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The consequences of Wari contact in the Nasca region during the Middle Horizon: archaeological, skeletal, and isotopic evidence

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ABSTRACT

During the Middle Horizon (AD 650–1000), the Wari polity expanded its sphere of control in various regions of the Andes, including Nasca on the south coast of Peru. The nature of the interaction between Wari and local communities varied. This study explores the consequences of Wari contact in the Nasca region at the site of La Tiza, which includes individuals dated to the Early Intermediate, Middle Horizon, and Late Intermediate periods. Using evidence for burial ritual along with demographic, paleopathological and isotopic data, population composition, mobility, diet, and health are investigated. $\delta^{13}C$ data indicate a relatively stable diet through time at La Tiza with evidence for continued maize consumption, and paleopathological results indicate health problems associated with this type of diet. $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ data suggest that most of the individuals buried at La Tiza were local to the area. However, two female adults from the Middle Horizon burials are characterized as nonlocal based on $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ values and several individuals overlap with the $^{87}Sr/^{86}Sr$ local range for the Wari heartland. In conjunction with the use of new tomb types during this period these results highlight the ideological and populational changes occurring with Wari contact at La Tiza.

1. Introduction

The Middle Horizon (AD 650–1000) in the Nasca region of Peru was a period of cultural and political transformation (Fig. 1). During this time, Wari, one of the first expansive polities to develop in the Andean region, was actively increasing its empire. Earlier studies, such as Menzel's (1964) examination of Middle Horizon ceramics, established that there was a close relationship between the Wari state and the Nasca culture. Subsequent work demonstrated variability in the nature of Wari control and the local response in various areas of the region. In the northern Nasca valleys many cemeteries dating to the Middle Horizon were documented with little evidence for domestic settlements. The burials in these cemeteries exhibit novel mortuary practices, indicating new political and social influences (Browne, 1992; Isla, 2001, 2009; Reindel, 2009; Silverman, 2002). In the southern valleys, Wari presence is clearer with many burials, habitation sites, a possible Wari administrative center at Pacheco, and economic colony at Pataraya (Conlee, 2010; Conlee and Schreiber, 2006; Menzel, 1964; Schreiber, 2001a, 2001b, 2005; Schreiber and Lancho Rojas, 2003).

Wari potters incorporated Nasca iconography into their designs, highlighting the shared belief system between the two regions and the religious importance of Nasca to Wari (Menzel, 1964). However, unlike Wari imperial activities in the highlands, there is little clear evidence of direct political control in the Nasca region (Schreiber, 1992). The level of investment by Wari was not uniform throughout the region and local peoples responded in diverse ways to Wari influence, from abandonment of settlements in the north, to population aggregation in the far south, and various levels of incorporation of the Wari style (Conlee, 2010; Conlee and Schreiber, 2006; Schreiber, 2001a). This study examines how Wari may have impacted the burial rituals, dietary regimes, health, and population composition of the Nasca peoples at the site of La Tiza, located in the southern Nasca drainage. Evidence of migration via oxygen and strontium isotope analysis, diet and health via carbon isotope analysis and pathological conditions, and demographic reconstruction are used to better understand the impact the Wari state had in Nasca. Specifically, archaeological indications of burial ritual

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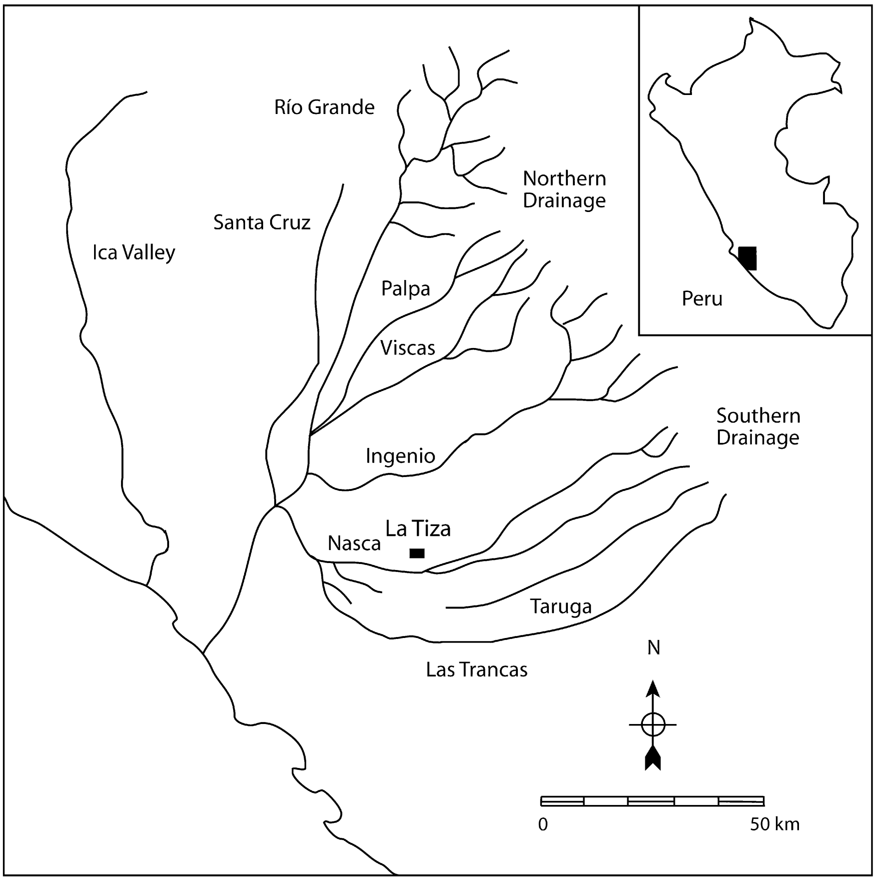

Fig. 1. Location of La Tiza.

in conjunction with demographic, paleopathological, and isotopic data are used to investigate the consequences of Wari contact at La Tiza and test the hypothesis that the changes observed in the Nasca region during the Middle Horizon were the result of increased direct interaction with the Wari state and immigrants from the highlands.

2. La Tiza

The site of La Tiza is located in the central Nasca Valley, where the Aja and Tierras Blancas river valleys merge near the modern town of Nasca (Fig. 1). The settlement spans over 30 ha, built on a steep hillside with abundant agricultural land nearby on the valley bottom. The site was occupied intermittently from the Middle Archaic (ca. 3500 BC) into the Late Horizon (AD 1476–1532). The site contains several domestic areas and cemeteries, most of which date between AD 1 and 1476 when intensive agriculturalists lived at the site and were part of complex political systems. Excavated over several seasons from 2004 to 2009, nine discrete single burials and ten tombs with multiple individuals were uncovered.

The Middle Horizon component of this site consists of 2–3 ha of domestic area and approximately 5 ha of mortuary structures. The Middle Horizon habitation area is small in comparison with the previous Nasca Culture occupation of the settlement during the Early Intermediate Period (AD 1–650) and the subsequent occupation in the Late Intermediate Period (AD 1000–1476). Middle Horizon Epochs 1 and 2, dating to the first half of the period when the Wari state was at its height, are represented in the ceramics, consisting of mostly the local Loro style, and more limitedly, the Wari imperial styles of Viñaque and Chakipampa. Calibrated radiocarbon dates from two Middle Horizon domestic structures (AD 653–774 and AD 664–829) correspond with the ceramic data (Conlee, 2010). The tombs dating to the Middle Horizon represent new types that were constructed partially aboveground and built of stone walls with features such as doorways, niches, plaster, and paint. Despite looting in all of the tombs, partially intact architecture, artifacts, and burials remained. Seventy of these tombs have been identified and recorded, and twelve of these have been fully excavated (two of which did not have sufficient preservation of human remains to be included in this study). Two forms of tombs were identified that are similar in construction technique but different in layout. One form is square or rectangular with dimensions ranging from 1.10 × 0.98 m to 2.70 × 2.40 m while the second form is round or oval and ranges from 0.80 to 2.90 m in diameter (Conlee, 2011). The elaborate grave goods found in both these tomb forms suggest possible high status and a close connection with Wari (Conlee, 2010, 2011). In addition to these new tomb styles, local burial practices were also continued at La Tiza during the Middle Horizon. Two individuals with calibrated radiocarbon dates of AD 688–891 and AD 783–1025 were buried in pits inside domestic structures in seated, flexed positions.

3. Materials and methods

3.1. Sample

While the main focus of this paper is the Middle Horizon population, the discrete burials dating to time periods preceding (Early Intermediate) and following the Middle Horizon (Late Intermediate) at La Tiza are also presented for comparative purposes. The demographic and carbonate isotopic data from a subset of these burials have been previously published in Conlee et al. (2009) and Buzon et al. (2011). Of the nine discrete burials, three date to the Early Intermediate Period, four date to the Late Intermediate Period, and two date to the Middle Horizon. Additionally, a minimum of forty-six individuals were uncovered in the ten Middle Horizon tombs that contained sufficiently preserved human remains for analysis. In addition to the previously published data, oxygen and carbon isotope ratios were measured for 17 individuals; strontium isotope ratios were measured for 15 individuals. The bone and enamel samples were taken from Middle Horizon tombs that were often looted, disturbed and incomplete. Thus, preservation precluded the standardization of bone and tooth types used in this study.

3.2. Skeletal analysis

When preservation allowed, age and sex data were collected following standard procedures using cranial and pelvic remains (Buikstra and Ubelaker, 1994). All skeletal material and dentition were examined macroscopically for pathological conditions (Buikstra and Ubelaker, 1994). Looting disturbed all of the tombs, resulting in fragmentary remains. As such, pathological observations are reported but frequency rates for specific conditions cannot be accurately calculated.

3.3. Isotope analyses

Carbon isotope ratios of bone and tooth carbonate, expressed as $\delta^{13}C$, reflect the isotope composition of whole dietary carbon sources (Ambrose and Norr, 1993). Plants using different photosynthetic pathways have distinct $\delta^{13}C$ values with C_4 plants having higher $\delta^{13}C$ values than C_3 plants and CAM plants (cacti and other succulents) with $\delta^{13}C$ values that can fall in between C_3 and C_4 plants. Maize (*Zea mays*), a C_4 plant, often ingested as beer (*chicha*), was an important food item during the Middle Horizon period (Kellner and Schoeninger, 2008). Additional botanical resources eaten in the region include lima beans (*Phaseolus lunatus*), other beans that were more rare (*Phaseolus vulgaris*, *Canavalia plagiosperma*), peppers (*Capsicum annuum*), huarango (*Prosopis* sp.), pacay (*Inga Feuillei*), lucuma (*Lucuma bifrea*), guava (*Psidium guajaba*), avocado (*Persea americana*), squash (*Curcurbita maxima*, *Curcurbita moshata*), achira (*Canna edulis*), manioc (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), peanut (*Arachis hypogaea*) (Conlee, 2000), potato (*Solanum* sp) (Silverman, 1993), jíquima (*Pachyrrhizus tuberosus*) (Valdez, 1994) and quinoa (*Chenopodium quinoa*) (Orefici and Drusini, 2003). In addition, San Pedro cactus (*Echinopsis pachanoi*) and prickly pear cactus (*Opuntia ficus-indica*), two CAM plants, may also have been available (Kellner and Schoeninger, 2008). Previous investigation of the carbon isotope variability in eight human enamel and bone carbonate samples from various periods at La Tiza and nearby Pajonal Alto provided a mean $\delta^{13}C_{(VPDB)}$ value of −6.7‰, with a relatively wide range of values from −4.1‰ to −8.4‰, suggesting a diet of primarily C_4 sources (Buzon et al., 2011).

Oxygen isotope ratios of human body tissues, expressed as $\delta^{18}O$, reflect the composition of consumed water sources (Longinelli, 1984) and are affected by hydrological, geographical, and climatological factors (Dansgaard, 1964; Gat, 1996; Bowen et al., 2007). In the Nasca region, rainfall is negligible and the rivers are fed by seasonal rains in the Andean highlands. The ancient inhabitants constructed *puquios*, horizontal wells, in order to access subsurface water, which was then emptied into a reservoir or irrigation canal (Schreiber and Lancho Rojas, 2003). Just before the time of the Paracas Culture (800–200 BC), aridification began, further increasing by the Middle Nasca Period (after AD 250). The Late Intermediate Period (AD 1000–1476) experienced more humid conditions (Eitel et al., 2005). Previous investigation of oxygen isotope variability in eight human enamel and bone carbonate samples from various periods at La Tiza and nearby Pajonal Alto provided a mean $\delta^{18}O_{c(VPDB)}$ value of −6.6‰ with a relatively narrow range, −5.0‰ to −7.6‰ (Buzon et al., 2011).

Strontium isotope values vary by the age and composition of the local geology, which is reflected in the soil and groundwater incorporated by plants and animals that are ultimately eaten by humans (Bentley, 2006; Ericson, 1985; Price et al., 1994; Sealy et al., 1995). If local foods are consumed, strontium isotope ratios of human tissues can reflect this local signature. La Tiza is located in a region that is dominated by the upper Jurassic Guanero Formation, a clastic sedimentary rock formation. In the Nasca region, beans constitute an important dietary source for strontium (Burton and Wright, 1995), while maize plays a minor role since it contains little strontium and calcium (Aufderheide and Allison, 1995). Marine resources and sea salt consumption can affect human strontium values, skewing towards the mean ocean value of $^{87}Sr/^{86}Sr = 0.7092$ (Burton, 1996; Faure, 1986; Wright, 2005). La Tiza is located approximately 50 km from the ocean and although marine shell was found at the site, it was less common than terrestrial animal remains. Very few fish remains were recovered, which is a pattern found at most sites in the southern Nasca drainage even where preservation is better (Conlee, 2000; Silverman, 2003). Overall, it appears that marine resources did not make up a large portion of the diet. Kellner and Schoeninger (2008) confirmed the largely terrestrial diet in their study of human bone collagen in the Nasca region. Previous investigations of strontium isotope variability in ten human enamel and bone carbonate samples from La Tiza and nearby Pajonal Alto provided a mean $^{87}Sr/^{86}Sr$ value of 0.70676, ranging from 0.70612 to 0.70770. Animals with small local ranges can be used as predictors of the local $^{87}Sr/^{86}Sr$ in humans (Bentley, 2006). Based on archaeological and modern rodent remains, the local strontium signature in the La Tiza area is $^{87}Sr/^{86}Sr = 0.70559–0.70727$ (Conlee et al., 2009).

3.4. Sample preparation

Tooth enamel (see specific tooth types in Table 1) and bone carbonate samples were used in this study. Tooth enamel was the preferred material because it is generally less susceptible to diagenetic contamination than bone or dentin (Lee-Thorp, 2002). For the looted tomb material, bone (cut from ribs or phalanges) was used when dental remains were not present. Tooth enamel reflects the isotope sources consumed during tooth crown development (various times during the first 16 years of life, see Table 2); bone reflects approximately the last several years of life, though the exact turnover rates vary by bone (Bentley, 2006). Using a diamond disk saw fitted to a dental drill, enamel samples were cut from the crown and the pulp and dentine were removed. Sampling targeted the area of the crown closest to the CEJ for consistency.

To remove contamination, tooth enamel was mechanically cleaned and the surface abraded (Nielsen-March and Hedges, 2000). A subset of samples was also assessed for contamination by measuring uranium concentrations, which can reflect uptake from groundwater (Hedges and Millard, 1995; values below 0.1 ppm were considered acceptable). The ratio of calcium to phosphorus (Ca/P) was also recorded for human bone samples. Normal bone has a Ca/P of approximately 2.1; diagenetic alteration can produce significant changes in this value due to the addition of minerals (Price et al., 1992). Solution mode ICP-MS was used for trace element analysis. Samples were rinsed in milliQ de-ionized water with ultrasonic agitation for 10 min, followed by an

Table 1
Isotopic and trace element results for La Tiza sample.

Isotope Sample #	Cultural Affiliation	Material	$^{87}Sr/^{86}Sr$	$\delta^{18}O_{c(VPDB)}$‰	$\delta^{18}O_{c(VSMOW)}$‰	$\delta^{18}O_{dw(VSMOW)}$‰	$\delta^{13}C$ ‰	Ca/P	Sr (ppm)	U (ppm)
2e	Middle Horizon	P4	0.70640	−6.8	23.9	−10.7	−4.1		149	bdl
2b		bone	0.70667					2.3	372	0.38
7e	Middle Horizon	C	0.70655	−7.1	23.6	−11.2	−6.7		70	bdl
7b		bone	0.70635					2.3	310	bdl
9e	Middle Horizon	M1	0.70747	−5.9	24.8	−9.3	−8.4		102	bdl
37	Middle Horizon	P3	0.70643	−7.2	23.5	−11.4	−6.5		108	0.0003
39	Middle Horizon	P4	0.70622	−6.3	24.4	−10.0	−7.2		170	0.0001
40	Middle Horizon	bone	0.70655	−7.9	22.8	−14.4	−8.8	2.4	249	0.015
41	Middle Horizon	P4	0.70632	−6.6	24.1	−10.4	−7.2		141	0.003
42	Middle Horizon	M3	0.70625	−6.5	24.2	−10.3	−5.8		283	0.010
43	Middle Horizon	M2	0.70657	−6.2	24.6	−9.7	−7.1		230	0.022
44	Middle Horizon	bone	0.70617	−6.6	24.1	−10.5	−9.2	2.2	131	0.005
46	Middle Horizon	P3	0.70561	−4.6	26.1	−7.4	−11.1		234	0.011
47	Middle Horizon	M1	0.70645	−6.0	24.7	−9.5	−8.4		90	bdl
48	Middle Horizon	P4	0.70632	−6.7	24.0	−10.6	−8.2		142	0.002
49		M3		−6.6	24.1	−10.5	−6.0			
50	Middle Horizon	P4	0.70620	−6.3	24.5	−9.9	−6.4		130	0.006
52	Middle Horizon	m2 (dec)	0.70647	−5.5	25.2	−8.74	−5.6		428	0.044
53	Middle Horizon	P4	0.70634	−7.0	23.8	−10.9	−7.0		498	0.092
55	Middle Horizon	M3		−7.3	23.3	−11.6	−6.3			
56	Middle Horizon	M2	0.70637	−6.0	24.7	−9.5	−7.7		760	0.006
57	Middle Horizon	bone		−7.6	23.1	−12.0	−7.8			
1	Early Intermediate	bone	0.70690					2.2	583	0.64
45	(Nasca 5)	bone	0.70682	−7.4	23.3	−11.7	−8.9	2.5	928	0.752
8e	Early Intermediate	c (dec)	0.70640	−7.6	23.1	−12.0	−8.0		203	0.69
8b	(Early Nasca)	bone	0.70667					2.3	284	bdl
38	Early Intermediate (Early/Middle Nasca)	bone	0.70675	−6.2	24.6	−9.8	−8.4	2.4		
3e	Late Intermediate	P4	0.70612	−5.0	25.8	−7.9	−7.2		104	bdl
3b		Bone	0.70662					2.3	192	0.15
4e	Late Intermediate	I1	0.70682	−6.5	24.2	−10.3	−7.0		80	0.22
4b		bone	0.70686					2.3	193	1.43
5	Late Intermediate	bone	0.70643					2.3	272	0.007
6e	Late Intermediate	P4	0.70643	−6.4	24.3	−10.1	−6.8		159	0.21
6b		bone	0.70655					2.0	255	1.09

Notes: 1. $^{87}Sr/^{86}Sr$, Sr, U results for samples #1–9 have been previously published in Conlee et al. (2009). 2. $\delta^{18}O$ and $\delta^{13}C$ results for samples #2–4 and 6–10 have been previously published in Buzon et al. (2011). 3. Abbreviations: c = carbonate, dw = drinking water, dbl = below detection level.

overnight ‘soaking’ in milliQ water. On the following day, samples were soaked in 6% H_2O_2 for 4 h. They were then rinsed with milliQ water and immersed in 16N HNO_3 and placed on a hot plate for several hours; complete digestion normally occurred within the first hour. The samples were then evaporated to dryness followed by the addition of 100 ml of 2% HNO_3. Prior to the ICP-MS analysis, internal standard solutions (As, In, Tl) were added to a 2.5 ml aliquot of sample solution. Trace element analyses of tooth enamel and bone samples were performed on a Thermo Finnigan Element2 HR (high resolution)-ICP-MS at the MITERAC (Midwest Isotope and Trace Element Research Analytical Center) facility, University of Notre Dame. Optimization of the ICP-MS instrument was achieved with the use of a 1 ppb multi-element (mass range from Li to U) tuning solution. Tuning consisted of optimization of torch assembly position, sample gas (Ar) flow rate, ion lens stack voltages, and reference mass calibration. Elemental abundances were quantified by external calibration using a 4-point calibration curve (1, 20, 50, 100 ppb), where a 10 ppb uranium solution measured in medium resolution mode (m/delta m ~4000) yielded ~700,000 cps with an uptake rate of ~0.5 ml/min.

Table 2
Tooth crown formation timing (Hillson, 1996).

Tooth type	Years after birth
Deciduous canine	*in utero*–9months
Deciduous second molar	*in utero*–11months
Incisor	<1 year–5 years
Canine	<1 year–7 years
Premolar	1.5 years–7 years
First molar	Birth–3 years
Second molar	2.5 years–8 years
Third molar	7 years–16 years

Enamel and bone carbon and oxygen isotope ratios were analyzed at the Purdue Stable Isotope (PSI) Facility, Department of Earth and Atmospheric Sciences. The tooth enamel and bone samples were lightly ground, treated sequentially with solutions of 5% NaOCl and 0.1M acetic acid for 3 days, rinsed and freeze-dried prior to analysis (Koch et al., 1997; Vennemann et al., 2001). The oxygen and carbon isotope composition of hydroxyapatite carbonate was analyzed using a Thermo Finnigan Delta V Isotope Ratio Mass Spectrometer (IRMS) following reaction at 75 °C with orthophosphoric acid and chromatographic isolation of CO_2 on a GasBench automated preparation device. Multiple analyses of a pure calcite reference material gave a reproducibility of 0.04% for $\delta^{13}C$ and 0.06% for $\delta^{18}O$.

Strontium isotope samples were prepared at MITERAC, University of Notre Dame and analyzed using a NuPlasma MC-ICP-MS instrument located at the Nu Instruments Ltd factory (Wrexham, UK). Samples were sonicated for 15 min in milliQ water and then in 5% acetic acid for 15 min. After an overnight leaching in 5% acetic acid, the acid was removed and samples were rinsed with milliQ prior to transfer to vials. The samples were digested in Savillex Teflon vials in 4 ml 16 N HNO_3 and placed on a hot plate at ~120 °C for 24 h. Digested samples were then uncapped and dried on a hot plate (~120 °C). All dried samples were dissolved in 3 ml of 0.75 N HCl and then loaded onto 10 cm ion exchange columns containing 1.42 ml of 200–400 mesh AG50W-X8 resin. Samples of 5 ml of 2.5 N HCl each were collected into Teflon vials with an added drop of H_3PO_4 and then left to dry overnight on a hot plate ($\sim$100 °C). Subsequent to ion chromatographic treatment of the samples, the Sr-bearing aliquots were diluted in a 2% HNO_3 solution ($\sim$1.5 ml) and aspirated into the ICP torch using a desolvating nebulizing system (DSN-100 from Nu Instruments Inc.). Strontium isotope data were acquired in static, multicollection mode using five Faraday collectors for a total of 400 s, consisting of 40 scans of 10 s integrations. Accuracy and reproducibility of the analytical protocol were verified by the repeated analysis of a 100 ppb solution of the NIST SRM 987 strontium isotope standard during the course of this study; this yielded an average value of 0.710254 +/− 0.000040 (2s standard deviation; $n = 9$ analyses).

4. Results

The age and sex data of the individuals excavated at La Tiza are presented in Table 3. The interments dated to the Middle Horizon include a minimum of forty-eight individuals, five of which were intact burials. The remaining skeletal material was disturbed and fragmented. Of these forty-eight, thirty-two were adults. A more precise age could be estimated for seven of these adults. All age categories are represented, from infant to older adult. Most of the tombs contained individuals of various ages.

The recorded pathological conditions are also presented in Table 3, including dental disease, indications of physiological stress, traumatic injuries, and developmental defects. Dental disease, including caries, abscesses, and antemortem tooth loss, is common in all of the time periods represented at La Tiza. In addition, evidence of nutritional deficiencies and disease stress is found in the La Tiza sample including linear enamel hypoplasia indicative of physiological disruption and osteoperiostitis associated with infection. Some developmental defects of the spine were found in the Middle Horizon and Early Intermediate period individuals. One Middle Horizon individual displayed block thoracic vertebrae, the failure of the developmental unit to separate (as opposed to fusion). This adult male also displayed a sacralized and bifurcated fifth lumbar vertebra (border shifting). Another Middle Horizon period sacrum (from a disturbed burial) exhibited spina bidifa. Spinal defects, including sacral cleft and sacral–caudal shifting at the coccyx border, were also observed in one Early Intermediate period individual. Few traumatic injuries were recorded in the Middle Horizon material. Two individuals, one dating to Nasca 5 phase of the Early Intermediate and the other to the Late Intermediate, were missing the cranium as well as first and second cervical vertebrae in otherwise intact burials. For the Nasca 5 burial, cutmarks on the third cervical vertebrae were evident (Conlee, 2007). This practice of decapitation was not found in any of the Middle Horizon remains.

Data from the geochemical analyses are presented in Table 1. The majority of the enamel samples have little to no uranium. However, the higher levels of uranium and elevated Ca/P ratios in the bone samples indicate possible diagenesis, and isotopic data from those samples should be interpreted with caution. The mean $\delta^{13}C_{c(VPDB)}$ value for the Middle Horizon human enamel and bone samples is $-7.3‰ \pm 1.5‰$, with a range of values from $-4.1‰$ to $-11.1‰$ and two apparent outliers defining either end of this range (Fig. 2). In comparison with the previously reported La Tiza samples from all three time periods ($-6.7‰$, Buzon et al., 2011), this mean is slightly, though not statistically, lower. Some of the teeth used in this study reflect a diet before weaning was complete. Previous work has shown that tooth enamel $\delta^{13}C$ values can become higher with increasing age, with large changes during the first 3 years of life (Wright and Schwarcz, 1998). The teeth with enamel that may have formed before weaning (deciduous teeth, first and second molars, possibly premolars) give $\delta^{13}C$ values that are distributed throughout the range of measured values. However, the two-second permanent molar samples show considerably higher values (mean = $-3.2‰$) despite the overlap in crown formation timing with other tooth types used in the study (Table 4). The $\delta^{13}C$ values from human tooth enamel have been shown to reflect the carbon isotope composition of the entire diet plus 11–12‰ (Passey et al., 2005). Previous studies have demonstrated that the range of values for maize, a common C_4 food in the region, is $\delta^{13}C = -10‰$ to $-14‰$; common C_3 foods such as beans, squash and potatoes have a lower range of values, $\delta^{13}C = -22‰$ to $-29‰$ (DeNiro and Hastorf, 1985; Tieszen and Chapman, 1992). Thus, the range of values for the Middle Horizon sample suggests the inclusion of maize in the diet and/or the incorporation of some CAM plants. Keeping the small sample sizes in mind, the $\delta^{13}C$ values for the Early Intermediate ($\delta^{13}C = -11.2‰$) samples show a significantly lower mean value than that for the Middle Horizon ($\delta^{13}C = -7.5‰$) samples (Fig. 2, one-sided t-test assuming unequal variance, $p = 0.01$).

The following equations were used to convert $\delta^{18}O_c$ values to estimate source water $\delta^{18}O$ in order to compare with published data:

$$\delta^{18}O_{c(VSMOW)} = 1.03091\ \delta^{18}O_{c(VPDB)} + 30.91 \text{ (Sharp, 2007)}$$

$$\delta^{18}O_{p(VSMOW)} = 0.98\ \delta^{18}O_{c(VSMOW)} - 8.5 \text{ (Iacumin et al., 1996)}$$

$$\delta^{18}O_{dw} = 1.54\ \delta^{18}O_p - 33.72 \text{ (Daux et al., 2008)}$$

The mean $\delta^{18}O_{c(VPDB)}$ value for the Middle Horizon human enamel and bone samples is $\delta^{18}O_c = -6.5‰ \pm 0.8‰$ (Table 1, Fig. 3). Sample #46 at $\delta^{18}O = -4.6‰$ is an outlier and could be considered nonlocal. This tooth (P3) could reflect a pre-weaning signal and have higher $\delta^{18}O$ value due to the ^{18}O-enrichment of breast milk relative to drinking water (Roberts et al., 1998; Wright and Schwarcz, 1998), though the $\sim$2‰ difference is more than is expected between pre-weaning and post-weaning teeth. Additionally, one individual for whom we obtained data for two teeth (sample #48 and #49), shows little difference between the third molar and fourth premolar suggesting minimal water intake from breast milk around the age of two years. Not all tooth types whose crowns may have developed before weaning have systematically higher values (Table 4). The comparison of $\delta^{18}O$ values by tooth type and bone indicates little variation. In comparison with Nasca valley water samples with a mean $\delta^{18}O$ of $-11.9‰$ (Buzon et al., 2011), the Middle Horizon mean calculated drinking water $\delta^{18}O$ value is slightly higher at $-10.4‰$. As suggested in the previous study, this offset might be accounted for by water practices, such as aboveground evaporative storage and the production and storage of chicha, a boiled maize beverage (Buzon et al., 2011).

The $^{87}Sr/^{86}Sr$ values from the La Tiza Middle Horizon sample range from 0.70561 to 0.70747 (Table 1, Fig. 4). The majority of these values fall within the established local range based on archaeological and modern rodent samples ($^{87}Sr/^{86}Sr$ = 0.70559–0.70727; Conlee et al., 2009). The average values of bone and various tooth types all fall within the established local range (Table 4). All but two of the samples fall within a very tight range, $^{87}Sr/^{86}Sr$ = 0.70617 to 0.70667. There are two outliers (adult females) with values of $^{87}Sr/^{86}Sr$ = 0.70747 and $^{87}Sr/^{86}Sr$ = 0.70561, endmembers of the distribution. With these outliers removed, the Middle Horizon ($^{87}Sr/^{86}Sr$ = 0.70637) samples have a mean $^{87}Sr/^{86}Sr$ value that is significantly lower than the EIP ($^{87}Sr/^{86}Sr$ = 0.70671) samples (Fig. 4, one-sided t-test assuming unequal variance, $p = 0.01$). The outlier $^{87}Sr/^{86}Sr$ value of 0.70561 as well as several values within the La Tiza local range overlap (Fig. 5) with the local range established for the Wari heartland (Tung and Knudson, 2008).

Table 3
La Tiza Skeletal sample demographic and paleopathological information.

Burial Provenience	Cultural Affiliation	Associated ^{14}C date	MNI	Age (years)	Sex	Isotope Sample #	Pathological Conditions
Sector V, Unit 17, Burial 2	Middle Horizon	AD 688–891	1	30–40	M	2e, 2b	Block thoracic vertebrae, sacralized & bifurcated L5, antemortem tooth loss, caries, dental abscesses
Sector V, Unit 47, Burial 7	Middle Horizon	AD 783–1025 AD 640–720 AD 740–770	1	45+	F	7e, 7b	Osteoarthritis, Schmorl's nodes, antemortem tooth loss, caries, dental abscess
Sector IV, Tomb 2	Middle Horizon		6	Adult	M?		Fractured femur
				Adult			
				Adult			
				Adult			
				Adult			
				5–6			
Sector II, Tomb 3	Middle Horizon		3	Adult			
				Adult			
				Adult			
Sector III, Tomb 4	Middle Horizon		4	Adult		42	
				Adult			
				Adult			
				Adult			
Sector III, Tomb 5	Middle Horizon		4	Adult		43	Spina bifida
				Adult		57	
				5–6		56	
				10–11			
Sector III, Tomb 6	Middle Horizon	AD 782–1021	6	Adult	F?	9e	
				Adult		44	
				Juv			
				Juv			
				25–35			
				50+			
Sector III, Tomb 34,	Middle Horizon		3	18–22	M	55	Linear enamel hypoplasia
Burial 10							
Burial 11				20–25	F	46	
Burial 12				0.5			
Sector III, Tomb 41	Middle Horizon		5	Adult		47	
				Adult		53	
				Adult			
				Infant			
				10–11			
Sector III, Tomb 42	Middle Horizon		5	Adult		39	Tibial osteoperiostitis
				Adult		50	
				<3		52	
				3–4			
				5–6			
Sector III, Tomb 52	Middle Horizon		5	Adult	F?	37	Maxillary sinus infection
				Adult			
				Adult			
				Infant			
				15–16		48, 49	
Sector III, Tomb 57	Middle Horizon		5	Adult	F?	40	
				Juv			
				Adol			
				Child			
				18–22			
Sector II, Unit 8, Burial 1	Early Intermediate (Nasca 5)		1	22–29	M	1, 45	Missing cranium, C1–C2, cutmarks on C3 vertebra, sacral cleft and sacral–caudal shifting
Sector V, Unit 46, Burial 8	Early Intermediate (Early Nasca)	AD 145–405	1	9–10	I	8e, 8b	Linear enamel hypoplasia
Sector II, Unit 55, Burial 9	Early Intermediate (Early/Middle Nasca)		1	18–22	F?	38	
Sector V, Unit 33, Burial 3	Late Intermediate	AD 1315–1435	1	25–35	F?	3e, 3b	Caries, dental abscesses
Sector V, Unit 33, Burial 4	Late Intermediate		1	1–1.5	I	4e, 4b	
Sector V, Unit 33, Burial 5	Late Intermediate		1	14–15	M?	5b	Missing cranium, C1–C2
Sector V, Unit 33, Burial 6	Late Intermediate		1	1.5	I	6e, 6b	Orbital lesions

Notes: 1. Adult = adult of indeterminate age, Juv = <18, Infant = 0–2 years, Adol = 13–17 years, Child = 3–14 years.

5. Discussion

The elaborate aboveground tomb types found at La Tiza with access-ways, plaster, paint, shell and copper artifacts, textiles, pottery, spindle whorls, mummy bundles and multiple burials reflect changes on a regional level that coincided with the Wari presence during the Middle Horizon (Conlee, 2010, 2011). Traditional burial practice of interment in pits with the burial in a flexed position continued along with this alternative burial practice of tomb structures at La Tiza. The practice of multiple burials, as well as the tomb shape and construction, has some similarities with traditions in the Wari heartland (Conlee, 2010), such as at

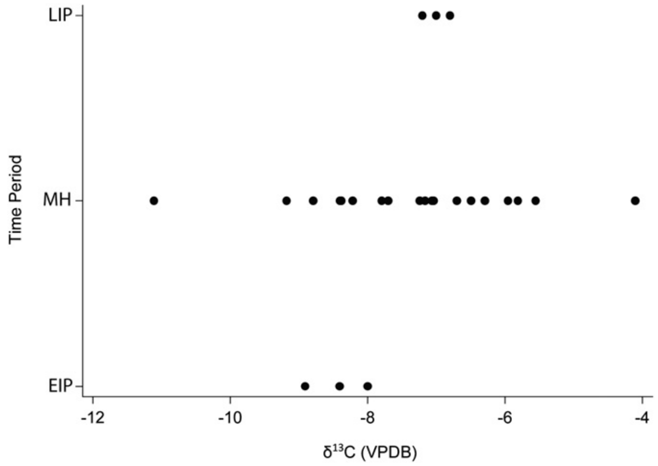

Fig. 2. $\delta^{13}C$ values from La Tiza by time period. EIP = Early Intermediate Period, MH = Middle Horizon, LIP = Late Intermediate Period.

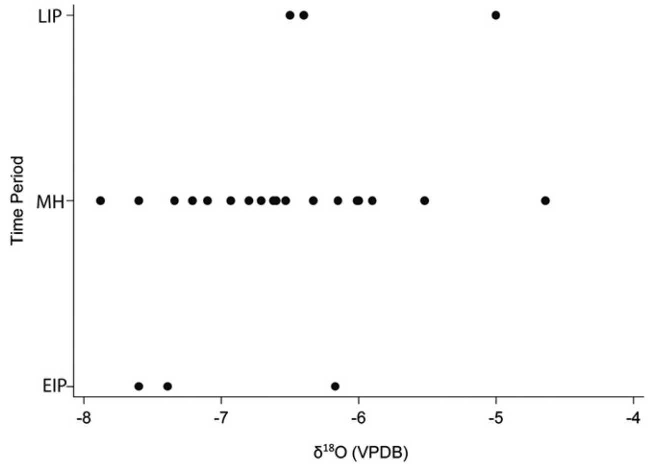

Fig. 3. $\delta^{18}O$ values from La Tiza by time period. EIP = Early Intermediate Period, MH = Middle Horizon, LIP = Late Intermediate Period.

Conchopata (Isbell, 2004; Isbell and Cook, 2002). The dramatic change in mortuary practices in regions that were interacting with Wari was common, though the variability may be too great to attribute to a centralized Wari control (Isbell, 2010). Conlee (2010) suggests that a new and widespread ideology was being expressed in the treatment of the dead and that the variability itself might be the unifying feature in the Wari contact experience.

These new burial traditions alongside the traditional practices indicate that not all segments of the Nasca population benefited from the relationship with Wari. Some Wari immigrants may have settled in the area, perhaps making alliances with local elites who profited through the procurement of material goods. The presence of these novel elaborate tombs with rich grave goods suggests that the people buried in them may have had higher status and a connection to the Wari state. New types of elites may have emerged (Conlee, 2010). There was also a continuation of traditional burial practices that were established in the region during the Early Intermediate. The practice of interring single individuals in pits in a flexed position with limited grave goods was continued in the Middle Horizon and subsequent Late Intermediate Period. The location of burial shifted to houses in the Late Intermediate instead of cemeteries as was common in the Early Intermediate suggesting a return to traditional practices but in a new sociopolitical context. The mausoleums and multiple burials of the Middle Horizon were abandoned and there is no evidence that this practice continued.

The demographic data from the La Tiza sample indicate that all segments of the population were buried in the Middle Horizon tombs including infants, children, adolescents, and adults of all ages. Family groups may have used these structures, as indicated by the representation of all ages and both sexes, though it was difficult to discern how long each tomb was used (Conlee, 2010). All of the Middle Horizon tombs included at least three individuals; the looting and disturbance likely resulted in an underestimation of burials in most tombs. In Tomb 34, three undisturbed burials (including two adults placed in a flexed position and an infant), only took up a third of the tomb space, suggesting that several more individuals could have been interred in each tomb.

Dietary reconstruction of the Middle Horizon individuals via carbon isotope analysis of enamel and bone carbonate reveals $\delta^{13}C$ values that are restricted to a ~5‰ range ($\delta^{13}C = -5.5$‰ to -10.3‰) for most of the individuals (with two outliers at $\delta^{13}C = -4.1$‰ and -11.1‰). This range is consistent with a diet including a significant fraction of C_4 carbon sources – between approximately 35% and 75% of diet based on endmember C_3 and C_4 values of -24 and -12‰, respectively – and is similar to ranges found in other Nasca samples (Knudson et al., 2009). During the Middle Horizon, Wari intensified maize production in many areas of their empire, establishing new villages to support the increased labor demands (Schreiber, 1987). However, analysis of bone collagen in Nasca samples has not indicated that maize consumption increased during the Wari imperial period in the region (Kellner and Schoeninger, 2008). Males and females show equitable consumption of maize, despite patterns of marked sex differences in *chicha* consumption found in other regions with males ingesting higher quantities (Kellner and Schoeninger, 2008). The lower mean value for the Early Intermediate samples in

Table 4
Mean isotopic results for bone and tooth types.

Material	N	$^{87}Sr/^{86}Sr$	$\delta^{18}O_{c(VPDB)}$‰	$\delta^{13}C$ ‰
bone	11	0.70663	−7.1	−8.62
deciduous c	1	0.70677	−7.1	−8.0
deciduous m2	1	0.70647	−5.5	−5.6
I1	1	0.70682	−6.5	−7.0
C	1	0.70655	−7.1	−6.7
P3/4	10	0.70624	−6.3	−7.2
M1	2	0.70660	−6.0	−8.4
M2	2	0.70647	−6.1	−3.2
M3	3	0.70625[a]	−6.8	−6.0

[a] This $^{87}Sr/^{86}Sr$ value is from only 1 sample.

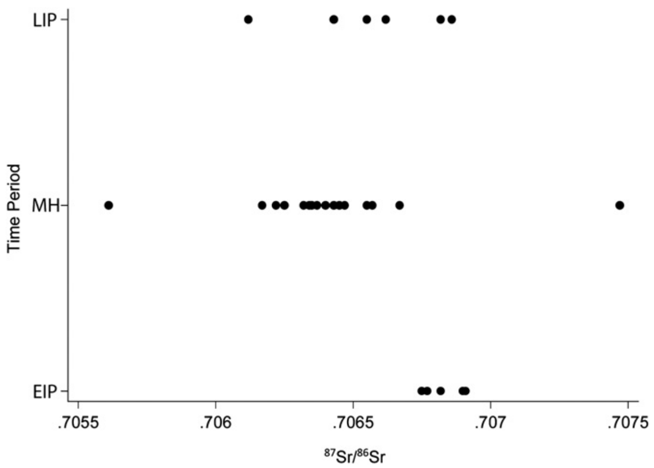

Fig. 4. $^{87}Sr/^{86}Sr$ values from La Tiza by time period. EIP = Early Intermediate Period, MH = Middle Horizon, LIP = Late Intermediate Period.

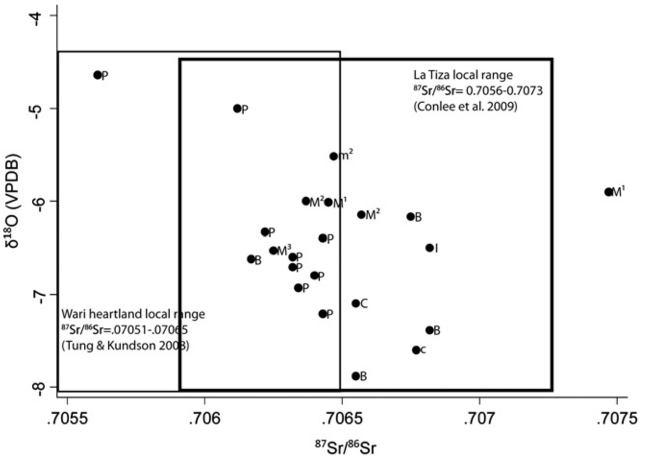

Fig. 5. δ^{18}O and ^{87}Sr/^{86}Sr values from La Tiza by tooth type in relation to La Tiza and Wari heartland local ranges.

comparison to the Middle Horizon may possibly suggest an increase in maize use between these periods at La Tiza. Evidence for maize in the Early Intermediate is found at many sites including Cahuachi, an early Nasca ceremonial site, where it was likely associated with the brewing and consumption of *chicha* during feasting (Vaughn, 2005; Silverman, 1993); expectedly, maize appears to have been a staple food throughout the time periods at La Tiza and other Nasca regions sites. Overall, the range of values suggests increased dietary diversification during the Middle Horizon, though the samples sizes for the Early Intermediate and Late Intermediate periods are admittedly very small. This unsurprising evidence for continued maize consumption is also supported by the some of the recorded pathological conditions (Table 3) such as dental disease, nutritional deficiencies, and infection associated with aggregated populations consuming high amounts of carbohydrates (Larsen, 1997; Tomasto Cagigao, 2009). Nutrition can also play a role in developmental defects, though these conditions have multifactorial etiologies such as chromosomal errors and/or environmental factors (epigenetic interaction), including mechanical, chemical, nutritional, maternal hormone or infection influences (Barnes, 1994).

Oxygen and strontium isotope analyses have been used successfully to identify first generation immigrants in many Andean skeletal samples; while additional analyses are always useful to better understand the isotope variability, the multitude of previous studies have provided important baseline data in the region (e.g., Andrushko et al., 2009, 2011; Conlee et al., 2009; Horn et al., 2009; Knudson, 2008, 2009; Knudson and Buikstra, 2007; Knudson and Price, 2007; Knudson et al., 2004, 2005, 2009; Slovak et al., 2009; Tung and Knudson, 2008; Turner et al., 2009). In conjunction with the earlier published data from La Tiza (Buzon et al., 2011; Conlee et al., 2009), the isotopic evidence suggests that most individuals buried at La Tiza cannot be distinguished from the local range. There are a few potential exceptions to this pattern (Fig. 5). One enamel sample (#46) with the highest measured δ^{18}O value (−4.6‰) lies outside of the previously characterized local range. This sample and sample #9e also have ^{87}Sr/^{86}Sr values that are outliers relative to the rest of the burials (Fig. 5). The strontium isotope ratio for #9e (0.70747) is higher than the upper limit previously established for local samples from La Tiza (Conlee et al., 2009), and #46 (0.70561) is at the extreme low end observed in local samples. Additionally, these two samples have δ^{13}C values on the low end of the sample range (#9e δ^{13}C = −8.4‰, #46 δ^{13}C = −11.1‰), which further emphasizes the possible foreign nature of these individuals. In combination, these data indicate that we might consider that the two young adult females represented by samples #9e and #46 were nonlocal, a phenomenon confined to the Middle Horizon at La Tiza. With the small EIP sample size in mind, the comparatively lower average Middle Horizon ^{87}Sr/^{86}Sr value may be indicative of population variation over time.

However, it is important to note that the La Tiza local range partially overlaps with the ^{87}Sr/^{86}Sr local range established for the Wari heartland (0.7051–0.7065, Tung and Knudson, 2008). Thus, ^{87}Sr/^{86}Sr analysis of the La Tiza samples may underestimate the number of Wari individuals who may have moved there, especially given the association with Wari related artifacts in elite tombs at the site. It is possible that individuals who overlap with the Wari local range were indeed immigrants who may have married into the community at La Tiza. Marriage alliances have been documented in ancient states in the Americas as way to establish relationships with other groups (e.g., Smith and Montiel, 2001; Spence, 2005; White et al., 1998). These possible marriages to members of the community at La Tiza could have helped establish or strengthen ties between Wari and high-ranking Nasca individuals. The higher δ^{18}O values, however, indicate possible origins in the northern Nasca river valleys or the Grande river valley below 300 m elevation in comparison with values for water samples in the region (Johnston et al., 2002; Webb et al., in press). Overall, these isotopic data suggest that Wari goods and ideas found in the archaeological evidence may have been accompanied by actual immigrants.

6. Conclusion

This study has investigated the consequences of Wari contact in the Nasca region during the Middle Horizon at the site of La Tiza. Mortuary practices and skeletal analyses indicate this was a period of change. The introduction of new tombs structures, multiple burials, and more varied grave goods highlights the spread of different ideas in conjunction with the continuation of traditional burial practices. Correspondingly, during the Middle Horizon, there is some evidence for the presence of nonlocal individuals at La Tiza via strontium and oxygen isotope analysis. We suggest that these foreigners may have married into the community at La Tiza. Continued or perhaps a slightly increased maize consumption is indicated by the carbon isotope data, suggesting dietary changes associated with the ideological shift. These Middle Horizon archaeological, demographic, paleopathological and isotopic data have provided a clearer understanding of the kinds of changes experienced by people in the Nasca region who lived at La Tiza as a result of their contact with Wari.

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