Ancient Mesoamerica (2024), **35**, 171–192
doi:10.1017/S0956536122000347

CAMBRIDGE UNIVERSITY PRESS

Research Article

Teotihuacan site 19:N1W5: Mortuary and oxygen isotope evidence for a Michoacan affiliation

Michael W. Spence[a], Sergio Gómez Chávez[b], Fred J. Longstaffe[c], Julie Gazzola[d], Grégory Pereira[e], Karyn Olsen[a] and Helen Perlstein Pollard[f]

[a]Department of Anthropology, Western University, London, Ontario, Canada; [b]Instituto Nacional de Antropología e Historia, Zona Arqueológica de Teotihuacan, Teotihuacan, Mexico; [c]Department of Earth Sciences, Western University, London, Ontario, Canada; [d]Instituto Nacional de Antropología e Historia, Mexico City, Mexico; [e]Centre National de la Research Scientifique, Paris, France and [f]Department of Anthropology, Michigan State University, East Lansing, Michigan, USA

Abstract

Site E19 (19:N1W5), near Tlailotlacan, the "Zapotec Barrio" of Teotihuacan, contains evidence of both Tlailotlacan and Michoacan affiliation. To verify and better understand the Michoacan relationship, 22 enamel and 19 bone samples from five E19-affiliated burials were analyzed to determine their oxygen isotope compositions, which provide an indication of an individual's area of residence when that particular tissue was forming. Because prismatic blades and Thin Orange ceramics from Teotihuacan occur widely in the Lakes Region of north central Michoacan we obtained samples from several sites there for comparative purposes. The results show that most of the E19 people had passed their later years in the Patzcuaro Basin of the Lakes Region. Although in E19 the archaeological evidence of this relationship declined over time, the isotopic evidence indicates that Patzcuaro ties continued to the end of E19's occupation. It seems that the people of E19, originally Michoacanos, gradually adopted a core identity as Teotihuacanos while continuing to deploy their Michoacan ancestry during their stays in Michoacan.

Resumen

En la estructura 19:N1W5 (E19), cerca del Tlailotlacan, el barrio Zapoteco de Teotihuacan, se localizaron evidencias arquitectónicas y cerámicas tanto de origen zapoteco como de filiación michoacana. Para comprobar y entender mejor la relación con Michoacán, 22 muestras de esmalte y 19 de hueso procedentes de cinco entierros de la E19, fueron analizadas para determinar la composición de isótopos de oxígeno estable que provee indicios del área de residencia de un individuo cuando el tejido en particular se estaba formando. Debido a que en sitios de la región de los lagos del centro norte de Michoacán, a más de 300 km de distancia, se han encontrado materiales teotihuacanos como navajillas prismáticas de obsidiana verde y cerámica Anaranjado Delgado, se obtuvieron muestras con propósitos comparativos. Los resultados obtenidos demuestran que la mayoría de los individuos de la E19 analizados, vivieron sus últimos años en la región de los lagos en la Cuenca de Pátzcuaro. Aunque la evidencia arqueológica en la E19 disminuye con el paso del tiempo, la evidencia isotópica indica que los vínculos con la región de Pátzcuaro se mantuvieron hasta el final de la ocupación. Los individuos de la E19 de origen michoacano parecen adoptar paulatinamente una fuerte identidad teotihuacana por conveniencias socio-políticas y al mismo tiempo seguían reiterando su ascendencia michoacana durante estancias en Michoacán.

Keywords: Teotihuacan; oxygen isotopes; Michoacán; Mesoamerica

Introduction

Structure 19:N1W5 (hereafter E19) is an apartment compound located near the west edge of the ancient Classic-period city of Teotihuacan (Figure 1; Millon et al. 1973). It is only 165 m east of what has been defined as the eastern border of Tlailotlacan, the Zapotec Barrio of Teotihuacan (Figure 2; Cid Beziez 1998:321–322; Spence 2002: Figure 6.1). In 1990–1991, Gómez Chávez directed an extensive series of excavations in the Zona Militar, including the almost complete excavation of E19 (Figure 3; Gómez Chávez 1998, 2002, 2012, 2017; Gómez Chávez and Gazzola 2007, 2021).

E19 is an informative and important site for a variety of reasons, but its most striking aspect is the mortuary and ceramic evidence for the presence of people from the modern state of Michoacan. Seven architectural units have been

Corresponding author: Michael Spence, spence@uwo.ca

Cite this article: Spence, Michael W., Sergio Gómez Chávez, Fred J. Longstaffe, Julie Gazzola, Grégory Pereira, Karyn Olsen, and Helen Perlstein Pollard (2024) Teotihuacan site 19:N1W5: Mortuary and oxygen isotope evidence for a Michoacan affiliation. *Ancient Mesoamerica* **35**, 171–192. https://doi.org/10.1017/S0956536122000347

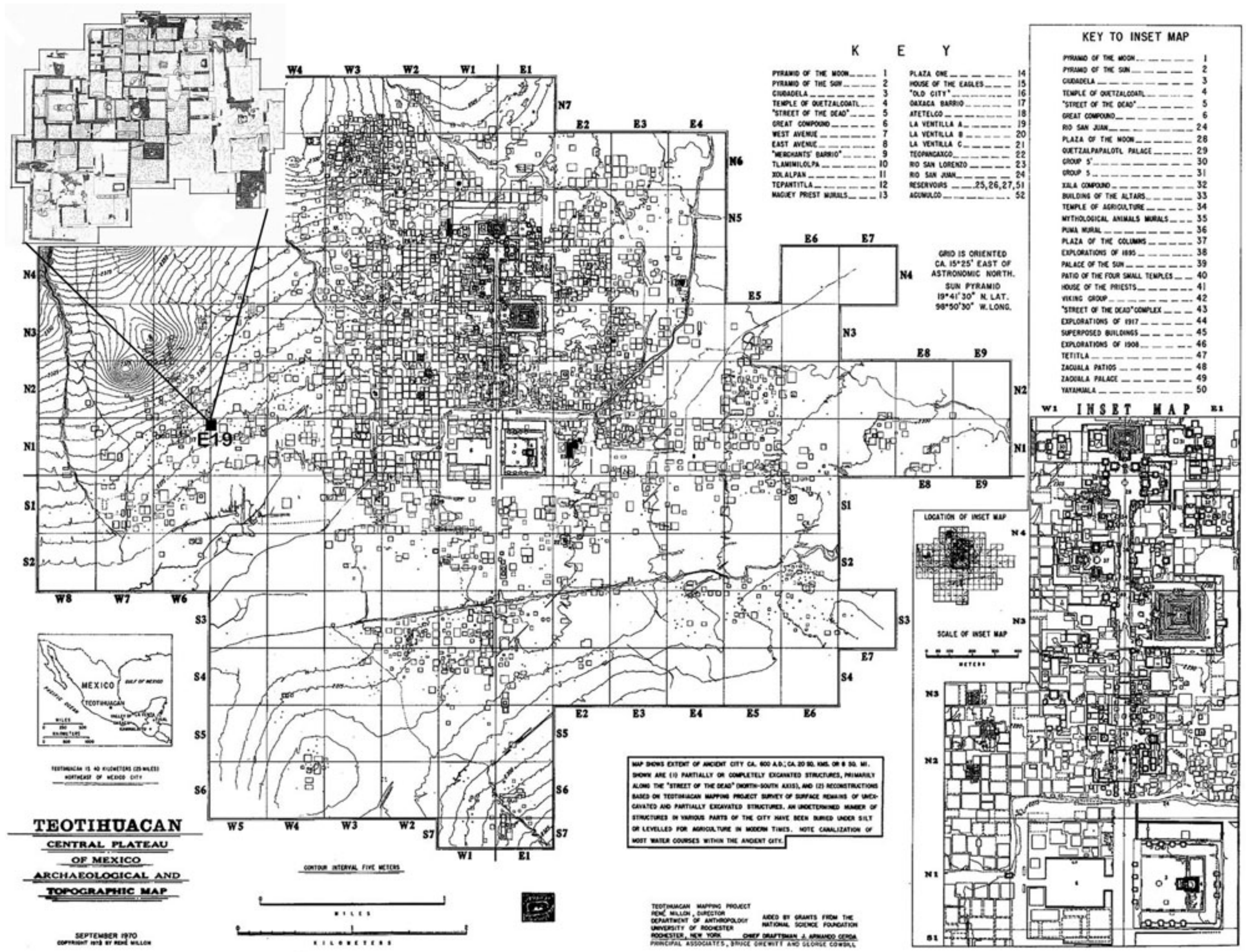

Figure 1. Teotihuacan map, showing location of E19 (inset). Map by René Millon and Gómez Chávez.

defined for the site based on the patios, plazas, walls, and passageways that divide and connect spaces. On a larger scale, the structure is clearly separated into two major sections, an earlier northern section and a somewhat later southern section. The earliest construction dates to the Early Tlamimilolpa phase (A.D. 170–250) but the site continued into the Metepec phase (A.D. 550–650; Cowgill 2015:Table 1.2).

E19 contains evidence of relationships with both Michoacan and Zapotec-related peoples, the latter surely derived from nearby Tlailotlacan. The Michoacan relationship is expressed in mortuary features, material culture associated with those features, cooking stoves different from the Teotihuacan ones, and perhaps in some biological data. In particular, there are patterns of cranial modification that do not appear elsewhere in Teotihuacan, although their foreign affiliation will require more detailed comparative analysis (Gómez Chávez and Gazzola 2007:120). These Michoacan links appear primarily in several mortuary contexts occurring in three of the architectural units. In contrast, the evidence of Tlailotlacan influence appears in the form of architectural features, including a tomb in Architectural Unit 7 (Gómez Chávez 2002:571, 602–604).

The architectural evidence of Tlailotlacan influence appears widely in the structure. It consists of tubular ceramic drain segments (Gómez Chávez 1998:1465), cobblestone floors (*pisos empedrados*), flagstone floors (*pisos enlajados*), and the *escapulario* variant of the talud-tablero architectural facade (lacking the lower enclosing element of the tablero). These are all common features of Tlailotlacan, for the most part derived ultimately from the Valley of Oaxaca Zapotec settlements (Gómez Chávez 1998:1465–1466; 2002:574, Photograph 2; Ortega Cabrera 2014:141–145). It should be noted that cobblestone floors do appear in other areas of Teotihuacan (e.g., Carballo et al. 2019; Storey 1992), but their frequency in Tlailotlacan coupled with the other Tlailotlacan elements in E19 leave no doubt that Tlailotlacan was the immediate source for their presence in E19.

Ritual deposits, however, have not been found in E19 despite their frequency in Tlailotlacan. Typically, such deposits consist of a ceramic vessel sitting upright on the base of a small pit, usually in a patio, with another vessel or simply some large sherds inverted over it as a cover (Spence 2002). These features have a long history in the Valley of Oaxaca, where they represent the long-standing Zapotec practice of burying the umbilical cord and/or afterbirth from a successful birthing in a covered jar in the

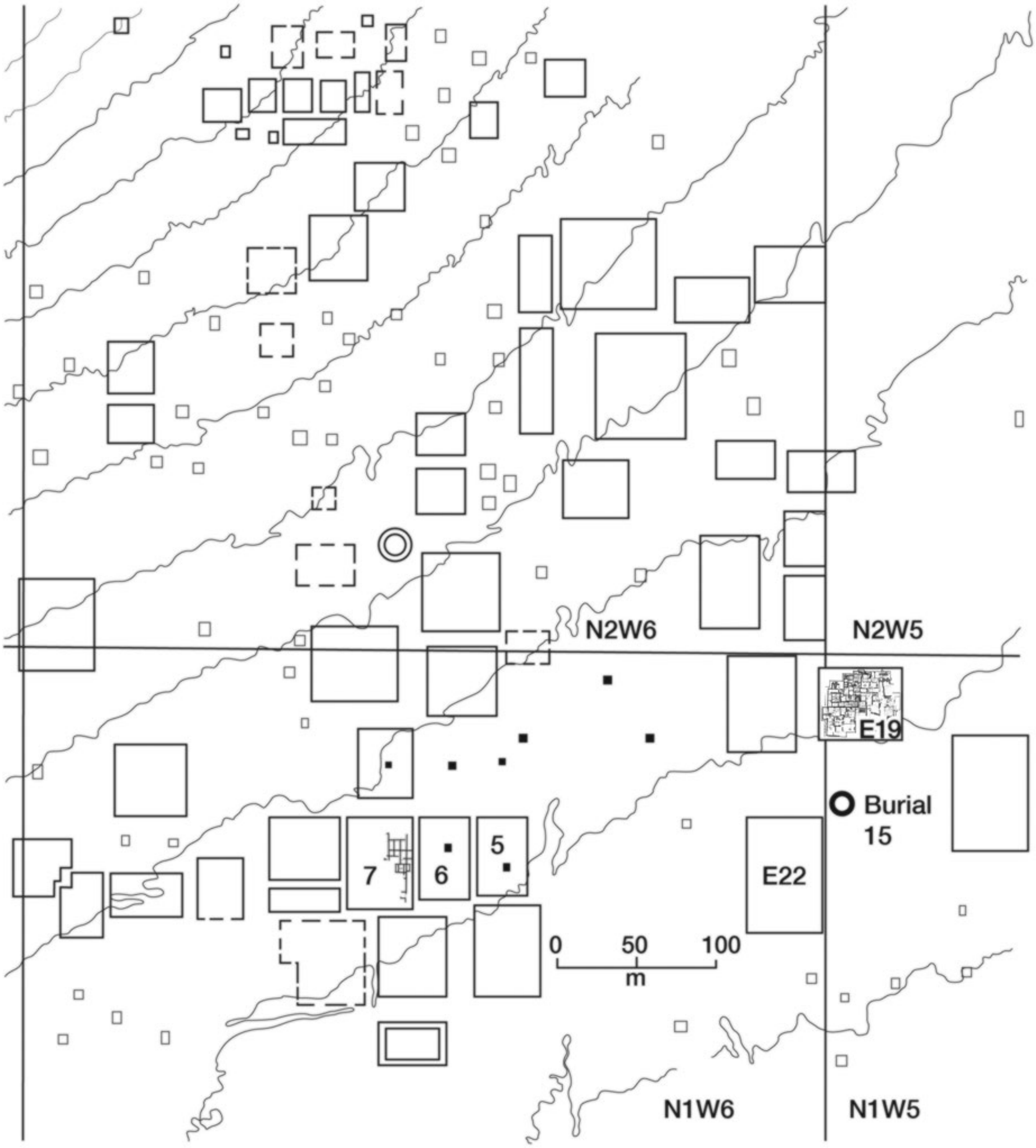

Figure 2. E19 and vicinity, with 22:N1W6 and Burial 15. The east edge of Tlailotlacan extends along the east side of 5:N1W6. Figure by Gómez Chávez.

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press

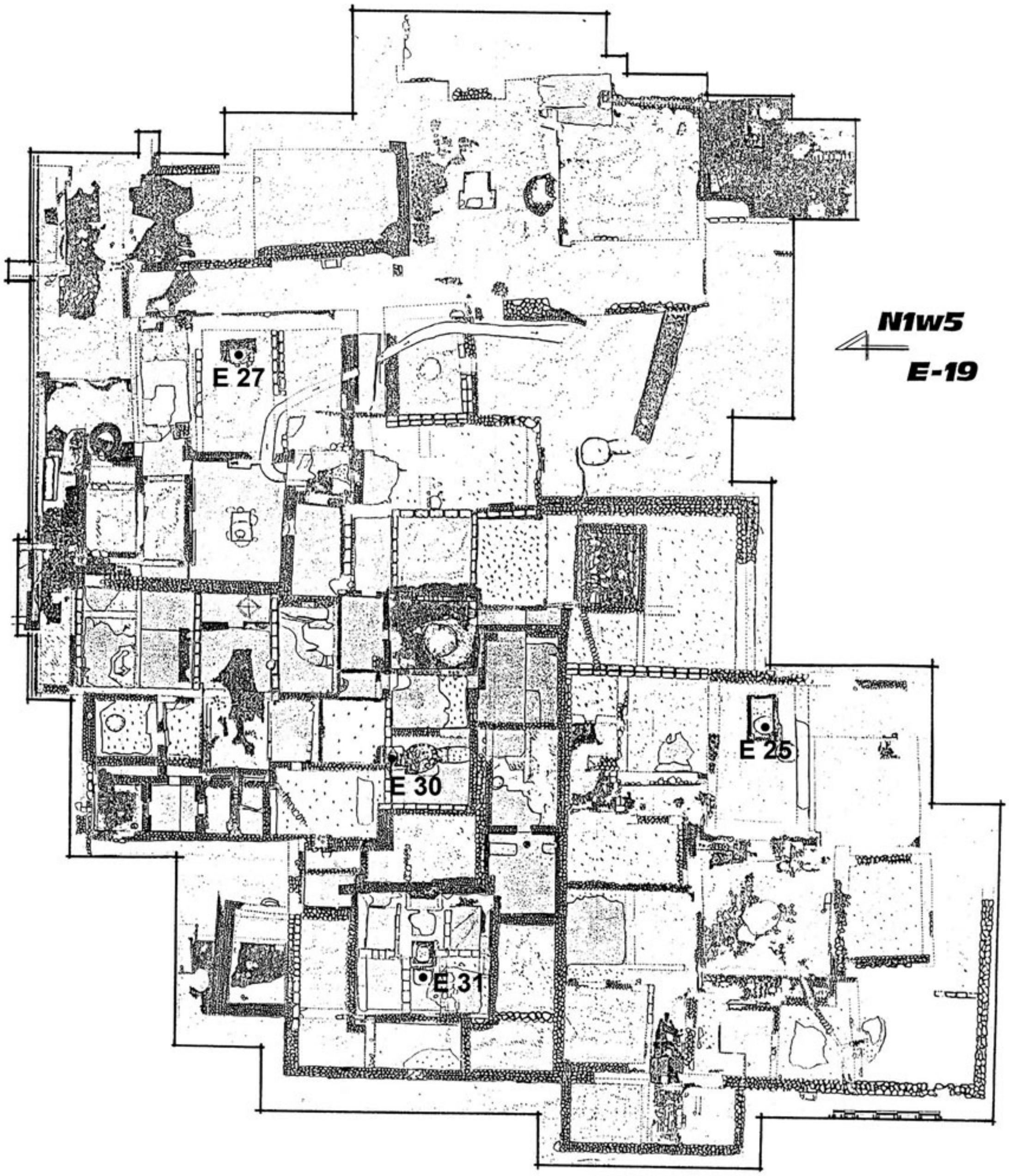

Figure 3. Plan of E19, showing Burials (Entierros) 25, 27, 30, and 31. Figure by Gómez Chávez.

family patio (Feinman et al. 2008; Lind and Urcid 2010:314, n4; Parsons 1936:76). The absence of such deposits in E19 suggests that there was no significant occupation of E19 by Tlailotlacanos despite the architectural evidence of their involvement in its construction. The one exception to this would be Architectural Unit 7, where the Zapotec tomb suggests a more substantial presence.

In order to clarify the proposed Michoacan and Tlailotlacan/Oaxacan relationships of E19, we conducted oxygen isotope analyses of dental enamel and bone samples from five of the excavated mortuary features, four of them within E19 and one a short distance beyond the apartment compound (Spence et al. 2006). A number of projects have demonstrated the advantages of using two or more isotopes, usually oxygen and strontium (Buckley et al. 2021; Manzanilla et al. 2012; Morales Puente et al. 2012; Price et al. 2007, 2021; Schaaf et al. 2012; White et al. 2007). In effect, they allow the triangulation of a source area (Spence and White 2009:237–239). The oxygen isotope analysis reported here, however, was done in 2004, before the development of the institutional collaborations that allowed multiple-isotope analyses. Nevertheless, single-isotope analyses like the present one can still provide reliable insight into the movements of people (e.g., Price et al. 2000; Spence et al. 2020).

The oxygen isotope composition of a person's teeth and bones is derived predominantly from the isotopic

Table 1. E19 sample: description, crystallinity indices (CI), and oxygen isotope compositions. A, adult; YA, young adult; MA, middle adult; OA, old adult; F, female; M, male; y, years; m, months.

Burial	Individual	Age	Sex	Tooth	Crown Complete[a]	CI	Enamel $\delta^{18}O_p$‰ VSMOW[b]	Bone	CI	Bone $\delta^{18}O_p$‰ VSMOW
25	No.1	OA	M	LLM1	2.5 y	3.8	+14.2	metatarsal	–	+12.2
25	No.2	MA	M	UPM2	7.5 y	3.9	+16.1	metatarsal	3.0	+14.3
30	No.1	45–50 y	M	LRPM1	6.5 y	3.8	+14.0	humerus	3.5	+12.1
30	No.2	8–9 y		dULM2	10.5 m	3.9	+15.7	tibia	4.1	+14.7
30	No.3	60+ y	F	LRM1	2.5 y	3.8	+14.3	humerus	3.4	+12.9
31	–	A	M	–	–	–	–	rib	3.7	+13.0
15	Level 22	A	M	LRM1	2.5 y	3.8	+13.9			
15	Level 10	1–2 y		dURI2	4.5 m	3.6	+15.4	rib	3.1	+12.3
15	Level 14	A	M	LLM3	13.5 y	3.8	+15.5	rib	3.4	+12.6
15	Level 17, cr1	A	M	URM2	7.5 y	3.7	+15.7	hyoid	3.2	+12.5
15	Level 17, cr2	A	M	URM3	13.5 y	3.6	+15.8	cervical	3.3	+11.7
15	Level 11	A	M	LRPM1	6.5 y	3.7	+15.5	hyoid	3.3	+12.8
15	Level 29	A	M	LRM2	7.5 y	3.7	+17.6	rib	3.6	+12.4
15	Level 13	4–5 y		dLLI2	1.5 m	Na	+15.6	rib	3.4	+13.1
27	Cranium 2	A	M	ULM2	7.5 y	3.8	+14.3			
27	Cranium 3	YA	F	ULC	5.5 y	3.7	+13.9			
27	Cranium 8	A	M	ULPM2	7.5 y	3.6	+12.7			
27	Cranium 7	A	M	URM2 URM3	7.5 y 13.5 y	3.5 3.7	+13.5 +14.1	temporal	3.7	+12.6
27	Cranium 13	11 y		URPM1	6.5 y	3.7	+14.6			
27	Cranium 1	8–9 y		dULM1 ULM1	4.5 m 3.5 y	3.6 3.7	+15.7 +12.0			
27	Cranium in C38	10 y		ULM2	7.5 y	3.7	+14.0	frontal	3.7	+12.7
27	Level 5, C9–10	A						rib	3.5	+13.0
27	Level 2, C17/23	A						rib	3.4	+13.2
27	Level 2, C27	3–7 y						lumbar	3.3	+12.6
27	C10	A						rib	3.4	+13.7

[a]Age of crown completion (Crc) stage, from median column of AlQahtani et al. (2010:Tables 2–8).
[b]Nursing effect corrections: dM1, dM2, permanent M1, and bones of children under three years reduced by 0.7‰, C by 0.35‰.

composition of the water that they drink (Longinelli 1984; Luz and Kolodny 1985). The oxygen isotope composition of the water in turn depends on the combination of a variety of factors including temperature, humidity, distance from the ocean, and altitude, leading to distinct oxygen isotope compositions characterizing the waters of different geographic regions (Stuart-Williams et al. 1996). The oxygen isotope ratio of an individual, therefore, allows us to place that person in a particular geographic location at the time of formation of the tissue from which the sample was taken, provided that: (1) baseline oxygen isotope compositions for drinking water and hence individuals from specific geographic locations are available; (2) the possible localities of interest where an individual may have resided can be inferred from other data; and (3) oxygen isotope baselines for these locations are analytically distinct within the limitations of the method.

Since dental enamel develops early in life and does not change thereafter, its isotopic composition will reflect the geographic location of an individual during the time of tooth formation. The isotopic composition of their bones, on the other hand, will reflect their more recent location because the components comprising bone will continue to turnover throughout the person's lifespan. Ideally, then, the isotopic composition of teeth and bones can allow us to identify a person's geographic relocation through time.

In fact, the analysis of different teeth, which form at different ages, can show movement during the individual's childhood (e.g., White et al. 2004a). The isotopic compositions of some of the earlier forming teeth, however, have to be corrected because of the trophic effect of breastfeeding. The values for deciduous molars and permanent first molars are adjusted downward by 0.7‰. Those for permanent canines are reduced by 0.35‰. The values for deciduous incisors, on the other hand, are not adjusted since they form in the womb and will simply match those of the mother (White et al. 2004a:393–394). Also, bone oxygen isotope compositions of children under the age of 3 years are reduced by 0.7‰.

The burials

The five burials selected for oxygen isotope analysis include a variety of features, ranging from a burial feature that has Michoacan parallels and offerings of Michoacan items to the Zapotec-style tomb. Unfortunately, most of the burials have yet to receive a full osteological analysis. In the cases of Burial 15, a repurposed well outside E19, and of Burial 31, a cremated adult male, there is no clear archaeological evidence of either Michoacan or Tlailotlacan relationship; the isotopic analysis may offer our only clue to their affiliation. Twenty-two enamel and 19 bone samples were collected from the individuals in the five burial features.

Feature dates are based on the architectural stratigraphy and the associated ceramics. Where possible we have used the specific phase designation, e.g., the Late Tlamimilolpa phase. When that level of precision was not possible the larger period designation was used, e.g., Tlamimilolpa period. Phase and period dates follow Cowgill (2015: Table 1.2).

Burial 25

Burial 25 is a Zapotec-style tomb in Architectural Unit 7 (Figure 3; Gómez Chávez 1998:1476, Figure 7, 2002:602–604). It is constructed much like the numerous tombs found throughout the nearby Tlailotlacan Barrio. Material items in the tomb include small mica, obsidian, and ceramic fragments. There were no Zapotec-style or Michoacan-style ceramic items. The tomb dates to the Tlamimilolpa period (A.D. 170–350).

Also present in the tomb were the fragmented and disarticulated skeletal elements of two incomplete adults. One individual is an elderly male, as determined by the mandibular morphology and the heavy dental attrition. The other was a male of middle age (Luis Alfonso González, personal communication 1991). A dental and bone sample were taken from each individual (Table 1).

Burial 30

Burial 30, located in Architectural Unit 1 (Figure 3), is a nearly square pit, widening slightly toward the base (Figure 4; Gómez Chávez 1998:1479, Figures 8–10, 2002:579–582, Figures 5, 8a, Photographs 4–6). It had been sealed at two different times with wide stone covers, indicating its use on two occasions. The large offering consisted mostly of Teotihuacan items but also included three bowls and one figurine from Michoacan (Figure 5).

The burial feature is similar to those that Pereira (1996, 1997) has designated "asymmetrical" or "niche" burials in Michoacan: a pit with one side expanded slightly or hollowed to hold a primary burial. The Michoacan examples in the Loma Alta site are in pits capped by slabs, commonly placed obliquely. They first appear in Loma Alta 2 (A.D. 0–350; Pereira 1996, 1997). Similar features also occur at Erongaricuaro in the Patzcuaro Basin (Begun 2013:114).

The disarticulated and burned skeletal remains of three individuals were present in the Burial 30 pit. One is an adult female (No. 3), 60 or more years of age by the auricular area and symphysis pubis methods (Lovejoy et al. 1985; Suchey and Katz 1998). The other adult (No. 1) is a male about 45–50 years old as determined using the same methods. The third individual (No. 2) is a child of eight to nine years by dental development (AlQahtani et al. 2010). A later Aztec intrusion has disturbed the feature, but the distribution of skeletal elements suggests that the adult female was the initial interment in the pit, in the Late Tlamimilolpa phase (A.D. 250–350), while the adult male and the child were buried in a later episode, in the Xolalpan period (A.D. 350–550). The stone cover of the first episode (reconstructed in Figure 4) had been originally placed at the top of the pit but was broken for the interment of the man and child. Most of the pieces were put in the bottom of the pit and a new stone cover was placed where the original one had been (Figure 4). Two samples, one bone and one dental, were taken from each individual (Table 1).

Burial 31

Burial 31 is a flexed, adult male, cremated in situ in a small pit in Architectural Unit 1 (Figure 3; Gómez Chávez and Gazzola 2021:89, Figure 3.13). No Michoacan materials were present in the feature. The associated ceramics date the burial to the Late Tlamimilolpa phase (A.D. 250–350). One bone and one dental sample were taken but analysis of the dental sample failed (Table 1). The bone sample, from a left rib, was analyzed successfully. Like the Burial 30 samples, it had been selected to avoid any obvious fire effects. The crystallinity index of 3.7 (Table 1) is within the acceptable range.

Burial 27

Burial 27 is located beneath a platform in Architectural Unit 3 (Figure 3; Gómez Chávez 1998:1481–1485, Figures 11–15, 2002:585–597, Figures 6–7, 8b, Photographs 7–12). It is a deep pit with a stone lining in the upper part, not characteristic of Teotihuacan burials (Figure 6). Some 65 items, mostly ceramic vessels, were present in the lowest level of the B27 pit (Figure 7). Among these were several greenstone encrustations apparently intended for dental modifications, some ceramic items and two figurines of Michoacan style (Figure 8), and a blade of Zinapecuaro obsidian. The bowls

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press

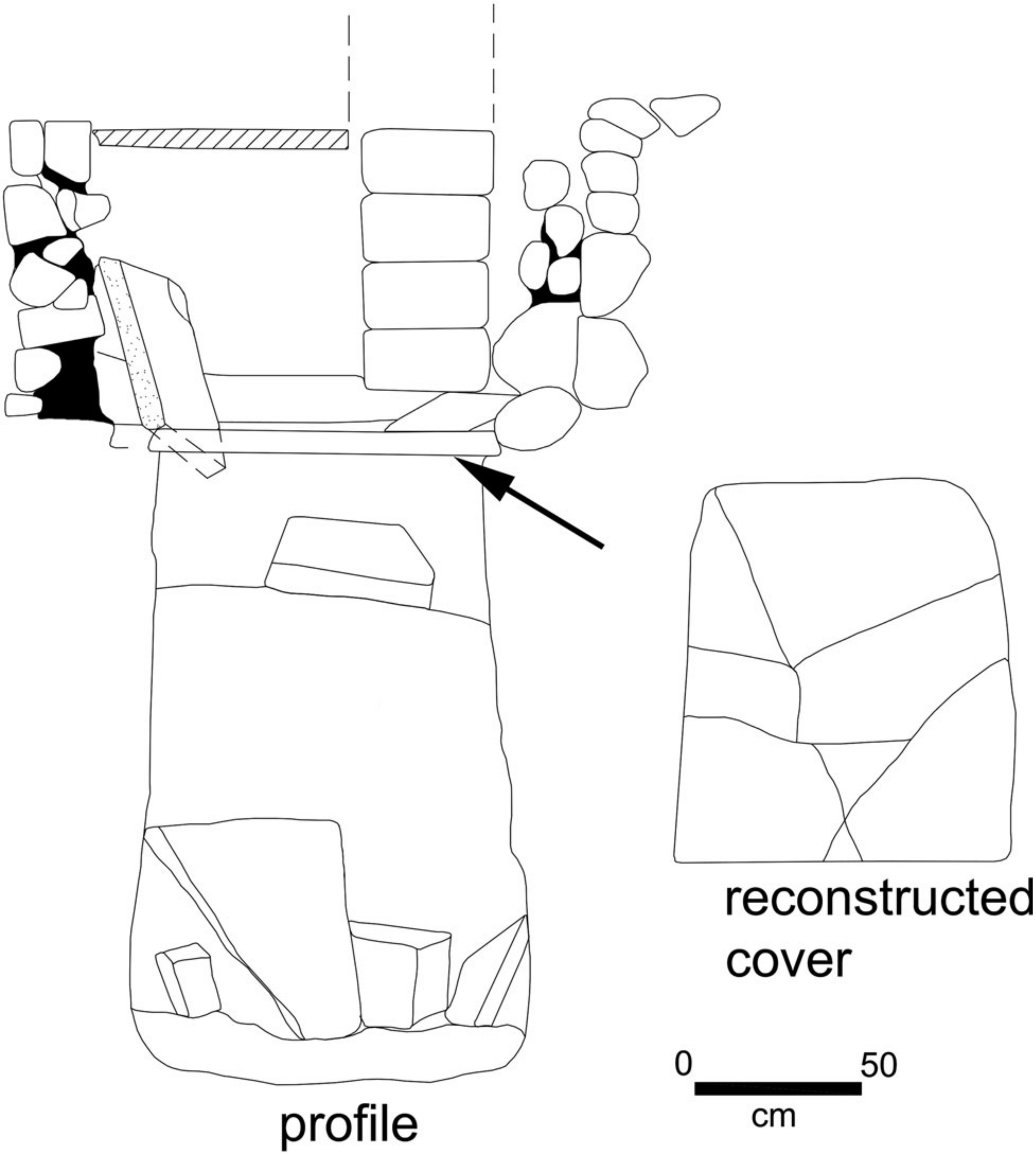

Figure 4. Profile of Burial 30 and reconstructed cover. Arrow indicates level at which covers had originally been placed. Figure by Gómez Chávez.

are much like those from Querendaro in the Cuitzeo area of northern Michoacan (Gómez Chávez and Gazzola 2021:88, Figures 3.9–3.10). Some of the crania have cranial modification of types not characteristic of Teotihuacan. They required techniques and instruments different from those used in Teotihuacan (Gómez Chávez 2002:597; Gómez Chávez and Gazzola 2007:120; Rosaura Yepes, personal communication 1998). Although possibly of West Mexico origin, more detailed comparisons will be necessary to establish their source. The offering ceramics and the architectural context of the pit place it in the interval between the Early Tlamimilolpa and Late Tlamimilolpa phases, ca. A.D. 250. The burials are among the earliest in E19.

All levels of the pit were filled with skeletal remains. Many of these were disarticulated and isolated elements but there were also some articulated segments, including some crania with mandibles and cervical vertebrae, and some torso segments. Unfortunately, our osteological

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press

Figure 5. Burial 30 grave offering. Photograph by Gómez Chávez.

analysis of the Burial 27 remains is incomplete, covering only about one-third of the collection. Furthermore, we are unable to say whether the analyzed third is fully representative of the other two-thirds. This means that our counts of skeletal elements (MNE) will provide only a conservative estimate of the minimum number of individuals (MNI) represented in the burial. An initial count of crania showed 10 adults and one subadult, but the later partial analysis of the collection identified four subadults among the postcranial remains; there are four unfused proximal epiphyses of the right tibia and 40 thoracic vertebra bodies with unfused arches. A revised MNI for Burial 27 would then be 14, but this estimate will likely grow with a full osteological analysis.

All of the human remains and artifacts had been deposited in the pit in a single event, not added to it sequentially over time. There were also a couple of articulated segments like the foot of "Burial" 26 (Figure 6) lying on the original surface from which the Burial 27 pit was excavated. They had apparently been left where they had fallen during the interment of the Burial 27 skeletal material, in the expectation that they would be covered by the platform that was to be constructed over the feature.

The ceramics and other offering items had been placed in the bottom of the pit with the skeletal elements mostly above them. None of the analyzed skeletal elements shows cutmarks or evidence of perimortem trauma. That is not to say that some cutmarks or other evidence of dismemberment would not appear with analysis of the whole collection, but their absence in the analyzed portion suggests that many, perhaps all, of the Burial 27 individuals had been placed there after some time and decomposition in a primary context elsewhere. The burial is, in effect, an ossuary.

Burial 27 is not representative of Teotihuacan mortuary practices, in which secondary burial is not common and collective (multiple) burials are virtually absent. Nor is it representative of the Lakes Region of Michoacan, where collective secondary burials are present but different in nature from Burial 27. They occur in well-constructed, stone-walled structures, and the burials had been added sequentially to the features over years or decades (e.g.. Pereira 1997, 1999; Pollard and Cahue 1999:267–269). Funerary Structure 1 of the Guadalupe site is one example. The burial structure is a square stone-walled feature, unlike the simple pit of Burial 27, but it contains an extensive set of secondary burials with only a few primary interments. The MNI is 35 and includes adults and subadults, most of them incompletely represented. Unlike Burial 27, the interments occurred as a series of events over a considerable length of time (Pereira 1999).

In a mixed and secondary assemblage like that of Burial 27 it is difficult to identify individuals for multiple (dental and bone) sampling. Such sampling was possible in two cases but for the most part only one sample per individual was obtained. Oxygen isotope analysis was conducted on 15 samples, 9 dental and six bone, representing at least eight individuals (Table 1).

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press

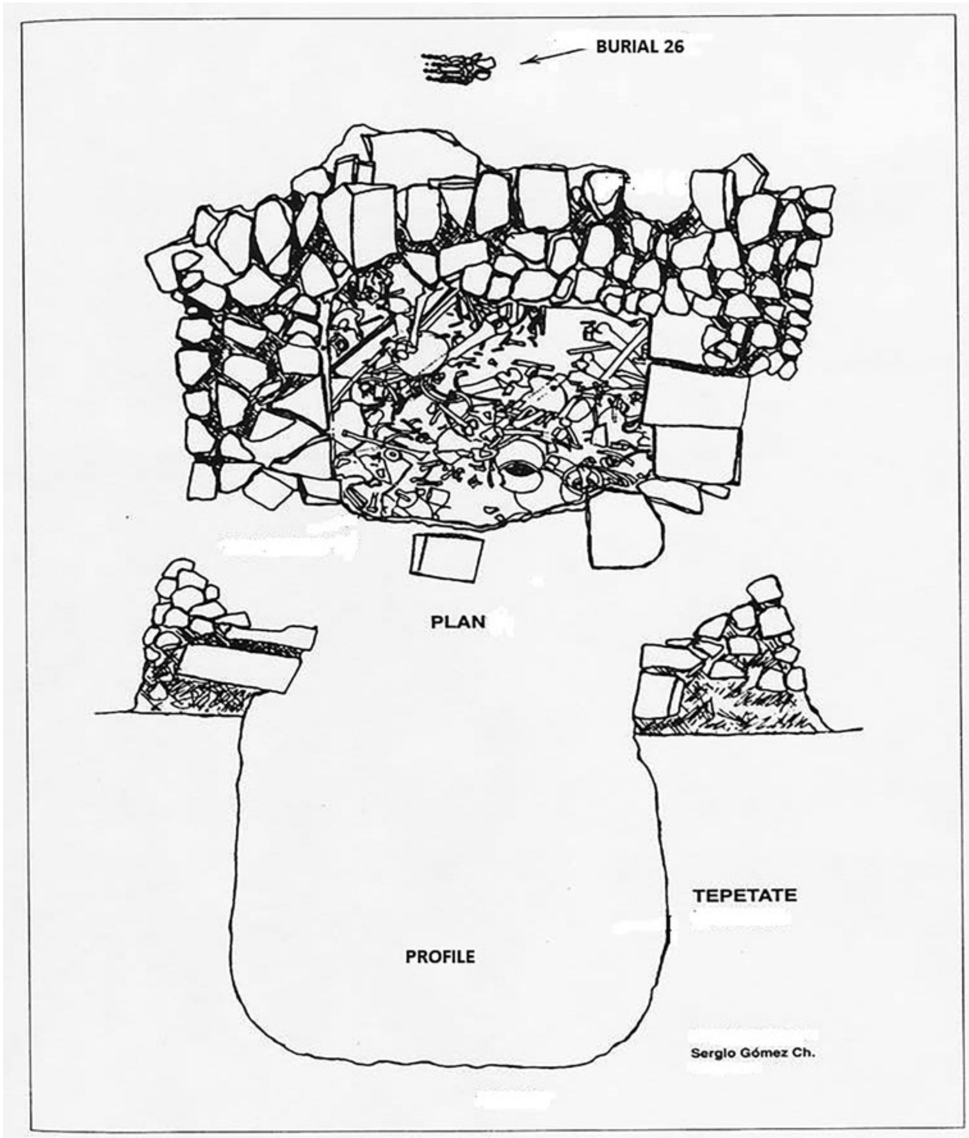

Figure 6. Profile and plan of B27 and "Burial" 26. Figure by Gómez Chávez.

Burial 15

Burial 15 lies in an open area outside E19, south of it and closer to site 22:N1W6 (Figure 2). The burial feature was originally a well, 83 cm in diameter at the top and slightly over 12 meters deep, that in the Early Tlamimilolpa phase (A.D. 170–250) probably provided water for a number of structures in the vicinity, including E19. At some point in the Late Tlamimilolpa phase (A.D. 250–350) it was converted into a burial feature and continued as such in the Xolalpan period (A.D. 350–550). Excavation of the feature neared but could not reach its bottom because of the danger of collapse. The absence of material in the lowest levels, however, indicates that the excavation must have reached very near the bottom of the well. Although the feature's skeletons have not yet received a comprehensive osteological analysis, an estimate suggests that there are at least 14 individuals represented. Also found were 25 canid burials, a jaguar cranium, pyrite discs, and numerous fragments of Teotihuacan theatre censers (Gómez Chávez 2012:97, n8; Pérez Ríos and Gómez Chávez 2022; Velázquez González 2013:63–65). The canids include examples of the hairless Itzcuintli and short-legged Tlalchichi dogs, both of West Mexico derivation. The artifacts are mostly fill inclusions rather than burial offerings. None of the small fragments are clearly of Zapotec or Michoacan style. Its persisting use in the Xolalpan period makes Burial 15 later in time than the other burials discussed here.

Unfortunately, we are unable to say with certainty which of the nearby structures were contributing burials to the feature. As will be shown, however, the oxygen isotope compositions from Burial 15 are similar to those of E19, suggesting that either E19 was responsible for the burials or that people with Michoacan ties were more

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press

Figure 7. Burial 27 grave offerings. Photograph by Gómez Chávez.

widespread in the area than just E19. Notably, the nearest structure, 22:N1W6, has been extensively excavated and its mortuary features and burial practices are much like those of Teotihuacan and unlike the Michoacan and Tlailotlacan-related burials of E19 (Cid Beziez and Torres Sanders 1999; Torres Sanders and Cid Beziez 2018). This suggests that the interments in Burial 15 were more likely of E19 than 22:N1W6 residents, but a more definite conclusion is not possible with the present evidence.

Some of the bodies had been deposited in the former well as complete and articulated corpses while others were partially or fully disarticulated and often incomplete. Several were tightly flexed and had probably been lowered or carried into the well as bundles. Layers of soil intervening between the burials indicate a lapse of time between interments and may have been deposited to reduce the smell of decomposition. It was possible in a number of cases to collect both dental and bone samples from the same individual. Males and females, and adults and subadults, were present. Sex could be assessed in the six sampled adults, although most of those assessments (all male) were made based on cranial features (Buikstra and Ubelaker 1994:19, Figure 4). With a fuller postcranial analysis some of those assessments may change. Adult age was not precisely determined but dental and skeletal evidence (AlQahtani et al. 2010; Scheuer and Black 2000) allowed age estimates for the two subadults represented in the sample. In all, 15 samples (eight dental and seven bone) were taken from eight individuals, six male adults and two subadults (Table 1).

Analytical methods

Sample preservation

Preservation of original oxygen isotope signals in bioapatite is prerequisite to any investigation that relies on such data to explore the origin of individuals. In that regard, phosphate oxygen was chosen as the target for bioapatite isotopic analysis in this paper because, under most conditions, it is much more resistant than structural carbonate to isotopic exchange and contamination after death and burial of the individual (Schwarcz et al. 1991; Shemesh et al. 1983). Preservation potential also varies significantly between bone and enamel, both of which were analyzed in the present study. Enamel is least likely to have undergone alteration of its original oxygen isotope composition after death and burial because it is more highly crystallized during formation and has a much lower organic content relative to bone (Quade et al. 1992). Bioapatite preservation, and hence a sample's suitability for isotopic analysis, was guided in the present study using the crystallinity index (CI), as defined by Shemesh (1990). Those measurements were completed at the Laboratory for Stable Isotope Science (LSIS), the University of Western Ontario, London, Ontario, Canada, using a Bruker Vector 22 Fourier Transform Infrared (FTIR) spectrometer following procedures detailed in Webb et al. (2014).

Values of CI for fresh human bone normally lie within the range ∼2.8–3.0, with higher values observed for archaeological bone (3.5–4.8; Webb et al. 2014). Higher values for bone are indicative of recrystallization, with values greater

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press

Figure 8. Burial 27 foreign offering items. Photograph by Gómez Chávez.

than 4.3 diagnostic of extensive recrystallization and potential isotopic exchange. The average CI for bone samples in this study was 3.3 ± 0.4 (1σ, n = 37; all errors reported hereafter are 1σ; Tables 1–3), with no value higher than 4.0. As is the norm, the CI for enamel values was slightly higher (3.6 ± 0.2, n = 32; Tables 1 and 2), reflecting its original higher crystallinity. These data suggest that all bioapatite samples analyzed for oxygen isotope compositions were well preserved. Restriction of analyses to the phosphate component of the bioapatite gives us further confidence that original oxygen isotope compositions have been measured.

Oxygen isotope analysis

The oxygen isotope compositions of bioapatite phosphate reported here were measured at LSIS in 2004. Bioapatite was first isolated from bone and enamel and converted into silver phosphate (Ag_3PO_4) following procedures described by Firsching (1961) and Stuart-Williams and Schwarcz (1995). The Ag_3PO_4 was then reacted with bromine pentafluoride at 610°C for a minimum of 16 hours to release stoichiometrically the oxygen inherited from the bioapatite, following the method first described for silicate and oxide minerals by Clayton and Mayeda (1963) and later adapted to silver phosphate by Crowson and colleagues (1991). The oxygen released from the silver phosphate was purified cryogenically and then converted to CO_2 by reaction with red-hot carbon. The success of these procedures was first evaluated by measuring the CO_2 yield produced from each Ag_3PO_4 sample. Theoretically, this yield should be 4.76 μmol per mg if all phosphate oxygen was recovered and no additional oxygen from contaminants added. Across all samples analyzed in the present study, an average yield of 4.64 ± 0.17 μmol per mg (n = 71) was obtained, which demonstrates quantitative recovery of oxygen without any contamination.

The oxygen isotope compositions of the CO_2, and hence the bioapatite phosphate, were then measured using a

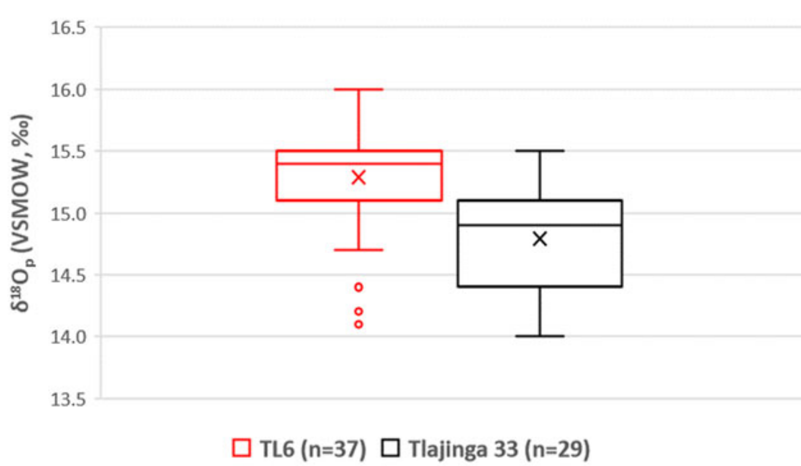

Figure 9. TL6 and Tlajinga 33 oxygen isotope compositions, within +14.0–16.0‰ range of Teotihuacan. Graph by Olsen.

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press

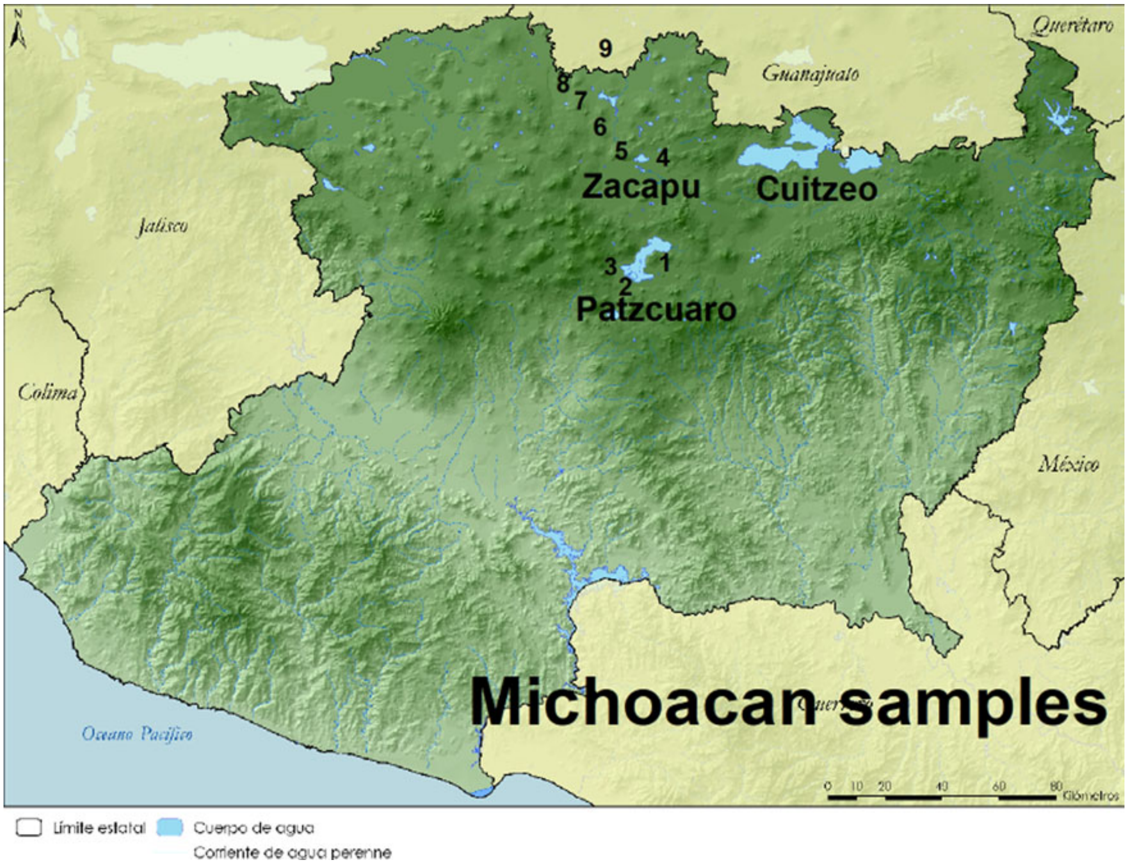

Figure 10. Sites of the Michoacán Lakes Region. (1) Tzintzuntzan. (2) Tocuaro. (3) Urichu. (4) Guadalupe. (5) Milpillas. (6) El Palacio. (7) San Antonio Carupo. (8) Los Portales. (9) Los Nogales, Guanajuato. Map by Pollard.

Micromass Optima dual-inlet, triple-collecting, gas-source stable isotope ratio mass spectrometer. The results are reported in the normal delta ($\delta^{18}O$) notation relative to Vienna Standard Mean Ocean Water in parts per thousand (‰; Coplen 2011). To test the accuracy of the measurements, replicate analyses of Aldrich Ag_3PO_4 (No. 33,738-2; accepted $\delta^{18}O_p$ = +10.8 ± 0.3‰; White et al. 2002) were performed during the present study. These analyses returned average $\delta^{18}O_p$ = +10.71 ± 0.31‰ (n = 22), which compares well with the accepted value. The average difference between duplicate analyses of samples (n = 7) was 0.29‰ (i.e., ± 0.15‰). Collectively, these results, and those for CI summarized earlier, indicate that the oxygen isotope data reported here are both accurate and precise, and are representative of the original oxygen isotope compositions of the bioapatite phosphate.

Results: The E19 samples

Moreiras Reynaga (2019; Moreiras Reynaga et al. 2021) has defined five broad zones for the oxygen isotope compositions bioapatite phosphate ($\delta^{18}O_p$) in Mesoamerica. Only Zones 1–3 need concern us here. Zone 1, with $\delta^{18}O_p$ typically in the +12.1–13.9‰ range, includes the Pacific Coast, West Mexico (with Michoacan), and the Valley of Oaxaca. Zone 2, characterized by $\delta^{18}O_p$ of +14.0–16.2‰, covers the central Mexico highlands, including the Basin of Mexico, as well as Morelos, Puebla, Hidalgo, and other areas.

Teotihuacan itself, although in Zone 2, has a slightly more limited range of +14.0–16.0‰ (White et al. 2004a). An additional factor to consider in the case of Teotihuacan, however, is the likelihood of some spatial variation within the +14.0–16.0‰ $\delta^{18}O_p$ range typical of the city. This could be caused by a variety of factors, such as the use of distinct water sources or a difference in altitude. To test this idea, we compared the $\delta^{18}O_p$ from site TL6 in Tlailotlacan (White 2004a) to that from two suites of skeletal material from the Tlajinga 33 site in the lower south part of Teotihuacan (Buckley et al. 2021; White et al. 2004b). Only enamel and bone ratios within the typical range of Teotihuacan were included in the analysis. The results show some distinctions, the TL6 $\delta^{18}O_p$ trending higher (average +15.3 ± 0.42‰; range +14.1–16.0‰; n = 37) than those from Tlajinga 33 (average +14.8 ± 0.42‰; range +14.0–15.5‰; n = 29), though with a considerable overlap (Figure 9). The difference is not statistically significant.

Zone 3, with $\delta^{18}O_p$ of +15.6–17.7‰, includes the southern highlands, northern Guatemala, and the eastern parts of Puebla and Hidalgo. There is some limited overlap in $\delta^{18}O_p$ between zones 2 and 3. Also, these ranges are very broadly defined configurations. Each zone encompasses a significant variability in $\delta^{18}O_p$ with some areas having

$\delta^{18}O_p$ above or below the typical range for that zone (White et al. 2004b).

Three areas are of particular interest for the identification of the external relationships of the E19 burials. One, of course, is Teotihuacan itself, in Zone 2. The other two regions of interest are the Valley of Oaxaca and the Lakes Region of northern and central Michoacan, both in Zone 1. This raises the problem of distinguishing between two such isotopically similar regions. The Valley of Oaxaca, however, may be of less relevance here. Although a number of architectural features and ceramics of Zapotec affiliation were found in E19 (Begun 2013), they were probably derived from Tlailotlacan, the nearby Zapotec Barrio, rather than being directly traceable to the Valley of Oaxaca.

It is worth noting that after the initial settling of Tlailotlacan there was apparently very little biological exchange between Tlailotlacan and the Valley of Oaxaca. Only two of a series of 56 $\delta^{18}O_p$ values from Tlailotlacan fall in the +12.0–14.0‰ range suggested for the Valley of Oaxaca (White et al. 2004a). Of two separate strontium isotope studies, with a total of 45 samples tested from Tlailotlacan, none fall in the 0.7074–0.7076 range of the Valley of Oaxaca (Nado 2017; Price et al. 2000).

Table 1 presents the available data for the E19 samples. Adult ages are, unfortunately, often recorded only as "adult" since there has been no comprehensive analysis of the E19 skeletal material. The enamel samples include a wide variety of teeth, and so of ages. We only analyzed teeth with crowns that had fully formed, at or past the "crown complete" stage. This is the stage recorded in Tables 1 and 2 for each tooth, based on data from the median columns of Tables 2–8 of AlQahtani et al. (2010). Later comparative analyses by AlQahtani et al. (2014) show that their system provides more accurate ages for tooth formation than the Schour and Massler, and Ubelaker, charts. Those "crown complete" ages, then, indicate the age reached by that particular individual while still living in the region characterized by the tooth's $\delta^{18}O_p$.

Individual 1 of Burial 25, the Zapotec-style tomb, has a bone $\delta^{18}O_p$ of +12.2‰. On the one hand this value might suggest that he came to E19 from the Valley of Oaxaca shortly before his death. On the other hand, his enamel value (+14.2‰) suggests that he passed his early childhood in Teotihuacan. This isotopic pattern is similar to many others in the E19 series, so the region represented by the bone value of Individual 1 may be the same one as in the other samples, and not the Valley of Oaxaca. Both the enamel and bone $\delta^{18}O_p$ of Individual 2, the other tomb occupant, are compatible with Teotihuacan residence. His enamel $\delta^{18}O_p$, however, is in the overlap between Zones 2 and 3 values and is 1.8‰ higher than his bone $\delta^{18}O_p$ of +14.3‰, so it is possible that he moved within Zone 2 after his childhood.

Burial 30 is in a feature that has parallels in the Lakes Region of Michoacan. Again, there is a mix of Zone 1 and Zone 2 values for $\delta^{18}O_p$. Individual 1 presents both enamel (+13.6‰) and bone (+12.1‰) $\delta^{18}O_p$ that indicate long-term residence in a Zone 1 area. Individual 3 seems to have moved from Teotihuacan to a Zone 1 location. The $\delta^{18}O_p$ of Individual 2, a child of eight to nine years at death, suggest residence in Teotihuacan throughout that brief lifespan.

Only a bone $\delta^{18}O_p$ (+13.0‰) is available for Burial 31. It suggests residence elsewhere before death, in a Zone 1 location, like the pattern of many other E19 individuals.

Because Burial 27 was a collective secondary burial we were able to obtain enamel and bone samples from the same individual in only two cases. The adult male represented by Cranium 7, with enamel $\delta^{18}O_p$ of +13.5‰ and +14.1‰ for successive teeth and then of +12.6‰ for the temporal bone, seems to have passed most or all his life in a Zone 1 environment, rather than Teotihuacan. The C38 Cranium child, only 10 years old at death, has an enamel $\delta^{18}O_p$ of +14.0‰, which could indicate residence in Teotihuacan or somewhere in Zone 1. The later frontal bone $\delta^{18}O_p$ of +12.7‰ is more firmly in the Zone 1 range. It is, then, quite possible that the child was born and perhaps even died in that environment. There are only enamel $\delta^{18}O_p$ values for the Cranium 1 child, but they show a clear picture of movement from Teotihuacan to a Zone 1 location sometime before the age of three, then burial in Teotihuacan after death at eight to nine years of age.

Values of bone $\delta^{18}O_p$ for Burial 27, presumably reflecting residence within the last decade or so of life, all indicate a Zone 1 environment. Their range, +12.6–13.7‰, shows some variability, perhaps because of varying degrees of equilibration to the Teotihuacan environment. In contrast, their enamel $\delta^{18}O_p$ are much more heterogeneous (+12.0–15.7‰), apparently showing childhood residence in a wider range of environments, including both Zone 1 and 2 locations. It seems, then, that the Burial 27 people originated in a variety of places and came together, some as children and some perhaps in marriage, to form a collective of some sort in a Zone 1 location. After some years there, at least long enough to equilibrate to the local oxygen isotope composition, they moved, or were brought, to Teotihuacan.

Burial 15, the converted well, offers a clearer understanding of the people's movements, in part because the discrete burials could provide enamel and bone samples for each individual and in part because the oxygen isotope compositions were quite homogeneous for both enamel and bone. With the possible exception of the Level 22 male (no bone isotopic data), all individuals passed some years in a Zone 1 environment (bone $\delta^{18}O_p$ = +11.7–13.1‰). With two exceptions, their enamel $\delta^{18}O_p$ fit tightly (+15.4–15.8‰) into the Teotihuacan range. In fact, these results conform well to the more northerly part of that locality, as can be observed for the $\delta^{18}O_p$ of nearby site TL6 (Figure 9). One exception is the Level 22 male, with an enamel $\delta^{18}O_p$ of +13.9‰ on a tooth formed in early childhood. The other exception is the Level 29 male whose +17.6‰ enamel $\delta^{18}O_p$ suggests childhood in a Zone 3 location. The Teotihuacan enamel $\delta^{18}O_p$ of the two young children in the sample (Levels 10 and 13) are from their deciduous lateral incisors which develop largely in utero and so actually reflect their mothers' residences. Their movement to the Zone 1 location may have occurred just before or after birth.

Table 2. CEMCA sample: description, crystallinity indices (CI), and oxygen isotope compositions. A, adult; F, female; M, male; y, years; m, months.

Site	Area	Burial	Age	Sex	Tooth	Crown Complete	CI	Enamel $\delta^{18}O_p$‰ VSMOW	Bone	CI	Bone $\delta^{18}O_p$‰ VSMOW	Period
Guadalupe	Zacapu Basin (Michoacan)	3-1	A	M	ULM3	13.5 y	3.5	+15.2	rib	2.7	+14.1	Middle Classic (A.D. 450–600)
	Zacapu Basin (Michoacan)	26-2	A	M?	URM1	3.5 y	3.5	+14.8	radius	3.1	+15.0	Middle Classic (A.D. 450–600)
	Zacapu Basin (Michoacan)	33	15–18y	?	LRM1	2.5 y	3.5	+15.9	rib	3.3	+14.8	Epiclassic (A.D. 600–800)
Milpillas	Zacapu Basin (Michoacan)	12	A	F	LRM1	2.5 y	3.6	+14.5	rib	3.0	+13.5	Middle Postclassic (A.D. 1250–1400)
	Zacapu Basin (Michoacan)	19	A	M	URM1	3.5 y	3.6	+15.3	rib	2.8	+13.6	Middle Postclassic (A.D. 1250–1400)
	Zacapu Basin (Michoacan)	26b	A	F	ULM3	13.5 y	3.5	+16.0	rib	2.7	+14.1	Middle Postclassic (A.D. 1250–1400)
El Palacio	Zacapu Basin (Michoacan)	1	A	F	LLM3	13.5 y	3.5	+17.0	rib	2.8	+14.7	Early Postclassic (A.D. 900–1200)
San Antonio Carupo	Northern Michoacan	2	10–12y	?	dLRM2	10.5 m	3.1	+16.5	rib	2.6	+14.0	Middle Postclassic (A.D. 1250–1400)
Los Portales	Northern Michoacan	2	A	F	LLM3	13.5 y	3.4	+17.6	rib	2.8	+13.5	Late Preclassic (200 B.C.)
Los Nogales	Bajío (Southern Guanajuato)	3-1	A	F	LLM1	2.5 y	3.3	+15.5	rib	2.8	+13.9	Epiclassic (A.D. 600–800)
	Bajío (Southern Guanajuato)	10-1	A	M	ULM3	13.5 y	3.3	+15.2	rib	2.8	+14.1	Epiclassic (A.D. 600–800)

Results: The Michoacan evidence

The archaeological data

The range of $\delta^{18}O_p$ characteristic of Teotihuacan is +14.0–16.0‰, while a set of samples from Monte Albán suggests a +12.0–14.0‰ range for the Valley of Oaxaca (Stuart-Williams et al. 1996; White et al. 1998). To assess the possibility of Michoacan relationships we obtained samples from a number of sites in the north central part of Michoacan (the "Lakes Region"), a trip of some 300 kilometers to the west from Teotihuacan, and an adjacent area of southern Guanajuato (Figure 10).

There is considerable evidence in Michoacan of exchange with Teotihuacan. In some places the relationship may have been stronger and more formal, perhaps close ties between elites. Some structures have talud-tablero facades. Some of these facades, like those in Tingambato, are Epiclassic (Punzo Díaz 2022; Rangel Campos 2018) and may be the result of local incorporation of Teotihuacan elite refugees fleeing the city's collapse (Pollard 2000:63; Spence 2000:257–258), or the return to their ancestral homeland of Michoacanos who had been living in Teotihuacan but could still claim some privilege in their original communities, which they had perhaps been visiting throughout the Classic period (Gómez Chávez and Gazzola 2007:132, 2021:94; Michelet and Pereira 2009:83). The examples of talud-tablero in the Lake Cuitzeo Basin sites may be of the Classic period, suggesting a relationship with Teotihuacan that in some cases extended beyond just exchange (Filini 2004, 2021; Filini and Cárdenas García 2007; Macías Goytia and Vackimes Serret 1988; Manzanilla López 1988; but see Michelet and Pereira [2009:79–80]). Thin Orange ware ceramics, blades of the Cerro de las Navajas green obsidian, and other indicators of exchange with Teotihuacan have been found in several Cuitzeo area sites (but see Filini [2021:219]). Some of the E19 Michoacan bowls match those of Querendaro, a Cuitzeo site (Gómez Chávez and Gazzola 2021:88, 93–94).

There is also evidence of exchange with Teotihuacan further west, in the Zacapu area (Figure 10). Thin Orange ware is present in sites there, although Evelyn Rattray says that the sherds that she examined from the Loma Alta site are an older variety of the ware, one present in the Puebla source area but not in Teotihuacan (Rattray in Carot 2001:33–36, Figures 31–36). Green obsidian blades that appear to be perfect examples of Teotihuacan knapping, however, make up 92 percent of the blades from Zacapu elite burial contexts (Carot 2001:Figures 41–45; Darras 1993a:169; 1993b:174). There are even two green obsidian needles like those made in the obsidian workshops of Teotihuacan (Carot 2001:Figure 46; Spence 1996:Table 2, Figure 2D).

Prismatic blades of the green Cerro de las Navajas obsidian and Thin Orange ceramics have also been found in the Urichu and Erongaricuaro sites on the southwestern side of Lake Patzcuaro. A Thin Orange sherd, analyzed by INAA, matched the composition of samples found in Teotihuacan (Pollard 2008:220). The blades occur in Loma Alta 2- and 3- and Jaracuaro-phase contexts. Pollard (1996; Pollard and Cahue 1999) suggests that local elites acquired them and other exotics to bolster their status. Begun (2008:314–316) notes that the Burial 27 figurines match those of the Patzcuaro Basin rather than the Loma Alta site (Zacapu Basin) version of that style. Also, some of the Michoacan-style ceramics of E19 analyzed by INAA match clay deposits in the Lake Patzcuaro Basin (Begun 2013:140; Neff 2011).

The available archaeological evidence alone does not allow us to say whether the people of E19 had their principal relations and perhaps ancestral ties with the Cuitzeo Basin, the Zacapu area, the Patzcuaro area, or even all of these localities. It does seem likely that, whatever their foreign interactions, they were not conducted as emissaries of the Teotihuacan state. E19 is a mid-level apartment compound near the western edge of the city, with no apparent role in the state apparatus (Begun 2013:167, 172). Rather, it is probably an example of those extensive, often kin-based groups that were active in exchange networks but operated outside the state's institutions (Gómez Chávez and Spence 2012:289–290). Manzanilla (2017:7, 38) has proposed a different model for Teopancazco, suggesting that caravans loaded with trade items travelled back and forth between Teopancazco and Veracruz. The E19 situation differs from this caravan model in some important respects. Virtually all of the E19 residents, including children, were involved in the movement, and sojourns in Michoacan were lengthy enough to allow the equilibration of their $\delta^{18}O_p$ to the local environment. Probably the movements and resettlements of the E19 people were responses to some as yet unidentified social or political factors, the material exchanges developing as a by-product of the relationships that were established rather than as causes of the resettlements.

Comparative oxygen isotope data

In order to identify the source area for the Michoacanos thought to reside in E19, we obtained bone and enamel samples from a number of sites in the Lakes Region of northern Michoacan (Figure 10). There are three major lakes in the region: Cuitzeo (1,840 m above sea level [asl]), |Zacapu (1,980 m asl) and Patzcuaro (2,033–2,035 meters asl in the Classic period; Pollard 2008:220). Lake Zacapu is 30 km west of Lake Cuitzeo and Lake Patzcuaro is 40 km southwest of Lake Cuitzeo but only 20 km south of Lake Zacapu. Unfortunately, we have no samples from the Cuitzeo area. An exchange relationship with Teotihuacan, however, does not necessarily mean that the Cuitzeo Basin was the original homeland of the E19 residents.

Samples from excavations by the Centro de Estudios Mexicanos y Centroamericanos (CEMCA) in and north of the Zacapu area are Late Preclassic (ca. 200 B.C.) to the Middle Postclassic period (A.D. 1250–1400). Dental enamel and bone samples (Table 2) were obtained for seven individuals from sites in the Zacapu Basin (Guadalupe, Milpillas, and El Palacio; Pereira 1999; Puaux 1989), and from two individuals from the Penjamillo area some 30 kilometers to the north (San Antonio Carupo [Faugère-Kalfon 1996] and Los Portales [Pereira 2006]). All these samples were obtained from the Michoacan Project excavations. Samples from two Epiclassic individuals come from Los Nogales, a Bajío settlement of southern Guanajuato excavated by the Barajas Project (Pereira 2013).

A second series of samples, all from bone, was obtained from sites in the Patzcuaro Basin (Table 3). The Urichu, Tzintzuntzan, and Tocuaro sites are clustered around the lake. All samples are Late Postclassic but for one Classic-period sample from Urichu. Although the climate in the region was somewhat wetter in the Late Postclassic period, there is no evidence that this had a significant effect on oxygen isotope compositions. The range in $\delta^{18}O_p$ of the three Late Postclassic Urichu samples (+12.1–13.1‰) encompasses the one Classic-period value (+12.9‰) from the site.

Comments on the Michoacan series

The CEMCA series has a range of enamel $\delta^{18}O_p$ of +14.5–16.0‰ (Table 2), excluding three, considerably higher values, most likely from outsiders who came to the area during or after their childhood: San Antonio Carupo Burial 2, a child with a deciduous second molar value of +16.5‰; El Palacio Burial 1, an adult woman with a third molar value of +17.0‰, whose cranial modification and body treatment are atypical for the area (Pereira and Barrientos 2020); and Los Portales Burial 2, another adult woman with a third molar value of +17.6‰. The fact that the two women were still in their childhood homeland when their third molar crowns had fully formed, around the age of 13.5 years, raises the possibility that they may have moved to northern Michoacan at the time of their marriage. The child, 10–12 years old at the time of death, may have moved as a child from the same foreign area at the time of development of the second molar crown, which usually occurs at about six to eight years (AlQahtani et al. 2010: Tables 5–6). At that time the child was either still living in the homeland or had only recently moved to San Antonio Carupo. By the time of death, some four years later, the child's bone $\delta^{18}O_p$ (+14.0‰) had equilibrated to the new environment.

These three individuals may have come from the same or different regions. Our understanding of the $\delta^{18}O_p$ of people across Mesoamerica is limited, but values of +16.5–17.6‰ are certainly not characteristic of either the Lakes Region of Michoacan or the Basin of Mexico and Teotihuacan. They are typical of Moreiras Reynaga's Zone 3, which includes the southern highlands of Mexico and highland Guatemala (Moreiras Reynaga 2019:98; Moreiras Reynaga et al. 2021; see also White et al. 2000). Zone 3 also includes some regions to the east of the Basin of Mexico, like the eastern parts of the states of Puebla and Hidalgo (Moreiras Reynaga et al. 2021: Figure 4). Nevertheless, it must be remembered that each of these broadly defined zones may encompass considerable variability, so high $\delta^{18}O_p$ values may occur in untested areas of Zone 2.

The range of bone $\delta^{18}O_p$ in the CEMCA series is +13.5–15.0‰, slightly lower than the enamel range (excluding the three individuals described above). This, like the enamel range, encompasses some variability but that may be due to movements within the Lakes Region, use of different water sources or, in a few cases, incomplete equilibration by immigrants to the local environment. The CEMCA combined bone and enamel $\delta^{18}O_p$ ranges that represent local values (+13.5–16.0‰) are very similar to the range characteristic of Teotihuacan (+14.0–16.0‰). This makes it difficult to distinguish individuals from the two regions using only oxygen isotope data.

The Patzcuaro series of bone $\delta^{18}O_p$ values (Table 3) ranges from +12.1 to +13.7‰, excluding one anomalous value of +15.2‰ from the young woman of Tocuaro. She may have been an immigrant, moving into the area from Zacapu, only 20 km to the north. The small overlap in bone $\delta^{18}O_p$ (+13.5–13.7‰) between the Patzcuaro and CEMCA samples is within the error (+0.3‰) of the method. The difference in bone $\delta^{18}O_p$ between the two areas is somewhat surprising, given their proximity. It may be due in part to the higher elevation of Lake Patzcuaro.

Discussion and conclusions

When we started this project we anticipated, or at least hoped, that the results would be straightforward: enamel $\delta^{18}O_p$ indicating early residence in Michoacan and bone $\delta^{18}O_p$ indicating later residence in Teotihuacan. We should have known it wouldn't be that easy. In fact, the data seem to suggest the opposite, yet the burials are in Teotihuacan. How to explain this unexpected pattern?

One consistent aspect is the occurrence of Zone 1 $\delta^{18}O_p$ (+12.1–13.9‰) in the bone samples of the E19 individuals. Every bone $\delta^{18}O_p$ of the two best represented burials (Burials 15 and 27), as well as the sole Burial 31 bone $\delta^{18}O_p$, one of the two Burial 25 bone $\delta^{18}O_p$, and two of the three Burial 30 bone $\delta^{18}O_p$ fall in this range. The Valley of Oaxaca has a similar range of $\delta^{18}O_p$ but, as discussed earlier, it is probably not a factor in this analysis. We have thus focused our attention on the Michoacan sector of Zone 1, and on the Lakes Region.

Teotihuacan materials, particularly Cerro de las Navajas green obsidian prismatic blades and Thin Orange ware ceramics, appear widely in the northern Michoacan Lakes Region. This informs us about where Teotihuacan goods were going, and it seems likely that the residents of E19 played a role in that distribution, but it does not necessarily identify their original homeland. That is a separate question, one best investigated with stable isotope analysis. To that end we acquired dental and bone samples from a variety of locations in the Lakes Region and some sites further to the north. While we do not have samples from the Cuitzeo Basin, as discussed earlier, the available Michoacan samples indicate a local origin for the people of E19 in the Patzcuaro Basin. Some of the E19 offering artifacts, like the figurines of Burial 27, also point to a Patzcuaro connection. The nature of that connection, however, may have changed over time.

The Michoacan-related mortuary features and artifacts appear in the earlier stages of E19, in the Tlamimilolpa period. In the Xolalpan period the architectural and ceramic evidence for a Michoacan relationship dwindles and disappears, suggesting that the residents of E19 had eventually embraced a Teotihuacan identity (Begun 2013:148–149,

Table 3. Patzcuro area sample: description, crystallinity indices (CI), and oxygen isotope compositions. F, female; M, male; y, years; m, months.

Site	Date	Burial	Age	Sex	CI	Bone $\delta^{18}O_p$‰ VSMOW	Comments
Urichu	Late Classic	B21	20–34 y	M	4.0	+12.9	Area 5 Tomb A.D. 400–600
Urichu	Late Postclassic	B4	35–49 y	M	3.6	+12.1	Elite burial
Urichu	Late Postclassic	B10	35–49 y	M	3.4	+13.1	Elite burial
Urichu	Late Postclassic	B31	Young adult	M	3.7	+12.1	Elite burial
Tzintzuntzan	Late Postclassic	PNW B3	20–34 y	M	3.5	+12.9	Main platform, base Yácata 3
Tzintzuntzan	Late Postclassic	B3.4c	20+ y	M	3.7	+13.7	Main platform, Edificio F
Tzintzuntzan	Late Postclassic	IV-T-1	20–34 y	F	2.7	+13.6	Main platform, Ossuary
Tócuaro	Late Postclassic	T-4	20–34 y	F	3.4	+15.2	Prehispanic central zone

163–170; Gómez Chávez 2002:607–608). If the Michoacan items in E19 burials represented Michoacan beliefs or practices, something that may be particularly likely in the case of the distinctive Michoacan female figurines in Burials 30 and 27 (Figures 5, 7, and 8), those associations had evidently been eroded by the Xolalpan period. The isotopic evidence, however, adds another dimension. To judge by Burial 15, some of the people of E19 passed years in Michoacan in the Xolalpan period, even after the architectural and ceramic evidence for a Michoacan presence at E19 had disappeared. Enamel $\delta^{18}O_p$ indicate that most of the Burial 15 individuals had probably been born and raised in Teotihuacan, in the E19/Tlailotlacan part of the city.

The Burial 27 people appear to have passed their early years in a variety of areas, which may have included Teotihuacan, the Patzcuaro Basin, or perhaps even the Zacapu Basin. In any event almost every bone $\delta^{18}O_p$ in the E19 series indicates movement to, and long-term residence in, the Patzcuaro Basin, starting in some cases in childhood (e.g., Cranium 1 of Burial 27) and in others as adolescents or adults. Although most of the adults have been tentatively identified as males, some females were present. People, then, were probably moving as families.

Their stay in the Patzcuaro area was long enough for their bones to remodel extensively, taking on the oxygen isotope compositions characteristic of that environment. Yet they were buried in Teotihuacan and virtually none of them shows any real shift in oxygen isotope compositions toward the Teotihuacan environment. This observation suggests their return to the city not long before death, although we do not really know how long that is. Rates of bone remodelling slow with age but are variable, depending to a considerable degree on the health and nutrition of the individual. It may take a decade or more for adult bones to fully remodel.

A small group like the E19 residents would not be likely to resist assimilation for long. Even the earlier burials have far more Teotihuacan than Michoacan items among their offerings (Figures 5 and 7). Still, the residents may have retained a residual Michoacan identity for some time, particularly if it offered some advantages. It would certainly have facilitated exchange and other relationships with people in the Lakes Region. In moving to the Lakes Region, invoking that identity would have eased their integration into local communities and locked in a socially protected role in Teotihuacan–Lakes Region relationships. Their return to Teotihuacan at a late point in their lives is a further indication that their core identity and the area that they now considered their homeland was Teotihuacan. Over time their Teotihuacan identity had become more fundamental and their Patzcuaro identity more instrumental. They would have shared, perhaps from the beginning, the benefits of Teotihuacan citizenship. They would also have been required to attend to its obligations, like taxation, corvée labor, and military service.

The erosion of a Michoacan identity might have been slowed if there had been a wider community of expatriate Michoacanos in Teotihuacan. Gómez Chávez and Gazzola (2007:114–115) note the presence of Michoacan ceramics at a number of other Teotihuacan sites, with a particularly interesting occurrence in site 4:N2E2. The Tlajinga barrio, however, offers the best evidence of another West Mexico connection. Although it is located at the south end of the city, some 2.7 kilometers from E19, it may also have had some ties with E19. The intensive core-blade production in site 17:S3E1 (Hirth et al. 2019) may have supplied the green obsidian blades found in Michoacan, perhaps via E19. The use of cobblestone floors in Tlajinga sites (Carballo et al. 2019; Storey 1992) also suggests a Tlajinga-E19 link, although they have been found elsewhere in Teotihuacan. The shaft tomb of Tlajinga 33 (Widmer 1987:354) is much like the one for Burial 5 in E19 (Gómez Chávez 2002:578, Figure 4).

The West Mexico relationships of Tlajinga 33, however, may not have been with sites in the Lakes Region of

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press

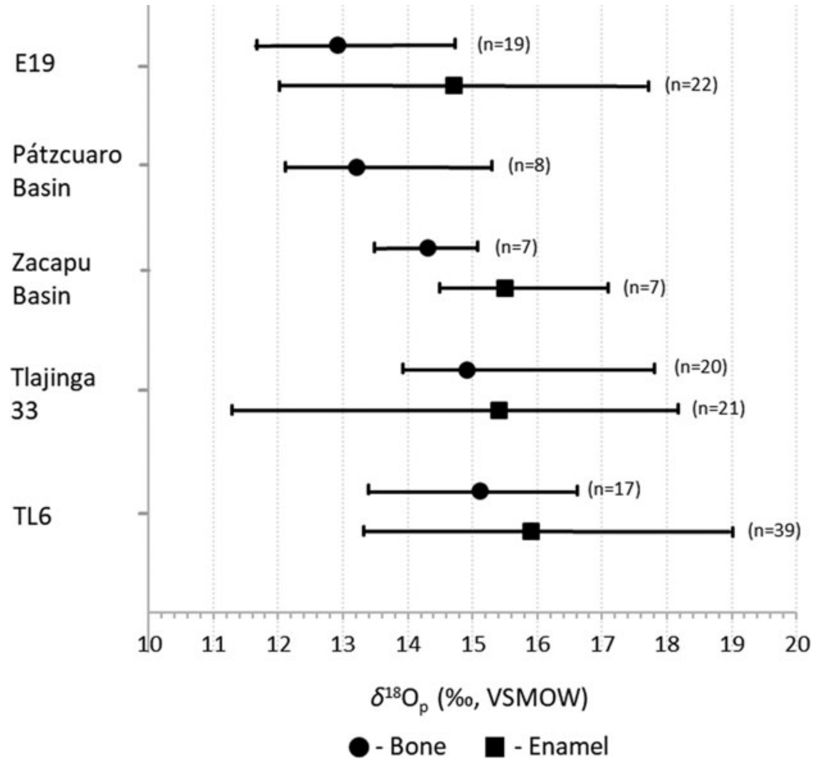

Figure 11. Means and ranges of oxygen isotope compositions of E19, Patzcuaro Basin, Zacapu Basin, Tlajinga 33, and TL6. Graph by Olsen.

Michoacan. The foreign $\delta^{18}O_p$ values of Tlajinga 33 include only one composition (Burial 6, +11.3 ‰ on enamel) that is compatible with Patzcuaro Basin values, but seven for enamel and two for bone lie in the +16.3–18.1‰ range (Buckley et al. 2021:Table 1; White et al. 2004b:Table 1). These higher $\delta^{18}O_p$ values were taken to represent the West Mexico area with which the Tlajinga people interacted for two reasons. One was the occurrence of three of these high $\delta^{18}O_p$ in the teeth of two of the individuals buried in the Tlajinga 33 shaft tomb. The other was the enamel $\delta^{18}O_p$ values of +16.2 and +16.9‰ for two teeth from Burial 10 in the substructure of Yácata 3 of the Main Platform in Tzintzuntzan (White et al. 2004b:184). Given that most of the $\delta^{18}O_p$ values from Tzintzuntzan and the other Lakes Region sites are lower, Burial 10 was probably not a good choice to represent the region.

The E19 mean and range of $\delta^{18}O_p$ for bone, is considerably lower than the ranges for bone determined for two other Teotihuacan sites, Tlajinga 33 (Buckley et al. 2021; White et al. 2004b) and TL6 of Tlailotlacan (Table 4, Figure 11; White et al. 2004a). All three sites had important foreign relationships, but apparently with different regions.

Table 4. Comparative oxygen isotope data.

Collection	Material	Number	$\delta^{18}O_p$ ‰ VSMOW (mean)	SD ‰	Range $\delta^{18}O_p$ ‰ VSMOW
E19	bone	19	+12.9	0.7	+11.7– 14.7
	enamel	22	+14.7	1.3	+12.0–17.6
Patzcuaro Basin	bone	8	+13.2	1.0	+12.1–15.2
Zacapu Basin	bone	7	+14.3	0.6	+13.5–15.0
	enamel	7	+15.5	0.8	+14.5– 17.0
Tlajinga 33	bone	20	+14.9	0.9	+13.9–17.7
	enamel	21	+15.4	1.5	+11.3–18.1
TL6	bone	17	+15.1	0.7	+13.4–16.5
	enamel	39	+15.9	1.0	+13.3–18.9

To date, E19 is the only site in Teotihuacan with a large suite of low $\delta^{18}O_p$ values. Other sites in its vicinity like 22:N1W6 (Cid Beziez and Torres Saunders 1999; Torres Saunders and Cid Beziez 2018) have not produced any evidence of West Mexico ties, but it might be worthwhile to conduct oxygen isotope analyses of some of their skeletons. Burial 15, after all, is closer to 22:N1W6 than to E19 and had no definite Michoacan materials, but still showed a strong pattern of low $\delta^{18}O_p$.

This reconstruction of population movements and affiliations is tentative, and admittedly runs the risk of conflating isotopes with identities. It is a hypothesis that will require further investigation before it can be accepted (or rejected) with confidence. That investigation should include several threads. Of particular importance is a comprehensive osteological analysis of all E19 burials: sex and precise age assessments, trauma, perimortem treatment (dismemberment, defleshing, decapitation), and morphology (cranial modification and rare anomalies like persisting metopic suture or cranial-caudal shifts in the vertebrae). Also, more isotopic analysis of the E19 burials, including those not considered in this study (e.g. Burials 5, 28, and 43), is necessary. These should include the earliest burials (Early Tlamimilolpa phase) to determine whether the original occupants of E19 were Patzcuaro Basin immigrants or Teotihuacanos who later developed a relationship with Patzcuaro Basin people. It would be helpful to have more than one enamel sample from each individual, to better track movement during childhood and adolescence. Strontium isotope as well as oxygen isotope measurements should be used, as the two methods complement each other (e.g., Buckley et al. 2021; White et al. 2007). Strontium isotope ratios may help to resolve the ambiguities in the oxygen isotope data between the Valley of Oaxaca and the Patzcuaro Basin, and between Teotihuacan and the Zacapu Basin. More samples from Michoacan, including the Cuitzeo Basin, will be needed. The isotopic data presented here confirm the Teotihuacan-Michoacan connection, pointing particularly to the Patzcuaro Basin as the Michoacan terminus and demonstrating that the relationship involved something deeper than just trade, but it will take more analyses to clarify the nature of that relationship.

References

AlQahtani, Sakher, Mark Hector, and Helen Liversidge
2010 Brief Communication: The London Atlas of Human Tooth Development and Eruption. *American Journal of Physical Anthropology* 142:481–490.
2014 Accuracy of Dental Age Estimation Charts: Schour and Massler, Ubelaker, and the London Atlas. *American Journal of Physical Anthropology* 154:70–78.

Begun, Erica
2008 The Many Faces of Figurines: Figurines as Markers of Ethnicity in Michoacan. *Ancient Mesoamerica* 19:311–318.
2013 *Detecting Ethnicity at Teotihuacan through Archaeology: The West Mexican Presence at Structure N1W5:19*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Iowa, Iowa City.

Buckley, Gina M., Rebecca Storey, Fred J. Longstaffe, David M. Carballo, Kenneth G. Hirth, and Virginia Renson
2021 New Perspectives on Migration into the Tlajinga District of Teotihuacan: A Dual-Isotope Approach. *Latin American Antiquity* 32:536–556.

Buikstra, Jane E., and Douglas H. Ubelaker (editors)
1994 *Standards for Data Collection from Human Skeletal Remains*. Arkansas Archaeological Survey Research Series 44. Arkansas Archaeological Service, Fayetteville.

Carballo, David M., Kenneth G. Hirth, Daniela Hernández Sariñana, Gina M. Buckley, Andrés G. Mejía Ramón, and Douglas J. Kennett
2019 New Research at Teotihuacan's Tlajinga District, 2012–2015. *Ancient Mesoamerica* 30:95–113.

Carot, Patricia
2001 *Le site de Loma Alta, lac de* Zacapu*, Michoacán, Mexique*. BAR International Series 920. Archaeopress, Oxford.

Cid Beziez, José Rodolfo
1998 Diacronía y sincronía en el sector oeste de la antigua ciudad de Teotihuacán. In *Los ritmos de cambio en Teotihuacán: Reflexiones y discusiones de su cronología*, edited by Rosa Brambila and Rubén Cabrera, pp.317–322. Instituto Nacional de Antropología e Historia, Mexico City.

Cid Beziez, José Rodolfo, and Liliana Torres Sanders
1999 Los entierros del occidente de la ciudad. In *Prácticas funerarias en la ciudad de los dioses: Los enterramientos de la antigua Teotihuacan*, edited by Linda Manzanilla and Carlos Serrano, pp. 285–344. Universidad Nacional Autónoma de México, Mexico City.

Clayton, Robert N., and Toshiko K. Mayeda
1963 The Use of Bromine Pentaflouride in the Extraction of Oxygen from Oxides and Silicates for Isotopic Analysis. *Geochimica et Cosmochimica Acta* 27:43–52.

Coplen, Tyler B.M.
2011 Guidelines and Recommended Terms for Expression of Stable-Isotope-Ratio and Gas-Ratio Measurement Results. *Rapid Communications in Mass Spectrometry* 25:2538–2560.

Cowgill, George L.
2015 *Ancient Teotihuacan: Early Urbanism in Central Mexico*. Cambridge University Press, New York.

Crowson, Ronald A., William J. Showers, Ellen K. Wright, and Thomas C. Hoering
1991 Preparation of Phosphate Samples for Oxygen Isotope Analysis. *Analytical Chemistry* 63:2397–2400.

Darras, Véronique
1993a La lítica tallada de Las Lomas; la industria tallada de Loma Alta. In *Arqueología de las Lomas en la cuenca lacustre de Zacapu, Michoacán, México*, edited by Charlotte Arnauld, Patricia Carot, and Marie-France Fauvet-Berthelot, pp. 168–171. Cuadernos de Estudios Michoacanos 5. Centre d'Études Mexicaines et Centraméricaines, Mexico City.
1993b La industria tallada de Loma Alta (Mich.66). In *Arqueología de las Lomas en la cuenca lacustre de Zacapu, Michoacán, México*, edited by Charlotte Arnauld, Patricia Carot, and Marie-France Fauvet-Berthelot, pp. 171–175. Cuadernos de Estudios Michoacanos 5. Centre d'Études Mexicaines et Centraméricaines, Mexico City.

Faugère-Kalfon, Brigitte
1996 *Entre Zacapu y Río Lerma: Culturas en una zona fronteriza*. Cuadernos de Estudios Michoacanos 7. Centro de Estudios Mexicanos y Centroamericanos, Mexico City.

Feinman, Gary M., Linda M. Nicholas, and Edward F. Maher
2008 Domestic Offerings at Palmillo: Implications for Community Organization. *Ancient Mesoamerica* 19:175–204.

Filini, Agapi
2004 *The Presence of Teotihuacan in the Cuitzeo Basin, Michoacán, Mexico*. BAR International Series 1279. Archaeopress, Oxford.
2021 Teotihuacan and West Mexico: Ritual, Exchange, and Interdependence. In *Teotihuacan and Early Classic Mesoamerica: Multiscalar Perspectives on Power, Identity, and Interregional Relations*, edited by Claudia García-Des Lauriers and Tatsuya Murakami, pp. 214–234. University Press of Colorado, Louisville.

Filini, Agapi, and Efraín Cárdenas García
2007 El Bajío, la cuenca de Cuitzeo y el estado teotihuacano. Un estudio de relaciones y antagonismos. In *Dinámicas culturales entre el Occidente, el Centro-Norte y la cuenca de México, del Preclásico al Epiclásico*, edited by Brigitte Faugère, pp. 137–154. El Colegio de Michoacán, Zamora.

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press

Firsching, F. Henry
1961 Precipitation of Silver Phosphate from Homogeneous Solution. *Analytical Chemistry* 33:873–874.

Gómez Chávez, Sergio
1998 Nuevos datos sobre la relación de Teotihuacán y el Occidente de México. In *XXIV Mesa Redonda de la Sociedad Mexicana de Antropología*, edited by Rosa Brambila Paz, pp. 1461–1493. Sociedad Mexicana de Antropología, Mexico City.
2002 Presencia del Occidente de México en Teotihuacan: Aproximaciones a la política exterior del estado teotihuacano. In *Ideología y política a través de materiales, imágenes y símbolos: Memoria de la Primera Mesa Redonda de Teotihuacan*, edited by María Elena Ruiz Gallut, pp. 563–625. Instituto Nacional de Antropología e Historia, Mexico City.
2012 Structure and Organization of Neighborhoods in the Ancient City of Teotihuacan. In *The Neighborhood as a Social and Spatial Unit in Mesoamerican Cities*, edited by M. Charlotte Arnauld, Linda R. Manzanilla, and Michael E. Smith, pp. 74–101. University of Arizona Press, Tucson.
2017 Foreigners' Barrios at Teotihuacan: Reasons for and Consequences of Migration. In *Teotihuacan: City of Water, City of Fire*, edited by Matthew H. Robb, pp. 102–107. University of California Press, Oakland.

Gómez Chávez, Sergio, and Julie Gazzola
2007 Análisis de las relaciones entre Teotihuacán y el Occidente de México. In *Dinámicas culturales entre el Occidente, el Centro-Norte y la cuenca de México, del Preclásico al Epiclásico*, edited by Brigitte Faugère, pp. 113–135. El Colegio de Michoacán, Zamora.
2021 Interaction, Ethnicity, and Subsistence Strategies among the Minority Groups of the Ancient City of Teotihuacan. In *Teotihuacan and Early Classic Mesoamerica: Multiscalar Perspectives on Power, Identity, and Interregional Relations*, edited by Claudia García-Des Lauriers and Tatsuya Murakami, pp. 74–102. University Press of Colorado, Louisville.

Gómez Chávez, Sergio, and Michael W. Spence
2012 Interaction among the Complex Societies of Classic-Period Mesoamerica. In *The Oxford Handbook of Mesoamerican Archaeology*, edited by Deborah Nichols and Christopher A. Pool, pp. 283–297. Oxford University Press, Toronto.

Hirth, Kenneth G., David M. Carballo, Mark Dennison, Sean Carr, Sarah Imfeld, and Eric Dyrdahl
2019 Evolution of an Obsidian Craft Workshop at Teotihuacan, Mexico. *Ancient Mesoamerica* 30:163–179.

Lind, Michael, and Javier Urcid
2010 *The Lords of Lambityeco: Political Evolution in the Valley of Oaxaca during the Xoo Phase*. University Press of Colorado, Boulder.

Longinelli, Antonio
1984 Oxygen Isotopes in Mammal Bone Phosphate: A New Tool for Paleohydrological and Paleoclimatological Research? *Geochimica et Cosmochimica Acta* 48:385–390.

Lovejoy, C. Owen, Richard Meindl, T. Pryzbeck, and Robert Mensforth
1985 Chronological Metamorphosis of the Auricular Surface of the Ilium: A New Method for the Determination of Age at Death. *American Journal of Physical Anthropology* 68:15–28.

Luz, Boaz, and Yehoshua Kolodny
1985 Oxygen Isotope Variations in Phosphate of Biogenic Apatites, IV: Mammal Teeth and Bones. *Earth and Planetary Science Letters* 75:29–36.

Macías Goytia, Angelina, and Katina Vackimes Serret
1988 Tres Cerritos, Cuitzeo, Michoacán. In *Primera reunión sobre las sociedades prehispánicas en el Centro Occidente de México, memoria*, edited by Rosa Brambila and Ana Crespo, pp. 161–164. Cuaderno de Trabajo 1. Centro Regional de Querétaro, Mexico.

Manzanilla, Linda R.
2017 Teopancazco: A Multiethnic Neighborhood Center in the Metropolis of Teotihuacan. In *Multiethnicity and Migration at Teopancazco: Investigations of a Teotihuacan Neighborhood Center*, edited by Linda R. Manzanilla, pp. 1–48. University Press of Florida, Miami.

Manzanilla, Linda R., Gabriela Mejía, Gerardo Jiménez, Peter Schaaf, Becket Lailson, Gabriela Solís, Pedro Morales, and Edith Cienfuegos
2012 Caracterización de la población multiétnica de Teopancazco por isótopos estables, isótopos de estroncio y elementos traza. In *Estudios arqueométricos del centro del barrio de Teopancazco en Teotihuacan*, edited by Linda R. Manzanilla, pp. 449–465. Universidad Nacional Autónoma de México, Mexico City.

Manzanilla López, Rubén
1988 Salvamento arqueológico en Loma de Santa María, Morelia, Michoacán. In *Primera reunión sobre las sociedades prehispánicas en el Centro Occidente de México, memoria*, edited by Rosa Brambila and Ana Crespo, pp. 2151–159. Cuaderno de Trabajo 1. Centro Regional de Querétaro, Mexico.

Michelet, Dominique, and Grégory Pereira
2009 Teotihuacan et l'Occident du Mexique. In *Teotihuacan: Cité des Dieux*, pp. 196–204. Musée du Quai, Branly, France.

Millon, René, R. Bruce Drewitt, and George L. Cowgill
1973 *Urbanization at Teotihuacan, Mexico: Volume 1, the Teotihuacan Map, Part 2*. University of Texas Press, Austin.

Morales Puente, Pedro, Edith Cienfuegos Alvarado, Linda R. Manzanilla Naim, and Francisco Javier Otero Trujano
2012 Estudio de la paleodieta empleando isótopos estables de los elementos carbono, oxígeno y nitrógeno en restos humanos y de fauna encontrados en el barrio teotihuacano de Teopancazco. In *Estudios arqueométricos del centro del barrio de Teopancazco en Teotihuacan*, edited by Linda R. Manzanilla, pp. 347–423. Universidad Nacional Autónoma de México, Mexico City.

Moreiras Reynaga, Diana K.
2019 *The Life Histories of Aztec Sacrifices: A Stable Isotope Study (C, N, and O) of Offerings from Tlatelolco and the Templo Mayor of Tenochtitlan*. Unpublished Ph.D. dissertation, Department of Anthropology, University of Western Ontario, London.

Moreiras Reynaga, Diana K., Jean-François Millaire, Ximena Chávez Balderas, Juan A. Román Berrelleza, Leonardo López Luján, and Fred J. Longstaffe
2021 Residential Patterns of Mexica Human Sacrifices at Mexico-Tenochtitlan and Mexico-Tlatelolco: Evidence from Phosphate Oxygen Isotopes. *Journal of Anthropological Archaeology* 62:101296

Nado, Kristin
2017 *Dietary Practices, Socioeconomic Status, and Social Mobility at Teotihuacan, Mexico*. Unpublished Ph.D. dissertation, School of Human Evolution and Social Change, Arizona State University, Tempe.

Neff, Hector
2011 Appendix B: INAA Report from Hector Neff. In *Detecting Ethnicity at Teotihuacan through Archaeology: The West Mexican Presence at Structure N1W5:19*, by Erica Begun, pp. 180–190. Department of Anthropology, University of Iowa, Iowa City.

Ortega Cabrera, Verónica
2014 *La presencia oaxaqueña en Teotihuacan durante el Clásico*. Unpublished Ph.D. dissertation, Programa en Estudios Mesoamericanos, Universidad Nacional Autónoma de México, Mexico City.

Parsons, Elsie
1936 *Mitla, Town of the Souls, and Other Zapotec Speaking Pueblos of Oaxaca*. University of Chicago Press, Chicago.

Pereira, Grégory
1996 Nuevos hallazgos funerarios en Loma Alta, Michoacán. In *Las cuencas del Occidente de México (Época Prehispánica)*, edited by Eduardo Williams and Phil C. Weigand, pp. 105–129. El Colegio de Michoacán, Zamora.
1997 Costumbres funerarias y sociedad del Clásico tardío en la cuenca de Zacapu, Michoacán. *Arqueología* 18:61–84.
1999 *Potrero de Guadalupe: Anthropologie funéraire d'un communauté pré-Tarasque du nord du Michoacán, Mexique*. BAR International Series 816. Archaeopress, Oxford.
2006 Las sepalturas. In *Cueva de Los Portales: Un sitio arcaico del norte de Michoacán*, edited by Brigitte Faugère, pp. 105–113. Instituto Nacional de Antropología e Historia, Mexico City.
2013 Cerámica funeraria del Cerro Barajas: Seriación y cronología. In *Tradiciones cerámicas del Epiclásico en el Bajío y regiones aledañas: Cronología e interacción*, edited by C. Pomédio, G. Pereira and E. Fernández-Villanueva, pp. 47–63. BAR International Series 2519. Archaeopress, Oxford.

Pereira, Grégory, and Isaac Barrientos
2020 Evidencias de cremación en el sitio de El Palacio, Zacapu, Michoacán. In *El Palacio. Historiography and New Perspectives on a*

Pre-Tarascan City of Northern Michoacán, Mexico, edited by Marion Forest, pp. 251–270. Paris Monographs in American Archaeology. Archaeopress, Oxford.

Pérez Ríos, Ofelia Karime, and Sergio Gómez Chávez
2022 *Informe del estudio de los restos óseos de la E19 y del pozo de agua de N1W5 y N1W6, temporada 2021*. Report to the Instituto Nacional de Antropología e Historia, Mexico City.

Pollard, Helen Perlstein
1996 La transformación de élites regionales en Michoacán central. In *Las cuencas del Occidente de México* (*Época Prehispánica*), edited by Eduardo Williams and Phil C. Weigand, pp. 131–156. El Colegio de Michoacán, Zamora.
2000 Tarascans and their Ancestors: Prehistory of Michoacán. In *Greater Mesoamerica: The Archaeology of West and Northwest Mexico*, edited by Michael S. Foster and Shirley Gorenstein, pp. 59–70. University of Utah Press, Salt Lake City.
2008 A Model of the Emergence of the Tarascan State. *Ancient Mesoamerica* 19:217–230.

Pollard, Helen Perlstein, and Laura Cahue
1999 Mortuary Patterns of Regional Elites in the Lake Patzcuaro Basin of Western Mexico. *Latin American Antiquity* 10:259–280.

Price, T. Douglas, James H. Burton, Lori E. Wright, Christine D. White, and Fred Longstaffe
2007 Victims of Sacrifice: Isotopic Evidence for Place of Origin. In *New Perspectives on Human Sacrifice and Ritual Body Treatments in Ancient Maya Society*, edited by Vera Tiesler and Andrea Cucina, pp.263–292. Springer, New York.

Price, T. Douglas, Linda Manzanilla, and William D. Middleton
2000 Immigration and the Ancient City of Teotihuacan: A Study Using Strontium Isotope Ratios in Human Bone and Teeth. *Journal of Archaeological Science* 27:903–913.

Price, T. Douglas, Michael W. Spence, and Fred J. Longstaffe
2021 The Temple of Quetzalcoatl, Teotihuacan: New Data on the Origins of the Sacrificial Victims. *Ancient Mesoamerica* 32:215–230.

Puaux, Olivier
1989 *Les pratiques funéraires tarasques: aproche archéologique et ethnohistorique*. Unpublished Ph.D. dissertation, Université de Paris 1, Panthéon-Sorbonne, Paris.

Punzo Díaz, José Luis
2022 Revisando las exploraciones arqueológicas en el sitio de Tingambato, Michoacán: Nuevos datos, nuevas tecnologías. *Latin American Antiquity* 33:79–96.

Quade, Jay, Thure E. Cerling, John C. Barry, Michele E. Morgan, David R. Pilbeam, Allan R. Chivas, Julia A. Lee-Thorp, and Nikolaas J. van der Merwe
1992 A 16-Ma Record of Paleodiet using Carbon and Oxygen Isotopes in Fossil Teeth from Pakistan. *Chemical Geology* 94:183–192.

Rangel Campos, David
2018 *Datación de la cerámica de Tingambato mediante la técnica de Arqueomagnetismo*. Tesis de licentiatura, Escuela Nacional de Antropología e Historia, Mexico City.

Schaaf, Peter, Gabriela Solís, Linda R. Manzanilla, Teodoro Hernández, Becket Lailson, and Peter Horn
2012 Isótopos de estroncio aplicados a estudios de migración humana en el centro del barrio de Teopancazco, Teotihuacan. In *Estudios arqueométricos del centro del barrio de Teopancazco en Teotihuacan*, edited by Linda R. Manzanilla, pp. 425–448. Universidad Nacional Autónoma de México, Mexico.

Scheuer, Louise, and Sue Black
2000 *Developmental Juvenile Osteology*. Academic Press, New York.

Schwarcz, Henry P., Linda Gibbs, and Martin Knyf
1991 Oxygen Isotope Analysis as an Indicator of Place of Origin. In *Snake Hill: An Investigation of a Military Cemetery from the War of 1812*, edited by Susan Pfeiffer and Ronald Williamson, pp. 262–268. Dundern Press, Toronto.

Shemesh, Aldo
1990 Crystallinity and Diagenesis of Sedimentary Apatites. *Geochimica et Cosmochimica Acta* 54:2433–2438.

Shemesh, Aldo, Yehoshuo Kolodny, and Boaz Luz
1983 Oxygen Isotopic Variations in Phosphate of Biogenic Apatites: II. Phosphoritic Rocks. *Earth and Planetary Science Letters* 64:405–416.

Spence, Michael W.
1996 Commodity or Gift: Teotihuacan Obsidian in the Maya Region. *Latin American Antiquity* 7:21–39.
2000 From Tzintzuntzan to Paquimé: Peers or Peripheries in Greater Mesoamerica. In *Greater Mesoamerica: The Archaeology of West and Northwest Mexico*, edited by Michael S. Foster and Shirley Gorenstein, pp. 255–261. University of Utah Press, Salt Lake City.
2002 Domestic Ritual in Tlailotlacan, Teotihuacan. In *Domestic Ritual in Ancient Mesoamerica*, edited by Patricia Plunket, pp. 53–66. Monograph 46. Cotsen Institute of Archaeology, Los Angeles.

Spence, Michael W., and Christine D. White
2009 Mesoamerican Bioarchaeology: Past and Future. *Ancient Mesoamerica* 20:233–240.

Spence, Michael W., Christine D. White, Julie Gazzola, Sergio Gómez Chávez, and Fred J. Longstaffe
2006 *Oxygen-Isotope Values and Population Movements in Structure 19, Teotihuacan*. Paper presented at the 71st Annual Meeting, Society for American Archaeology, San Juan.

Spence, Michael W., Karyn Olsen, M. Oralia Cabrera Cortés, and Fred J. Longstaffe
2020 San José 520: An Unusual Teotihuacan Settlement System. *Latin American Antiquity* 31:720–732.

Storey, Rebecca
1992 *Life and Death in the Ancient City of Teotihuacan*. University of Alabama Press, Tuscaloosa.

Stuart-Williams, Hilary Le Q., and Henry P. Schwarcz
1995 Oxygen Isotope Analysis of Silver Orthphosphate Using a Reaction with Bromine. *Geochimica et Cosmochimica Acta* 59:3837–3841.

Stuart-Williams, Hilary Le Q., Henry P. Schwarcz, Christine D. White, and Michael W. Spence
1996 The Isotopic Composition and Diagenesis of Human Bone from Teotihuacan and Oaxaca, Mexico. *Palaeogeography, Palaeoclimatology, Palaeoecology* 126:1–14.

Suchey, Judy, and Darryl Katz
1998 Applications of Pubic Age Determination in a Forensic Setting. In *Forensic Osteology: Advances in the Identification of Human Remains*, edited by Kathleen Reichs, pp. 204–236. Charles C. Thomas, Springfield.

Torres Sanders, Liliana, and José Rodolfo Cid Beziez
2018 *Vida y salud en conjuntos habitacionales del sector oeste de Teotihuacan*. Instituto Nacional de Antropología e Historia, Mexico City.

Velázquez González, Miguel Angel
2013 *Los pozos de agua como elementos urbanos en el desarrollo de la ciudad de Teotihuacan*. Tesis de licentiatura, Escuela Nacional de Antropología e Historia, Mexico City.

Webb, Emily C., Christine D. White, and Fred. J. Longstaffe
2014 Investigating Inherent Differences in Isotopic Composition between Human Bone and Enamel Bioapatite: Implications for Reconstructing Residential Histories. *Journal of Archaeological Science* 50:97–107.

White, Christine D., Michael W. Spence, Fred J. Longstaffe, and Kimberley R. Law
2000 Testing the Nature of Teotihuacán Imperialism at Kaminaljuyú Using Phosphate Oxygen-isotope Ratios. *Journal of Anthropological Research* 56:535–558.
2004a Demography and Ethnic Continuity in the Tlailotlacan Enclave of Teotihuacan: The Evidence from Stable Oxygen Isotopes. *Journal of Anthropological Archaeology* 23:385–403.

White, Christine D., Michael W. Spence, Fred J. Longstaffe, Hilary Le Q. Stuart-Williams, and Kimberley R. Law
2002 Geographic Identities of the Sacrificial Victims from the Feathered Serpent Pyramid, Teotihuacan: Implications for the Nature of State Power. *Latin American Antiquity* 13:217–236.

White, Christine D., Michael W. Spence, Hilary Le Q. Stuart-Williams, and Henry Schwarcz

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press

1998 Oxygen Isotopes and the Identification of Geographical Origins: The Valley of Oaxaca Versus the Valley of Mexico. *Journal of Archaeological Science* 25:643–655.

White, Christine D., Rebecca Storey, Fred J. Longstaffe, and Michael W. Spence

2004b Immigration, Assimilation and Status in the Ancient City of Teotihuacan: Stable Isotope Evidence from Tlajinga 33. *Latin American Antiquity* 15:176–198.

White, Christine D., T. Douglas Price, and Fred J. Longstaffe

2007 Residential Histories of the Human Sacrifices at the Moon Pyramid: Evidence from Oxygen and Strontium Isotopes. *Ancient Mesoamerica* 18:159–172.

Widmer, Randolph J.

1987 The Evolution of Form and Function in a Teotihuacan Apartment Compound. In *Teotihuacan: Nuevos datos, nuevas sintesis, nuevos problemas*, edited by Emily McClung de Tapia and Evelyn Childs Rattray, pp. 317–368. Universidad Nacional Autónoma de México, Mexico City.

https://doi.org/10.1017/S0956536122000347 Published online by Cambridge University Press