The Teotihuacan Dream: An Isotopic Study of Economic Organization and Immigration

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Located in the central Mexican highlands, Teotihuacan (Figure 1) was the center of a very powerful state whose influence was felt throughout all of Mesoamerica. Like most other large cities in ancient and modern times, it attracted and depended upon immigrants for its physical, cultural, and economic survival. Spence has devoted much of his career to understanding Teotihuacan's relationship with foreign polities (e.g. via his work on obsidian and mortuary behavior [Sempowski and Spence 1994; Spence 1967; 1974; 1981, 1984; Spence et al. 1984]) as well as the dynamics of ethnicity within the ancient city through his excavations in the city's Oaxacan Barrio (Tlailotlacan) located in the western part of the city (see Gibbs, this volume, Figure 3; Spence 1974, 1976, 1989, 1992, 1996). Big metropolitan cities are often perceived as either melting pots where newly arrived inhabitants lose their cultural identity in the processes of assimilation, or as ethnic mosaics where migrants aggregate in neighborhoods (barrios) that maintain and promote homeland identities. Both of these scenarios are probably overly-simplistic, but whatever the fate of immigrants, they were essential for the biological maintenance of the city because of extremely high infant mortality rates (Storey 1991; 1992). Given the need to accept immigrants for its biological survival, state governance would have been compelled to find ways of balancing its economic imperative (i.e., the need for a strong, stable economy and workforce) with its social and political imperatives (i.e., the need for allegiance and cohesiveness in the face of external forces). Because Teotihuacan contained enclaves of distinct ethnic groups whose inhabitants probably arrived with a vision for greater economic opportunity, we assume that its rulers must have continuously struggled to find this balance. The survival of the city for over 750 years illustrates the long term success of both the state and its immigrants in negotiating their interests.

Ancient economic relationships are most often studied by examining the movement of artifacts between polities and/or regions, but reconstructing movements of people into and out of the city can enrich our understanding of economic dynamics in ancient cities. In this chapter oxygen isotope ratios in phosphate of bones and teeth, and carbon and nitrogen isotope ratios in bone collagen are used to identify foreigners by reconstructing migration and dietary histories of individuals. These data will be used to investigate: 1) how the state may have negotiated the balance of its imperatives with foreign traders and artisans, 2) how these new "citizens" may have acted as cultural and economic agents for themselves and their homelands, and 3) the implications of their behaviour for the economic organization of the state.

Figure 1. *Map of Teotihuacan.*

Spence (2005) has noted that although world-systems theory and core-periphery models of economic behaviour in Mesoamerica have been supplanted by peer polity and network strategy models, it is still commonly assumed that elite goals drive the circulation of non-local goods and that economic structures are inextricably linked to political structures. He has advocated the need to be open to the possibility that some economic institutions might have operated independently from political structures but still played important social and economic roles. One such example is the Zapotec diaspora trade network whose presence in Teotihuacan is evident at the site of Tlailotlacan (Spence 2005). In this network strategy model Spence described an economic system for the procurement of foreign goods that probably complemented that of the state and must have existed with its consent, or possibly encouragement. The mechanism for the success of this trade network, as revealed through isotopic analyses, was the long term maintenance of travel between various termini in the network and the long sojourning (and probable socialization) of the young in their homelands (White et al. 2004c).

We extend this study by investigating the movements and diets of individuals found in two other sites within Teotihuacan i.e., the Merchants' Barrio and Tlajinga 33. The inhabitants of these sites were engaged in trade and production of consumer goods, but their cultural and ethnic characters differed from Tlailotlacan. Thus, they provide an opportunity to examine variability in economic systems operating in the ancient city in relation to both immigrants and state power.

The Merchants' Barrio

Excavated by Evelyn Rattray, Universidad Nacional Autónoma de México, the Merchants' Barrio covered approximately 4 hectares of land spanning both sides of the San Juan river on the northeastern edge of the city. The peripheral location may have some symbolic significance, i.e., it was not "downtown" or spatially integrated with what one would expect in terms of centralized market activity for most cities. The barrio appears to have been established between 350 and 450 A.D. (Late Tlamimilolpa phase), which is approximately 350 to 500 years after the earliest appearance of the city (Patlachique phase 150 B.C. to 0).

The Merchants' Barrio appears to have been a conglomeration of multi-ethnic residents who participated in long distance trade rather than a distinct ethnic enclave like the Oaxaca Barrio (Tlailotlacan) (Spence 1992). Material evidence such as ceramics, lithics, architecture, and funerary practices suggest cultural associations with the Gulf Coast, the Maya Lowlands and the state of Puebla (Rattray 1987). How the inhabitants of the Merchants' Barrio were connected to their homelands is unclear, but understanding this relationship is crucial for reconstructing Teotihuacan's economic interactions with polities contained within its sphere of influence. Were its inhabitants long distance traders actively moving across the landscape in a circuit, as was the case for the later Aztec model of the "pochteca" merchant, or were they agents of trade with their homelands who were permanently ensconced in the city, as one might expect of foreign economic ambassadors?

Twenty-three individuals were sampled from three successive phases spanning about 300 years: Late Tlamimilolpa (200-250 A.D., n = 3), Early Xolalpan (450 to 550 A.D, n = 15), and Late Xolalpan (550 to 650 A.D., n = 8) (Table 1). (We note that this chronology has been altered slightly in the past and is still subject to future revision.) Three areas were excavated within the barrio. The Xocotitla and Mezquititla groups are located on the west side of the San Juan river and the Nopalera group on the east side. Although samples were taken from each, the majority come from the Xocotitla group. Seven structures were sampled from these groups as well as material interred in a shrine in the West Plaza of Xocotitla.

The sample is comprised mainly of secondary burials, which reflects the dominant mortuary treatment in the barrio and contrasts with the usual Teotihuacan practice of individual primary interment. Burial 5-8 is an extreme example of this practice, constituted of 34 individuals found

Table 1. *Stable isotope data for mortuary and biological variables by site.*

Site/Phase	Structure	Group/Burial	Type	Sex	Age	$\delta^{18}0_p0/00$VSMOV	YIELD[a]	YIELD[b]	CI[c]	δ^{13}Ccol0/00 VPDB	% YIELD[d]	C/N
MERCHANTS' BARRIO												
Late Tlamimilolpa (350 - 450 A.D.)												
Xocotitla	3	9	S		SA	15.3	3.9	1.0	3.8	-9.9*	1.1	3.5
Mezquititla	10-11	22a	S		A	15.4	4.7	1.2	4.4	-8.0	5.8	2.4
Mezquititla	10-11	22b	S		SA	**16.6**	4.5	1.2	4.4			
Early Xolalpan (450 - 550 A.D.)												
Xocotitla	2	5-8	S		A	**13.9**			3.2	-8.2	5.2	3.3
Xocotitla	2	5-8	S		A	14.2		3.7		-9.1	4.2	3.3
Xocotitla	2	5-8	S	F	YA	14.2	4.7	0.9	3.6	-10.5*	1.1	3.2
Xocotitla	2	5-8	S	F	YA	14.4			3.9	-8.5	5.4	3.4
Xocotitla	2	5-8	S	F	MA	14.7			3.5	-7.9	4.1	3.3
Xocotitla	2	5-8	S	F	YA	14.2	4.8	1.2	3.3	.8.9	5.4	3.4
Xocotitla	2	5-8	S		YA	14.5	4.9	.9	3.6	-8.5	3.7	3.4
Xocotitla	2	5-8	S		SA	15.9	4.6	.6	3.5			
Xocotitla	2	5-8	S	F	MA	14.0	4.9	.5				
Xocotitla	WP	14b	P	F	YA	15.2	4.6	1.3				
Xocotitla	WP	14c or e	P	F	YA	**17.9**[PM]	4.8	1.3				
Xocotitla	12	24-25d		F	YA	**13.9**	4.7	.8	3.0			
						16.8[C]	4.8	1.0	3.2			
Xocotitla	12	24-25			A	**16.1**	4.8	1.0	3.2			
Xocotitla	12	32	animal	14.9	4.8	1.1	3.3					
Xocotitla	2	5-8	animal	15.8	4.6	.8						
Late Xolalpan (550 - 650 A.D.)												
Xocotitla	4	10a	P	M	YA	15.7	4.7	.8	4.0	-8.6	3.0	3.3
						17.9[PM]	4.1	1.4	3.2			
Xocotitla	4	10c	S		SA	**16.6**			3.1	-6.9	9.9	3.3
Xocotitla	4	11a	S	M	YA	**15.2**	4.9					
Xocotitla	4	11b	S		SA	15.6	4.8	1.0	3.9	-8.0	3.2	3.4
Xocotitla	4	13b	P	F	YA	15.1	4.8	1.0	3.9			
						15.6	4.5	.8	3.5	-8.4	7.3	3.3
						15.9[M]	4.7	1.3	3.2			
Xocotitla	WP	17	P	F	MA	**17.8**	4.8	.5				
						16.4[C]	4.6	1.5	3.2			
Nopalera	15	33a	S	M	MA	14.2	4.8	.8				
						11.7[C]	4.9	1.4	3.3			
Nopalera	15	33b	S	M	YA	16.3	4.7	1.1	4.2	-7.5	3.7	3.3

Table 1 (cont.'d). *Stable isotope data for mortuary and biological variables by site.*

Site/Phase	Structure	Group/Burial	Type	Sex	Age	$\delta^{18}0_p0/00$VSMOV	YIELD[a]	YIELD[b]	CI[c]	δ^{13}Ccol0/00 VPDB	% YIELD[d]	C/N
TLAJINGA 33												
Tlamimilolpa/Early Xolalpan (A.D. 200-550)												
	56			M	33	14.6			4.1	-8.7	4.1	3.2
						15.5[C]	4.7	.4	3.4			
	6			F	45-55	14.4			4.3	-8.5	3.4	3.3
						11.3[PM]	4.9	.8	3.3			
	11			M	45-55	15.0			3.9	-8.4	1.0	3.4
	12			?	15-19YA					-9.5	6.5	3.3
	15			F	30-35	14.4	4.8	.8	3.8	-12.8*	.5	4.9
	16			M	A	15.1	4.7	.7	3.2	-7.1	4.9	3.2
	21			?	2-3	**13.9**			3.6	-7.3	7.8	3.2
	28			?	3-4	**13.9**			3.8			
	39			?	<1	14.1			2.9			
	42a			M	45-55	14.3			3.7	-7.9	5.3	3.3
						14.5[C]	5.0	1.1	3.1			
	42b			M	50-60	15.1	4.6	1.2	3.4	-8.5	9.6	3.3
						15.0[C]	4.8	1.0	3.5			
	43			M	40-60	14.4	4.7	.9	3.6	-7.4	4.6	3.3
	44			M	45-55	15.2	4.8	1.1	3.9	-8.5	8.7	3.3
						17.1[1]	4.8	.7	3.5			
	45a			M	40-50	**16.3**[1]	4.8	1.2	3.2			
	49			F	A	15.0	4.7	.8	3.3	-6.9	8.4	3.2
	55			?	<1	14.0	4.9	.6				
	58			F	40-50	**17.7**	4.8	1.0	3.5	-8.2	3.8	3.3
	62b			?	15-19	**16.9**	6	1.0	3.3			
Late Xolalpan/Metepec (A.D. 550-650)												
	5			?	NB	15.1			3.6	-7.1	2.5	3.4
	17b			F	A	14.7			3.5			
	23			M	20-25					-8.5	1.0	3.3
	61			M	40-50	15.2			3.8	-6.8	4.4	3.4
	50b			M	35-39	**17.2**[M3]	4.7	1.8	3.2			
	50c			M	30-35	14.6	4.8	.6	4.0	-7.6	5.4	3.2
	50d			M	50-60	**17.3**[PM]	4.7	1.9	3.2			

* Poor sample integrity is suspected, therefore omitted from anthropological interpretation, but still included in means for collagen yield and C/N ratios; Samples in **bold** are outside the expected range for Teotihuacan.

[a]CO_2 YIELD (in µmoles CO_2/mg Ag_3PO_4); [b] Ag_3PO_4 YIELD (in mg produced/mg starting material); [c] %YIELD collagen (percentage of collagen/starting material); [d]CI = crystallinity index

S = secondary burial, P = primary burial; NB = newborn, SA = subadult, YA = young adult, MA = middle adult, A = adult, I = incisor, C = canine, PM = premolar, M = first molar, M3 = third molar; WP = West Plaza

in a pit under the ramp of Circular Structure 2. With the exception of Burials 13a and 13b, who were in a shaft tomb, the dominant burial facility was a simple pit.

The total population (extrapolated from the assumption that all of its rectangular structures were family residences) is estimated to have been about 850 (Spence et al., 2004). There are also a large number of circular structures that are thought to have been used for food storage (Limon 1990) and whose origination is enigmatic (Rattray 1990). These circular structures and the residential architecture were commonly configured around a plaza containing an altar, which suggests the organization of small nuclear family groups as social units that conducted rituals and shared food. Along with the placement of architecture, the lack of public structures suggests a non-centralized social organization. This configuration contrasts with the stereotypical apartment compound used by the majority of Teotihuacan residents (e.g., Tlajinga 33). Thus, the state did not exercise strict control over the social organization of the barrio, but at the same time its inhabitants did not present themselves as a strong and cohesive social unit.

The foreign ceramics at the site were imported, rather than locally manufactured in the homeland style, and occur in high proportions. In the Late Tlamimilolpa phase, Maya wares from Yucatan, Campeche, and Belize were most common (Ball 1983). In the following Xolalpan period, Gulf Coast wares dominated the assemblages, which suggests a possible shift in trading partners. Another ceramic anomaly is the absence of comales (griddles used in the preparation of tortillas), which are common in the rest of the city. Comales are also absent in contemporaneous Maya and Gulf Coast regions (Rattray 1990), which could suggest immigration from this region and conservative maintenance of homeland cooking practices in Teotihuacan.

Tlajinga 33

Tlajinga 33 was an apartment compound typical of Teotihuacan dwellings. Excavated under the direction of William Sanders, Pennsylvania State University, it is located south of the ceremonial core close to the north-south axis of the site. Its residents are thought to have belonged to a kin group, as is the case for all apartment compounds in the city (Millon 1976, 1981; Spence 1994). Status was largely achieved and held by adult males, particularly after Late Tlamimilolpa times. Although Tlajinga 33 was occupied from the Early Tlamimilolpa to Metepec phases (A.D. 200-650), most of the sample in this study is contemporaneous with that from the Merchants' Barrio (Late Tlamimilolpa to Late Xolalpan, Table 1). During its early phases, the economic base of this site was lapidary craft production (Widmer 1987, 1991), but during the Xolalpan period there was a shift to ceramic manufacture. Storey and Widmer (1999) have noted that this change affected the social and economic autonomy of the compound, dampening status differences among its inhabitants. Ceramics also became more standardized, which suggests economic intervention and control by the state (Storey and Widmer 1999). Furthermore, a broader scale analysis of ceramics at Teotihuacan suggests that production was organized at the neighborhood level (Krotser and Rattray 1980), which might indicate that state expectations or orders were indirectly filtered down to the compound.

Archaeologists have thought that Tlajinga was biologically homegrown because there were few foreign artifacts recovered from Tlajinga 33 relative to other compounds in the city (Widmer and Storey 1993). There is very little evidence for foreign origins of the inhabitants, the main exceptions being the shaft tomb similar to those found in West Mexico (Michoacán) (Widmer 1987) and a few Michoacán-style figurines (Barbour, personal communication 2002).

Oxygen-Isotope Analysis

The use of oxygen-isotope ratios to identify geographic relocations from skeletal material is based on the premise that "we are what we drink" i.e., our tissues reflect the isotopic composition of the water we imbibe (mainly from liquid), which is, in turn, determined by the physical and climatic

environment in which we live. Further details of the theoretical basis and methodology for oxygen-isotope analysis may be found in previous publications (White et al. 2000a, 2002). Oxygen-isotope compositions ($\delta^{18}0$) are measured relative to the Vienna Standard Mean Ocean Water (VSMOW) standard (Coplen 1994) and expressed as parts per thousand (‰) using the formula:

$$\delta^{18}0 = \frac{(^{18}0/^{16}0_{sample} - {}^{18}0/^{16}0_{standard})}{(^{18}0/^{16}0_{standard})} \quad x1000$$

The oxygen-isotope composition of imbibed water is transferred to body water and then into bones and teeth during the process of mineralization (Longinelli 1984; Luz et al. 1984). We have chosen to analyze phosphate ($\delta^{18}0_p$) because it dominates the inorganic portion of skeletal material and is generally better preserved than carbonate (Bryant et al. 1994; 1996; Koch et al. 1989; MacArthur and Herczig 1990; Reinhard et al.1996; Stuart-Williams et al. 1998).

Because tooth enamel does not remodel after it is formed (unlike bone), it provides a permanent record of water imbibed during its formation. Bone continuously remodels and therefore its isotopic composition slowly equilibrates, or changes, to reflect that of any new environment. By comparing teeth formed at different times during growth and development, or teeth with bone in the same individual, it is possible to identify relocations as well as the approximate age(s) of movement. The length of time it takes for bone to completely change its isotopic composition varies by age, i.e., it will happen more quickly in children than in adults. Although the precise time it takes for complete turnover is still not well-defined, it is estimated to be in the order of 10 to 25 years for cortical bone (Libby et al. 1964; Parfitt, 1983; Stenhouse and Baxter 1979) but much shorter for trabecular bone (Fazzalari et al., 1997; Manolagas 2000; Parfitt 1983). Because bone turnover is a continuous and slow process, it is difficult to use it for fine definition of the timing of relocations. Sojourns in foreign locations might be too short to even register in bone. Longer stays could, on the other hand, be obliterated over time through isotopic re-equilibration upon return to the city. Therefore, although bone $\delta^{18}0$ values that fall outside the Teotihuacan range do indicate time spent foreign locations, they could also reflect, in part, varying degrees of readjustment to the Teotihuacan environment.

The main source of water for children who are breastfeeding is mother's milk, which is enriched in $^{18}0$ relative to imbibed water (White et al. 2000a; 2004a; Williams et al. 2005; Wright and Schwarcz 1998). Although controlled studies have not yet been conducted to determine the exact degree of enrichment, previous analyses at other Mesoamerican sites and at Tlailotlacan indicate that the $\delta^{18}0_p$ values of breastfeeding children are elevated by about .7 ‰ (White et al. 2000a; Wright and Schwarcz 1998). Because children in most Mesoamerican populations are typically breastfed until about 3-4 years of age (Dolphin 2000; Song 1997; Storey 1992; White et al. 1994; Williams et al. 2004; Williams et al. 2005; Wright and Schwarcz 1998), their $\delta^{18}0_p$ values have been adjusted downward by .7 ‰ to control for this variable. The $\delta^{18}0_p$ values of newborns and infants would, however, still reflect maternal compositions and hence were not adjusted.

Previous studies of archaeological skeletons have established a baseline range of $\delta^{18}0_p$ values (14 to 16 ‰) that characterizes the Teotihuacan environment (White et al. 1998; 2002; 2004b; Figure 2). The 2 ‰ variability in this range is also typical of archaeological sites elsewhere in Mesoamerica where it was possible to control for local residency (White et al. 2000a, 2000b; 2001; 2004b, 2004c) and has been used to separate those who lived in Teotihuacan from those who came from several other Mesoamerican locations (White et al. 2000a, 2001, 2002, 2004b). Factors contributing to the breadth of this range include; climatic seasonality, individuals who have moved from nearby and similar micro-environments, and/or the consumption of large quantities of imported foods with high water contents. Most sites analyzed so far are distinct in isotopic composition from Teotihuacan, but there is some overlap in $\delta^{18}0_p$ values between sites.

Tests of postmortem alteration have demonstrated that oxygen-isotope compositions of this

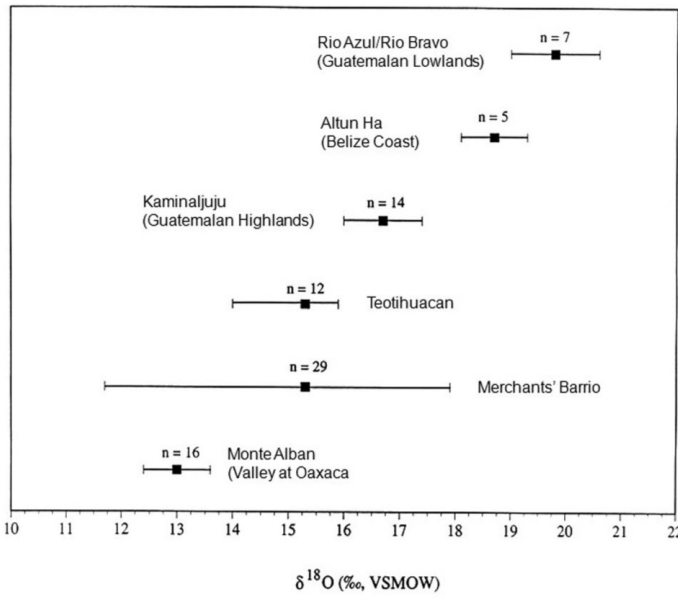

Figure 2. *Comparison of range of $\delta^{18}0_p$ values from the Merchants' Barrio and Tlajinga 33 with those used for controls at a variety of Mesoamerican sites.*

sample were not changed during diagenesis. The crystallinity index (CI) was used to assess to possibility that bone and/or enamel had been recrystallized post mortem. The mean CI for bone is 4.0 ± .4 and for enamel it is 3.3 ± .1 (Table 1). The CI values do not correlate with $\delta^{18}0_p$ values in either bone (Pearson's r = -.144, n = 19) or enamel (Pearson's r = -.047, n = 6), which suggests that recrystallization did not adversely affect the $\delta^{18}0_p$ values. Similarly, a lack of correlation between $\delta^{18}0_p$ values and phosphate yield (for bone Pearson's r = -.050, n = 19; for enamel Pearson's r = -.096, n = 6) suggests that there was no preferential recovery of one isotope over the other during the precipitation of phosphate.

Carbon-Isotope Analysis

The use of stable carbon-isotope analysis is based on the premise that "we are what we eat", i.e., the foods we consume are reflected in skeletal tissues. Isotopic variation in plants, which form the base of the food chain, is passed on to their consumers with tissue-dependent systematic differences created by processes of isotopic fractionation. The stable isotope ratios of carbon ($\delta^{13}C$) are measured relative to the Vienna PeeDee belemnite (VPDB) standard (Coplen 1994) and expressed in parts per mil (‰) as δ values. The $\delta^{13}C$ values in this study come from collagen, which is the main organic component of bone. They reflect the position of the consumer in the food chain because the $\delta^{13}C$ values of collagen ($\delta^{13}C_{col}$) are about 5 ‰ higher than those of its diet, and there is about a 1 ‰ increase with each trophic level. The $\delta^{13}C_{col}$ values of herbivores will most closely approximate those of plants, but most humans are omnivores; hence their $\delta^{13}C_{col}$ values will reflect not only the plants but also the animals they consume (Ambrose and Norr 1993; Krueger and Sullivan 1984; Lee-Thorp et al. 1989; Tieszen and Fagre 1993).

Three kinds of photosynthetic pathways create the stable carbon-isotope variability in plants during processes of photosynthetic discrimination against ^{13}C. The C_3 pathway results in the most negative values (modern average is -26.5 ‰, O'Leary 1988; Smith and Epstein 1971) and includes most wild plants, trees, nuts, fruits and vegetable cultigens. Less discrimination against ^{13}C during photosynthesis occurs in the C_4 pathway, resulting in less negative $\delta^{13}C$ values (modern average is -12.5 ‰, O'Leary 1988). Maize is the agricultural staple in Mesoamerica and, like many other tropical grasses, is a C_4 plant. Another

C_4 plant, amaranth, has also been found among the floral remains of Teotihuacan likely as a weed (McClung de Tapia and Tapia Recillas 1993:707, 715).

C_3 and C_4 plants have $\delta^{13}C$ values ranges that are bimodally distributed (O'Leary 1988), but the more flexible photosynthetic processes of the third group of plants, CAM or Crassulacean acid metabolism plants, have $\delta^{13}C$ values spanning -27 to -12 ‰. Mainly cacti and succulents, some of these were likely consumed (mostly as beverages) and could contribute to an apparent C_4 signature, especially the nopal (Opuntia) and the maguey (*Agave*) cacti. Interpretation of ancient $\delta^{13}C$ values must also take into consideration the fact that the modern burning of fossil fuels has changed the isotopic ratio of atmospheric carbon used during photosynthesis. Therefore ancient plants had $\delta^{13}C$ values that are about 1.5 ‰ higher than present vegetation (Friedli et al. 1986; Keeling et al. 1979; Marino and McElroy 1991).

Post-mortem alteration, or diagenesis, of collagen is normally assessed using its C/N ratio. All of the C/N values in this sample are within the acceptable range of 2.9 to 3.7 defined by DeNiro (1985) (Table 1). The average for C/N ratios is 3.3 (range is 2.4 to 3.5), and there is no statistically significant correlation between $\delta^{13}C_{col}$ values and C/N ratios (Pearson's r = .165, df = 12). Low collagen yields are also indicative of post-mortem alteration (Ambrose 1990; DeNiro and Weiner 1988). The average collagen yield in this sample is 4.5% (range is 1.1 to 9.9%) and there is a statistically significant correlation between $\delta^{13}C_{col}$ values and collagen yields (Pearson's r = -.709, df = 12) caused by two samples with yields of 1.1%. These samples have not been included in the anthropological interpretation.

Economy, Ethnicity and Time

The most striking feature of the Merchants' Barrio data is the extreme variation in $\delta^{18}0_p$ values (11.7 to 17.9 ‰) (Figure 2). The exact locations of the homelands cannot be specifically identified at this point, but we can speculate that there are at least two: one with very low $\delta^{18}0_p$ values (e.g., 11.7 ‰) and one (possibly two) with $\delta^{18}0_p$ values between 16.3 and 17.9 ‰. Such values were also obtained for some sacrificial victims from the Feathered Serpent Pyramid at Teotihuacan (White et al., 2002), which confirms the state's longstanding interest in these regions. Although foreign artifacts are generally uncommon in Teotihuacan burials (Sempowski and Spence 1994), they regularly occur among the barrio burials. Of the 7 burials that contain foreign artifacts, 5 also have foreign $\delta^{18}0_p$ values (Table 2). It is currently not possible, however, to tell if the human isotopic compositions are consistent with the place of suspected artifact manufacture because we do not yet have enough isotopic values representing possible homelands.

The majority of bone $\delta^{18}0_p$ values (17/24 or 70‰) fall within the range established for Teotihuacan. We, therefore, infer that most of the inhabitants had lived in Teotihuacan for a long time before their death, probably most of their adult lives. The teeth, however, exhibit a greater range of $\delta^{18}0_p$ values and reveal histories of life elsewhere before the age of six (Figure 3). All teeth indicate a childhood dwelling in a foreign location, and all but one individual (Xocotitla, Burial 17) for whom both tooth and bone were analyzed, had moved from elsewhere to Teotihuacan. Foreign values (particularly values higher than 16 ‰) are found in both bone and enamel throughout the entire sequence of the site (Figure 4). One of earliest burials (Late Tlamimilolpa, Burial 22) is foreign, as is the most recent (Burial 10-12) (Table 1).

The sample is not large enough to determine any temporal trend in the degree of movement between homelands and the city, so it is not possible at present to confirm that there was a shift in population composition from Maya to Gulf Coast peoples as the ceramics might suggest (Ball, 1983). Nonetheless, two of the most recent burials (Burials 10a, 17) have very high $\delta^{18}0_p$ values that might indicate a Gulf Coast location.

The contrast between the foreign values found in enamel and the dominance of Teotihuacan values in bone provides a means of extrapolating relationships between economic behavior and the

Table 2. *Relationship between $\delta^{18}O_p$ values of individuals and their associated foreign artifacts at the Merchants' Barrio.*

Burial #	$\delta^{18}O_p$ (0/00)	Artifact Type	Probable Origin of Manufacture
Late Tlamimilolpa			
9	15.6	ceramics	Gulf Coast
22*	**16.6**	ceramics, shell beads	Maya and Gulf Coast
Early Xolalpan			
5-8	**13.9**	ceramics, marine shell	Gulf Coast
Late Xolalpan			
13*	15.1	shaft tomb, ceramics	Maya, Gulf Coast
	15.6		
	15.9		
14*	15.2	ceramics	Puebla
	17.9		
17	**17.8**	ceramics	Puebla
	16.4		
33*	14.2	ceramics, slate disk	Puebla (and elsewhere?)
	11.7	shell buttons	
	16.3		

* Burial includes more than one individual. Artifacts listed are not in direct association with any particular individual. Samples in **bold** are outside the expected range for Teotihuacan.

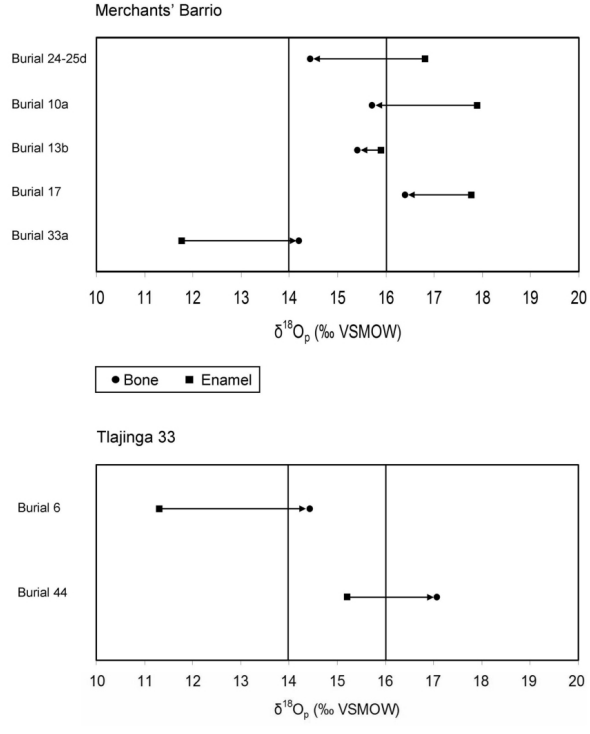

Figure 3. *$\delta^{18}O_p$ values for individuals who relocated. Arrows show the direction of movement from earliest to latest periods in their lifetimes.*

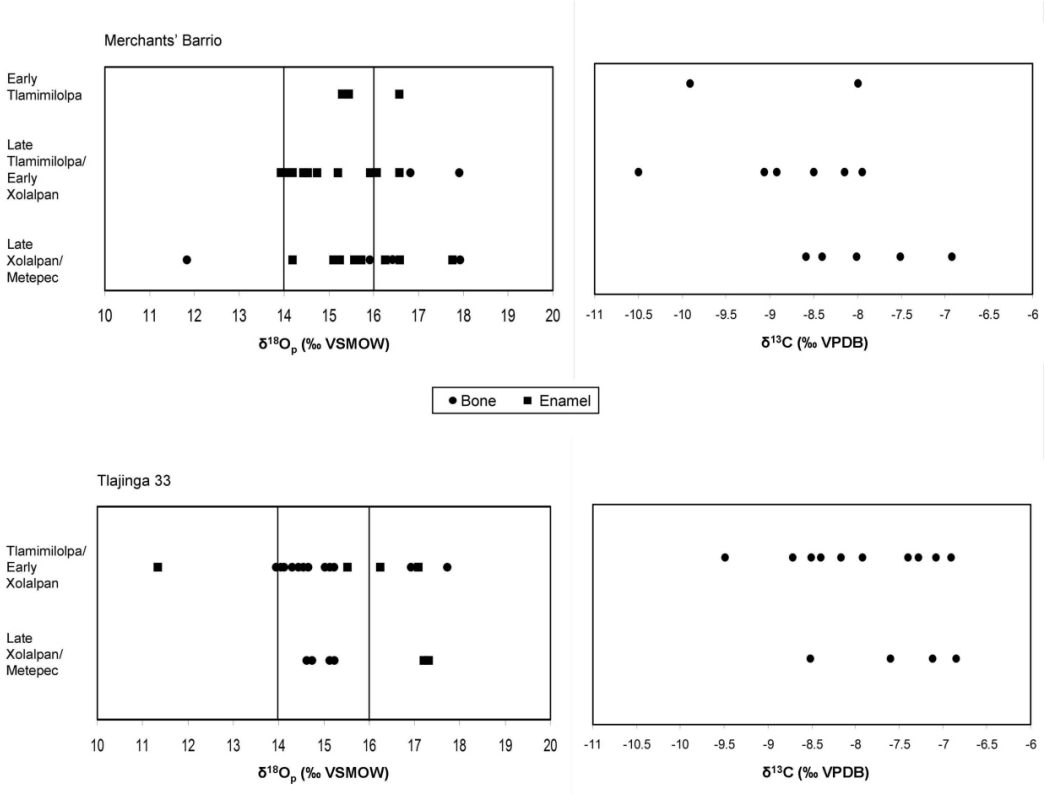

Figure 4. *Comparison of* $\delta^{18}O_p$ *values for the Merchants' Barrio and Tlajinga 33 by time period.*

fate of ethnic identities in the big city. The inhabitants of the Merchants' Barrio appear to have emigrated mostly in their youth. They took up permanent residence in the city but maintained economic relations with their homelands. The continuous emigration to Teotihuacan throughout the temporal sequence of the sample indicates that foreign traders may have been in perpetual control of the Barrio's economy, i.e., the state did not expropriate their businesses either during life or after their death to gain more economic control. We can infer that the inhabitants of the Merchants' Barrio acted as agents of trade for their homelands at either personal or corporate levels rather than as agents for the Teotihuacan state using the barrio as a home base. The state might have tolerated this economic system because it conferred to the "merchants" the risk and cost of long distance trade, but benefited the state through profits from taxing imported goods or perhaps by collecting on some kind of franchise fee. Teotihuacan is often thought to have provided a model for much of the social and political organization of Tenochtitlan, the great capital of the Aztec empire. The behaviour of its foreign merchants, however, contrasts strongly with the Aztec trade model in which merchants (*pochteca*) traveled in routes between their home base in the city and foreign regions, often acting as agents of the state (Berdan 1982). Thus, the traders of Teotihuacan and Tenochtitlan had very different political and social identities.

In terms of diet, the average $\delta^{13}C_{col}$ value of -8.5 ‰ (± .9 ‰, range -9.1 to -6.9 ‰, n = 12) is similar to that found at Tlajinga 33 (-7.9 ‰ ± .8 ‰, range -9.5 to -6.9 ‰, n = 16) (Table 1, Figure 4), and is indicative of dependency on maize and/or maize-based protein. Only the data from the Xolalpan phases are sufficient to use for a temporal comparison. There is a slight rise in C_4 consumption in the Late Xolalpan phase,

similar to that found at Tlajinga 33. This is likely caused, however, by the foreign outliers in the Late Xolalpan phase. There is a strong correlation between $\delta^{13}C_{col}$ and $\delta^{18}0_p$ bone values (Pearson's r = -.729, df = 10, p> .01), which indicates that foreigners are differentiated by their diets. Two Late Xolalpan individuals whose $\delta^{18}0_p$ bone values lie outside the Teotihuacan range (Burials 10c and 33b) have diets that are more heavily C_4-dependent. Because they were both young, their bone reflects a homeland cuisine. These data would be consistent with origins in the Gulf Coast area where the consumption of marine resources would exaggerate the C_4 signal, and would support the ceramic data indicating a strong Gulf Coast presence in the barrio during the Late Xolalpan.

When the foreign individuals are removed from the data set, the significant correlation disappears (Pearson's r = -.385, df = 8). Among the rest of the sample $\delta^{13}C_{col}$ values are highly uniform i.e., within an approximate 1‰ range. This finding suggests that homeland diets were largely abandoned in favour of local Teotihuacan foods. Although the inhabitants would have depended primarily on the Teotihuacan food market, some foreign foods may have been brought to the city, which would account for the .6 ‰ difference between the Merchants' Barrio and Tlajinga 33. These data nicely illustrate the difference between cuisine and diet. Although the absence of comales indicates that the Merchants' Barrio inhabitants brought their cuisine (food preparation methods) with them, they accepted most of the foods available in the city. Like the Merchants' Barrio, the $\delta^{18}0_p$ values of bone at Tlajinga 33 indicate long term residence in Teotihuacan, but those of enamel suggest immigration after childhood (White et al., 2004b; Table 1). One third of those analyzed had moved to the city from elsewhere, perhaps to join the workforce at the site, and had lived at the site for many years before their death (White et al. 2004b). The isotopic evidence for immigration at the compound is consistent with the assumption made from demographic analysis that it was biologically necessitated by an extremely high infant mortality rate (Storey 1992).

Also like the Merchants' Barrio, foreign $\delta^{18}0_p$ values are found at Tlajinga 33 throughout the temporal sequence with no shift over time in the origins of immigrants (Table 1, Figure 4). The range of $\delta^{18}0_p$ values is also very similar (11.3 to 17.7 ‰) suggesting that immigrants in both neighborhoods are being drawn from similar regions. As mentioned above, however, the inhabitants of Tlajinga 33 do not have many foreign artifacts associated with their burials. The most distinctive example of foreign influence is a shaft tomb in Michoacán style (Burials 50b, 50c, 50d). These burials have similar $\delta^{18}0_p$ values that are different than local values. Our initial interpretation (White et al. 2004b) suggested Michoacán as a possible origin for these individuals, but subsequent analyses of larger numbers of samples from Michoacán (unpublished data) calls this interpretation into question.

In terms of diet, mean $\delta^{13}C_{col}$ values also rise slightly from the beginning of the sequence to the end (-8.1 ‰ [mean Tlamimilolpa/Early Xolalpan, n = 12] to -7.5 ‰ [mean Late Xolalpan/Metepec, n = 4]) (White et al. 2004b; Table 1, Figure 4) but the sample is not large enough to test this change statistically. Like the Merchants' Barrio, Tlajinga 33 would have been dependent on state-produced food but would not likely have had the same opportunities for supplementation through direct trade. Because of the ceramic evidence for state control of production (Storey 1991), it is also possible that the state provisioned the compound with food either directly or indirectly, which would explain the low isotopic variability. There is no correlation between $\delta^{13}C_{col}$ and $\delta^{18}0_p$ bone values, which indicates that even those who were recent arrivals to the city did not have significantly different diets, unlike the pattern seen at the Merchants' Barrio.

In spite of the continued influx of immigrants over time, the low variability among $\delta^{13}C_{col}$ and $\delta^{18}0_p$ bone values, and the relative absence of non-Teotihuacan artifacts or structures may be taken as evidence that the inhabitants of Tlajinga 33 experienced greater cultural assimilation than the Merchants' Barrio. The inhabitants of Tlajinga 33 don't seem to have had the same

continual contact with their homeland(s) as those living in the barrio (although this should be tested further using a larger sample of teeth). One reason for the difference could be greater state control of production and economy. Other possible explanations could include differences in motivations and necessity. Although all these immigrants may have come to the city for economic betterment, those at the Merchants' Barrio needed to maintain foreign contact to enable trade, whereas the artisans of Tlajinga 33 could easily sell their skills to the state without maintaining homeland connections.

Gender and Age

Both males and females in the Merchants' Barrio have foreign $\delta^{18}0_p$ enamel values (Table 1, Figure 5) indicating childhood in a foreign location. Two of the three women with foreign values (Burials 24-25d, 17) moved from one foreign location to another, where they lived for quite a long time before their death. They were either visiting the city or had just recently arrived when they died. Both were buried next to a shrine, which suggests high status. Artifactual mortuary data also suggest that Merchants' Barrio women had high status in general, which is consistent with findings at Tlailotlacan (Spence 1992, White et al. 2004c). In particular, Merchants' Barrio women were often buried with ritual paraphernalia, which suggests their responsibility for ritual practices in their community (Spence et al. 2004). Although a larger sample and further testing using both tooth and enamel would be useful, most women and children had local values. Proportionately more men than women (3/4 compared to 3/10) came from elsewhere. Both of the men with enamel values had come from a foreign location and all but one man in the sample had local bone $\delta^{18}0_p$ values. It therefore appears that the males arrived in the city at a young age and resided there permanently. Combined with the apparent high status for women, this could suggest an uxorilocal marriage pattern, in which women were recognized for maintaining population stability and were involved in the barrio's economic function. The $\delta^{13}C_{col}$ values do not add significantly to these interpretations. Female $\delta^{13}C_{col}$ values average -7.9 ‰ ± .8 (n = 3), which is consistent with the adult mean (-8.0 ‰ ± .6, n = 14), but it is not possible to test differences between females and males or adults and children because of sample sizes.

At Tlajinga 33 the mean $\delta^{18}0_p$ bone values are similar for males and females (males = 14.8 ± .4 ‰, n = 9; females = 15.2 ± 1.4 ‰, n = 5) (Figure 5). Females are distinguished by having the highest and the lowest $\delta^{18}0_p$ enamel values among the samples (17.7 ‰ and 11.3 ‰) even though there are only five individuals. One of these (Burial 58) had arrived only recently and was too old (40-50 yrs) to have come for the purpose of marriage, and the other (Burial 6) was the same age but may have come for marriage because her bones had sufficient time to re-equilibrate to local values. About one third of the males had also emigrated mostly during their youth/adolescence, perhaps after being recruited to maintain craft production. Thus, both men and women were moving to the city. Most were coming from the same area ($\delta^{18}0_p$ range = 16.3 to 17.7 ‰, possibly somewhere in West Mexico). The mean $\delta^{13}C_{col}$ values for males and females are identical (-7.9 ‰). This finding is consistent with that from the Merchants' Barrio and indicates equal access to foods.

Although a significant portion of both male and female inhabitants of Tlajinga 33 came from elsewhere, all children appear to have been born locally (Table 1, Figure 5). Most of the children in this sample are pre-weaning age so the $\delta^{18}0_p$ values of their bones are reflecting the water flux of their mothers during pre-natal and nursing periods. Mothers are, therefore, remaining in the city while pregnant and during the breastfeeding period, unlike a pattern previously observed at Tlailotlacan, the Oaxacan Barrio, where mothers were traveling or sojourning afar during this time (White et al. 2002). The mortuary contexts of the children suggest that they were accorded high status. They were all associated with ceramic offerings and half were under an altar in a major courtyard, i.e., a public location usually associated with social recognition. The high status of the children in death supports the hypothesis that

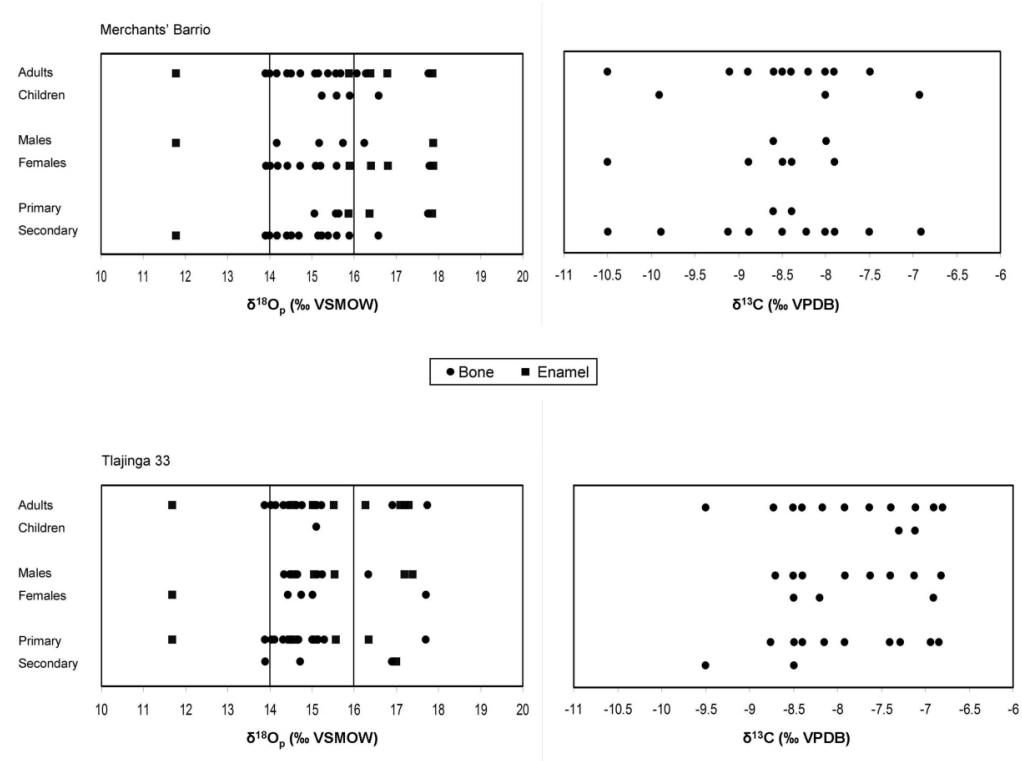

Figure 5. *Comparison of $\delta^{18}O_p$ values for the Merchants' Barrio and Tlajinga 33 by sex, age, and mortuary treatment.*

children were especially valued. The community likely recognized their importance for maintaining population stability in the face of high infant mortality. The $\delta^{13}C_{col}$ values of children (-7.2 ‰, n = 2) probably also reflect those of their mothers, but are higher than those of adults in general (-8.0 ± .8 ‰) (Figure 5).

Mortuary Treatment and Status

Mortuary treatment at both the Merchants' Barrio and Tlajinga 33 includes secondary and multiple burials, which are uncommon for indigenous Teotihuacan burial sites (Sempowski and Spence 1994). There are substantially more secondary burials at the Merchants' Barrio than at Tlajinga 33, however. Secondary burials with foreign $\delta^{18}0_p$ values are most easily interpreted as remains of relatives transported by immigrants to rest nearby (White et al. 1998; White et al. 2004b). The subadults 10c and 22b in the Merchants's Barrio are likely examples of transported deceased children who originated from the same location and/or died *en route* to the city. However, secondary interments are also part of normal mortuary treatments involving transfer of the body (or part(s) thereof) in various stages of decomposition from one kind of facility to another within the same site for some ideological reason. They can also result from the movement of individuals from their original resting place because of building or reconstruction. There are foreign $\delta^{18}0_p$ values in both primary and secondary burials from the Merchants' Barrio, and no association between $\delta^{13}C_{col}$ values and mortuary treatment (Figure 5). The same lack of distinction exists at Tlajinga 33 (Figure 5). It therefore appears that the inhabitants of both areas of Teotihuacan were maintaining some of their cultural practices and these were not restricted to first generation immigrants or those who had longer histories in the city.

The use of mortuary facilities and grave goods for assessing individual social status can be con-

founded by several behaviours e.g., multiple use of a facility over time, the addition of retainers to the burial, the donation of goods by the griever(s) to emulate status, etc. Nonetheless, we assume that disposal facilities representing much construction time and effort, containing exotic and valuable goods, and located in public places were likely to contain high status individuals. Tombs and shrines or altars are normally considered to be high status burial locations and are found at both the Merchants' Barrio and Tlajinga 33.

Some high status individuals at both locations had foreign values, but foreign origin is not consistently associated with status. For example at the Merchants' Barrio, the young female in the shaft tomb (Burial 13b) had $\delta^{18}0_p$ bone and enamel values indicating that she had always lived in the city, and among the 5 individuals from Structure 4, which might have been inhabited by elite individuals because of the presence of a shaft tomb (Rattray 1990), only two were of foreign origin, one of whom had recently arrived. The latter also had a distinctive $\delta^{13}C_{col}$ value, which suggests that they brought their status with them. Conversely, five of the six burials from two shrines (West Plaza [WP] and Structure 12), some of whom were also recent arrivals to the city (e.g. Burial 17), had foreign $\delta^{18}0_p$ values. As centrally located public structures, shrines normally reflect high status and perhaps provide the most compelling evidence that individuals of foreign origin may often have been accorded high status in death, perhaps as business or community leaders of some sort.

There is less evidence available to denote status at Tlajinga 33. Nonetheless, two of the individuals from the Michoacán-style shaft tomb (Burials 50b and 50d) had foreign enamel $\delta^{18}0_p$ values that were virtually identical, and the $\delta^{18}0_p$ value of the individual for whom only bone was available (Burial 50c) was in the Teotihuacan range. It is likely that all of these individuals had come from elsewhere and all lived in the city for a long time, but further sampling would be required to test this idea. There is no evidence of a recently arrived immigrant being buried in a high status context, unlike the Merchants' Barrio. Therefore, status at Tlajinga 33 was probably largely achieved, or earned, so it was theoretically possible to reach the "Teotihuacan Dream". State control over production and resources, however, probably made this difficult. By contrast, Merchants' Barrio immigrants experienced more variable economic outcomes. Sometimes they were able to bring high status with them (although it may have been initially achieved), but they were also able to earn it after arrival.

Conclusions

Movements of individuals across the landscape are often motivated by economic opportunism and can be reconstructed using oxygen-isotope ratios in bone and enamel phosphate, and sometimes carbon-isotope ratios in bone collagen. The ancient city of Teotihuacan was no different than modern cities in its ability to attract immigrants who probably relocated to better their lives and ultimately participated in different economic sectors. Populations of both the Merchants' Barrio (traders) and Tlajinga 33 (artisans) were biologically maintained by a high rate of immigration. Immigrants came from many locations throughout the sphere of Teotihuacan's political and ideological influence, and the influx continued throughout the temporal sequence of the site. Most immigrants appear to have relocated after adolescence and taken up permanent residence in the city. Their presence was not only essential for the biological reproduction of the city, but also for its economic functioning.

Although both neighbourhoods shared these dynamics, their economic identities were different (merchants versus artisans). Furthermore, their ability to maintain ethnic identities differed probably because they had different economic relationships with the state. The artisans of Tlajinga 33 appear to have experienced greater cultural and economic assimilation, as inferred from the equilibration of both oxygen- and carbon-isotope ratios to local values in adulthood. Both men and women moved to the city, but most of the children were born locally. Although children achieved high status through death

because of their value to the biological survival of the group, the small number of immigrants associated with high status indicates that the "Teotihuacan Dream" was difficult to realize. These data are consistent with archaeological evidence of state control over production and with world systems or core-periphery models in which the economic and political needs of states are superordinate.

In contrast, the long distance traders of the Merchants' Barrio appear to have experienced greater economic agency and hence greater cultural survival. Dietary and archaeological evidence suggests that some of these traders were also able to maintain their cuisine, but adopted Teotihuacan diets. The possibility that they may have had regular access to imported foods should be tested further. There appears to be a more clear marriage pattern in this neighbourhood, most immigrants being men who married local women. Women appear to have relatively high status, perhaps because of their role in maintaining social structure and ritual practices. Foreign origin, and even recent arrival from elsewhere, is often associated with high status, but doesn't determine a good economic outcome for immigrants. Therefore, the traders appear to have had more access to the "dream".

The ethnic identities in the Merchants' Barrio are diverse, as are the origins of its inhabitants, so it cannot be considered an enclave like Tlailotlacan, the Zapotec neighbourhood first excavated by Spence. Although it has an economic identity within the city, the Merchants' Barrio didn't likely have a consolidated political identity that was threatening to the state. The continuous influx of immigrants to the trading houses suggests that the state allowed these people to operate more independently than the artisans at Tlajinga 33. Indeed, it is possible that the multi-ethnic structure of the barrio was encouraged, or even enforced, by the state. Its merchants also had different political identities from the *pochteca* traders of the Aztec. Although many of Teotihuacan's state dynamics are thought to have provided models for the later Aztec empire, foreign economic relations developed in Aztec Tenochtitlan succumbed to much greater state control with long distance *pochteca* trade. The economic system of the Merchants' Barrio might have simply been the most efficient means of maintaining good foreign trade relations and profit and, like Tlailotlacan, provides another example of a complementary network strategy within the ancient city.

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