by population size controls for the effects of genetic drift in small populations (Relethford and Harpending 1994; Relethford 1996; Steadman 2001; Scherer 2007). In numerous examples that apply an **R** matrix to continuous quantitative traits, scholars incorporate estimated census size (N_c) as a proxy for N_e . These census estimates are typically derived from settlement pattern or archaeological survey data (Scherer 2007). Assuming that the drift effective population size has a constant relationship with census size (such as in the one-third relationship mentioned

above), all that is needed is the relative census sizes. For example, if there were three villages where the first two villages had equal sizes while the third village was twice as large, the relative census sizes would be 0.25, 0.25, and 0.5.

As Steadman (2001) and Scherer (2007) note, estimating census size from archaeological contexts and mortuary assemblages is problematic. In many bioarchaeological contexts, like with the dataset to be presented in Chapter 5, census estimates are often unavailable. In those instances, the unscaled **R** Matrix is calculated with all samples weighted equally (Relethford and Harpending 1994; Schmidt et al. 2011). Despite a methodological preference for scaling population estimates proportionally, Relethford and Harpending (1994:253) assert that the Harpending-Ward model remains a “potentially useful tool in situations where demographic history is unknown.” Nystrom (2006:338) demonstrated that the pattern of Relethford-Blangero residuals differed only in one trial when population estimates varied.

The elements of the **R** matrix are (Relethford and Blangero 1994:253)

$$r_{ij} = \frac{(p_i - \bar{p})(p_j - \bar{p})}{\bar{p}(1 - \bar{p})},$$

where p_i and p_j are the allele frequencies of populations i and j , and $\bar{p}$ is the mean allele frequency over all populations weighted by the relative population size. The variables in the **R** Matrix are then averaged over all alleles and the genetic

distance to the regional centroid (r_{ii}) is obtained from the diagonals of the **R** matrix.

In the **R** Matrix, estimates of gene flow can be derived by comparing observed ($\bar{v}_i$) and expected [$E(\bar{v}_i)$] within-group phenotypic variation (Relethford and Harpending 1994; Relethford 1996; Steadman 2001; Scherer 2007).

Expected within-group variation is calculated as $E(\bar{v}_i) = \bar{v}_w(1 - r_{ii}) / 1 - F_{st}$, where ($\bar{v}_w$) is the pooled mean within-group variation across populations, (r_{ii}) is the genetic distance to the regional centroid, and (F_{st}) is the average genetic distance across all subpopulations (Relethford and Harpending 1994; Relethford 1996; Steadman 2001; Nystrom 2006; Scherer 2007). The difference between observed phenotypic variance ($\bar{v}_i$) and expected phenotypic variance $E(\bar{v}_i)$ is the residual. Positive residuals indicate greater levels of external migration (i.e., gene flow) while negative residuals are indicative of less than average outside contact (Relethford and Harpending 1994; Relethford 1996; Steadman 2001; Scherer 2007). In the case of positive residuals, these groups have greater within group variation than would be predicted by their distance from the regional centroid. This greater within-group variation is a consequence of external gene flow.

Estimates of F_{st} , the average genetic distance across all subpopulations is derived as the average weighted diagonal of the **R** Matrix

$$F_{st} = \sum_{i=1}^g w_i r_{ii}$$

where w_i is the relative population size of i , and g is the number of populations (Relethford and Blangero 1990; Steadman 2001; Nystrom 2006). As Steadman (2001) notes, estimates of F_{st} are often used in cross-cultural comparisons regardless of time period, geographic region, or type of dataset.

Estimates of biological distance (d^2) are also calculated from elements of the **R** Matrix where

$$d_{ij}^2 = r_{ii} + r_{jj} - 2r_{ij}$$

following Relethford and Blangero (1994) and Harpending and Jenkins (1973). Visualization of biological distances between groups is accomplished through classical (metric) multidimensional scaling (MDS) (Relethford and Blangero 1990; Relethford 1996; Steadman 1998). The graphical representation of biological distance is achieved by plotting eigenvectors of the first few principal coordinates from the distance matrix (Relethford and Blangero 1990; Relthford 1996; Steadman 2001; Nystrom 2006; Scherer 2007).

Artificial Cranial Vault Modification

Biological anthropologists have demonstrated an interest in studying the practice of artificial cranial modification (ACM)¹⁵, cranial vault modification (CVM), or intentional vault modification (ICM). Though differences in

¹⁵ In the past, researchers have oftentimes referred to this practice as cranial deformation. Today's researchers have moved away from describing the practice in the same way. Given the implicit negative connotation of the word *deformation* several alternative terms have been utilized. While this is the case, recent examples (i.e., Jimenez et al. 2012) still refer to the practice in this way.

terminology appear throughout the literature, researchers studying the phenomenon agree that it is initiated while individuals are very young so that their plastic, malleable neurocrania can be shaped into a number of different forms (see Torres-Rouff 2007, 2009; Torres-Rouff and Yablonsky 2005 for a review).

The practice of ACM has been investigated for numerous reasons. First, a body of literature has emerged testing the role of ACM on overall cranial growth and development (Anton 1989; Cheverud et al. 1992; Konigsberg et al. 1993; Jimenez et al. 2012). Researchers have investigated in what ways, if at all, modifying the neurocranium alters dimensions of the craniofacial region and cranial base. Other lines of inquiry have investigated whether or not ACM alters cranial form so drastically that traditional craniometric measures and/or non-metric traits cannot be used for biological distance analyses (Cocilovo 1975; Rhode and Arriaza 2006). Second, recent studies (Knudson and Blom 2009; Duncan 2009; Torres-Rouff 2009) utilize modified cranial shapes to investigate questions regarding ethnicity and identity. These studies are substantially more qualitative in nature and have been grouped into studies which can be classified as applications of social bioarchaeology (Knudson and Stojanowski 2009; Baadsgaard et al. 2011).

In perhaps the earliest comprehensive morphological analysis of ACM, Anton (1989) studied a sample of Peruvian crania presenting three distinct types of modification. She utilized radiographic tracings and took a number of angle

measurements to investigate differences between the two groups of modified crania and a control sample of unmodified crania. Ultimately, Anton found that individuals presenting fronto-occipital modification had increased facial dimensions than those individuals with unmodified crania. Anton did not find significant differences in nasal region or palate between modified and unmodified groups.

In a subsequent study, Cheverud and colleagues (1992) compared differences in unmodified and fronto-occipitally modified crania from Peru and British Columbia. They utilized a novel three-dimensional approach to collect data from craniometric landmarks and subsequently performed a finite element scaling analysis to elucidate shape differences between modified and unmodified groups. Ultimately, these researchers found that fronto-occipital modification did influence cranial vault, base, and face measures in both the Peru and British Columbia samples. Interestingly, Cherverud et al. (1992) also detected differences in the degree of variation between the two geographically divergent populations and indicate that fronto-occipital modification may not create the same type of cranial change across all groups that engage in the practice.

In a departure from metric investigations, Konigsberg and colleagues (1993) investigated the role of ACM in influencing non-metric trait frequencies in a large sample of crania representing both North and South American populations. The crania in this sample presented a wide variety of modification styles. These

researchers scored approximately 40 non-metric traits and utilized a univariate probit analysis to investigate the relationship between modification and trait frequencies. They next performed separate biological distance analyses on the unmodified and modified groups in order to examine the effect of ACM on biological distances. Ultimately, Konigsberg et al. concluded that while some non-metric traits are affected significantly by ACM, such effects do not hinder calculation of biodistances.

In another methodological study, Rhode and Arriaza (2006) tested the list of ten craniometric measurements recommended for use in South American populations presenting ACM. Originally published by Cocilovo (1975), this list of measurements has been utilized heavily throughout South America, as many studies have investigated samples that contain high numbers of modified individuals. Working with approximately 350 archaeological Chilean crania, Rhode and Arriaza subsequently scored ACM and measured each cranium utilizing the recommended list of ten inter-landmark distances. Rhode and Arriaza utilized a multivariate analysis and concluded that numerous measurements were adversely affected by ACM and should subsequently be discarded prior to initiating a biological distance analysis.

In a recent study utilizing a geometric morphometric approach to investigate differences between modified and unmodified crania, Ross and Ubelaker (2009) utilized a Microscribe digitizer to register both facial and vault

landmarks in a sample of 65 crania. After Procrustes superimposition, the authors utilized the computer program Morpheus to run a multivariate analysis of variance on both the modified and unmodified samples. Ultimately, Ross and Ubelaker (2009) found no significant effects on facial and cranial base landmarks, however, they did find differences between unmodified and modified groups with respect to vault landmarks.

Two additional studies which document ACM are of particular interest to the work presented here, primarily because each of these has examined material that comprises the study sample discussed in Chapter 5. In an analysis of the skeletal population from Machu Picchu, Peru, Verano (2003) utilized 15 craniofacial dimensions that he argues are unaffected by cranial vault modification in Peruvian populations. He utilized these measurements and discriminant function analysis to determine if individuals interred at Macchu Pichu were typical of Cuzco highlanders or if they were from other coastal sites. In another study, Haun and Cock Carrasco (2010) examined individuals recently recovered from the cemetery of Puruchucho-Huaquerones near Lima, Peru. In this sample, approximately 85% of individuals were characterized by some type of ACM. The authors of this study found that three of Verano's craniofacial dimensions were affected by ACM and were thus subsequently removed from their dataset prior to performing discriminant function analysis.

Lastly, in a recent contribution by Nystrom and Malcom (2010), the authors utilized metric data from a series of crania dated to the Chiribaya polity (772 – 1350 AD) to investigate sex-specific phenotypic variability and social organization. In their study, the authors utilized a sample of 291 crania, of which approximately 53% presented some type of modification style. Ultimately, the authors concluded “that cranial modification is not significantly influencing the variability of the craniomandibular metric phenotypic traits used in these analyses” (Nystrom and Malcom 2010:387).

ACM presents a possibly confounding variable for anyone interested in performing biological distance analysis on an affected sample of crania. Moreover, the literature suggests that while traditional vault measures are significantly influenced by the practice, portions of the craniofacial skeleton might very well be unaffected and suitable for biodistance analysis. Given the usefulness of biodistance analysis for providing answers to anthropological questions in numerous regions of the world where ACM is commonplace, investigators continue to utilize odontoskeletal data which are relatively unaffected by the practice. As will be discussed in Chapter 5, this study investigates biological distances in a sample of individuals despite a high frequency of intentionally modified crania.

Ecogeographic Variation and Andean Population Structure

In addition to considering the effects of ACM on biological distance studies in the Andes, another fundamental concept related to the study of Andean population structure is ecogeographic variation related to low-high altitude adaptation (Ross et al. 2008). Scholars have observed this phenomenon for decades and have classically recognized a clear distinction between individuals from coastal and highland locales throughout the Andes (Newman 1943; Dittmar 1966). Typically, studies have focused on cranial remains and have elucidated distinct morphological differences between coastal and highland groups (Newman 1943; Ericksen 1962; Dittmar 1966; Ross et al. 2008).

In a recent study by Ross and colleagues (2008), the trend of low-high altitude adaptation was demonstrated in an analysis of 237 individuals representing two populations of coastal inhabitants and two groups of highland inhabitants. In their study, Ross and colleagues (2008) included the well-known Yauyos sample from the W.W. Howells worldwide craniometric database, along with one other population from the Peruvian highlands (Cajamarca) and two groups from the central coast near present-day Lima (Ancón and Makatampu). With the exception of the Yauyos sample which has never been conclusively dated, the samples from the other three sites all pre-date the Late Horizon (Ross et al. 2008). Notably, Ross et al. (2008) determined that much regional variation of pre-Columbian Peruvian populations could be delineated between coastal and

highland groups (Figure 10). Ultimately, these scholars conclude that the Yauyos sample falls comfortably within the highland group and that low-high altitude adaptation explains much of the variation observed in Andean skeletal populations regardless of temporal association (Ross et al. 2008).

In addition to tracking low-high altitude adaptation in cranial remains from the Andes, other biological anthropologists have investigated the phenomenon with the post-cranial skeleton. Weinstein (2005) investigated body and limb proportions in a sample of 346 individuals drawn from both coastal and highland populations in Peru and Chile. Of note, Weinstein (2005, 2007) included individuals recovered from the highland Inka site of Machu Picchu in her study sample. The other samples utilized by Weinstein (2005) cover a broad range of time and span from the Archaic period in Chile (3210–1720 BC) through the Late Intermediate Period on the central coast of Peru (AD 1000–1476).

Weinstein (2005) found that body size and limb lengths varied along an altitudinal gradient. More specifically, Weinstein (2005) noted that individuals were larger from the coastal sites and that individuals from the high altitude locales were smaller-bodied. She concluded that ecogeographic variation was a likely explanation for significant differences found in the body proportions of coastal and highland groups (Weinstein 2005).

In a subsequent analysis utilizing the same dataset from the 2005 study, Weinstein (2007) examined thoracic morphology between coastal and highland

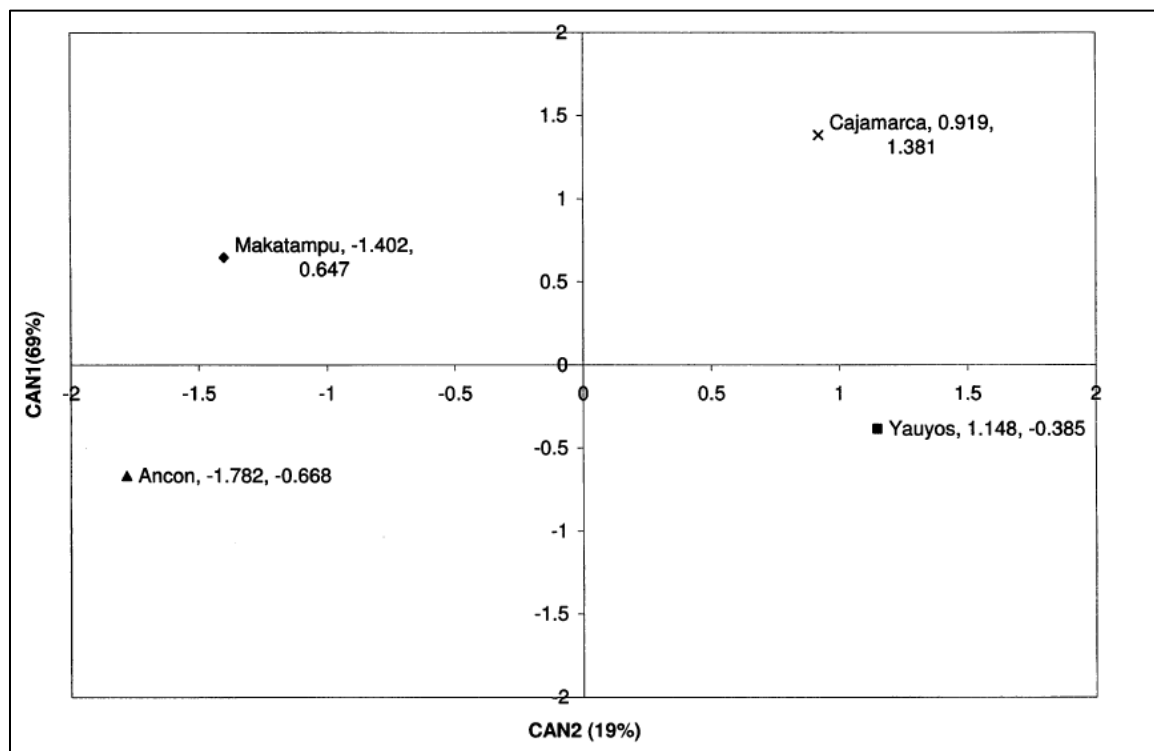


Figure 10. Figure 2 from Ross et al. (2008:164) depicting differentiation between coastal and highland populations.

groups. In this more recent update, Weinstein (2007) tested the hypothesis that high altitude populations would exhibit statistically larger thoracic cavities than coastal inhabitants. This hypothesis was based on the well-known trend of highland populations exhibiting larger lung volumes than their coastal counterparts (Greksa and Beall 1989). Weinstein (2007) analyzed measurements of the manubrium, vertebrae, and ribs in order to test this hypothesis and confirmed the trend in the majority of her study sample. For example, she found that Atacama highlanders from Chile had larger thoracic cavities than coastal populations from Ancón. Interestingly, however, highlanders from the site of Machu Picchu did not conform to the expected highland group classification (Weinstein 2007). To the contrary, individuals from the Machu Picchu sample presented thoracic morphology which appeared to be a heterogeneous mix of both coastal and highland morphologies. Weinstein (2007:47) concluded that “variation[s] in thoracic skeletal morphology suggest that these individuals are from both ancient Andean highland and coastal regions.” Moreover, Weinstein (2007) surmises that this variation was the likely result of Inka resettlement at Machu Picchu.

Biological Distance Studies on the Inka

According to Ross et al. (2008:158:), “although Peru has a rich history of investigations of human skeletal remains, biological distance studies based on craniometrics are limited to nonexistent.” Moreover, there are even fewer

published biodistance studies on the Inka as compared to other populations from the New World. This is surprising, given the wealth of ethnohistorical and archaeological literature that is available and the intensity that the Inka have been studied. Moreover, preservation in the Andes tends to be remarkably good¹⁶ in undisturbed contexts and many hundreds, if not thousands, of skeletal remains have been recovered. Without doubt, the bulk of bioarchaeological work has investigated other topics such as ACM, subsistence, diet, trauma, and warfare/human sacrifice. Only recently, have biological distance studies appeared at greater rates in the literature on Andean bioarchaeology; however many of these studies have focused on other temporal periods (Sutter and Cortez 2005; Sutter and Verano 2007).

Perhaps the most well-known biodistance analysis on the Inka is Verano's (2003) study of the Machu Picchu skeletal collection. In addition to investigating questions regarding the site's demographic composition, Verano (2003) utilized craniometric data to examine questions regarding biological distance and geographic origins of those interred at the site. Interestingly, however, the samples from which the Machu Picchu remains were compared were not from Late Horizon Inka contexts. Verano (2003) compared the Machu Picchu remains to individuals drawn from earlier time periods (i.e., Middle Horizon and Late

¹⁶ Perhaps no better example of remarkable preservation exists than that of the *qhapaq ucha* (capacocha), or children who were sacrificed on mountaintop shrines during the reign of the Inka. Mummies of *qhapaq ucha* have been recovered from contexts of over 6,300m (Reinhard 1999; Previgliano et al. 2003).

Intermediate Period) from the north coast and from undated contexts in the central highlands. At the time of Verano's (2003) study, no other securely dated Inka contexts had been documented, making comparisons of Late Horizon contexts virtually impossible.

Recently, Haun and Cock Carrasco (2010) performed biological distance analyses on the cemetery assemblage from the complex of Puruchuco-Huaquerones on the central coast of Peru near Lima. At the time of its excavation, the cemetery from this archaeological complex was described as the largest Inka cemetery ever recorded (Murphy et al. 2010ab; Gaither and Murphy 2011). Drawing from a sample of 165 adults, Haun and Cock Carrasco (2010) sought to determine if inhabitants interred in the cemetery of Huaquerones were local inhabitants who spent their lives on the central coast or if they represented a population of relocated *mitmaqkuna*. Like Verano (2003), Haun and Cock Carrasco (2010) compared the craniometric data from the cemetery of Huaquerones to samples drawn from Middle Horizon and Late Intermediate Period north coast sites and from undated contexts in the central highlands. Ultimately, Haun and Cock Carrasco (2010:218) conclude "preliminary results indicate that the Huaquerones cemetery population does not represent a multiethnic community [and]...these results are also suggestive of a population native to the region"

In a final recent example that applied biological distance analysis to Inka cemetery assemblages, Salter-Pedersen (2011) examined the cemetery structure from the site of Rinconada Alta located on the central coast of Peru (located in close proximity to the complex of Puruchuco-Huaquerones). In this study, Salter-Pedersen (2011) utilized both craniometric and non-metric variables to investigate both intra- and inter-site variability. Salter-Pedersen's (2011) work is the first to compare two or more Late Horizon Inka contexts. In her work on Rinconada Alta, the author utilized samples from the cemetery complex of Puruchuco-Huaquerones and the Urubamba River Valley near Cuzco. Though the Urubamba sample has been poorly documented, Salter-Pedersen asserts that it is associated with the Inka occupation. Ultimately, Salter-Pedersen (2011) concluded that there was little difference between cemetery sectors at Rinconada Alta. Moreover, Salter-Pedersen (2011:167) concluded that "biological distance analyses do not support the hypothesis that several different ethnic or cultural groups are present" at the site.

Chapter Summary

According to Stojanowski and Buikstra (2004), biological distance analysis occupies an important space within the analytical toolkit of 21st century bioarchaeologists. These authors argue that model-bound quantitative genetic approaches provide a nuanced view of within-group variation, along with estimates of extralocal gene flow. The model developed by Relethford and

Blangero (1990) has equipped bioarchaeologists with a useful tool for examining multiple components of population structure.

The ability of the Relethford-Blangero (1990) model to estimate levels of extra-regional gene flow is fundamentally important to questions related to biodistance studies of Inka resettlement. As described in Chapter 3, individuals from territory incorporated by the Inka were often forcibly migrated to new populations across the empire. In some instances, populations were not incorporated into the labor tribute system and individuals were not uprooted and moved. Across the empire, populations simultaneously existed which reflected new groups of heterogeneous immigrants and homogeneous unsettled populations (Rowe 1982; Cornejo 2002; D'Altroy 2002; Weinstein 2007; Covey 2009; Malpass and Alconini 2010).

Given that the Andean Cordillera is characterized by two distinct ecological zones divided along an altitudinal gradient, bioarchaeologists investigating population variation resulting from imperial policies should keep this reality in mind. In the case of Late Horizon mortuary contexts, populations which deviate from expected ecogeographic groupings may potentially be interpreted as those affected by Inka resettlement.

It has been suggested from the few cases described above that Andean populations can be split into coastal and highland groups based on metric analyses of both cranial and post-cranial remains. Moreover, as Ross et al. (2008) reiterate,

geographic barriers such as the Cordillera are effective barriers which limit gene flow between groups and serve to promote *in situ* microevolution of both coastal and highland populations. In the case of the Inka, forced resettlement offers one potential explanation for exaggerated heterogeneity between expected coastal and highland morphological patterns. Though populations were likely resettled within their own ecological zone by the Inka, Weinstein (2007) provides at least one example where it appears that individuals from both coastal and highland locales were relocated to Machu Picchu. When what is known about ecogeographical Andean variation is coupled with biological distance analysis of Inka mortuary contexts, a more nuanced picture of Inka resettlement may emerge. Late Horizon coastal and highland populations which deviate from the typical pattern described in the work of Ross et al. (2008) and Weinstein (2005, 2007) may potentially be interpreted as artificially altered by Inka resettlement strategies.

Though bioarchaeological research on Inka resettlement is on-going by scholars working throughout the empire, I argue that artificial populations created by Inka resettlement can be deciphered through analysis of **R** Matrix residuals coupled with an understanding of pre-Inka population variation resulting from altitudinal adaptation. As with Weinstein (2007), Inka contexts which deviate from the expected coastal/highland dichotomy may cautiously be interpreted as a population which was resettled. Table 4 presents a simple model which interprets both positive and negative Relethford-Blangero residuals of a hypothetical Inka

Table 4. Explanatory model for Relethford-Blangero residual interpretation in an Inka mortuary context

Negative Relethford-Blangero Residuals	Positive Relethford-Blangero Residuals
• Local population not subject to Inka resettlement • Resettled population relocated <i>en masse</i> to a new locale • Small population of local <i>or</i> resettled population homogenized by genetic drift	• Heterogeneous resettled population comprised of individuals from diverse regions of the empire • Local population engaged in exogamous mate exchange • Resettled population engaged in long distance mate exchange • Pre-existing heterogeneity across Andean populations

mortuary context. Given that a resettled population might be composed of individuals from locations around the empire, positive Relethford-Blangero residuals might provide some information about the heterogeneity of resettled populations. Conversely, a population demonstrating negative Relethford-Blangero residuals could be interpreted as a group that was not populated with a resettled group of outsiders. While exogamous mate exchange among Late Horizon communities also remains a possible explanation for positive Relethford-Blangero residuals, resettlement cannot be discounted as a potential explanatory mechanism. This model considers effects of population size and genetic drift on small populations; therefore, genetic drift might also offer an explanation for populations presenting negative Relethford-Blangero residuals.

Though scholars have yet to tease apart rates of gene flow among and between groups in any Inka context, it is clear that numerous possibilities exist which provide reasonable hypotheses related to Inka population structure. Of these hypotheses, population resettlement is one scenario that can be explained through interpretation of the Relethford-Blangero (1990) model. Moreover, incorporating datasets which demonstrate that Andean population variation is heavily influenced by adaptation to altitude may also assist in deciphering which Late Horizon populations have been subjected to resettlement. Late Horizon populations which deviate from an expected coastal or highland pattern might be

comprised of individuals from both regions, as seen in the example from Weinstein (2007). The remaining chapters of this study examine potential Inka resettlement strategies by calculating the **R** matrix from craniometric data from five Inka mortuary contexts and four other Andean populations from documented coastal and highland locales.

Chapter 5 – Materials and Methods

“The variety of burial customs recorded archaeologically throughout the Andes is so complex as to defy description.” (D’Altroy 2002: 194)

“[B]iological studies can inform our knowledge about the actual people who comprised the empire. While such studies are in their infancy, they show much promise in providing new results about the varying Inka policies in the provinces.” (Malpass and Alconini 2010:195)

Though Inka resettlement practices have been described by Inka scholars, few studies have attempted to quantify the result of these practices on individuals living under Inka imperial rule. It is hypothesized here that a model-bound population genetic approach utilizing an **R** matrix may offer some insight into phenotypic variation resulting from the aforementioned socio-political practices.

To explore patterns of phenotypic variation, craniometric data were collected from three spatially distinct coastal Inka cemeteries on the central coast of Peru (Huaquerones, 57AS03, and Pachacamac) and two highland Inka mortuary contexts located near Cuzco (Machu Picchu and Colmay). Among these five sites, both hinterland (i.e., periphery) and heartland (i.e., core) contexts are represented. Figure 10 depicts the geographic distribution of each site in Peru. These include well documented Inka sites that have been described for over a century, remarkable recent discoveries of the late 20th century, and ‘rediscovered’ material relocated after decades of curatorial mystery. As will be described below, these sites vary in terms of initial collection strategies, skeletal preservation and previous archaeological research. Nonetheless, these



Figure 11. Map of Inka sites sampled¹⁷.

¹⁷ Note that Huaquerones and 57AS03 are both located at the large site complex of Puruchuco-Huaquerones located near Lima.

been securely dated to the Late Horizon and comprise a significant number of Inka mortuary contexts that have ever been recorded.

Late Horizon Site Descriptions

Machu Picchu

Perhaps of all Inka sites ever described, none is better known than Machu Picchu. Named a UNESCO World Heritage site in 1983, Machu Picchu remains one of the most widely visited archaeological sites in the world. Since the ‘rediscovery’ of Machu Picchu in 1911 by Hiram Bingham, the site has attracted international attention and is a popular tourist destination. It is located 80km northwest of Cuzco at an attitude of 2,450 meters above sea level and covers an area of nearly 32, 600 hectares. Excavation and recovery of the Machu Picchu human skeletal remains was initiated in 1912 under the direction of Hiram Bingham.

In 1912, Yale University sponsored an expedition where artifacts and human skeletal remains were collected from around the Sacred Plaza and numerous adjacent caves. The burials were originally examined by George Eaton who worked as the project’s physical anthropologist (Eaton 1916). Eaton’s recovery strategy and detailed drawings have been described as atypical of early 20th-century archaeological fieldwork protocols, and as a result, the Machu Picchu

samples remain ‘a surprisingly intact and valuable research collection’ (Verano 2003: 67).

Recently, Verano (2003) reanalyzed the Machu Picchu skeletal assemblage to reassess several of Eaton’s findings, most notably the demographic composition of the sample. In the 1916 monograph, Eaton determined that most of the Machu Picchu sample was female (109 females and 26 males). As Verano (2003) notes, this skewed sex distribution led Bingham to conclude that Machu Picchu was an *aqllawasi*¹⁸ and that the majority of the interments represented “Virgins of the Sun.” Though this interpretation was questioned for by numerous scholars, Verano’s (2003) publication was the first source to definitively argue that the sex distribution of burials was relatively balanced and that the individuals were most likely not *aqllakuna*¹⁹. These findings corroborate the work of others (i.e., Hyslop, 1990; Burger and Salazar-Burger 1993; Miller 2003; Salazar and Burger 2004) who suggest that Machu Picchu was a royal estate for the Inka emperor Pachacuti. A novel application of strontium isotope analysis by Turner and colleagues (2009) suggested that those individuals interred at the site represented a geographically diverse group, most likely drawn from disparate locales and relocated to Machu Picchu as part of a complex labor tribute system.

¹⁸ See Chapter 4 for a discussion of this term.

¹⁹ See Chapter 4 for a discussion of this term.

Possibly as a result of its high visibility, the site of Machu Picchu has been mired in controversy over cultural patrimony and site management (Gerstenblith 2010; Zan and Lusiani 2011). Decades of dispute between Yale University and the Government of Peru over the custodianship of the Machu Picchu artifacts was only recently resolved when in November 2010 a Memorandum of Understanding was signed between the two parties (<http://opac.yale.edu/Peru/english/mou.html>). Ultimately, the agreement dictated that all objects be repatriated to Peru by December 2012 and established the International Center for the Study of Machu Picchu and Inca Culture, a cooperative venture between Yale University and the University San Antonio Abad of Cusco.

Colmay

Unlike Machu Picchu, the site of Colmay has received virtually no archaeological attention. Colmay is located approximately 35 kilometers west of Cuzco at an elevation of 3,485 meters above sea level (Andrushko 2007). During the original survey by the German archaeologist Max Uhle in 1909, numerous stone architectural features were recorded. Stylistically described as imperial Inka, Andruskho (2007) and Andrushko and Verano (2008) suggest that Colmay may have functioned as a potential imperial estate and mortuary complex or *tambo*. During this survey in 1909, Uhle also collected 61 skulls and described a mortuary feature as “a cave tomb opened about 70 years ago with all the bones mixed” (Uhle 1909: 20-23). The skeletal remains from Colmay are currently

curated at the Phoebe A. Hearst Museum of Anthropology on the campus of the University of California-Berkeley.

Recent work on Andean trepanation practices by Andrushko and Verano (2008) has demonstrated that 35.1% of available crania (n=59) from Colmay present one or more well-healed trepanations. The authors utilize these data to argue that trepanation was a medical procedure practiced by Inka specialists. Moreover, in a more recent publication Andrushko and Torres (2011) report that perimortem cranial injuries were present in 11.1% of the total sample, data which they use to support a hypothesis of increased violence during Inka expansion.

Puruchuco-Huaquerones (Huaquerones and 57AS03)

The archaeological complex of Puruchuco-Huaquerones is located on the central coast of Peru approximately 12 km southeast of the present day capital of Lima in the Rímac Valley (Haun and Cock Carrasco 2010; Murphy et al. 2010ab; Gaither and Murphy 2011). Topographically, the complex contains two hills (*cerros*) called Puruchuco and Huaquerones (Haun and Cock Carrasco 2010). The well-known palace (and present-day archaeological site museum) of Puruchuco is located to the west of *cerro* Puruchuco and was originally restored by Jiménez Borja from 1953 and 1956 (Tabio 1965; Jiménez Borja 1988; Haun and Cock Carrasco 2010). The archaeological complex contains several cemeteries of which two are called Huaquerones and 57AS03 (Figure 11). These cemeteries are contemporaneous and located less than 2km from each other



Figure 12. Location of Huaquerones and 57AS03²⁰

²⁰ Adapted from Murphy et al. 2010ab, 2011.

(Murphy et al. 2010ab, Murphy et al. 2011).

Though looting has affected Puruchuco-Huaquerones throughout its history, the cemetery of Huaquerones began to suffer additional destruction in 1989 when people fleeing violent activity resulting from the *Sendero Luminoso* (Shining Path) settled the modern-day community of Tupac Amaru (Haun and Cock Carrasco 2010). As a result of the destruction to Huaquerones, a large-scale archaeological salvage project was initiated in 1999 by the Peruvian archaeologists Guillermo Cock Carrasco and Elena Goycochea (Cock 2002; Cock and Goycochea 2004). The salvage project resulted in the recovery of the largest Inka cemetery ever discovered which included 1,286 mummy bundles (Haun and Cock Carrasco 2010). Mortuary offerings and funerary associations are numerous and include a variety of objects including textiles, ceramics, musical instruments, weaving implements, and botanical foodstuffs (Murphy et al. 2010ab, Murphy et al. 2011). Work on the material culture is on-going and the vast majority of archaeological interpretations have yet to be published.

Among mortuary contexts, six types of mummy bundles, or *fardos*, have been described (Haun and Cock Carrasco 2010). In addition, approximately 6% of bundles that were recovered presented a false head (*falsa cabeza*). Bundles with false heads were typically larger, contained multiple individuals, and yielded a higher number of funerary associations (Haun and Cock Carrasco 2010). As

mentioned in Chapter 4, few biological distance studies have been conducted on the Inka, however, the work of Haun and Cock Carrasco (2004:216) suggests “that the people in Huaquerones do not represent an artificially constructed group” and that the cemetery is composed of individuals from the central coast of Peru. Individuals from both Huaquerones and 57AS03 were interred in typical Late Horizon style: seated in a flexed position wrapped within the textile bundles (Murphy et al. 2010ab; Murphy et al. 2011; Gaither and Murphy 2012).

A subset of burials from 57AS03 has been described as distinct from the typical Late Horizon pattern. These burials possess funerary associations and were not positioned in a flexed position (Murphy et al. 2010ab; Murphy et al. 2011; Gaither and Murphy 2012). To the contrary, these burials were buried in either one or two textile layers in either prone or supine positions. Many of the individuals from this subsample of 57AS03 presented perimortem injuries, including those probably caused by Spanish weaponry, a finding that has led scholars to conclude that some individuals interred at 57AS03 provide direct evidence of Spanish contact and perhaps were associated with the 1536 Siege of Lima (Murphy et al. 2010ab; Murphy et al. 2011; Gaither and Murphy 2012).

Pachacamac

Quoting from Stanish and Bauer’s (2007) discussion of monumental sites across the Inka empire, the authors draw on the chronicles to describe the importance of the religious center of Pachacamac:

“In magnitude, devotion, authority and richness, the Temple of Pachacama[c] was second only to the magnificent [Cusco] Temple of the Sun. Since it was a universal sanctuary, people came to the Temple of Pachacama[c] on pilgrimages from all over the Inka Empire, and there they made their votive offerings. (Cobo 1990:85 [19653:book 13, chapter 17]).

As these authors indicate, Pachacamac (located approximately 40km from Lima and approximately 23km from Puruchuco-Huaquerones), functioned as an important religious center for generations of Andean people prior to the arrival of the Spanish. According to Stanish and Bauer (2007), Pachacamac may have been constructed as early as the Wari occupation of the central coast of Peru. Constructed of massive adobe platform temples, Pachacamac housed an idol whom many people traveled to see for religious purposes and spiritual guidance. (D’Altroy 2002; Stanish and Bauer 2007). According to MacCormick (1991:55-61), Atawallpa consented to the destruction of the idol by Hernando Pizarro as part of his infamous ransom for freedom.

It is well known that after the Inka incorporated Pachacamac into their empire, an *aqllawasi* was established at the site (Tiballi 2010). In addition to the physical structure of the *aqllawasi* (where a reconstruction stands today), the Inka also established a cemetery, often termed the Cemetery of the Sacrificed Women. It is in this cemetery that deceased *aqllakuna* were buried after their deaths. In her treatment of *aqllakuna* as a tool of Inka statecraft, Tiballi (2010) reiterates that the function of these women was to serve the Inka state in a diverse number of

ways, most notably through textile production. Like Mackey (2010), Tiballi (2010) underscores that very few *aqllawasi* have ever been systematically excavated.

Unfortunately, the human remains recovered from Pachacamac have been mostly lost to history. In 1896, the German archaeologist Max Uhle excavated the Cemetery of the Scarified Women in its entirety (Uhle and Grosse 1903; Uhle and Shimada 1991; Eeckhout and Owens 2008; Tiballi 2010). Excavations yielded over 1000 artifacts, most of which were represented by textiles. In addition to material culture, 46 mummified human skulls were excavated and transferred to the University of Pennsylvania Museum. Though post-cranial remains were likely recovered simultaneously with the cranial remains, they were discarded as an artifact of late 19th century recovery practices (Tiballi 2010).

According to Tiballi (2010), the skulls from the Cemetery of the Sacrificed Women were de-accessioned from the Museum and transferred to the now defunct Wistar Institute in 1915. Sometime in the 1960s, the skulls were transferred to the University of Pennsylvania School of Medicine where they were transformed into teaching specimens (Figure 12). This transfer was not well-documented by either institution and was only revealed when the skulls were discovered in a Medical School closet in August 2009 (Tiballi 2010).

Unfortunately, only 20 crania and 9 mandibles have been located and 26 are still



Figure 13. Photograph of mummified remains from Pachacamac before and after processing²¹

²¹ See Figure 28 Tiballi (2010:199). The image on the left side is perhaps the only surviving photograph of human remains recovered from Pachacamac by Max Uhle (Uhle and Shimada 1991: Plate 18). The image on the right is the same individual after removal of soft tissue.

missing. All data are not lost; however, because accession numbers written on each cranium could be linked to the few surviving records corroborating numerical designations between Uhle's numbering system, the University of Pennsylvania Museum catalog, and the Wistar Institute's numbering system (see Tiballi 2010 Appendix S).

Non-Inka Coastal and Highland Samples

In addition to samples from Late Horizon Inka contexts described above, data from another 237 individuals are included in the study sample. These data include two highland groups and two coastal groups from Peru. Additional coastal and highland samples are included in order to further investigate Andean population variation patterned along a coastal-highland altitudinal gradient. The highland groups include the Yauyos sample from W.W. Howells worldwide craniometric database (Howells 1973) and the sample from Cajamarca described by Ross et al. (2008). The coastal samples are from Ancón and Makatampu and described by Ross et al. (2008). Data collection for Cajamarca, Ancón, and Makatampu was completed by Dr. Ann Ross and graciously provided to the author. The data from these sites comprise part of a forthcoming Western Hemisphere Craniometric Database (Ross, personal communication) and summarized in Table 5.

Table 5. Non-Inka Coastal and Highland Samples.

Group	Ecological Zone	Reference	Males	Females	Total
Yauyos	Central Highlands	Howells (1973)	55	55	110
Cajamarca	Northern Highlands	Ross et al. (2008)	14	16	30
Ancón	Central Coast	Ross et al. (2008)	37	10	47
Makatampu	Central Coast	Ross et al. (2008)	29	21	50
		Total	135	102	237

Sex and Age Estimates

As has been described, the skeletal remains from the five Late Horizon sites included in this study have been previously analyzed; therefore, data were mined from unpublished collections files and/or published reports of sex and age (i.e., Verano 2003; Andrushko and Verano 2008; Murphy et al. 2010ab). Sex and age estimates were typically derived from well-known pelvic and cranial indicators and individuals were classified into Young Adult, Middle Adult, and Old Adult age cohorts following Buikstra and Ubelaker (1994). Individuals were included in this analysis if fusion of the spheno-occipital synchondrosis had commenced or was complete (Shirley and Jantz 2011). In some instances, sex estimates were indeterminate because morphological indicators of the cranium were ambiguous and those cases were excluded. Crania from 315 individuals are represented in the Inka study sample. Table 6 presents the overall sex distribution and Table 7 presented the overall sex distribution by age. Sex estimates for the Yauyos sample were reported by Howells (1973) and Ann Ross provided sex data for individuals from Cajamarca, Ancón, and Makatampu. The final sample size included 552 individuals.

Table 6. Sex estimates of the Inka skeletal assemblage

	Sex		Total
	Female	Male	
57AS03	31	43	74
Huaquerones	62	69	131
Colmay	22	19	41
Machu Picchu	30	19	49
Pachacamac	19	1	20
Total	164	151	315

Table 7. Sex distribution by age cohort of the Inka samples.

		Sex		Total
		Female	Male	
Young-Adult	57AS03	9	17	26
	Huaquerones	27	26	53
	Colmay	7	3	10
	Machu Picchu	8	9	17
	Pachacamac	8	1	9
	Total	59	56	115
Middle Adult	57AS03	16	23	39
	Huaquerones	30	39	69
	Colmay	12	13	25
	Machu Picchu	11	7	18
	Pachacamac	11	0	11
	Total	80	82	162
Old Adult	57AS03	6	3	9
	Huaquerones	5	4	9
	Colmay	3	3	6
	Machu Picchu	11	3	14
	Total	25	13	38

Craniometric Data Collection Methods

Craniometric data were recorded as three dimensional coordinates of craniometric landmarks originally defined by Howells (1973). These craniometric points represent Type I, II, and III landmarks defined as either landmarks located at the juxtaposition of tissues (i.e., bregma), maxima of local curvature (i.e., basion), or anatomical extremes (i.e., euryon) (Bookstein 1991; Slice and Ross 2009; Weisensee and Jantz 2011; McKeown and Schmidt 2013). Landmarks collected in this study are presented in Figure 13 and Figure 14. Table 8 summarizes the landmarks that were collected. All landmarks were registered with a MicroScribe-3DX digitizer interfaced with a laptop computer running 3Skull, a three dimensional coordinate data collection program written by Stephen Ousley (2004) (Figure 15).

3Skull generates two Advantage Architect databases, one containing 3D coordinates and a second with the traditional Howells dataset calculated from the three dimensional coordinates (McKeown 2000; McKeown and Schmidt 2013). In this study, only Howells measurements were utilized though three dimensional coordinates have been utilized to conduct biological distance analyses of numerous populations (McKeown 2000; McKeown and Schmidt 2013).

Table 8. Craniometric landmarks registered via Microscribe digitizer ²²

Measurement	Measurement
1. prosthion-Howells	36. left frontomolare temporale
3. subspinale	37. left frontotmalare anterior
4. left alare	38. left frontotemporale
5. left inferior nasal border	39. left sphenion
6. right inferior nasal border	40. left krotaphion
7. left alare	41. left maximum frontal point
8. left alpha	42. left stephanion
9. left nasale inferius	43. right stephanion
10. right nasale inferius	44. right maximum frontal point
11. right alpha	47. right frontotemporale
12. left nasomaxillary suture pinch	48. right frontomolare anterior
13. nasal bone elevation	49. right frontomolare temporale
14. right nasomaxillary suture pinch	50. right marginal process
15. deepest point on nasal bone profile	51. right jugale
16. right zygoorbitale	52. nasion
17. left zygoorbitale	53. glabella
18. lower orbital border	54. supraglabellare
19. upper orbital border	55. bregma
20. cheek height superior point	56. lambda
21. cheek height inferior point	57. left asterion
22. left ectoconchion	58. left eurion
23. left dacryon	59. left radiometer point
24. right dacryon	60. left porion
25. right ectoconchion	61. left mastiodale
26. right zygion	62. left radiculare
29. right zygomaxilare	73. left ectomolare
30. left zygomaxilare	74. left M1 anterior point
31. left zygotemporale inferior	75. right ectomolare
32. left zygotemporale superior	103. metopion
33. left zygion	104. parietal subtense point
34. left jugale	105. vertex
35. left marginal process	106. opisthiocranion
	107. occipital subtense point

²² For definitions of these landmarks see Howells (1973), and Weisensee and Jantz (2011).

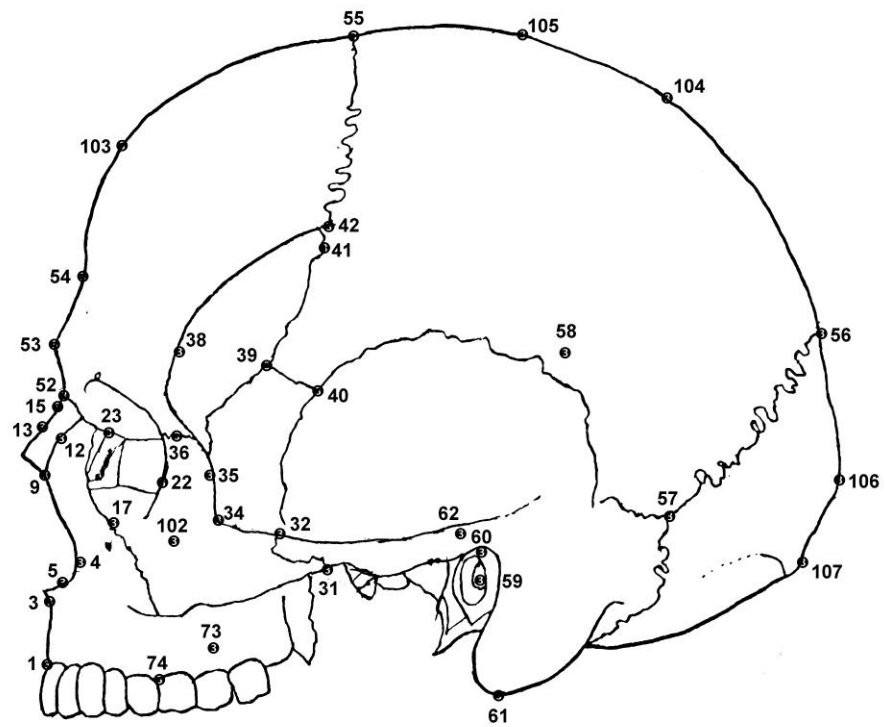


Figure 14. Lateral View of Craniometric Landmarks Registered with Microscibe (from the left side)

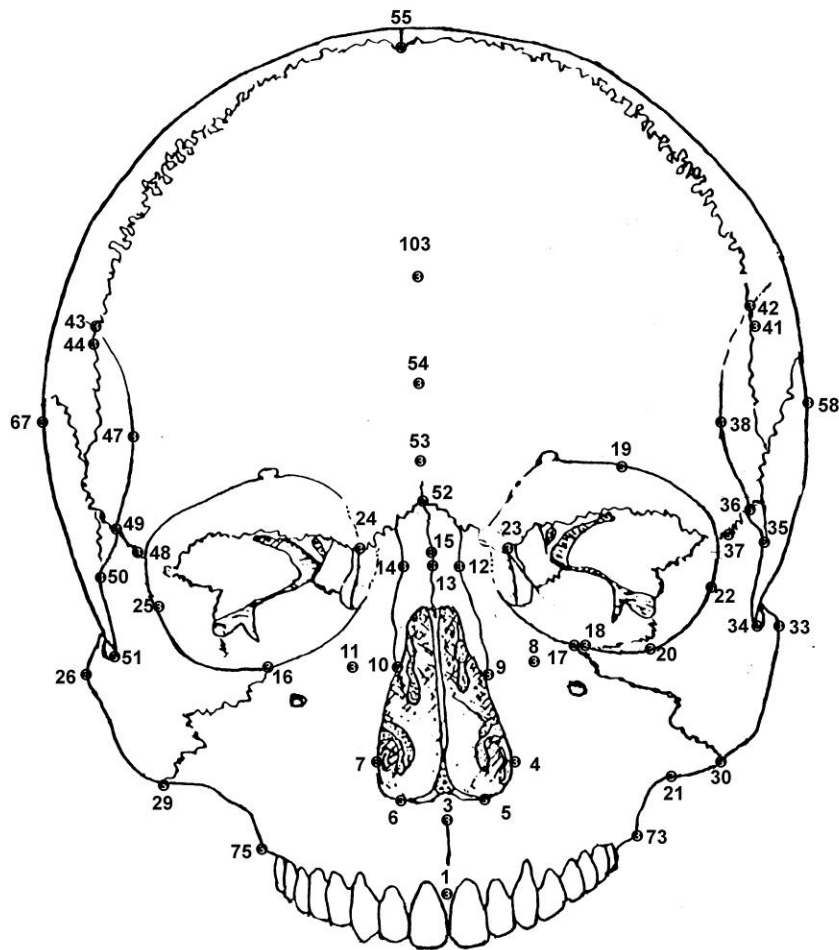


Figure 15. Anterior View of Craniometric Landmarks Registered with Microscribe.



Figure 16. Position of each cranium as it is digitized with the Microscribe.

Data Screening and Selection of Variables

Before any type of biological distance analysis can be conducted on craniometric distances or non-metric traits, several confounding factors must be considered. In this section, I will outline those procedures that were utilized to mitigate ACM, intra-observer error, sex influences, and the problem of missing data.

As discussed in Chapter 4, Andean bioarchaeologists have long dealt with skeletal samples presenting modified crania. Following Verano (2003), fifteen craniofacial measurements purported to be relatively unaffected by intentional cranial vault modification were extracted from the Advantage Architect database containing the Howells (1973) measurements. This study follows Verano (2003) and Haun and Cock Carrasco (2010) and only examines those variables in this analysis (Table 9). Subsamples of crania from the sites of Machu Picchu, Colmay, and Pachacamac were digitized twice in order to examine patterns of intra-observer error (n=32).

Though missing data are often common in bioarchaeological contexts, computation of an **R** Matrix requires a complete variance-covariance matrix; therefore, missing values were imputed with SPSS 20.0 via an expectation-maximization (EM) algorithm for all five sites. (Nystrom 2006; Scherer 2007). Prior to imputation effects of antemortem tooth loss were considered on missing

Table 9. Craniometric distances utilized by Verano (2003)²³

Measurement	Definition
Basion-nasion length (BNL)	Direct length between basion and nasion
Basion-prosthion length (BPL)	The facial length from prosthion to basion
Nasion-prosthion height (NPH)	Upper facial height from nasion to prosthion
Nasal height (NLH)	The average height from nasion to the lower point on the border of the nasal aperture on either side
Nasal breadth (NLB)	The distance between the anterior edges of the nasal aperture at its widest extent
Orbit height (OBH)	The height between the upper and lower borders of the left orbit, perpendicular to the long axis of the orbit and bisecting it
Orbit breadth (OBB)	Breadth from ectoconchion to dacryon
Biorbital breadth (EKB)	The breadth across the orbits from ectoconchion to ectoconchion
Interorbital breadth (DKB)	The breadth across the nasal space from dacryon to dacryon
Bimaxillary breadth (ZMB)	The breadth across the maxillae, from one zygomaxillare anterior to the other
Palate Breadth (MAB)	The greatest breadth across the alveolar border, wherever it is found
Malar length, inferior (IML)	The direct distance from zygomaxillare anterior to the lowest point of the zygo-temporal suture on the external surface, on the left side
Malar length, maximum (XML)	Total direct distance of the malar in a diagonal direction
Minimum cheek height (WMH)	The minimum distance, in any direction, from the lower border of the orbit to the lower margin of the maxilla
Nasion-bregma chord (FRC)	The frontal cord, or direct distance from nasion to bregma

²³ (definitions after Howells 1973)

data (see Rhode and Arriaza 2006). Antemortem tooth loss is a common phenomenon encountered in archaeological samples which influences collection of numerous craniometric landmarks, particularly those landmarks located on the maxillae of intact crania (i.e., prosthion and ectomolare). Given the high frequency of antemortem tooth loss within the sample, and subsequent missing distances calculated from those landmarks, the craniometric distances BPL, NPH, and MAB were removed prior to imputation of missing data or analysis of intra-observer error. An analysis calculating the intraclass coefficient between repeated measures of the twelve remaining Howells distances described by Verano (2003) was performed. This analysis was conducted in order to determine if intra-observer error significantly affected data collection. Intra-observer error was not found to be statistically significant for any of the remaining twelve measurements (Table 10). Missing data in the dataset was imputed prior to screening for sex effects.

To control for sex, all variables were transformed into z-scores using the respective summary statistics from the two sexes (Williams-Blangero and Blangero 1989; Steadman 1998, 2001; Nystrom 2006; Scherer 2007). The study sample was not controlled for age effects in order to maximize the inclusion of all remaining craniometric variables described by Verano (2003).

Table 10. Intraclass correlations of twelve craniometric variables

Measurement	Intraclass Correlation	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
BNL	.993 ^c	.984	.996	131.321	29	29	<.001
NLH	.999 ^c	.997	.999	787.286	28	28	<.001
NLB	.977 ^c	.951	.989	43.357	28	28	<.001
OBH	.982 ^c	.953	.992	69.915	29	29	<.001
OBB	.949 ^c	.891	.977	19.271	27	27	<.001
DKB	.985 ^c	.965	.994	78.702	27	27	<.001
ZMB	.993 ^c	.978	.997	171.381	25	25	<.001
EKB	.985 ^c	.949	.994	92.126	26	26	<.001
IML	.993 ^c	.985	.997	152.150	27	27	<.001
XML	.995 ^c	.986	.998	249.855	26	26	<.001
WMH	.996 ^c	.975	.999	455.511	26	26	<.001
FRC	.985 ^c	.968	.993	64.824	28	28	<.001

R Matrix

The statistical package RMET 5.0 (Relethford 2003) was used to generate the **R** matrix, estimates of F_{st} , Relethford-Blangero residuals, and biological distance from a total of twelve craniometric variables (see Chapter 6). RMET 5.0 analyses were performed with heritabilities equal to 1.0 and 0.55, respectively (Konigsberg and Ousley 1995; Stojanowski 2004; Nystrom 2006). Numerous authors assert that while heritabilities of 1.0 are conservative estimates, heritabilities set to 0.55 are appropriate for craniometric variables (Konigsberg and Ousley 1995; Stojanowski 2004; Scherer 2007). As mentioned previously, the **R** Matrix was calculated with all population sizes set equally given that settlement pattern data and census figures are unavailable for the sites utilized in this analysis.

Mantel Test

To assess if spatial distances across sites impacted biological distances between groups in this sample, correlation matrix analysis was performed. As has been demonstrated by other scholars, geographic distance can influence biological distance values (Konigsberg 1990; Stojanowski 2004; Steadman 2001; Scherer 2007). Konigsberg (1990) demonstrated that if mate-exchange networks are patterned over a fixed temporal period, a positive correlation will exist between geographic and biological distance. Konigsberg (1990) developed this isolation-

by-distance model to investigate post-marital residence patterns between populations in west-central Illinois.

A common approach in biological distance literature is to utilize Mantel matrix tests to examine the correlation between geographic and biological distances (Smouse and Long 1992; Relethford and Crawford 1995). In some instances, investigators test temporal associations as well. Given that all samples in this study are from Late Horizon Inka contexts, Mantel matrix correlation analysis is only utilized to infer whether or not geographic distance influenced biological distances between groups. The Mantel test indicates if samples from a particular environment (i.e., geographic distance) are similar in regards to biological distance (Smouse and Long 1992). In instances where the Mantel test demonstrates that biological and geographic distance are not statistically correlated, workers have concluded that that geographic distance is not an effective barrier to gene flow (Steadman 2001; Scherer 2007).

A Mantel test was used to investigate the correlation between biological and geographic distances. In the case presented here, geographic distances between sites were not calculated as straight-line distances between sites given the obvious barrier of the Andean Cordillera. Rather, information on the Inka road system (after Hyslop 1984:frontispiece) (Figure 16) was used in conjunction with Google Earth Pro to calculate approximate distances between each of the five sites in kilometers (Table 11). The Mantel test utilized complete enumeration

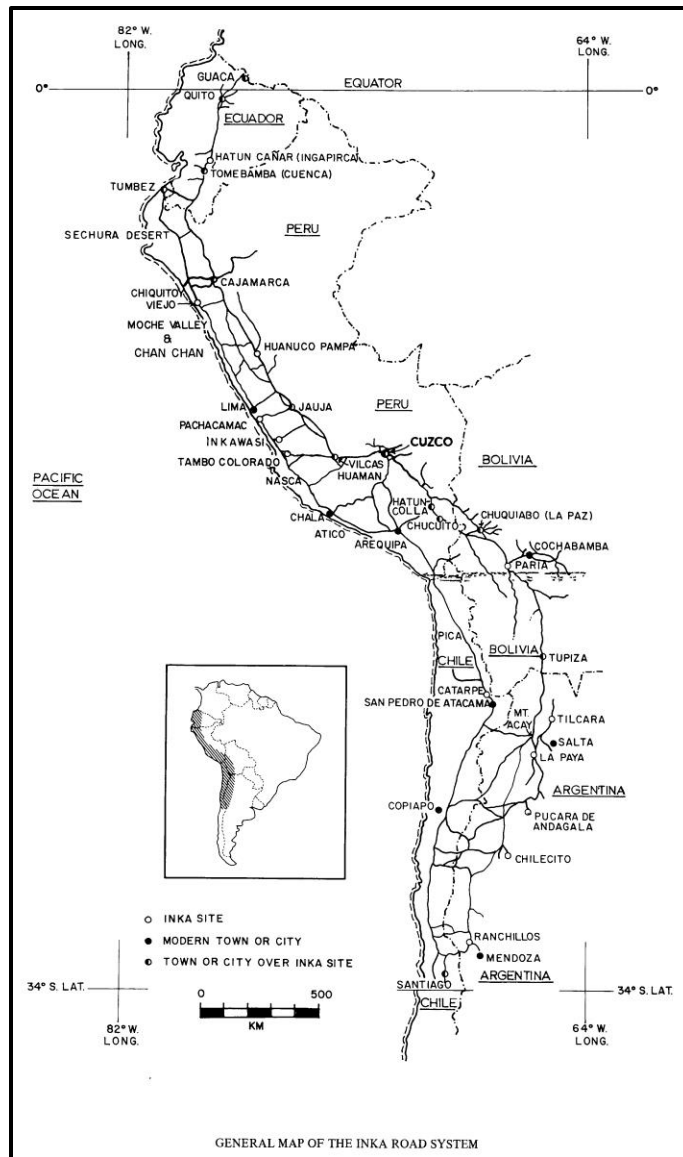


Figure 17. General Map of the Inka Road System²⁴

²⁴ After (Hyslop 1984: frontispiece)

Table 11. Geographic distances between sites in kilometers

	Colmay	Huaquerones	57AS03	Pachacamac
Huaquerones	608			
57AS03	608	0.7		
Pachacmac	585	23	23	
Machu Picchu	111	712	712	689

of 120 permutations (Königsberg 2013, personal communication).

Chapter 6 – Results

Summary statistics of the craniometric variables are presented in this chapter. In addition, results of the **R** matrix analysis are presented here, along with results from the matrix correlation analysis. The final sample included craniometric data from 552 individuals drawn from five Inka mortuary contexts (n=315) and four non-Inka mortuary contexts (n=237). Twelve craniometric variables were selected for inclusion in the **R** matrix through variable screening procedures discussed in Chapter 5. Analyses were first conducted of all nine sites pooled together in order to investigate coastal-highland patterning followed by an analysis of the five Late Horizon Inka samples.

Summary Statistics

According to numerous quantitative studies within biological anthropology appropriate summary statistics of metric datasets should be provided so that future hypotheses can be tested when raw data is unavailable (Konigsberg 1991; Konigsberg et al. 1998; Uhl et al. 2013). Uhl et al. (2013) recommend that authors report vector means of raw data, as well as variance-covariance matrices of site-specific datasets. Vector means of the twelve craniometric variables are reported in Table 12 and variance-covariance matrices for each site are reported in Tables 13 – 21. Vector means and variance-covariance matrices data are derived from the imputed dataset. Sample sizes for each site are reported in Chapter 5.

Table 12. Vector means of the twelve craniometric variables by site²⁵

	BNL	NLH	NLB	OBH	OBB	DKB	ZMB	EKB	IML	XML	WMH	FRC
57AS03	96.473	49.0135	23.4459	35.5811	38.6892	20.0676	97.5811	95.4459	31.4324	52.4189	21.8649	103.986
Huaquerones	96.0687	48.916	23.0687	35.3511	38.5725	19.9542	97.4885	95.4504	31.1908	51.542	22.084	104.695
Colmay	93.122	47.000	23.171	36.390	36.585	20.976	94.463	92.146	32.000	48.683	21.707	111.951
Machu Picchu	90.3265	46.0408	23.2449	36.3878	36.9592	19.5102	91.6939	91.5918	29.3469	47.4694	19.7143	103.816
Pachacamac	92.700	47.650	24.250	35.350	37.350	19.950	94.500	92.250	30.050	48.800	21.000	104.400
Yauyos	93.291	49.000	24.600	34.209	37.536	20.282	94.355	93.118	33.664	50.291	23.255	107.400
Ancon	94.8844	49.000	24.8085	35.5106	39.1064	20.1915	97.3135	95.5957	34.1277	50.617	21.5745	105.809
Cajamarca	94.5189	47.9	24.2	35.2	37.9667	20.0667	94.4137	93.0097	33.3603	49.8646	20.7273	107.167
Makatampu	96.4226	47.42	24.96	34.2	38.14	20.6432	96.2547	94.74	34.7155	51.4938	21.28	105.52

²⁵ Sample sizes are reported in Chapter 5.

Table 13. Variance-covariance matrix of craniometric variables for 57AS03

BNL	NLH	NLB	OBH	OBB	DKB	ZMB	EKB	IML	XML	WMH	FRC
24.088											
3.761	5.767										
2.266	.871	3.072									
-1.333	.718	-.222	7.699								
1.861	.580	.086	1.402	2.710							
1.543	-.261	.737	2.536	.556	4.475						
10.352	3.759	1.778	1.932	2.882	3.083	20.274					
9.362	2.761	2.209	.203	3.757	2.737	9.354	10.497				
8.094	1.830	1.777	-1.049	.616	.313	4.074	4.270	12.468			
8.648	.802	.317	3.452	2.721	2.629	9.507	5.742	9.556	21.151		
4.298	2.290	.938	-1.044	.108	.502	5.244	2.609	2.635	2.660	7.214	
10.335	4.165	4.088	1.022	1.489	1.672	6.871	7.061	7.376	3.800	6.806	26.041

Table 14. Variance-covariance matrix of craniometric variables for Huaquerones

BNL	NLH	NLB	OBH	OBB	DKB	ZMB	EKB	IML	XML	WMH	FRC
21.403											
7.875	9.016										
-.005	.029	3.603									
3.806	3.030	.206	4.168								
3.337	1.833	1.037	1.428	3.077							
2.149	.658	1.057	.539	.173	3.583						
11.751	6.211	1.682	3.581	2.803	3.046	20.975					
8.323	3.930	3.177	3.025	4.848	3.605	9.455	12.819				
7.294	3.678	.887	.902	1.467	1.501	3.521	4.706	11.648			
7.262	4.607	.547	.485	.849	2.148	7.949	4.669	8.765	13.542		
3.625	2.622	.025	.778	.128	.965	4.628	1.493	1.668	3.154	3.585	
11.275	5.805	.575	2.677	2.722	.517	9.450	5.454	4.005	6.421	3.234	26.506

Table 15. Variance-covariance matrix of craniometric variables for Colmay

BNL	NLH	NLB	OBH	OBB	DKB	ZMB	EKB	IML	XML	WMH	FRC
21.960											
6.425	10.900										
2.954	1.075	2.995									
1.451	1.800	.707	3.394								
4.127	2.600	.798	1.216	3.299							
6.228	2.925	1.279	-.640	.440	7.124						
12.967	7.100	3.694	.315	2.772	5.787	20.655					
13.982	6.675	3.074	.991	4.712	7.579	13.305	16.478				
6.050	1.825	.975	.325	2.475	3.700	4.650	8.125	10.550			
8.490	4.425	.330	.452	2.065	3.942	7.201	7.898	6.175	9.522		
4.462	6.675	1.351	.192	.876	3.643	6.139	4.219	.750	2.805	8.062	
4.681	5.400	.134	6.145	4.729	1.224	-3.127	5.782	4.300	3.559	2.260	39.648

Table 16. Variance-covariance matrix of craniometric variables for Machu Picchu

BNL	NLH	NLB	OBH	OBB	DKB	ZMB	EKB	IML	XML	WMH	FRC
10.558											
2.882	6.957										
.252	-.073	3.439									
.600	2.005	-.243	4.201								
.347	.877	.177	2.454	4.457							
1.517	1.229	.185	-.431	-1.604	4.963						
6.560	3.492	2.493	3.580	4.071	1.576	32.884					
3.719	2.934	1.790	3.766	4.775	1.629	11.289	11.705				
2.134	.756	1.726	-.450	-1.111	2.090	3.108	2.478	8.731			
3.364	-.770	3.299	1.314	-.022	2.797	1.334	5.904	5.084	48.713		
1.283	2.074	.217	-.804	-1.033	1.670	4.057	.485	3.789	4.408	6.250	
6.290	2.903	.233	.739	-1.841	-.800	9.193	.090	2.753	-15.974	.405	35.778

Table 17. Variance-covariance matrix of craniometric variables for Pachacamac

BNL	NLH	NLB	OBH	OBB	DKB	ZMB	EKB	IML	XML	WMH	FRC
14.221											
-2.847	32.239										
2.132	-2.013	3.566									
-1.942	-1.871	-1.092	2.661								
1.742	-3.450	.382	.976	3.082							
1.563	-1.703	2.171	-.718	-.613	4.576						
9.526	-4.026	.553	-1.868	1.447	1.079	16.684					
5.447	-7.171	2.145	.697	4.118	1.908	4.237	8.197				
4.174	-.350	-.645	-.334	-1.492	.266	-.868	-1.592	11.313			
6.884	1.821	-.684	-1.242	-1.189	1.095	6.842	-.421	7.063	11.011		
2.263	5.684	-1.474	-1.000	-.368	-.737	4.053	-.789	1.684	3.579	4.316	
-8.874	7.200	-4.211	.326	-4.832	-.137	-4.421	-9.737	.453	1.400	1.579	26.884

Table 18. Variance-covariance matrix of craniometric variables for Yauyos

BNL	NLH	NLB	OBH	OBB	DKB	ZMB	EKB	IML	XML	WMH	FRC
20.263											
7.330	7.413										
2.778	.569	3.251									
.764	1.725	-.328	2.038								
3.567	1.982	.409	.648	2.343							
4.532	.844	1.417	-.050	.655	4.333						
12.933	6.734	3.116	1.008	2.872	4.193	22.965					
11.103	4.835	2.736	1.149	4.413	5.177	11.527	14.087				
9.218	3.651	2.130	.190	2.677	2.830	4.414	8.104	13.400			
11.052	5.505	2.356	.342	2.843	3.156	8.859	8.754	11.502	15.401		
5.623	3.358	1.442	.075	.853	1.313	7.221	3.658	3.316	5.237	5.825	
13.406	6.514	1.317	1.640	3.783	2.639	11.178	9.943	7.383	9.717	4.521	23.068

Table 19. Variance-covariance matrix of craniometric variables for Ancón

BNL	NLH	NLB	OBH	OBB	DKB	ZMB	EKB	IML	XML	WMH	FRC
19.838											
9.953	12.261										
2.434	1.935	4.115									
1.299	2.065	.143	2.907								
4.711	2.717	.564	1.314	3.575							
2.678	2.696	1.168	.574	.566	4.376						
17.104	10.651	4.795	1.661	6.417	5.633	37.195					
11.001	8.087	2.725	2.254	6.174	4.688	17.057	15.724				
6.350	5.196	-.366	.238	1.660	.584	.084	3.922	9.983			
9.360	9.283	.360	-.191	2.063	1.640	8.497	6.907	9.289	18.154		
6.890	5.630	.352	-.321	1.220	1.801	10.174	4.650	2.947	6.507	7.424	
9.153	7.326	3.289	1.817	2.521	2.559	10.951	6.334	2.416	6.251	6.243	22.071

Table 20. Variance-covariance matrix of craniometric variables for Cajamarca

BNL	NLH	NLB	OBH	OBB	DKB	ZMB	EKB	IML	XML	WMH	FRC
27.422											
14.926	12.093										
2.311	2.124	3.062									
3.996	2.676	1.028	2.579								
6.845	3.617	1.283	1.938	4.378							
4.964	3.110	1.090	.710	1.726	3.306						
17.780	10.241	5.085	3.620	5.497	5.004	30.791					
9.887	4.821	3.556	3.080	6.776	3.906	15.378	16.917				
3.440	2.017	.400	.443	2.004	1.079	4.090	3.483	6.274			
5.694	2.482	.603	.476	1.804	1.113	5.315	2.226	3.984	5.437		
7.024	4.404	.389	.022	1.577	1.122	6.518	1.712	1.090	2.687	5.705	
15.521	5.362	.276	1.241	3.213	2.713	20.611	9.502	3.636	5.732	6.166	33.040

Table 21. Variance-covariance matrix of craniometric variables for Makatampu

BNL	NLH	NLB	OBH	OBB	DKB	ZMB	EKB	IML	XML	WMH	FRC
26.310											
9.713	9.106										
3.282	2.017	4.202									
1.569	2.669	-.094	2.898								
5.193	3.348	1.393	.931	3.511							
2.159	.398	1.577	-.563	.867	4.272						
16.283	7.993	3.499	2.668	5.964	4.055	25.792					
12.525	6.213	3.989	1.135	7.017	4.789	15.797	17.870				
8.848	3.190	1.603	.278	2.945	1.052	4.621	7.048	12.949			
14.198	5.790	2.566	.423	4.477	2.181	11.027	10.733	12.298	16.743		
6.981	3.553	1.399	.657	1.613	1.435	6.993	4.789	4.046	5.590	6.083	
15.652	9.287	3.511	2.098	4.171	1.703	13.113	9.056	5.904	10.160	6.729	27.193

R Matrix Results

Table 22 presents the F_{st} estimate among the total sample, which was 0.098 when heritability was assumed to equal 0.55. A heritability estimate of 0.55 was chosen to facilitate comparisons with other published studies from Andean South America. Table 22 also presents the F_{st} estimate for the five Inka samples which was 0.078. These values are consistent with other F_{st} estimates derived from craniometric studies which have been conducted on South American populations from Andean contexts in Peru and mirror similar patterns of among-group genetic variability from other regions in the Andes (Nystrom 2006; Klaus 2008).

As demonstrated by Ousley (1995), analyses of pre-contact South American samples generated high overall F_{st} estimates which ranged from 0.33 – 0.39. Given the continental scale of Ousley's (1995) study, F_{st} estimates of this magnitude are to be expected. Klaus' (2008) F_{st} estimate of 0.009 was derived from populations of post-contact individuals from the Lambayeque Valley on the North Coast of Peru. Klaus (2008) links this reduction in among-group heterogeneity to several potential causal mechanisms including epidemic disease and geographic isolation by colonial Spaniards who divided the local community into *parcialidades* [groups organized by kinship and economic specialization].

The F_{st} estimate for the Inka samples of 0.078 generated in this study is also similar to findings from other regions of the New World (Table 23). In these

Table 22. F_{st} estimates for sites utilized in this study and other South American samples

Site, Population, or Region	F_{st}	Reference
Post-contact Mórrope, Lambayeque, Peru	0.009	Klaus 2008
Wari and Post Wari, Ayacucho, Peru	0.029	Kemp et al. 2009
Late Horizon Huaquerones and 57AS03, Peru	0.0365	Murphy et al. 2008
Late pre-Hispanic Lambayeque, Peru	0.041	Klaus 2008
Inka Mortuary Contexts, Peru	0.078	this study
Late pre-Hispanic Chachapoyas, Peru	0.09	Nystrom 2006
Total Andean Samples, Peru	0.098	this study
South American Indians	0.33–0.39	Ousley 1995

Table 23. Minimum F_{st} estimates for other New World archaeological samples

Site, Population, or Region	F_{st}	Reference
Ohio Valley	0.078	Tatarek and Sciulli (2000)
Algonquian	0.055	Jantz and Meadows (1995)
Coosa Chiefdom (TN and GA)	0.052	Harle (2010)
Iroquoian	0.045	Langdon (1995)
Tennessee Mississippians	0.028	McCarthy (2011)
Illinois Mississippians	0.010	Steadman (2001)

studies, authors argued that gene flow between groups was a likely explanation for relatively low F_{st} estimates. In the case of the Eastern Woodlands of North America, Tatarek and Scihulli (2000) maintained that enough gene flow occurred between Late Prehistoric groups in Ohio to obscure marked differentiation between populations. Harle (2010) and McCarthy (2011) observed similar patterns of group micro-differentiation in Mississippian populations from East Tennessee and North Georgia.

Biological distances between all nine sites included in the analysis are included in Table 24. As described previously, the biological distances were calculated without population size information given that settlement pattern data and census figures for all sites are presently unavailable. Like with Ross et al. (2008), small distances between the coastal sites of Ancón and Makatampu are noted, as are minimal distances between the highland sites of Cajamarca and Yauyos. In addition, the smallest distances are observed between the Inka sites of 57AS03 and Huaquerones. These distances are best visualized in Figure 18 which provides a plot of the first two eigenvectors derived from the biological distance matrix. The first eigenvector accounts for 40.3% of the total variation and loosely separates the sites along a coastal-highland ecological gradient. The second eigenvector accounts for 36.4% of the total variation and separates the sites of Machu Picchu and Colmay from the highland sites of Cajamarca and Yauyos.

Table 24. Biological distances between all groups²⁶

	57AS03	Huaquerones	Machu Picchu	Colmay	Pachacamac	Yauyos	Cajamarca	Ancon	Makatampu
57AS03	*	0.006502	0.036525	0.05361	0.031282	0.040283	0.043641	0.035532	0.036317
Huaquerones	0.002896	*	0.033755	0.047686	0.033402	0.029911	0.043641	0.034065	0.034956
Machu Picchu	0.248041	0.259762	*	0.040348	0.04401	0.040283	0.04452	0.041533	0.048515
Colmay	0.491966	0.46245	0.222464	*	0.057109	0.041858	0.047916	0.053848	0.054204
Pachacamac	0.072061	0.101627	0.150158	0.258224	*	0.038406	0.034774	0.034615	0.03849
Yauyos	0.354328	0.352097	0.355905	0.335875	0.138654	*	0.029921	0.025221	0.027044
Cajamarca	0.25052	0.283008	0.221643	0.239145	0.05611	0.120982	*	0.023672	0.023364
Ancon	0.227137	0.25601	0.257994	0.40501	0.077636	0.125963	0.041837	*	0.023904
Makatampu	0.248425	0.284141	0.372282	0.423782	0.107605	0.154857	0.042303	0.072643	*

²⁶ Biological distances are below diagonal and standard errors are above.

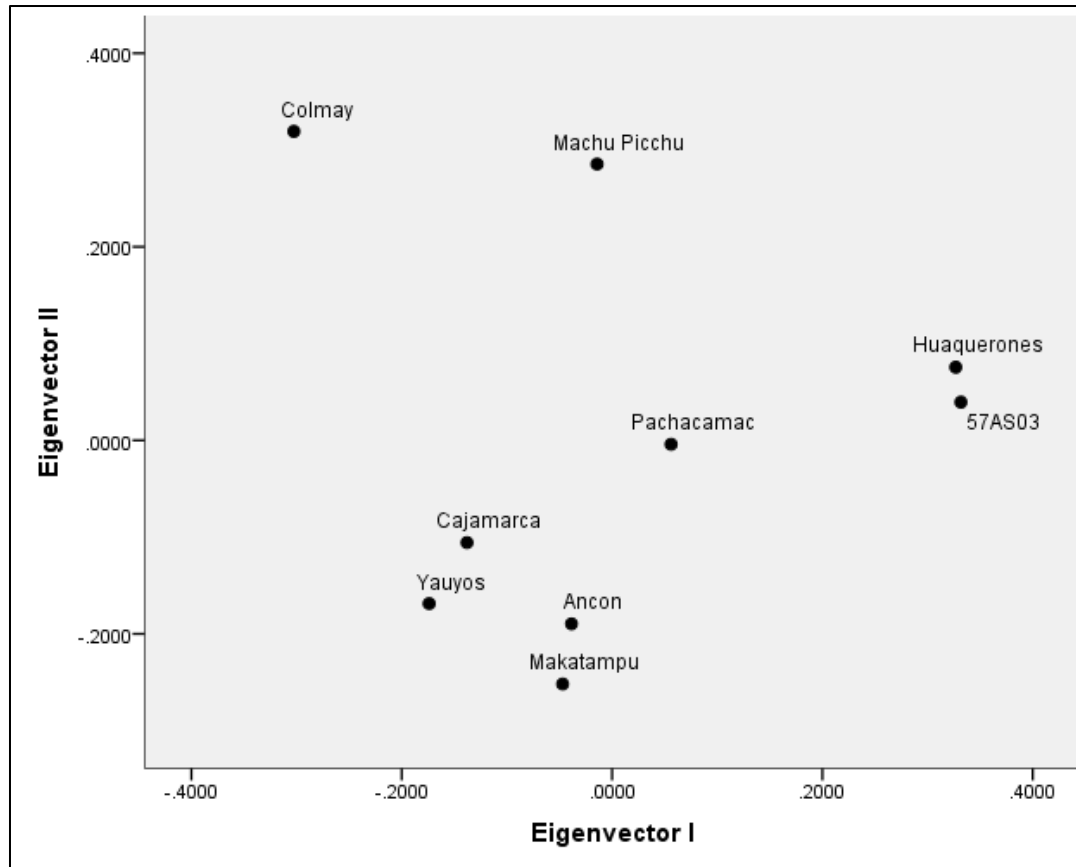


Figure 18. Principal coordinate plot of first and second eigenvectors of biological distances between all sites

Biological distances between the five Inka mortuary sites are presented in Table 26. Biological distances between Huaquerones and 57AS03 are exceptionally small suggesting some continuity between the two populations. Despite some differences in mortuary treatment between the sites, particularly with atypical burials recovered from 57AS03 (see Murphy et al. 2010ab), biological distance results suggest that individuals interred in both Huaquerones and 57AS03 are likely members of the same community. Given that less than one kilometer spatially separates these cemeteries, these findings are not surprising. 57AS03 and Pachacamac have the next smallest biological distances between them, following by Pachacamac and Huaquerones.

As described previously, Pachacamac is geographically close to Huaquerones and 57AS03 which might explain the small biological distances between these locales. However, given the reality of a small sample size from Pachacamac, interpretations of biological distances between this site and the two cemeteries from the Puruchuco-Huaquerones complex are difficult. Future analysis investigating the relationship between Pachacamac, 57AS03, and Huaquerones might best be explored through strontium isotopic analysis. Moreover, future recovery of the missing Pachacamac sample at the University of Pennsylvania would add to the sample size and further the interpretive potential of this dataset.

Table 25. Biological distances between Inka groups²⁷

	Huaquerones	57AS03	Machu Picchu	Colmay	Pachacamac
Huaquerones	*	0.00655	0.033787	0.043356	0.034112
57AS03	0.002823	*	0.036449	0.048528	0.030417
Machu Picchu	0.254457	0.24133	*	0.038922	0.04737
Colmay	0.371101	0.39079	0.200614	*	0.053716
Pachacamac	0.104337	0.06431	0.174973	0.218604	*

²⁷ Biological distances are below diagonal and standard errors are above.

Biological distance analysis of the five Inka sites appears to also confirm continuity between the sites of 57AS03 and Huaquerones. This is best presented in Figure 19, a plot of the first two eigenvectors derived from a principal coordinates analysis of the Inka biological distance matrix. The first eigenvector accounts for 68.2% of the variation and loosely separates the sites along a coastal-highland ecological gradient. Given the small geographic distances between these sites and other research suggesting continuity between the two populations (i.e., Murphy et al. 2008; Murphy et al. 2010ab), biological distances presented here suggest that individuals interred at Huaquerones and 57AS03 were likely members of the same community. The region of origin of these individuals will be considered in further detail in Chapter 7. The second principal coordinate accounts for 22.4% of the variation and appears to separate Colmay from the four Inka sites.

Table 26 presents results from the matrix correlation analysis between geographic distance and biological distance matrices from the Inka samples. Biological distances were not significantly correlated with geographic distances in these samples. Given the complex nature of the Inka road system introduced in Chapter 3 and depicted previously, it is clear that Inka infrastructure facilitated the movement of individuals across the empire (Hyslop 1984; Bauer 2006; Julien 2012). Despite the geographic barrier of the Cordillera, these results suggest that

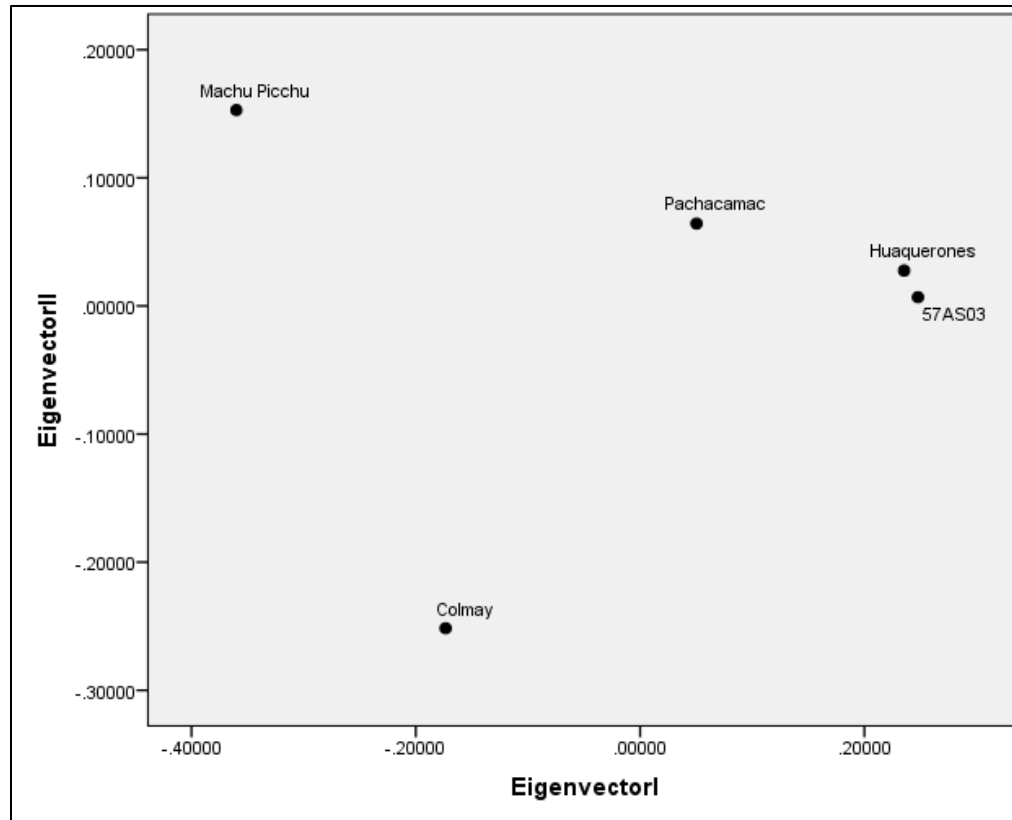


Figure 19. Principal coordinate plot of first and second eigenvectors of biological distances for Inka sites

Table 26. Matrix correlation analysis between biological and geographic distance

Matrix Comparison	Correlation	R²	<i>p</i>-value
Craniometric Distance*Inka Road Distance	0.8598	0.7392	0.2000

As has been described by numerous Inka scholars, mobility was a hallmark of Inka imperialism (Malpass 2003; D'Altroy 2002; Covey 2006; Burger et al. 2007; Malpass and Alconini 2010); therefore, it is not surprising that geographic distance did not hinder movement in these samples. Unfortunately, isotopic studies tracking residential mobility have only been conducted on two Inka mortuary assemblages at this time (i.e., Andrushko et al. 2009; Turner et al. 2009); therefore, the degree to which movement has been elucidated on an individual level remains largely unknown. As will be discussed in Chapter 7, future isotopic studies of other Inka mortuary assemblages will supplement existing literature in this understudied area.

The Relethford-Blangero residuals for all nine sites are presented in Table 27 and are derived from a heritability estimate of 0.55. The residuals indicate that the pre-Inka sites from the highlands, Yauyos and Cajamarca, were experiencing less than average gene flow. In addition, the pre-Inka site from the central coast of Peru, Makatampu, also appears to have experienced less than average gene flow. Relethford-Blangero results suggest that the pre-Inka site of Ancón may have experienced elevated levels of gene flow. Other bioarchaeological studies have confirmed this trend and have indicated that Ancón may have experienced elevated levels of migration beginning in the Middle Horizon onward (Slovak et al. 2009; Pink 2013). Relethford-Blangero results indicate that two of the Inka sites from the central coast, Huaquerones and

Table 27. Relethford-Blangero residuals for all sites.

<u>Population</u>	<u>r(ii)</u>	<u>Observed</u>	<u>Expected</u>	<u>Residual</u>
57A	0.11063	0.913	0.927	-0.015
Huaquerones	0.12313	0.825	0.914	-0.089
Colmay	0.214259	1.099	0.819	0.28
Machu Picchu	0.131294	1.167	0.906	0.261
Pachacamac	0.002876	1.107	1.04	0.067
Yauyos	0.115931	0.705	0.922	-0.217
Ancon	0.061862	0.982	0.978	0.004
Cajamarca	0.037336	0.797	1.004	-0.207
Makatampu	0.088872	0.867	0.95	-0.084
$h^2 = 0.55$ $F_{st} = 0.098466$ $se = 0.005223$				

57AS03 experienced less than average gene flow, while Pachacamac experienced greater than average gene flow. The Inka sites from the Cuzco region, Machu Picchu and Colmay, also appear to have experienced greater levels of gene flow.

The Relethford-Blangero analysis was also conducted on the five Inka sites alone with heritability levels set to both 1.0 and 0.55. These results are presented in Table 28 and mirror the trend when the analysis was conducted on all nine sites. The residuals indicate that populations from Huaquerones and 57AS03 were receiving less than average gene flow while groups from Colmay, Machu Picchu, and Pachacamac were experiencing greater than average gene flow.

Two plots of observed within-group variation ($\bar{v}_i$) against genetic distance to the centroid $r_{(ii)}$ demonstrates deviations from the model originally outlined by Harpending and Ward (1982) and Relethford and Blangero (1990) (Figures 20-21). Figure 20 presents all nine sites and Figure 21 presents only the Inka mortuary contexts. In both Figures, the populations from Machu Picchu, Colmay, and Pachacamac appear to violate the null hypothesis of a linear relationship described by Relethford and Blangero (1990) and fall above the expected theoretical linear relationship, suggesting an elevated level of gene flow. In both Figures, the Inka sites of 57AS03 and Huaquerones fall below the expected linear relationship indicating that these sites most likely were composed of more genetically isolated, homogenous populations.

Given that resettled populations were composed of individuals from

Table 28. Relethford-Blangero Analysis for Inka Sites

	r_(ii)	Observed	Expected	Residual
57A	0.030672	0.863	0.975	-0.112
Huaquerones	0.036438	0.786	0.969	-0.184
Colmay	0.082351	1.045	0.923	0.122
Machu Picchu	0.048145	1.083	0.958	0.126
Pachacamac	0.002993	1.05	1.003	0.047
$h^2 = 1.0$				
$F_{st} = 0.040120$				
$se = 0.005697$				
57A	0.058533	0.863	0.987	-0.123
Huaquerones	0.066402	0.786	0.978	-0.193
Colmay	0.152728	1.045	0.888	0.157
Machu Picchu	0.091579	1.083	0.952	0.131
Pachacamac	0.02383	1.05	1.023	0.027
$h^2 = 0.55$				
$F_{st} = 0.078$				
$se = 0.007071$				

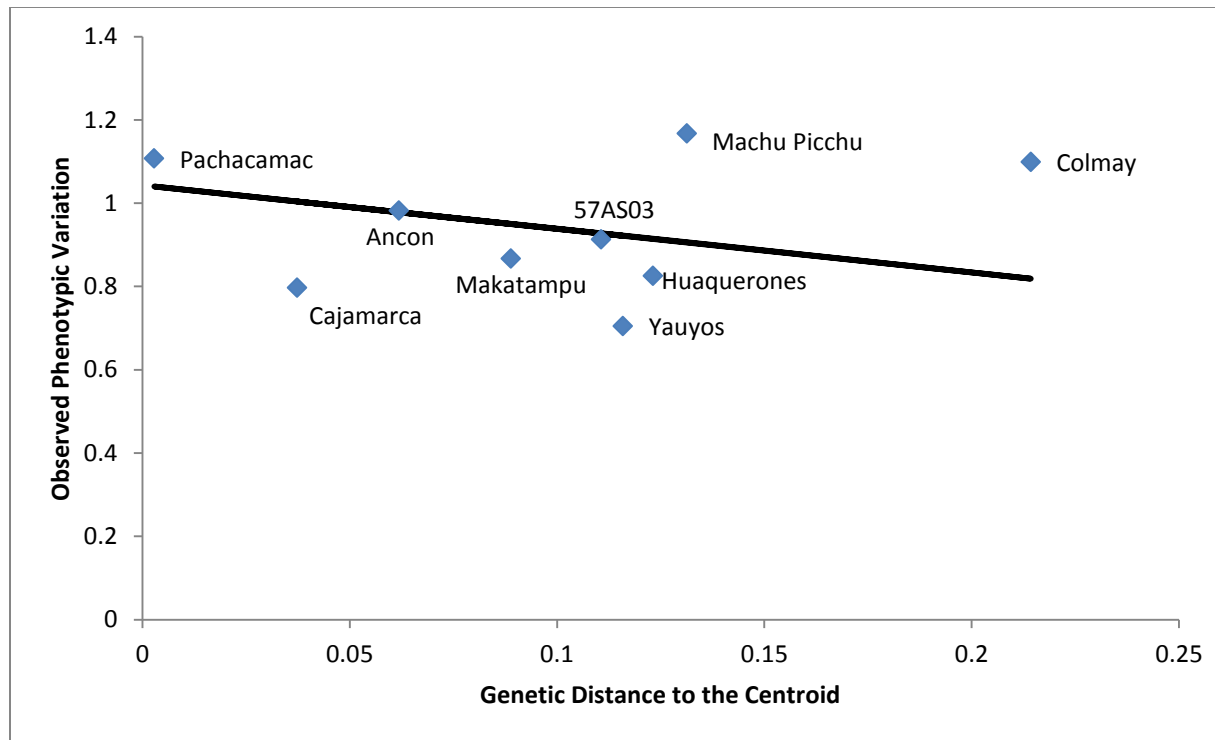


Figure 20. Plot of genetic distance to the centroid against observed within-group phenotypic variance for all sites²⁸

²⁸ The diagonal line represents the expected theoretical relationship between the distance to the centroid and within-group variation (Relethford 1995:55). $h^2 = 0.55$.

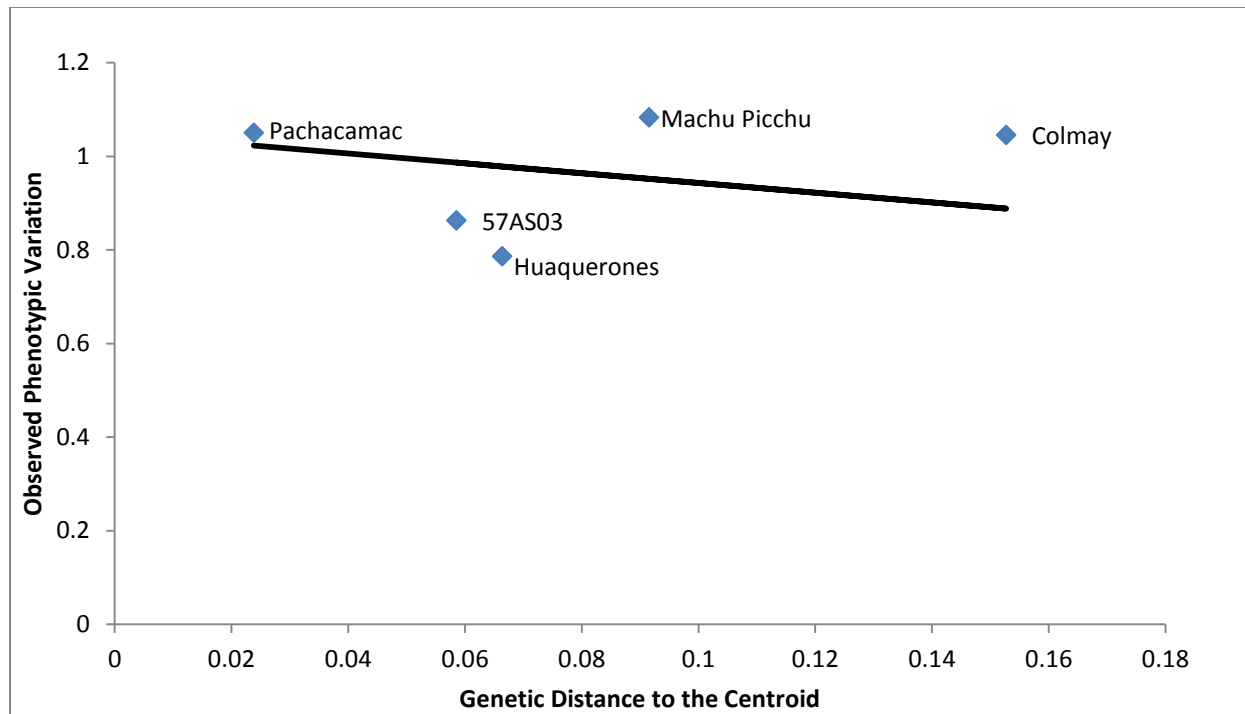


Figure 21. Plot of genetic distance to the centroid against observed within-group phenotypic variance for Inka sites²⁹

²⁹ The diagonal line represents the expected theoretical relationship between the distance to the centroid and within-group variation (Relethford 1995:55). $h^2 = 0.55$.

multiple localities around the Inka Empire, it is reasonable to infer resettlement as a potential explanation for elevated levels of gene flow generated for Machu Picchu, Colmay, and Pachacamac. While the function of Colmay has not been investigated archaeologically, scholars are united in their interpretations of both Machu Picchu and Pachacamac as locales populated with immigrants relocated from around the empire (Uhle and Shimada 1991; D'Altroy 2002; Verano 2003; Salazar and Burger 2004; Burger et al. 2007; Turner et al. 2009; Tiballi 2010). While elevated levels of gene flow at Pachacamac should be interpreted cautiously due to the sample size, positive residuals indicating heterogeneity at Machu Picchu can be interpreted as the result of resettled population. Moreover, Turner and colleagues (2009), suggest that the populace from Machu Picchu was drawn from as many as six distinct regions.

Chapter 7 – Discussion, Summary, and Future Directions

Before results from this study can be discussed in context of Inka resettlement and an overarching bioarchaeology of empire, several limitations must be addressed. First is the issue of sample size. While this work has included some of the best well preserved and most accessible Late Horizon Inka samples available for study, it is limited in that only five Inka sites are included. Obviously, increasing the number of populations would be ideal, particularly in regions outside of Cuzco. Recent edited volumes by Malpass (1993) and Malpass and Alconini (2010) have demonstrated the importance of investigating Inka imperialism outside of the Cuzco heartland.

In addition, studies which investigate population structure in the Andes must confront the reality of human variation shaped by microevolutionary processes related to altitudinal adaptation. As described earlier, numerous studies have indicated that Andean populations can be classified along an altitudinal gradient into broad coastal and highland groups (Weinstein 2005, 2007; Ross et al. 2008). This phenomenon is critical for Andean bioarchaeologists to recognize before attempting to interpret the effects of imperial policies on population structure.

In the study presented here, craniometric data from four pre-Inka contexts were included in order to gauge the degree of altitudinal patterning across the Andes prior to the Late Horizon. As described earlier, craniometric data

demonstrated the populations from Ancón, Makatampu, Yauyos, and Cajamarca can be sorted into broad coastal and highland groups (Ross et al. 2008). In the context of this study, these sites were used for comparative purposes to determine whether or not Late Horizon Inka sites fit an expected separation into either a coastal or highland group. Moreover, previous studies utilizing post-cranial data have demonstrated that the Inka site of Machu Picchu deviated from an expected highland pattern and likely included individuals who had been resettled from coastal locales (Weinstein 2005, 2007). Unfortunately, post-cranial remains were not collected from the Inka site of Colmay; however, comparisons of the craniometric data discussed in Chapter 5 suggest significant deviation from an expected highland pattern.

While it is clear that Andean population structures are shaped by a host of competing mechanisms ranging from evolutionary forces (i.e., genetic drift) to cultural practices (i.e., Inka resettlement policies), scholars studying bioarchaeological populations from this region can utilize what is known about coastal-highland patterning as starting point for investigating site-specific population variation. In the case presented here, biological distances from the four non-Inka contexts and the coastal Inka locales suggest that the populations were differentiated along a well-defined coastal-highland gradient while biological distances suggest that the Inka sites of Colmay and Machu Picchu deviate from the other highland locales. Admittedly, the study's dataset would be enhanced by

adding data from pre-Inka contexts in the Cuzco highlands and future analyses should strive to include data from other locales across the Cordillera to further investigate pre-Inka highland population structure.

As described in Chapter 5, the study sample ranges from individuals who are exceptionally well preserved to those that are only represented by cranial remains. Given the uncertainty of assessing sex from cranial remains alone (i.e., Walker 2008; Spradley and Jantz 2011), some caution should be extended to those sites where only crania were available. Future analyses of these data for sex-specific movement will have to consider removing those individuals only represented by cranial remains or attempt to quantify sexual dimorphism through metric, geometric morphometric, or genomic modalities. Ultimately, if bioarchaeologists are to extract information from samples collected over a century ago (and in the case of Pachacamac transformed into teaching specimens), some liberties with sex assessments are necessary given the lack of sexually dimorphic pelvic indicators. Finally, bioarchaeologists working in the Andes must recognize the limitations of studying samples presenting ACM. As Nystrom and Malcolm (2010) note, there are at least six competing lists of cranial and mandibular measurements which are said to be of use in contexts where ACM is present.

Despite the modest number of Late Horizon sites presented here, this study provides some insight into the practice of Inka resettlement through model-bound biological distance analysis. As described above, analyses of Late Horizon

populations are enhanced by inclusion of clearly differentiated coastal and highland populations. As seen from both plots of the biological distance analysis, those Inka sites from the Cuzco heartland appear to depart from the typical highland pattern. While the function of Colmay remains enigmatic, numerous scholars have suggested that Machu Picchu was comprised of a heterogeneous population relocated to the site in order to fulfill labor tribute obligations (Verano 2003; Salazar 2007; Turner et al. 2009). Biological distances that deviate from a highland trend, positive Relethford-Blangero residuals and analysis of the relationship between regional distance to the centroid and observed phenotypic variation all suggest a heterogeneous population at Machu Picchu. When these results are taken in context with what is known about the function of Machu Picchu as an imperial palace populated with *yanakuna* who were responsible for its day-to-day operation, previously described assertions about the origins and function of these individuals cannot be rejected (Verano 2003; Salazar 2007; Turner et al. 2009; 2012).

Results presented in Chapter 6 suggest that the Late Horizon individuals from Colmay and Pachacamac appear more heterogeneous than their contemporaries interred at 57AS03 and Huaquerones. Positive Relethford-Blangero residuals and analysis of the relationship between regional distance to the centroid and observed phenotypic variation suggests heterogeneity in both the population from Pachacamac and Colmay. Given Colmay's proximity to the

imperial capital of Cuzco and its strategic location near the Inka road system, it is not surprising that individuals recovered from this site do not fit a model of an expected homogenous highland population.

Unlike the results obtained for Machu Picchu and Colmay, the Relethford-Blangero residuals and plots of regional distance to the centroid against observed phenotypic variation indicate that populations from Huaquerones and 57AS03 were experiencing low levels of gene flow and appear homogeneous. When coupled together, these results suggest that 57AS03 and Huaquerones were likely comprised of individuals buffered from the Inka's diverse resettlement policies. Huan and Cock Carrasco (2010) synthesize ethnohistorical information about the local Central coast Ychma population and biological distance analysis to infer that Inka resettlement did little to affect the population structure at Puruchucho-Huaquerones.

Results from this study confirm Huan and Cock Carrasco's (2010) findings and suggest that resettlement of 57AS03 and Huaquerones did not reshape the structure this community. While analyses of other mortuary data (i.e., material objects) from 57AS03 and Huaquerones are on-going, these findings confirm that the Inka did not apply the same resettlement policy in equal ways to all locales incorporated into the empire. Forthcoming studies will supplement what is known about the degree to which the Inka impacted the lives of individuals interred at 57AS03 and Huaquerones; however, this work suggests

that the composition of the population did not change significantly after the Inka incorporated this region into their empire.

Site-specific use

This research confirms considerable genetic heterogeneity at Machu Picchu, corroborating findings of Verano (2003) and Turner et al. (2009). As suggested by Salazar (2001, 2007) and Salazar and Burger (2004) individuals interred at this monumental site were most likely non-elite workers who were relocated to fulfill specific labor tribute obligations. Moreover, Salazar and Burger (2004) reiterate that there is consensus among Inka scholars that Machu Picchu was built as a palatial retreat for the Inka emperor Pachacuti. Salazar and Burger (2004) argue that Machu Picchu would have been utilized by the Inka during the summer months of June, July, and August; however, it would have been maintained the rest of the year by skilled staff of resettled individuals. Once relocated to Machu Picchu, the individuals never returned to their homelands and were interred on-site after their deaths. Upon arriving at Machu Picchu, these individuals functioned as *yanakuna* and were charged with overseeing the day-to-day activities associated with the imperial palace. Recent strontium isotope work by Turner and colleagues (2009) on the Machu Picchu sample indicates that individuals were drawn from as many as six different regions throughout the Inka Empire.

Results from this study have also indicated that Colmay was likely populated with individuals drawn from diverse contexts from throughout the Inka Empire. As mentioned in Chapter 5, no archaeological excavations have been initiated at Colmay and only surface surveys have been conducted. Given the proximity of Colmay to the imperial cosmopolitan capital of Cuzco, and its location near the Inka road system, it is not surprising that the population recovered from this site represents a heterogeneous sample suggestive of resettlement. Interesting, as described by Andrushko (2007) and Andrushko and Verano (2008), approximately 35% of the Colmay skeletal sample presented one or more trepanations. Though little is known if Uhle preferentially collected trepanned crania, trepanation data might provide some insight into the overall function of Colmay. For example, the site may have functioned as a kind of medical treatment facility or convalescence center; however, this hypothesis can only be tested through extensive archaeological investigations. According to Andrushko and Verano (2008), Inka medical specialists were skilled at performing the procedure; therefore, archaeological excavations might be designed to test a hypothesis related to this particular function of the site. Moreover, future isotopic analyses might provide insight into the origins of individuals interred at Colmay and provide an additional line of evidence indicating multiple regions of origin for these individuals. Given that Andrushko and colleagues (2009) utilized strontium isotope analysis to examine the

population structure of Chokepukio (also located in Cuzco heartland), similar analysis may also offer a more nuanced interpretation of Colmay's function during the Late Horizon.

Though tentative due to the small sample size, Relethford-Blangero analyses indicate that the individuals recovered from Pachacamac were resettled from multiple locations. Given what is known about the context of the cemetery excavated by Max Uhle (Tiballi 2010), it is not surprising that the females in this sample may have been drawn from numerous locations around the empire. Though Pachacamac functioned as an important religious center for many centuries prior to its incorporation by the Inka, it was repurposed as an important imperial center in the late 15th century (Eeckhout and Owens 2008; Eeckhout 2013). Given what is known about importance the *aqllawasi* that was built on site, as well as the women who were incorporated into the Inka's network of *aqllakuna*, the heterogeneity seen among this population fits the pattern expected at a religiously important imperial center. Like with Colmay, future isotopic analyses would be helpful to examine questions related to the geographic origins of these individuals.

Results from the Relethford-Blangero analysis indicate that unlike individuals from Colmay and Machu Picchu, populations from Huaquerones and 57AS03 were more homogenous than their contemporaries from the highland locales. Moreover, biological distance results suggest that individuals from these

two locales were likely drawn from the same community. Previous work of Haun and Cock Carrasco (2010) suggested that individuals from Huaquerones did not represent a multiethnic community. Moreover, their work indicated that individuals from Huaquerones did not represent a community of people resettled *en masse* based on archaeological evidence suggestive of a local central Peruvian coast tradition called Ychma. Given the continuity between the samples drawn from 57AS03 and Huaquerones, archaeological evidence suggestive of the Ychma tradition, and ethnohistorical evidence suggesting that the Inka did not incorporate the central coast into their empire until approximately AD 1470 (see Rostworowski 1975), it appears that individuals from these two mortuary complexes were local people from the central coast of Peru and not incorporated into the Inka's resettlement system. Though few other provincial cemeteries from the Inka Empire have been described, it appears that individuals interred at the provincial locale of Puruchuco-Huaquerones were much less affected by imperial resettlement policies than in other regions (Rowe 1982; Andrushko et al. 2009).

Though additional bioarchaeological samples from other geographic locations are needed, it is clear that all locales under Inka control were not subjected to imperial rule and relocation. The Inka labor tribute system was not applied equally across the empire. While resettlement was certainly utilized at Machu Picchu, Colmay, and most likely Pachacamac, its effects are not seen in

the Huaquerones and 57AS03. Future work with samples from other parts of the empire might aid in understanding the way in which individuals were incorporated into the labor tribute system elsewhere.

The results presented in this study underscore the importance of avoiding the temptation of conceptualizing all of those who lived under imperial jurisdiction in the same homogeneous way. Moreover, results presented here indicate that biological distance analysis offers a unique and valuable contribution to the bioarchaeology of the Inka. Biological distance analysis allows investigators to understand rates of gene flow, population heterogeneity, and among-group variation in ways that forms of analyses do not. Given the recent work of Frankenberg and Konigsberg (2011) demonstrating the advantages of model-bound biological distance studies, future studies of the Inka, as well as other imperial polities, might consider applying the Relethford-Blangero model in a similar way as it was presented here.

Empire Theory

As described in Chapter 2, anthropological archaeologists have typically applied two theoretical approaches to the study of ancient empires: WST and the territorial-hegemonic power continuum. Both approaches have their merits and offer frameworks for understanding imperial dynamics across empires. While core-periphery relations are clearly important to understand in imperial contexts, archaeologists have moved away from exclusively embracing this monolithic

paradigm. Schreiber (1992:69) reiterated this perspective when she proposed the notion of a “mosaic of control” for describing the way in which imperial polities were best interpreted. In the case of the Inka, scholars have embraced this perspective and adopted the territorial-hegemonic model over the last several decades (Malpass 1993; Malpass and Alconini 2010).

In addition, recent contributions have examined the nuanced way in which Inka power relations were negotiated across the empire (Burger et al. 2007). Like with this study, other scholars are investigating specific Inka practices and recognizing the variation across the empire. What has emerged is a clear notion that Inka power was variable and dependent on myriad variables. Given the complexity and diversity seen across the empire in all aspects of Inka administration, the territorial-hegemonic approach appears to offer the greatest flexibility for interpreting complex imperial relationships.

In the case of the administrative tool investigated here (i.e., forced resettlement), this study demonstrates that while direct control was levied towards some individuals who were moved or migrated to the sites of Machu Picchu, Colmay, and Pachacamac, other locales were not incorporated into the resettlement network at all. In other words, indirect hegemonic control was levied on those individuals inhabiting the archaeological zone of Puruchucho-Huaquerones who ultimately were not part of the resettlement network. The ways in which individuals from Huaquerones and 57AS03 were affected by imperial

administration continues to be investigated as enormous amounts of archaeological data continue to be studied. While this study indicates that individuals from Huaquerones and 57AS03 were not members of a resettled community, their scope of their interaction with Cuzco remains to be fully elucidated.

Bioarchaeology of Empire

Tiffany Tung's (2003) doctoral dissertation called attention to an emerging specialty within bioarchaeology: the bioarchaeology of empire. As described in Chapter 2, Tung outlined five research foci that would allow bioarchaeological scholars to study archaeological empires with data derived from human skeletal remains. Given the complexity imperial polities, each of these topical areas provide bioarchaeologists with a framework for testing hypotheses related to imperial polities. In the study presented here, resettlement and forced migration were examined through biological distance analysis. Given the ability of biological distance analysis to inform what is known about population structure, it is my hope that this work influences future methodological tools utilized by bioarchaeologists. The Relethford-Blangero (1990) model can be applied to other populations in other regions and temporal periods and can be derived from both metric and non-metric datasets (see Pink 2013). As was discussed in Chapter 4, biological distance analyses have aided in elucidating patterns of population

structure and will hopefully continue to be incorporated into analysis of ancient empires.

Besides biological distance analysis, it is clear that bioarchaeologists working in the Andes have also relied upon isotopic analyses to investigate resettlement and migration. While isotopic analyses have generated many new observations about populations under imperial control, those studies can be enhanced when population genetic parameters are considered alongside isotopic datasets. Unfortunately, the only site from this study that has been explored with both methodological approaches is Machu Picchu. Certainly additional work is warranted where these datasets are investigated together. While few scholars have investigated both types of data simultaneously, I am optimistic that this trend will change as both biological distance and stable isotope analysis continue to be investigated by bioarchaeologists.

Future Directions

Though numerous sources indicate that Inka localities experienced imperial domination in varying ways, this is the first study to demonstrate multiple resettlement approaches from the perspective of bioarchaeology. On the one hand some locales were populated with diverse numbers of resettled people while on the other hand locations were buffered from the practice of resettlement altogether. This result fits well within the territorial-hegemonic model recently described by Malpass and Alconini (2010).

While this study provides some insight into Inka resettlement practices via biological distance analysis, more sites are obviously needed to further elucidate what is known about this aspect of the Inka's imperial strategy. Table 29 presents ten other documented Late Horizon Inka contexts that might yield potentially useful bioarchaeological data. Unfortunately, only two locales outside of Peru are represented here. Given what is known about the geographic extent of the empire, a lack of mortuary samples in other regions obviously limits the scope of future analyses. Perhaps one remedy to this problem is the dissemination of results in Spanish language publications that might interest local audiences in the Andes. It is quite likely that scholars working throughout the Andes might know of Late Horizon assemblages which could be added to this list. Clearly, as described by Turner and Andrushko (2011), scholars based in the United States have much to gain by international collaboration with scholars and other stakeholders who might have an interest in studying Inka imperialism.

Another potential area of interest to Inka scholars that has seen little research is an investigation of Late Horizon post-marital residence practices. While post-marital residence might be difficult to decipher in samples comprised of resettled populations, those locales which were buffered from the practice may provide valuable datasets. Cemetery contexts described in Table 17, along with data from Huaquerones and 57AS03 might be useful places to begin examining this question. In addition, three dimensional geometric morphometric methods

Table 29. Future Inka sites for potential study

Site or Group	Location	Number of Individuals	Reference
Rinconada Alta	Rimac Valley, Peru	78	Salter-Pedersen (2011)
Huaca Santa Cruz	Rimac Valley, Peru	81	Cornejo (2004)
Chokepukio	Cuzco Valley, Peru	89	Andrushko (2007)
Sacsahuaman	Cuzco Valley, Peru	43	Andrushko (2007)
Kanamarca	Espinar Province, Peru	38	Andrushko (2007)
Qhataqasapatallacta	Cuzco Valley, Peru	28	Andrushko (2007)
Farfan	Jequetepeque Valley, Peru	98	Mackey (2010)
Wanka sites	Upper Mantaro Valley, Peru	107	Owen and Norconk (1987)
Puerta La Paya	Salta Province, Argentina	202	Ambrosetti (1902)
Diaguita-Inka	La Serena, Chile	?	Rosado (1998); DiGangi (2010)

which have been applied in other regions of the world (i.e., McKeown 2000) are also worth exploring questions related to both Inka resettlement and post-marital residence rules. Ultimately, many more contributions are to be expected from bioarchaeologists who have an interest in understanding Inka imperialism.

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Vita

Jonathan Daniel Bethard was born in Lynchburg, Virginia on October 10, 1981.

Raised in Bedford County, Virginia Jonathan graduated from Jefferson Forest High School in 1999 and then migrated (by choice) to Knoxville, Tennessee where he enrolled at The University of Tennessee for more than a decade.

Thankfully, those years culminated with Jonathan receiving a PhD from the Department of Anthropology in 2013. During his tenure in Knoxville, Jonathan was fortunate to gain invaluable anthropological experience in several contexts: living in a society that voted for the GOP in three presidential elections, teaching stints at the University of Tennessee-Chattanooga and Maryville College, and full-time employment as a tenure-track faculty member at Mississippi State Community College. While at Mississippi State Jonathan collaborated with the Tennessee Consortium for International Studies (TNCIS) where he was able to participate in several study abroad trips and willingly took undergraduates to South Africa and Peru. In addition to teaching, he gained valuable fieldwork experience by working on anthropological projects in Virginia, Illinois, Peru, Haiti, Colombia, and Algeria. Jonathan is currently on the faculty at Boston University where he teaches various courses in forensic anthropology and bioarchaeology. Though his scholarly heart is in the Andes, Jonathan will be expanding his research program to the Old World during the summer of 2013 on a bioarchaeological project in Romania.