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Investigating Regional Mobility in the Southern Hinterland of the Wari Empire: Biogeochemistry at the Site of Beringa, Peru

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ABSTRACT Empires have transformed political, social, and environmental landscapes in the past and present. Although much research on archaeological empires focuses on large-scale imperial processes, we use biogeochemistry and bioarchaeology to investigate how imperialism may have reshaped regional political organization and regional migration patterns in the Wari Empire of the Andean Middle Horizon (ca. AD 600–1000). Radiogenic strontium isotope analysis of human remains from the site of Beringa in the Majes Valley of southern Peru identified the geographic origins of individuals impacted by the Wari Empire. At Beringa, the combined archaeological human enamel and bone values range from $^{87}Sr/^{86}Sr = 0.70802 - 0.70960$, with a mean $^{87}Sr/^{86}Sr = 0.70842 \pm 0.00027$ (1σ, $n = 52$). These data are consistent with radiogenic strontium isotope data from the local fauna in the Majes Valley and imply that most individuals were local inhabitants, rather than migrants from the Wari heartland or some other locale. There were two outliers at Beringa, and these "non-local" individuals may have derived from other parts of the South Central Andes. This is consistent with our understanding of expansive trade networks and population movement in the Andean Middle Horizon, likely influenced by the policies of the Wari Empire. Although not a Wari colony, the incorporation of small sites like Beringa into the vast social and political networks of the Middle Horizon resulted in small numbers of migrants at Beringa. Am J Phys Anthropol 145:299–310, 2011. © 2011 Wiley-Liss, Inc.

Throughout space and time, empires have transformed political, social, and environmental landscapes. However, much research on ancient empires has focused on the large-scale, population-level processes that transformed the landscape and political economy. Here, we use biogeochemistry and bioarchaeology to investigate how imperial processes may have reshaped regional political organization and regional migration patterns in the Wari Empire of the Andean Middle Horizon (ca. AD 600–1000). We first provide an introduction to theories aimed at understanding the strategies and effects of imperial rule, followed by a discussion of the Wari Empire of the Central Andes. We then describe the use of biogeochemistry in archaeological residential mobility studies more generally and the biogeochemical signatures of the Central and South Central Andes more specifically. After presenting our materials and methods, we present our radiogenic strontium isotope results from the Wari-affiliated site of Beringa in the Majes Valley of Peru, followed by our interpretations of these data. We conclude with a discussion of the influence of the Wari Empire on reorganizing and restructuring regional trade routes and its effect on residential mobility at village sites like Beringa.

IMPERIAL POLICIES AND LOCAL PRACTICES

In the recent years, our understanding of the range of imperial political strategies has increased dramatically as scholars have applied a variety of theoretical approaches. Some of these include hierarchical perspectives (e.g., Blanton and Feinman, 1984) informed in large part by world systems theory and the notion that the imperial core is dominant over peripheral regions, controlling production and distribution of goods and labor as well as the creation and maintenance of ideologies that seemingly benefit the imperial center (Wallerstein, 1974). Other models of imperial political strategies emphasize a heterarchical mode of rule, which may or may not be hierarchical, where various leaders or factions share similar positions of authority and influence (Crumley, 1995). Instead of one singular pole or pyramid of authority, there may be several that are horizontally

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analogous, though still part of a hierarchy. There are also agent-centered models that use practice theory and Bourdieu's (1977) concept of *habitus*, in which subliminal, everyday decisions by humans generate specific practices, resulting in a worldview and set of actions that may not be externally imposed (e.g., Janusek, 2004). Other agent-centered models acknowledge the influential role of the periphery (e.g., Stein, 2002), deemphasizing the authority of the core.

Through these diverse theoretical models, archaeologists have developed sophisticated frameworks for understanding ancient empires, including both territorial empires that established direct rule and hegemonic empires that ruled indirectly (Smith and Montiel, 2001; Stein, 2002). As the territorial versus hegemonic methods of rule may oversimplify, leading to generalized explanations for what were complex and nuanced interactions, scholars are also documenting multiple and variable strategies of rule within and between ancient empires (e.g., Algaze, 1993; Woolf, 1998; Alcock et al., 2001; Given, 2004; Gosden, 2004; Smith and Schreiber, 2005; Stein, 2005). Much of these insights stem from detailed studies of material culture that have improved our understanding of ancient political processes; however, a focus on material culture alone leads to limited insights (e.g., Morrison and Lycett, 1994; Sinopoli, 1994), revealing the need for bioarchaeological perspectives that place individuals at the center of analysis.

Biogeochemistry and bioarchaeology can provide this important perspective by focusing on the role of the individual in empires (Andrushko et al., 2006; Kellner, 2006; Buzon and Richman, 2007; Tung, 2007a; Kellner and Schoeninger, 2008). Identifying the geographic origins of individuals living during an imperial reign reveals individual life histories and elucidates the role of individual and group population movements in imperial formation, consolidation, and expansion. Here, we investigate how Wari imperial policies and practices shaped regional migration patterns through radiogenic strontium isotope analysis of human skeletal remains from the Wari-affiliated site of Beringa, in the Majes Valley of southern Peru.

The Wari Empire of Peru

In the Central Peruvian Andes, the Middle Horizon (ca. AD 600-1000) is characterized by the emergence and spread of the Wari Empire. During the Middle Horizon, the capital site of Huari near the modern city of Ayacucho rapidly became one of the largest sites in the pre-Columbian Andes (Isbell et al., 1991; Isbell, 1997, 2004). After Huari, the site of Conchopata was arguably the most important Wari heartland site (see Fig. 1). Ongoing research shows that Conchopata had a planned architectural core that included elite and intermediate-elite residences (Isbell, 2004; Tung and Cook, 2006), intensive pottery production (Cook, 1984–1985; Pozzi-Escot, 1991; Isbell, 2000; Ochatoma and Cabrera, 2000), elaborate ritual activities (Tung, 2008), and large public feasts (Cook and Benco, 2000). Other Wari heartland sites helped support the Wari polity through intensive agricultural production that likely fed people in the urban centers (Isbell and Schreiber, 1978; Schreiber, 1987a, 1992; Anders, 1991).

Based on the distribution of Wari-affiliated sites and Wari-style material culture, the best supported view is that the Wari expansionist empire spread throughout the Andes through military might and religious means (Menzel, 1964, 1968; Isbell and Schreiber, 1978; Feldman, 1989; Schreiber, 1992; Tung and Knudson, 2010). As Tung (in press) argues, the savvy integration of militarism and ritual exceptionalism—particularly in the realm of captive-taking, trophy head processing, and the ritual celebrations of those acts—was a major factor in the expansion and maintenance of Wari imperial authority. Moreover, Wari political leaders and state agents maintained a variable system of political control depending on local infrastructure, local elites, and state goals (Schreiber, 2005). Schreiber (1987b, 1992, 2001, 2005) argues that Wari imperial investment and expansion varied according to a region's distance from the Wari heartland, local political organization, wealth potential, and local tolerance of outside rule.

Outside of the Wari heartland, Wari-affiliated sites are found as far north as the Huamachuco Valley (Topic, 1991a) and as far south as the Moquegua Valley (Williams, 2001; Moseley et al., 2005). Within this large geographical area, Wari influence varied. For example, Wari leaders established a provincial administrative and ritual center at Cerro Baúl in the Moquegua Valley (Williams, 2001; Moseley et al., 2005) and in other regions, such as Pikillacta in the Department of Cusco (McEwan, 2005) and Viracochapampa in the northern Andes (Topic, 1991b). However, the Majes Valley where Beringa is located has no intrusive Wari administrative sites, and so it is unlikely that Wari colonizers settled there. The presence of Wari-style artifacts and Ayacucho-sourced obsidian (Tripcevich, 2010, Personal Communication) indicates that Majes Valley communities were within the orbit of Wari influence and integrated into Wari trade networks (Tung, 2007b; Goldstein, 2010). Given Beringa's location between the Wari heartland and the Wari administrative center of Cerro Baúl, traders would have passed through the region, others may have temporarily or permanently resided there, and Beringa inhabitants may have sojourned elsewhere before returning home.

Biogeochemistry and archaeological residential mobility

Migration in ancient polities like the Wari Empire can be investigated using biogeochemical techniques. Radiogenic strontium isotope analysis has become an important archaeological tool for the investigation of residential mobility [see Bentley (2006)]. Briefly, the ratio of two naturally occurring isotopes of strontium, ^{87}Sr and ^{86}Sr, can identify the geologic region or regions in which an individual lived during enamel formation in childhood and bone formation in adulthood (Ericson, 1985; Price et al., 1994a,b). In bedrock, ^{87}Sr forms as rubidium (^{87}Rb) decays, so that ^{87}Sr/^{86}Sr values in bedrock are dependent on the age and initial composition of the bedrock (Faure, 1986). Within a given ecosystem, ^{87}Sr/^{86}Sr values in soils, plants, animals, and the humans that consume these resources will reflect the ^{87}Sr/^{86}Sr values in the bedrock. Therefore, if strontium from that geologic region was consumed, the ^{87}Sr/^{86}Sr value in an individual's dental enamel will reflect the geologic region or regions in which the individual lived during childhood when the enamel was forming [see Bentley (2006)]. In the Andes, radiogenic strontium isotope analysis has been successfully applied to understand migration and trophy—taking activities in the Nasca polity (Conlee

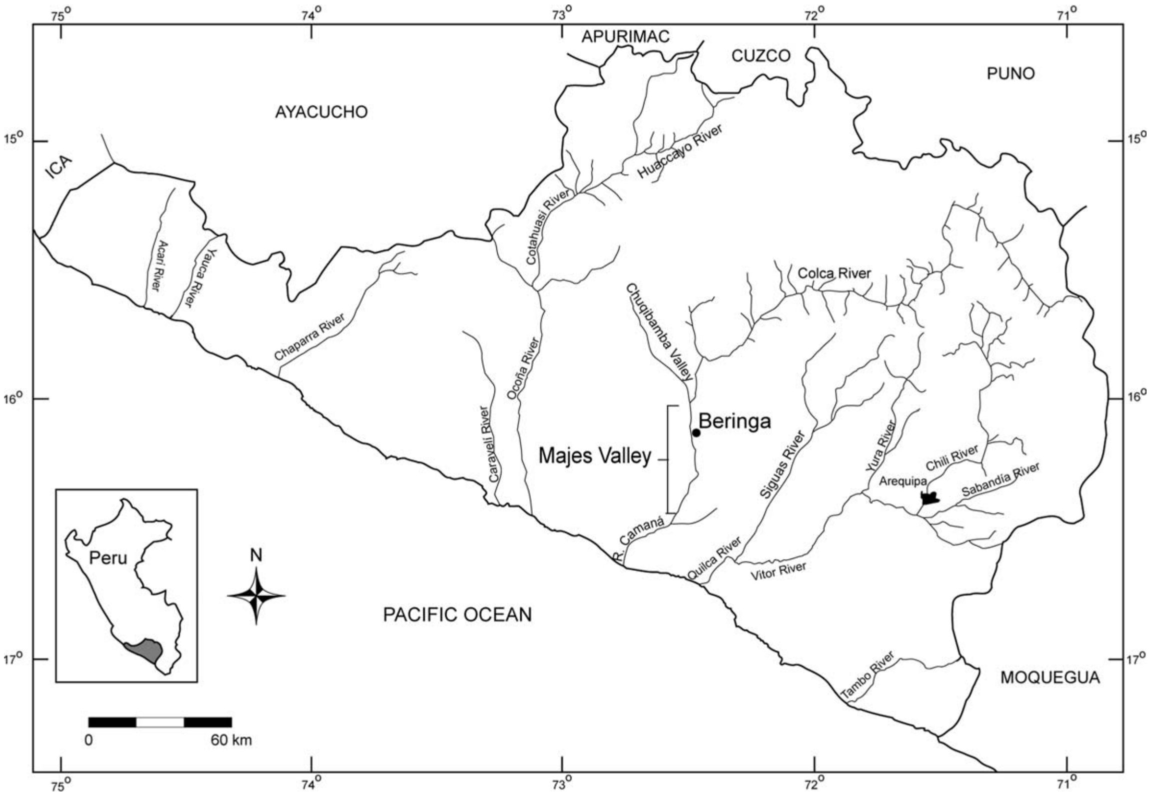

Fig. 1. Map of the Central Andes with sites discussed in the text.

et al., 2009; Knudson et al., 2009), the Wari Empire (Knudson and Tung, 2007; Tung and Knudson, 2008; Slovak et al., 2009; Tung and Knudson, 2010), the Tiwanaku polity (Knudson et al., 2004, 2005; Knudson and Price, 2007; Knudson, 2008), the Chiribaya *señorío* (Knudson and Buikstra, 2007; Knudson and Price, 2007), and the Inka Empire (Andrushko et al., 2009; Turner et al., 2009).

RADIOGENIC STRONTIUM ISOTOPE SIGNATURES IN THE CENTRAL AND SOUTH CENTRAL ANDES

Bedrock geology and radiogenic strontium isotope signatures

Andean geologic variability ensures that radiogenic strontium isotope signatures can identify some kinds of residential mobility. The Majes Valley, where Beringa is located, is composed largely of sedimentary rocks, including Tertiary continental rocks and Jurassic-Cretaceous volcanic sedimentary facies (Bellido et al., 1956). However, the Majes River originates in the late Cenozoic andesites of the Colca Valley (Bellido et al., 1956), which are also present in the Ayacucho Formation of the Wari heartland. Therefore, the water and sediments around Beringa likely contain a mixture of these geologic zones, increasing the likelihood that Majes Valley and Wari heartland radiogenic strontium isotope ratios will differ.

The Wari heartland in the Ayacucho Basin consists of various late Cenozoic formations (Mégard et al., 1984; Wise, 2004). However, the agricultural fields that likely provided the majority of dietary strontium are located in the Ayacucho Formation (Tung and Knudson, 2008). As noted earlier, the Ayacucho Formation consists of late Cenozoic andesites, felsic lavas, and ash flow tuffs as well as lacustrine and fluvial sandstone, siltstone, and mudstone (Mégard et al., 1984; Wise, 2004).

Other areas under Wari influence include the southern coasts of Peru, northern highlands, and *yungas* zones and highlands of the Central Andes. Although the Peruvian coastal region is composed largely of Quaternary sedimentary rocks, the coastal alluvial and riverine soils likely experience inputs from the Cenozoic volcanic rocks in the neighboring highlands (Bellido et al., 1956). For example, the Wari-influenced site of Ancón is located on an alluvial floodplain, which is heterogeneous and composed in part of Cenozoic basalts and other volcanic rocks (Bellido et al., 1956). In addition, the Nazca Drainage south of Lima also consists of alluvial and riverine soils, with inputs from the Cenozoic volcanic rocks in the adjacent highlands (Bellido et al., 1956). Similarly, the Moquegua Valley, where the Wari outpost of Cerro Baúl is located, is characterized by Cenozoic volcanic rocks, such as andesites (Bellido et al., 1956).

Radiogenic strontium isotope data are not currently available for bedrock in the Majes Valley or the Ayacucho Basin. However, exposed bedrock samples from late Cenozoic volcanic rocks in northern Chile exhibit mean $^{87}Sr/^{86}Sr = 0.70646 \pm 0.00020$ (1σ, $n = 8$) (Rogers and Hawkesworth, 1989). Similarly, late Cenozoic volcanic rocks from Arequipa, Peru, three valleys south of the Majes Valley, exhibited a range of $^{87}Sr/^{86}Sr = 0.7067 - 0.7079$ ($n = 16$) (James, 1982).

Bioavailable strontium isotope signatures in the Wari Empire. In addition to understanding bedrock geology, we also emphasize the importance of examining

TABLE 1. Radiogenic strontium isotope data from modern and archaeological faunal bones samples from the Central and South Central Andes

Site, country	Laboratory number	Specimen number	Material	$^{87}Sr/^{86}Sr^{a}$
Ayacucho, Peru	F1229	AYA-0001	*Cavia porcellus* (modern)	0.707204[a]
Ayacucho, Peru	F1230	AYA-0002	*Cavia porcellus* (modern)	0.706306[a]
Ayacucho, Peru	F1231	AYA-0003	*Cavia porcellus* (modern)	0.706555[a]
Ayacucho, Peru	F1233	AYA-0005	*Cavia porcellus* (modern)	0.705762[a]
Ayacucho, Peru	F1234	AYA-0006	*Cavia porcellus* (modern)	0.705841[a]
Beringa, Peru	ACL-0245	BER-41048.1073	*Cavia porcellus* (archaeological)	0.70784
Beringa, Peru	ACL-0246	BER-41030.2210	*Akodon* sp.? (archaeological)	0.70858
Beringa, Peru	ACL-0248	BER-41001.1022	*Cavia porcellus* (archaeological)	0.70832
Beringa, Peru	ACL-0249	BER-41045.1936	*Canis familiaris* (archaeological)	0.70839
Beringa, Peru	ACL-0250	BER-41001.1051	*Cavia porcellus* (archaeological)	0.70858
Beringa, Peru	ACL-0251	BER-41002.1034	*Cavia porcellus* (archaeological)	0.70845
Majes, Peru	F1709	MAJ-0001	*Cavia porcellus* (modern)	0.70860
Majes, Peru	F1710	MAJ-0002	*Cavia porcellus* (modern)	0.70860
Majes, Peru	F1711	MAJ-0003	*Cavia porcellus* (modern)	0.70858
Majes, Peru	F1712	MAJ-0004	*Cavia porcellus* (modern)	0.70861
Majes, Peru	F1713	MAJ-0005	*Cavia porcellus* (modern)	0.70859

[a] These faunal samples from the Central and South Central Andes were analyzed on a thermal ionization mass spectrometer at the University of North Carolina at Chapel Hill and have been previously published (Knudson and Tung, 2007).

bioavailable strontium isotope signatures (Price et al., 2002; Evans and Tatham, 2004). For individuals living in the Majes Valley, bioavailable strontium isotope signatures were determined through radiogenic strontium isotope values in modern and archaeological faunal samples, as discussed in the results and interpretation sections. In the Ayacucho Basin, five modern faunal samples [guinea pig (*Cavia porcellus*)] ranged from $^{87}Sr/^{86}Sr = 0.705762$ to $^{87}Sr/^{86}Sr = 0.707204$ (Table 1; Knudson and Tung, 2007). In addition, individuals buried at the Wari heartland site of Conchopata, and interpreted as local inhabitants based on mortuary context, exhibited mean $^{87}Sr/^{86}Sr = 0.705803 \pm 0.000348$ (1σ, $n = 11$; Tung and Knudson, 2008). New studies on a much larger burial sample from Conchopata show that local mean $^{87}Sr/^{86}Sr = 0.70572 \pm 0.00011$ (1σ, $n = 44$; Tung and Knudson, in review). If there are individuals from Beringa who had lived in the Ayacucho Basin during enamel or bone formation, then they should exhibit radiogenic strontium isotope values similar to the Conchopata mean values noted earlier.

Data on bioavailable strontium isotope signatures are also available from the coastal and highland zones influenced by the Wari Empire. On the Peruvian coast, modern and archaeological guinea pigs (*Cavia porcellus*) from near Ancón exhibited mean $^{87}Sr/^{86}Sr = 0.70654 \pm 0.00012$ (1σ, $n = 5$); however, because the Ancσn population consumed strontium from marine foods, their radiogenic strontium isotope values generally ranged from $^{87}Sr/^{86}Sr = 0.7075 - 0.7081$ (Slovak et al., 2009). In the southern Nazca Drainage, modern and archaeological small mammals exhibited mean $^{87}Sr/^{86}Sr = 0.706319 \pm 0.000439$ (1σ, $n = 15$) (Conlee et al., 2009), while archaeological humans from the northern Nazca Drainage who were interpreted as local to the region exhibited mean $^{87}Sr/^{86}Sr = 0.706673 \pm 0.000477$ (1σ, $n = 13$) (Knudson et al., 2009). In the Moquegua Valley, modern small mammals exhibited mean $^{87}Sr/^{86}Sr = 0.70625 \pm 0.00018$ (1σ, $n = 3$) (Knudson et al., 2004). Therefore, while radiogenic strontium isotope analysis can identify movement between the Wari heartland and regions with inputs from Central Andean Cenozoic volcanic rocks, such as the Majes Valley or the Moquegua Valley, it is not possible to distinguish between the southern coast and the Moquegua Valley.

Strontium sources at Beringa, Peru. Although carbon and nitrogen isotopic data on paleodiet are available from parts of the Wari Empire (Finucane et al., 2006; Kellner and Schoeninger, 2008; Finucane, 2009), we do not yet have these data for the site of Beringa and instead rely on extensive botanical and faunal analyses. Inhabitants of Beringa had access to a variety of riverine and agricultural resources, including crayfish (*Cryphiops caementarius*) and domesticated plants such as maize (*Zea mays*), beans (*Phaseolus* sp.), squash (*Cucurbita* sp.), and sweet potato (*Ipomoea batatas*) (Tung, 2007b). Fruits such as *pacay* (*Inga feuillei*) were common, and *molle* (*Schinus molle*), a pepper tree berry that was fermented to make *chicha de molle*, was ubiquitous (Tung, 2007b). Faunal remains included llamas (*Lama glama*) and guinea pigs (*Cavia porcellus*), which would have constituted much of dietary protein (Tung, 2007b). Marine products were present at Beringa, though less common than local riverine resources (Tung, 2007b).

Given the probable diet at Beringa, based on botanical and faunal analyses, it is likely that the high-calcium foods that would have provided the most strontium to the diet were high-calcium terrestrial foods, with smaller inputs from highland salt sources and water [see Davis and Foster (1958), Haghiri (1964), Kulp and Slatker (1958), Mauchline and Templeton (1966)]. The small amount of marine resources consumed by Beringa inhabitants could potentially contribute a marine radiogenic strontium isotope signature, since $^{87}Sr/^{86}Sr = 0.7092$ in seawater (Veizer, 1989). However, the meat of mollusks and fish are relatively low in calcium and would have likely not contributed large amounts of calcium and strontium to the diet, though seaweed consumption could have contributed larger amounts of calcium and strontium (Mauchline and Templeton, 1966; Shiraishi, 2005). With the exception of the marine strontium sources, the other significant strontium sources are local to the Majes Valley.

MATERIALS

Excavations at the site of Beringa were directed by Tung in 2001 (Resolución 615, granted to Tung by the National Institute of Culture-Lima) and focused on recovering human remains from the mortuary area in

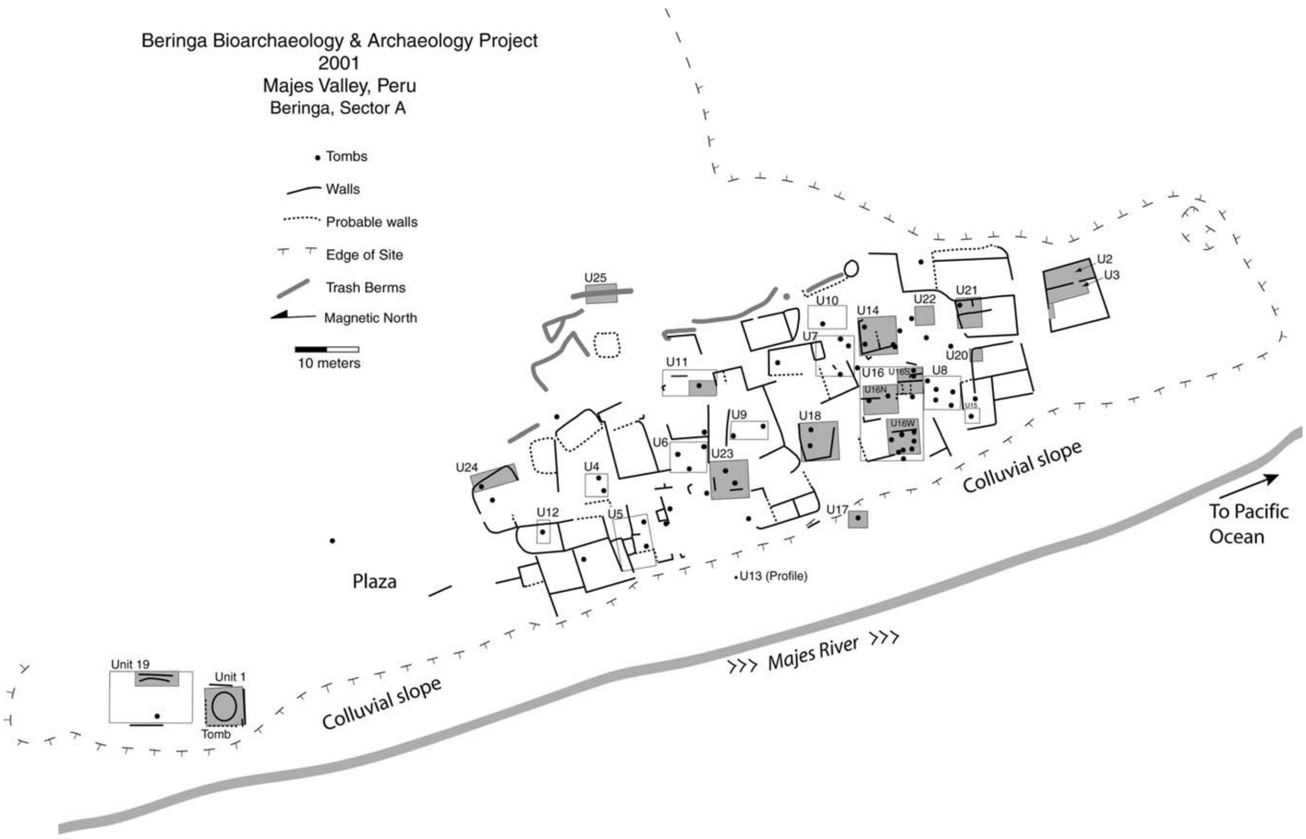

Fig. 2. Map of the archaeological site of Beringa, Peru.

Sector A (Figs. 2 and 3; Tung, 2003, 2007b). The mortuary population consists of at least 236 individuals, 151 of whom date to the Middle Horizon occupation (Tung, 2007b). Samples were collected for biogeochemical research using a sampling strategy that reflects the age and sex composition of the mortuary population (Table 2). When possible, enamel and bone samples were collected from multiple dental and skeletal elements to identify changes in residential mobility over an individual's lifetime.

METHODS

Enamel and bone samples were prepared at Arizona State University in the Archaeological Chemistry Laboratory using established procedures (Knudson and Price, 2007). Enamel was collected using a Dremel Mini-Mite equipped with a carbide burr from the buccal or lingual portion of the tooth crown. Bone was mechanically cleaned with a Dremel Mini-Mite equipped with a carbide burr and then chemically cleaned with a series of weak acetic acid washes (Sillen and LeGros, 1991; Knudson and Price, 2007). Radiogenic strontium isotope ratios were obtained at the W.M. Keck Foundation Laboratory for Environmental Biogeochemistry at Arizona State University. Strontium was separated from the sample matrix with EiChrom SrSpec resin (50–100 μm in diameter). Major, minor, and trace elemental concentrations, including calcium (Ca), phosphorus (P), barium, (Ba), and strontium (Sr), were measured on a quadrupole inductively coupled plasma mass spectrometer (Q-ICP-MS). Radiogenic and stable strontium isotopes were measured on a Neptune multicollector inductively coupled plasma mass spectrometer, where SRM-987 exhibited $^{87}Sr/^{86}Sr = 0.710265 \pm 0.000010$ (2σ, $n = 25$), compared to $^{87}Sr/^{86}Sr = 0.710263 \pm 0.000016$ (2σ) in analyses of international standard SRM-987 (Stein et al., 1997).

RESULTS

Modern and archaeological faunal samples

To more accurately determine the bioavailable strontium isotope signatures for local inhabitants of the middle Majes Valley, radiogenic strontium isotope ratios in modern and archaeological small mammals were examined (Table 1) (Price et al., 2002; Evans and Tatham, 2004). Modern faunal samples [guinea pig (*Cavia porcellus*)] from local farmers near the town of Aplao in the Majes Valley exhibit mean $^{87}Sr/^{86}Sr = 0.70860 \pm 0.00001$ (1σ, $n = 6$) and range from $^{87}Sr/^{86}Sr = 0.70858 - 0.70861$ (Table 1). Radiogenic strontium isotope signatures in archaeological faunal samples [guinea pig (*Cavia porcellus*), mouse (*Akodon* sp.), and dog (*Canis familiaris*)] from Beringa exhibit mean $^{87}Sr/^{86}Sr = 0.70836 \pm 0.00027$ (1σ, $n = 5$) and range from $^{87}Sr/^{86}Sr = 0.70784 - 0.70858$ (Table 1).

Archaeological human samples

The ratio of calcium to phosphorus in a subset of archaeological bone samples [mean Ca/P = 2.07 ± 0.16 (1σ, $n = 19$)] is consistent with biogenic bone, where Ca/P

Fig. 3. Air photo of the archaeological site of Beringa, Peru.

= 2.1; therefore, there is little evidence of diagenetic contamination in the archaeological human samples. At Beringa, the combined archaeological human enamel and bone values range from $^{87}Sr/^{86}Sr = 0.70802 - 0.70960$ (Table 2), with a mean $^{87}Sr/^{86}Sr = 0.70842 \pm 0.00027$ (1σ, $n = 52$). Specifically, the archaeological human enamel values range from $^{87}Sr/^{86}Sr = 0.70814 - 0.70959$ (Table 2), with a mean of $^{87}Sr/^{86}Sr = 0.70841 \pm 0.00026$ (1σ, $n = 27$), while archaeological human bone values range from $^{87}Sr/^{86}Sr = 0.70802 - 0.70960$ (Table 2), with a mean of $^{87}Sr/^{86}Sr = 0.70842 \pm 0.00029$ (1σ, $n = 25$).

DISCUSSION

Regional migration in the Wari Southern Hinterland

Identification of "local" and "non-local" individuals buried at Beringa. One way to define the "local" radiogenic strontium isotope signature of a given region is as the mean and two standard deviations of the radiogenic strontium isotope values of modern and/or archaeological small mammals from the region (Price et al., 2002; Evans and Tatham, 2004). Using this definition, all modern and archaeological faunal samples from the Majes Valley exhibit mean $^{87}Sr/^{86}Sr = 0.70856 \pm 0.00039$ (1σ, $n = 11$), so the "local" range of the middle Majes Valley is $^{87}Sr/^{86}Sr = 0.7078 - 0.7093$. Using this criterion, 50 of 52 archaeological human enamel and bone samples exhibited a radiogenic strontium isotope signature within the "local" range; the two exceptions are specimen numbers ACL-0028 (BER-51103.0033.00, $^{87}Sr/^{86}Sr = 0.70960$, L rib) and ACL-0044 (BER-51001.1293.01, $^{87}Sr/^{86}Sr = 0.70959$, LRM3) (Fig. 4).

Alternatively, some scholars have used mean human bone values to define a "local" radiogenic strontium isotope range [see discussions in Bentley et al. (2007) and Knudson (in press)], because archaeological human bone reflects place of residence in the years before death. Although assuming that individuals lived in the communities in which they were buried is not always appropriate, here, we make that assumption when exploring different ways to define "local." At Beringa, archaeological human bone exhibited a mean of $^{87}Sr/^{86}Sr = 0.70842 \pm 0.00029$ (1σ, $n = 25$), so that the "local range" of the Majes Valley is $^{87}Sr/^{86}Sr = 0.7078 - 0.7090$. Using a "local" range defined by archaeological human bone samples, 50 of 52 archaeological human enamel and bone samples exhibited a radiogenic strontium isotope signature within the "local" range; the exceptions are the same specimens identified by the method noted earlier.

TABLE 2. Radiogenic strontium isotope data from archaeological human samples collected from Beringa, Peru

Laboratory number	Specimen number	Material	Age (years)[a]	Sex[a]	$^{87}Sr/^{86}Sr$[b]
ACL-0001	BER-51001.0997.00	rib	I	?	0.70838
ACL-0002	BER-51001.1004.00	L femur	I	?	0.70830
ACL-0003	BER-51017.0116.00	L rib 1	C (5-6)	?	0.70842
ACL-0004	BER-51017.0100.00.01	LRM1	C (5-6)	?	0.70836
ACL-0005	BER-51017.0059.00	R fibula	MA	M	0.70833
ACL-0006	BER-51017.0078.00	L rib 1	MA	M	0.70834
ACL-0007	BER-51017.0050.14.05	ULC1	MA	M	0.70842
ACL-0008	BER-51017.0050.14.01	ULM2	MA	M	0.70842
ACL-0009	BER-51017.0051.	LLM3	MA	M	0.70834
ACL-0010	BER-51017.0039.15.07	URM3	MA-OA	F	0.70843
ACL-0011	BER-51017.0039.15.05	URC1	MA-OA	F	0.70840
ACL-0012	BER-51017.0024.00	R rib	MA-OA	F	0.70868
ACL-0013	BER-51017.0044.00	L metatarsal	MA-OA	F	0.70841
ACL-0015	BER-51025.0029.00	R rib	T (16-19)	M	0.70839
ACL-0016	BER-51025.0002.01.02	LRM1	T (16-19)	M	0.70847
ACL-0017	BER-51025.0002.01.01	LRM2	T (16-19)	M	0.70836
ACL-0018	BER-51025.0002.01.10	LLC1	T (16-19)	M	0.70847
ACL-0019	BER-51030.0040.00	L fem D3	I	?	0.70831
ACL-0020	BER-51030.0032.00	L rib	I	?	0.70819
ACL-0021	BER-51039.0018.04	R rib	MA	F	0.70802
ACL-0022	BER-51039.0002.00.02	LLM2	MA	F	0.70821
ACL-0023	BER-51039.0002.00.03	LLM3	MA	F	0.70815
ACL-0024	BER-51039.0026.00	R femur	MA	F	0.70814
ACL-0025	BER-51102.0122.00	R rib	C-T (10-15)	?	0.70835
ACL-0026	BER-51102.0091.18.13	LLM1	C-T (10-15)	?	0.70845
ACL-0027	BER-51102.0091.18.14	LLM2	C-T (10-15)	?	0.70838
ACL-0028	**BER-51103.0033.00**	**L rib**	**I**	**?**	**0.70960**
ACL-0029	BER-51134.0023.00	L rib	I	?	0.70832
ACL-0030	BER-51134.0052.00	L ulna	T-YA (17-24)	F	0.70822
ACL-0031	BER-51134.0002.14	LLM2	T-YA (17-24)	F	0.70842
ACL-0032	BER-51134.0002.11	LLI2	T-YA (17-24)	F	0.70837
ACL-0033	BER-51134.0002.10	LLC1	T-YA (17-24)	F	0.70838
ACL-0034	BER-51134.0001.14.01	ULM3	T-YA (17-24)	F	0.70832
ACL-0035	BER-51147.0057.00	R femur	I	?	0.70833
ACL-0036	BER-51034.0026.00	R femur	I	?	0.70857
ACL-0037	BER-51011.0827.00	metatarsal	MA	M	0.70838
ACL-0038	BER-51011.0817.00	R calcaneus	MA	M	0.70881
ACL-0039	BER-51011.0802.00	R rib	MA	M	0.70827
ACL-0041	BER-51001.1290.00	mandible	MA	M?	0.70849
ACL-0042	BER-51001.1290.01	LRM2	MA	?M	0.70844
ACL-0043	BER-51001.1293.02	LRM1	MA	M	0.70859
ACL-0044	**BER-51001.1293.01**	**LRM3**	**MA**	**M**	**0.70959**
ACL-0258	BER-51001.1295	LLM1	C	?	0.70840
ACL-2169	BER-51011	rib	A	?	0.70835
ACL-2170	BER-51001.0889	ULP2	A	?	0.70840
ACL-2171	BER-51008.0004	URM2	YA	F	0.70833
ACL-2172	BER-51008.0002	URM2	YA	M?	0.70832
ACL-2173	BER-51008.0029	URM3	YA	M	0.70846
ACL-2174	BER-51008.0031	ULM1	C	?	0.70814
ACL-2175	BER-51008.0017	LRM1	YA	M?	0.70840
ACL-2176	BER-51001.0888	LRM1	C	?	0.70838
ACL-2177	BER-51039.0001	URM1	MA	F	0.70821

[a] Osteological data was determined by Tung (2003) and is presented using the following abbreviations: I, infant; C, child; T, teenager; YA, young adult; MA, middle adult; A, adult; F, female; M, male; M?, possible male.
[b] Individuals identified as "non-local" based on radiogenic strontium isotope values are in bold.

In addition, descriptive statistics can be used to help define a "local" range (Wright, 2005; Knudson, in press). The complete dataset of archaeological human samples exhibits mean $^{87}Sr/^{86}Sr = 0.70842 \pm 0.00027$ (1σ, $n = 52$; Table 3). When the two highest outlier values are removed to create a trimmed dataset, the mean $^{87}Sr/^{86}Sr = 0.70837 \pm 0.00002$ (1σ, $n = 50$; Table 3). The trimmed dataset exhibits a mean and median that are more similar, and a smaller standard deviation, standard error, and variance. The trimmed dataset is also normally distributed, suggesting that the two outliers removed from the trimmed dataset were truly outliers (Wright, 2005). The two outliers are the same samples identified in both methods described earlier.

Life histories of "non-local" individuals buried at Beringa

Three different analytical techniques identified the same two "non-local" individuals at Beringa, a middle-aged adult male (ACL-0044) and an infant (ACL-0028). Thus, among this study subsample, 2 of 22 (9%) Middle Horizon individuals are "non-local." Here, we discuss the

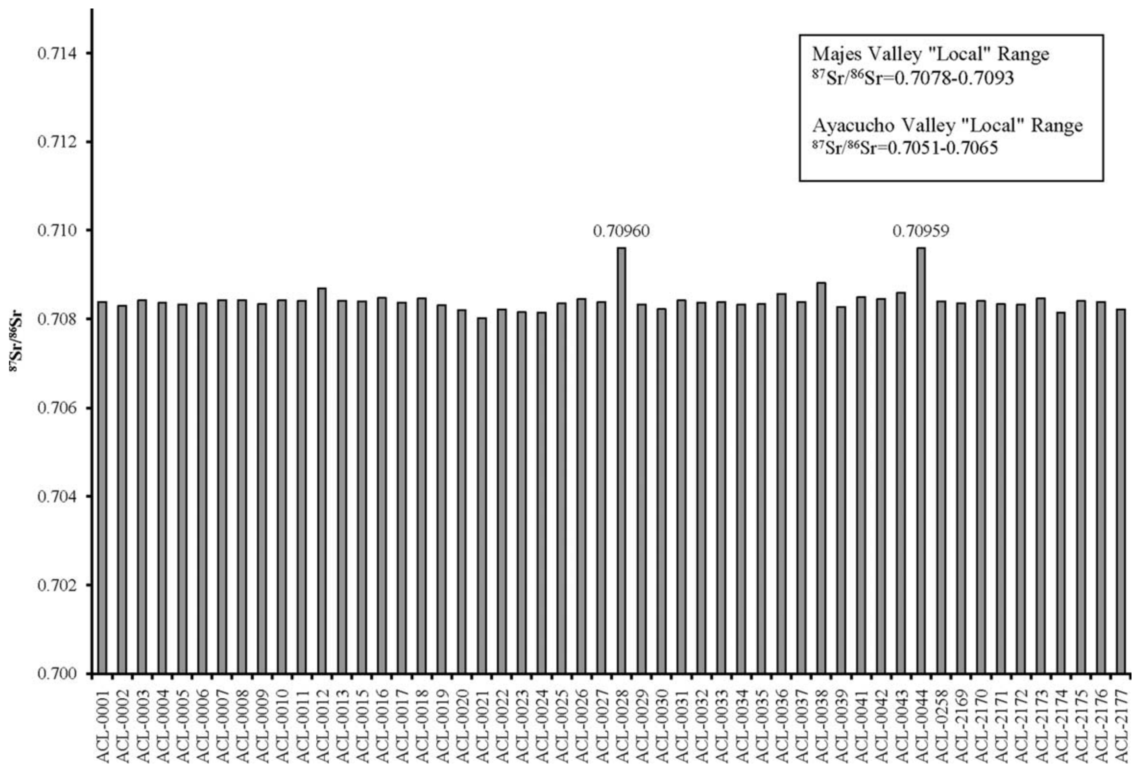

Fig. 4. Radiogenic strontium isotopes values from archaeological human bone and enamel from individuals buried at the archaeological site of Beringa, Peru. Radiogenic strontium isotope values for two outliers are labeled as well.

TABLE 3. Descriptive statistics for radiogenic strontium isotope data from Beringa, Peru

	Complete dataset	Trimmed dataset
Mean $^{87}Sr/^{86}Sr$	0.70842	0.70837
Standard Deviation	0.00027	0.00013
Standard error	0.00004	0.00002
Count	52	50
Minimum	0.70802	0.70802
Maximum	0.70960	0.70881
Sample variance	7.38E-08	1.77E-08
Kurtosis	12.83359	2.49824
Skewness	3.25407	0.39291
Median $^{87}Sr/^{86}Sr$	0.70838	0.70838
Mode	0.70821	0.70821
Range	0.00158	0.00079

mortuary contexts and life histories of these two individuals in more detail.

The male was recovered from Unit 1 at the northern end of the site (see Fig. 2). He was interred in a large circular tomb (1.4 m deep and 4.5 m in diameter) in which at least 76 individuals were buried. A radiocarbon date from a textile bundle in the tomb shows that it was used in the Middle Horizon (cal. AD 689–879, 2σ; Tung, 2007b). The "non-local" radiogenic strontium isotope value from the adult male is from the later-forming third molar (ACL-0044, $^{87}Sr/^{86}Sr = 0.70959$, LRM3), while the early-forming first molar exhibits a "local" radiogenic strontium isotope ratio (ACL-0043, $^{87}Sr/^{86}Sr = 0.70859$, LRM1; Table 2). This means that his infancy/early childhood was spent in the middle Majes Valley or a region with similar radiogenic strontium isotope values, and his later childhood was spent in a different geological locale. Since he was later buried at Beringa, he either voluntarily returned or was forcibly moved to his place of infancy. It is also possible that mourners moved his body there for burial. Currently, we have no bone radiogenic strontium isotope ratios from this individual, so it is unknown if he lived in the middle Majes Valley in the immediate years before his death.

The "non-local" infant (ACL-0028, $^{87}Sr/^{86}Sr = 0.70960$, L rib) was 10–16 months old at the time of death and was likely still breastfeeding. Thus, the "non-local" radiogenic strontium isotope value is also a likely measure of the infant's mother's breast milk, which would not have appreciably changed from the mother, to breast milk, to the bones of the infant [see Discussion in Dupras and Tocheri (2007), Mays (2003), Wright and Schwarcz (1998), and Wright and Schwarcz (1999)]. The infant exhibited porotic hyperostosis, a cranial lesion suggestive of general physiological stress (Walker et al., 2009). Skeletal preservation was good, and no other lesions were observed on this nearly complete infant skeleton. The infant was buried in a simple cist tomb in Unit 16 W, located in the south-central portion of the site, and associated artifacts in and around the tomb include Wari-style ceramics (Owen, 2007). Other associated artifacts include a 20-cm round basket made from local reeds, a plain textile bag, and two plain-ware, black ceramics (Owen, 2007). All those items appear locally procured and produced and are similar to other goods found in local tombs; this suggests that the "non-local" infant was afforded mortuary treatment similar to what Beringa "locals" received. One notable difference, however, was the inclusion of a non-local marine mollusk (family *Olividae*) in or around the infant's tomb (Gladwell, 2002).

Interestingly, the two "outlying" values at Beringa are consistent with those who consumed strontium from marine resources, because sea water exhibits $^{87}Sr/^{86}Sr$ = 0.7092 (Veizer, 1989). However, trace element analysis of the infant, ACL-0028 (Ba/Sr = 0.03) is not consistent with substantial consumption of marine resources (Burton and Price, 1990, 2000) and is the same as the Ba/Sr values in archaeological herbivorous guinea pigs (*Cavia porcellus*). Thus, while the marine gastropod was associated with the "non-local" infant and the radiogenic strontium isotope ratio is consistent with consuming marine resources, trace element analysis suggests limited marine resources in the diet. Light stable carbon and nitrogen isotope analyses are ongoing and will test the hypothesis that they derive from a Pacific coastal zone.

It is highly unlikely that the "non-local" male and infant derive from the Wari imperial heartland. The two "non-local" radiogenic strontium isotope values are higher than "local" faunal radiogenic strontium isotope values obtained from Ayacucho (Knudson and Tung, 2007) and from Conchopata burials in the Wari heartland (Tung and Knudson, 2008). This is consistent with the lack of intrusive Wari administrative sites in the middle Majes Valley.

Instead, the two "non-locals" are consistent with radiogenic strontium isotope values found in Pacific coastal regions, as previously discussed, or in the Ilo Valley of southern Peru and the Lake Titicaca Basin of Peru and Bolivia (Knudson and Buikstra, 2007; Knudson and Price, 2007; Knudson, 2008, in press). In light of the trace element analysis, suggesting a nonmarine diet for the infant, the higher radiogenic strontium isotope value may instead reflect residence in the Lake Titicaca Basin or the Ilo Valley (Knudson and Buikstra, 2007; Knudson, 2008; Knudson and Torres-Rouff, 2009). Finally, we note that the "non-local" radiogenic strontium isotope values at Beringa could also result from the consumption of strontium from a variety of different geological zones.

Wari influence and regional migration. Because there is no evidence for an intrusive Wari administrative site in the middle Majes Valley, it is unlikely that Wari colonizers from the Ayacucho Basin settled there (Tung, 2007b). Rather, Wari influence in the region was likely orchestrated through local elites, who then had privileged access to Wari trade networks and Wari goods (Tung, 2007b; Goldstein, 2010; Tung, in press). Additionally, the high level of trauma at Beringa, particularly on the posterior of the skulls of both males and females, suggests that they were subject to raids by other regional polities or by Wari military agents (Tung, 2007b). If so, it is unlikely that Wari peoples from the Ayacucho Basin settled there and were victimized in these raids and other violent conflicts. The absence of Wari colonizers in the Majes Valley is supported by the radiogenic strontium isotope data, which did not identify any individuals with radiogenic strontium isotope ratios that match that of the Wari heartland in Ayacucho Basin.

Instead, the possibility that the "non-local" individuals buried at Beringa derived from geologic zones located in the Pacific coastal areas, or what is now southern Peru, parts of Bolivia, or northern Chile, is consistent with the notion that the Middle Horizon was marked by expansive trade networks and population movement, likely influenced by local, historically durable trade practices and policies of the Wari Empire. As argued by Tung (2007a), Wari state agents used variable strategies in their interactions with different communities, which likely contributed to the restructuring of regional trade networks and political alliances. Local customs and historical trading practices, both in opposition to and in corroboration with Wari imperial policies, would have contributed to the novel forms of population interaction and migration in the south-central Peruvian Andes. In this rural, peripheral site of the Wari Empire, immigrants constituted 9% (or 13% if the mother of the infant is included) of the village population. In sum, while the radiogenic strontium isotope ratios indicate that there were no colonizers from the Wari heartland, the evidence supports a scenario in which there may have been regional vertical migration between the coast and highlands and horizontal migration from valley to valley.

The likelihood that people of the southern Peruvian Andes migrated between valleys and along the vertical archipelago—from the high altitude *puna*, to the agricultural rich *yungas* zone, and the marine resource-rich Pacific coast—can also be seen in the distribution of goods such as food resources, obsidian, metals, ceramics, and textiles. Moreover, Nash (2009) reports the presence of unique painted stone tablets (*placas pintadas*) at the Wari-affiliated site of Cerro Mejía in the Moquegua Valley and suggests that some inhabitants of Cerro Mejía may have been migrants from the Majes/Chuquibamba region, where *placas pintadas* are a common, local tradition. Clearly, this period of horizontal integration, spurred on by the dominant influence from the two powerful Middle Horizon states—Wari and Tiwanaku—would have required extensive trade networks and the attendant mobility of individuals and llama caravans to move those goods. As such, even small village sites like Beringa were tied into these vast social and political networks, leading to the occasional migrant at the settlement.

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