Trace-Element Analysis of Oaxacan Ceramics: Insights into the Regional Organization of Ceramic Production and Exchange in the Valley of Oaxaca during the Late Classic (AD 550-850)

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PROJECT BACKGROUND:

Although the Valley of Oaxaca is home to one of the best documented examples of primary state formation, expansion, and subsequent decline in the New World (Blanton *et al.* 1999), many questions remain about the valley's ***economic networks*** and their relation to political developments, particularly in the centuries preceding state dissolution toward the end of the Late Classic (AD 650-850).

Archaeologists have long tied the emergence of specialized craft production and regional networks of exchange to the centralization of political authority and the stability provided by a state-level administrative system (Brumfiel and Earle 1987; Clark and Parry 1990; Service 1975). Yet it has become increasingly clear that ancient economies varied considerably, both in terms of degree of political control and level of commercialization (Blanton *et al.* 1996; M. Smith 2004). An area of active research is how relationships between political and economic institutions influenced the overall resilience of states as political entities, and how the economic behavior of common households contributed to or responded to political change.

At the end of the Late Classic, after 1300 years of political dominance over the region, the hill-top city of Monte Albán gradually fell into decline and was largely abandoned (Blanton 1978; Winter 2003; Blomster 2008). Monte Albán's longevity must have been due, in part, to the resilience of its political and economic institutions, raising the question of what conditions precipitated its loss of authority and eventual collapse. Current evidence suggests that by the Classic Period (AD 550-850), production and exchange in the Valley of Oaxaca were articulated through a network of periodic markets (Feinman and Nicholas 2012), but we have little solid information on the spatial scale and organization of this system, much less on how it developed or dissolved in response to political change, or how these factors affected households' production, consumption, and exchange decisions.

This study focuses on pottery - a key component of every household's inventory - as a mechanism for tracking such changes in economic organization. Our current understanding of the location of pottery production and the spatial scale over which economic transactions occurred in the valley is based largely on the distribution of ceramic types in regional surveys (Feinman 1980; Kowalewski *et al.* 1989), supplemented (and revised) by recent analyses of excavated materials from key sites (e.g. Elson and Sherman 2007; Feinman and Nicholas 2012; Markens and Martínez López 2009). These data suggest that (1) during the early periods of Monte Albán dominance (prior to *ca.* 200 CE), pottery production generally remained non-centralized and locally distributed, although the exchange of high-quality ceramics between elite segments was an important means of valley-wide integration; (2) during the Monte Albán IIIA (*ca*. 200 - 500 CE) period, Monte Albán emerged as an important center for ceramic production and distribution; and (3) by the end of the Monte Albán IIIB/IV periods (*ca.* 500 - 850 CE), ceramic access became more localized and exchange links between regions ruptured as the valley became politically balkanized. All of these hypotheses, however, stand to be verified and refined using robust measures of ceramic exchange, such as those provided by compositional analyses of ceramic pastes.

The collaborative projects presented here examine the Late Classic (late MA IIIB/IV or Xoo phase) and were designed to elucidate intra-valley ceramic production and exchange in the final centuries preceding the decline of the Monte Albán state. To date, we have completed trace-element analyses of over 1300 ceramics vessels via instrumental neutron activation analysis (INAA), and we have begun to identify centers of pottery production and to trace the movement of pottery vessels from producer to consumer. Questions driving this study included:

(1) What was the economic role of Monte Albán during this time period? Is there evidence that the political capital was also a center of manufacture of domestic goods such as pottery, or that it was a hub for exchange transactions as a regional market center?

(2) What was the spatial scale and intensity of exchange interactions during the Xoo phase as viewed from a regional perspective? How far did ceramic vessels travel from producer to consumer?

3) Is the overall pattern of exchanges consistent with what we would expect with a hierarchically integrated market network? If not, in what key ways does it differ?

4) Finally, is there any evidence of divisions within the valley during the Xoo phase, indicating that political fragmentation created barriers to exchange? That is, do all parts of the valley share exchanges with Monte Albán, or do some sites appear to have been relatively isolated?

Working with materials from residential structures, the projects recognize the household as a critical unit of production and consumption within the Zapotec state (Feinman and Nicholas 2007). By comparing households of differing social status, location, and participation in craft production, we hope to gain information not only on the scale of exchange interactions, but on patterns of consumption and market participation, and potential change through time.

The research activities undertaken here represent a two-prong approach. These include, first, a clay survey and chemical characterization of ceramic raw materials to document regional trends and intra-valley variation in clay composition throughout the valley, supplementing earlier work completed by Minc and Sherman (2011). The goal of these analyses is to establish a regional framework to support intra-valley ceramic provenance determinations. Second, we conducted trace-element analyses of ceramic samples from Late Classic-period sites of interest, from collections under the control of Mexico's *Instituto Nacional de Antropologia e Historia* (INAH). By focusing on both production debris and residential waste, we are able to examine patterns of production and consumption at the household level, and to examine evidence for inter-community exchange in basic utilitarian goods.

(1) Survey of field clays in the Valley of Oaxaca.

In order to establish a basis for fine-grained ceramic provenance determination in the Valley of Oaxaca, Minc had initiated the Oaxaca Clay Survey in 2007 with support from the Wenner-Gren foundation (Minc and Sherman 2011). In 2012, Leah Minc and OSU graduate student Jeremias Pink conducted additional clay sampling over a period of several weeks in order to fill in lacunae apparent in the original survey. To date, the Oaxaca Survey has now sampled natural clays in more than 300 locations throughout the valley (Fig. 1).

The clay survey was designed to capture variation in clay composition throughout the valley, as this reflects differences in parent material, weathering, erosion, and redeposition. The bedrock geology of the valley is quite complex, consisting of three main complexes:

- Metamorphic complex of Precambrian date, consisting largely of dioritic gneisses along the western side of the valley, but with localized outcrops of meta-granites and meta-anorthosites;

- Sedimentary complexes of largely Cretaceous date, consisting of limestones, conglomerates, and very fine-grained calcareous mudstones known locally as calcilutites that extend in an irregular band through the center;

- More recent (i.e. Tertiary) volcanic complexes of andesite and ignimbrite in the eastern arm, and along the eastern side of the southern arm.

Because of this complexity, we had initially stratified our field sampling strategy to evaluate clays associated with a variety of different bedrock types. In our second field season, we conducted more intensive surveys around potential ceramic production sites (including San Agustín, Cuilapan de Guerrero, and Loma del Trapiche), as well as Classic-period sites whose ceramics are being analyzed as part of this study: Monte Albán, Jalieza, Dainzú-Macuilxóchitl, El Palmillo, and Yaasuchi.

Our survey to locate clays consisted of pedestrian and vehicle survey to identify places where soil profiles were exposed, such as river and stream cuts, road cuts, and excavations for house foundations. Exposed strata were tested in the field for clay content using the ribbon method, and clay-rich strata sampled for analysis. In addition, clay locations were briefly described and documented photographically, and lat-long coordinates recorded with a handheld GPS unit.

All clay samples were exported to the OSU Archaeometry lab for processing, where the clays were formed into tiles, dried, and fired at 800˚ C for 1 hour in an oxidizing environment, to convert them into the equivalent of sherds prior to analysis. The clay samples were then characterized via INAA using protocols identical to those used for ceramics.

The resulting clay data enable us to model how clay composition varies within the valley. Using spatial averaging algorithms, we created a series of contour maps that indicate how element concentrations vary spatially (for details on methodology, see Minc and Sherman 2011). Data from 306 field clay and modern pottery locations were utilized, with input data consisting of concentration values for 29 elements (Al, As, Ba, Ca, Ce, Co, Cr, Cs, Dy, Eu, Fe, Hf, K, La, Lu, Mn, Na, Nd, Rb, Sc, Sm, Ta, Tb, Th, Ti, U, V, Yb, and Zn). The concentration data were first screened for global and local outliers, and transformed to $\log_{10}$ values to better conform to a gaussian distribution. Following interpolation, we generated a regular 1-km grid of smoothed concentration values for each element. This grid was cropped to correspond to the Valley of Oaxaca settlement survey boundary, resulting in 2823 grid points within the valley against which the composition of archaeological ceramics could be compared. This final grid provides more uniform spatial coverage and extrapolates slightly beyond the spatial extent of the original clay survey data points.

Results of the OCS survey and analysis indicate that groups of elements clearly track the influence of different bedrock types, and contribute to regional differences in clay composition. For example, Ba, Mn, and the REE (including La as shown in Fig. 2A) reflect the distribution of metamorphic parent materials. Calcium content, not surprisingly, is an excellent marker of the influence of sedimentary strata (Fig. 2B), while Cs, Rb, and As reflect the influence of andesite and particularly ignimbrite (Fig. 2C). When the topo maps for all elements are combined, they provide a profile of average clay composition over a regular 1-km grid within the valley.

In addition, the clay survey data clearly indicate the complexity of clay formation within the valley. Geological parent materials that appear as discrete units on maps of surficial bedrock, are not in actuality monolithic or homogenous units on the ground. Rather, superimposed units can be spatially interdigitated, with metamorphic, sedimentary, and volcanic rock strata contributing to local clay composition. Further, these parent materials are discontinuous at the surface, such that outcrops of the same material may create similar clays in spatially distinct areas. These maps, do however, reveal general trends in clay composition and provide a sense of the scale of geochemical variability (that is, which areas share highly similar clays and therefore represent a single geochemical "source"). Most importantly, the clay survey results allow us to match ceramics to specific areas on the landscape and to establish ceramic provenance within the Valley of Oaxaca (Minc *et al.* 2013; Minc and Pink 2013).

(2) Selecting ceramic samples representing Late Classic Zapotec pottery production and consumption. With permission from the *Instituto Nacional de Antropologia e Historia*, Minc and colleagues examined archived ceramic collections, with an eye to selecting a sample of sherds for export and compositional analysis. Our sample focused on two types of collections: materials from domestic contexts from Classic-period sites (MA IIIB/IV), and production debris or "wasters" from known ceramic producing centers (Fig. 3; Table 1). Details on sampling strategy follow below for each of these sites.

Table 1. Overview of Ceramic Sample Analyzed

Site	Total Ceramic Sample
Monte Albán	194
Yaasuchi	311
Jalieza	245
Dainzú	149
Lambityeco	113
El Palmillo	259
Loma del Trapiche	25
Cuilapan	31
San Agustín	45
Total to date:	1372

● **Monte Albán**

Monte Albán remained the political capital of the Zapotec state and its largest population center from its founding in *ca.* 300 BCE, to its abandonment at the close of the Late Classic (MA IIIB/IV) period, in *ca*. 800 CE. Yet there is considerable debate concerning its economic role and the extent to which it functioned as an economic central place for the surrounding region. Based on the paucity of production debris encountered in surface surveys of the site, Blanton (1978) suggested that Monte Albán played a largely political role, and was not a significant producer of basic goods such as ceramics. In contrast, Feinman (1982:197-200, 1985:215-220) argued that Monte Albán was a center of specialized ceramic production at least during the Late Classic, based on the abundance and distribution of fairly standardized vessel forms and pastes in the immediate hinterlands of the site.

More recently, Markens and Martínez López (2009) have summarized direct evidence of ceramic production (the presence of kilns and associated ceramic wasters) at Monte Albán. They conclude that during the Terminal Formative (MA II or Nisa phase), Monte Albán was a major producer of at least one ceramic ware, i.e., the elaborate *crema* vessels used to signal elite status (Elson and Sherman 2007). Thirty-one kilns dating to the Nisa phase have been encountered in the site center, some in close proximity to the main plaza of the site, suggesting that political elites may have exerted a controlling interest over the manufacture of these high status wares (Markens and Martínez López 2009:139).

In contrast, evidence for ceramic production in later time periods is much less abundant. During the Late Classic period (Xoo phase), at the peak of Monte Albán's power, evidence of ceramic production is so far limited to six kilns, all located within relatively low status residential areas far from the political center (Markens and and Martínez López 2009:140; Fig. 4). The kilns are of two types: (1) a simple circular pit with the walls reinforced with stone; and (2) the more technically sophisticated updraft kiln consisting of two chambers, an upper firing chamber for the vessels and a lower one for the fuel (Markens and Martínez López 2009:141-142; Winter and Payne 1976). In spite of clear advances in firing technology, however, production appears to have been organized as a household industry and the volume of vessels produced was fairly low.

Our MA IIIB/IV (Xoo phase) sample from Monte Albán was designed to elucidate this community's role as both a producer and a consumer of ceramics. In collaboration with Marcus Winter, Robert Markens, and Cira Martínez López (Centro INAH, Oaxaca), we selected a total of 174 Xoo phase sherds comprising the main pastes or wares identified for Classic-period ceramics (Markens 2004, 2008), from collections archived at the ex-Convento de Cuilápam (Table 2). The ceramics represent household production and consumption within two residential areas, as well as wasters drawn from throughout the site.

The first residential area located approximately 1 km northeast of the main plaza. Three main contexts were sampled. **House 3** (PMA 72-73 Est. 3) is a small domestic structure with a single patio, immediately adjacent to two kilns, and interpreted as the low-status residence of potters. Ceramic samples from fill south and east of the patio presumably represent vessels utilized in household activities. **Feature 5** (PMA 72-73 E. 5) is a large, cylindrical updraft kiln excavated into bedrock and constructed of stone and adobe, roughly 1.5 m in diameter and 0.7 m in depth (Winter and Payne 1976). The kiln contained burned earth and stones, but few sherds. **Feature 71** (PMA 72-73 E. 71) is a somewhat smaller updraft kiln, with a diameter of 1.0 m, which contained large sherds from reconstructable vessels; these have been interpreted as kiln furniture (broken vessels used to support or cover the vessels to be fired). No clear wasters (warped or blistered sherds representing over-firing) were found in either context, and some of the kiln contents may represent household debris thrown in after they were abandoned.

Our second residential production facility was a medium-status Late Classic Period residence (PSCMA-91, **Unidad Habitacional A**) located on Terrace 508 (Blanton 1978) on the slope of Cerro el Plumaje (Fig. 5). The location was just a few meters east of the access road going to Monte Albán, and the residence (also referred to as House Pitayo-A) was excavated as part of a salvage operation when the road to the site was expanded in 1991 (González Licón 1999). The house consisted of at least six rooms with stone walls built around a central patio; the overall house plan is square (10 x 10 m) with an interior patio area of 5 x 5.50 m. Associated ceramics indicate that the house was built during MA IIIA and occupied until period MA V (González Licón *et al.* 1999; González Licón 2003:83). No ceramics were sampled from the house proper.

This domestic structure had an associated activity area with double-chambered updraft kiln **(Elemento 1**), located to the south of the house compound. The kiln was constructed of stone and lined with clay, and measured 1.5 m in diameter and 1.4 m deep where most complete (cf. Markens and Martínez-López [2009: 142] who state the dimensions as only 60 cm deep). As described by Markens and Martínez-López (2009: Table 3) the kiln was full of burned earth and stones, and ceramics with spongy pastes and vitrified surfaces. We analyzed a sample of 14 sherds from this context (MA_87 – MA_100), some of which are clearly production debris.

Finally, we sampled a small collection of **ceramic wasters** (N=20) recovered from various locations at the site and archived at the ex-Convento de Cuilápam under the rubric "*defectos de cocción*". All are of *gris* paste, and display bloating, warping, cracking, and/or vitrification characteristic of over-firing. The samples range in date from MA Late I to MA IIIB/IV, with 10 samples assigned to the Late Classic (see Appendix I for illustrations).

As a whole, the Monte Albán sample is designed to determine which ceramic wares were produced at Monte Albán during the Late Classic and to establish a compositional signature for ceramic production at this site. Analyses of household consumption will examine whether ceramic production at Monte Albán matched the demand for pottery of its residents, or whether local residents imported pottery from elsewhere in the valley.

Table 2. Sample of ceramics from Monte Albán by context and ware

Context	***Café***	***Café cremoso***	***Café fina***	***Gris***	***Gris cremoso***	**Total**
House 3	10	16	0	29	24	79
Feature 05 (large kiln)	3	3	0	0	1	7
Feature 71 (small kiln)	17	11	4	22	20	74
House A, Feature 1 (kiln)	0	0	0	11	3	14
Wasters	0	0	0	20	0	20
Total	30	30	4	82	48	194

● Jalieza

Located in the Ocotlán-Zimatlán arm of the valley, "Greater Jalieza" emerged as a major population center during the Late Classic, second in size only to Monte Albán. Recent investigations at the site directed by Christina Elson (2005; Elson *et al.* 2010) have explored the remains of two Late Classic civic-ceremonial buildings and two residences, and conducted systematic surface collections of a random sample of structures throughout the site.

The two Late Classic residences are located both located along the ancient road leading from Jalieza over the pass to the Tlacolula subvalley (Fig. 6). **House 2** is located adjacent to a small ceremonial mound group (Mounds 16 and 17) that may have controlled access to the pass, while **House 7** is on a high terrace near the top of the slope. Both structures were made of stone, adobe, and plaster and incorporate stone-lined tombs, suggesting they belonged to people occupying middle-to-upper levels of local society. Both residences contained abundant domestic and ritual pottery smashed on the patio floor. At House 7, the pottery included 91 reconstructable vessels (including bowls, jars, and *apaxtles*) stored in the west side of the patio. The presence of burned *adobe* covering the pottery suggests that the house and its contents were destroyed by a conflagration (Elson *et al.* 2010:18). At Structure 2, in contrast, the mix of debris on the patio suggests a midden built-up from neighboring residences after the house was abandoned. No evidence of ceramic production was encountered at either locale, but both structures provide insights into consumption practices and participation in exchange networks.

Trace-element analyses were designed to provide clear indications of the proportion of local vs. imported ceramics at this important Late Classic center, and indicate whether exchange interactions were affected by the declining power of the Zapotec state. With permission from INAH and the local community of Sto. Tomás Jalieza, Leah Minc and OSU graduate student Sarah Walker reviewed the Jalieza collections stored in the local museum and selected a total of 245 artifacts for analysis (Table 3). This sample includes 89 vessels from Structure 2, 78 vessels from the patio of Structure 7, and 68 vessels collected during surface survey from 8 different areas that were recorded as having exclusively or predominantly Late Classic material (Elson *et al.* 2010). In addition, 10 samples of mold-made ceramic figurines were included. Analyses of these samples will be completed as part of Ms. Walker's thesis research during the 2014-2015 academic year.

Table 3. Sample of ceramic vessels from Jalieza by context and ware

Ware	Est. 2	Est. 7	Surface	Total
Amarillo	2	0	1	3
Café	20	14	14	48
café con engobe negro	2	5	2	9
Gris	44	55	44	143
gris con engobe negro	4	4	1	9
gris oxidado	17	0	1	23
Figurines	5	2	3	10
Total	89	78	68	245

● **Dainzú-Macuilxóchitl**

Dainzú-Macuilxóchitl is a large dispersed settlement located in the Tlacolula arm of the Oaxaca Valley, some 20 km southeast of Monte Albán. Regional surveys (Kowalewski *et al.* 1989) and limited excavations at the site (Bernal 1967; Bernal and Oliveros 1988; Oliveros 1997) show occupation extended from the Formative period (Rosario phase *ca.* 700 - 500 BCE) to European contact.
Recent research conducted by Ronald (Sonny) Faulseit has focused on the Late Classic period at Dainzú, with the goal of clarifying the domestic economy of the site and its role within the Zapotec state during its apogee and subsequent decline. In 2007-2008, Faulseit conducted intensive mapping and controlled

surface collection of domestic terraces largely dating to the Late Classic; he returned to the site in 2009 to conduct excavations of a sample of residential terraces (Faulseit 2008, 2012, 2013).

Our sample of ceramics comes from Terrace S19, located on the southern edge of the site (Fig. 7). Excavations revealed an earlier eastern patio complex, consisting of three rectangular houses with stone foundations arranged around a central patio dating to MA IIIB/IV, and a later, western complex, constructed in a similar manner. For this study, collaborator Ronald Faulseit selected a sample of 148 sherds, of which 119 samples date to the Xoo phase (Table 4). This sample includes evidence of ceramic production, in the form of 21 *gris* wasters marked by warping and blistering (Fig. 8), which establish a compositional signature for the site. The remainder of the Xoo sample included a cross-section of the major wares and vessel forms common at the site, and was designed to examine evidence for participation in exchange systems and possible differential access to traded wares based on status differences within the site. Filling out the sample are ceramics diagnostic of earlier and later periods, including ten G23 hemispherical vessels with large incised grooves dating to the Middle Classic (MA IIIA/IIIB transition), and 19 vessels characteristic of the Early Post-classic/Liobaa phase, including six G3M and 13 *ollas* with cross-hatch striations on their exterior (chronology following Markens 2008).

Table 4. Sample of ceramics from Dainzú by context and ware

Vessel form:	***Amarillo***	***Café***	***Gris***	***Total***
Cajete (MA IIIA)	0	0	13	13
Cajete (Liobaa)	0	0	3	3
Cajete cónico	20	3	4	27
Cántaro	0	0	15	15
Chirmorlera	0	0	5	5
Desecho de Cerámica	0	0	21	21
Olla sencilla	7	14	6	27
Pasta Café con Lineas Externas (Liobaa)	0	13	0	13
Sahumador con Mango Hueco	0	0	4	4
Sahumador con Mango Sólido	0	19	1	20
Total	27	48	72	148

● **Lambityeco**

Located roughly midway between Dainzú-Macuilxóchitl and Mitla in the center of the Tlacolula subvalley, Lambityeco is one of the most well studied secondary centers in the Valley of Oaxaca. Between 1962 and 1974, a comprehensive surface survey and targeted excavations were conducted at the site under the direction of John Paddock. Identification of numerous differences in construction methods and ceramic assemblages relative to Monte Albán led Paddock to propose that the site was principally occupied following the decline of Monte Albán during the Early Postclassic (or MAIV; AD 600-750) (Paddock 2003[1983]). However, Lambityeco is now widely recognized to be contemporaneous with the height of Monte Albán's occupation during the Xoo phase of the Late Classic (or MAIIB-IV; AD 650-850) (Feinman and Nicholas 2011; Lind and Urcid 2010; Markens *et al.* 2010; Winter 1989).

During the Late Classic, Lambityeco was one of the principal political and economic centers in the Tlacolula subvalley, and was the second largest center (after Dainzú-Macuilxóchitl) in terms of both population and mound volume (Lind and Urcid 2010:34-40). And yet, soils in the vicinity of the site were generally too thin or saline to support maize agriculture, especially given the low rainfall of the Tlacolula subvalley (Lind and Urcid 2010:49-51), suggesting that Lambityeco residents were dependent upon other communities for access to staple goods. Lind and Urcid (2010) have argued that Lambityeco acted as a political and economic "district center" where residents engaged in domestic craft production for exchange to supply the majority of household needs. While residents of Lambityeco would have likely engaged in production of multiple commodities, the most economically important good produced at the site was salt. Since the 1970s, survey and excavation at the site has revealed substantial evidence that many households at Lambityeco took advantage of the saline soils of the area to engage in intensive domestic salt production (Lind and Urcid 2010:51-60). While there is less direct evidence of ceramic production at the site, unusually high densities of Xoo phase ceramics, including wasters, suggest that this may have been an important household economic activity as well.

To establish a trace-element signature for ceramic production at Lambityeco and to evaluate the degree of interaction with other centers within and beyond the Tlacolula subvalley, a sample of 113 Xoo phase ceramics were selected for trace element analysis from collections taken during two seasons of excavation conducted by Martínez López and colleagues (2006) as part of a salvage operation associated with an expansion of the International Highway (Table 5). The majority of the sample was taken from two commoner residences (Structure 1 and Structure 2) in 'Area B', a residential ward located 50 m east of Mounds 195 and 190 (Fig. 9); the patio area of Structure 2 was used to process salt. Our ceramic sample from Structure 1 consisted of 53 ceramics, while 5 samples were selected from Structure 2. Notably, this sample included 8 wasters displaying warped and bloated pastes and representing domestic production of *cántaros* or thin-walled water jars.

Table 5. Sample of Xoo phase ceramics from Lambityeco by context and ware

Type	Area B, Estructura 1	Area B, Estructura 2	Area C, Elemento 1	Total
Amarillo	1	0	17	18
Café	9	0	0	9
café cremosa	1	0	0	1
Gris	32	5	33	71
gris con engobe negro	0	0	5	5
gris oxidado	4	0	0	4
gris Pulido	1	0	0	1
negro Pulido	5	0	0	5
Total	53	5	55	113

The remainder of the Lambityeco sample was selected from 'Area C', a second commoner residential area (ca. 130 m E-W by 50 m N-S), located adjacent to and parallel with the highway (Ruta 190) north of Mounds 184 and 196 (Fig. 9). Specifically, our sample of 55 ceramics was drawn from Elemento 1, a very productive midden deposit located within Area C. The midden was roughly oval in shape, 3 by 5 m in size and 60 cm deep. The midden appears to have served as fill to level the landscape, in that it had been deposited in an irregular depression. It contained a large quantity of ceramics dating to the Xoo phase, including semi-complete cajetes cónicos of the G.35 type, along with figurines, *sahumadores, ollas*, lithic fragments, charcoal, carbonized seeds, and animal bones. In total, 43 bags containing nearly 16,000 sherds were recovered, of which the vast majority (99.3%) date to the Xoo phase. No ceramic wasters were noted in this midden collection, so our sample is taken to represent debris from nearby households.

● El Palmillo

El Palmillo is a large hilltop terrace settlement situated at the far eastern edge of Tlacolula arm of the Valley of Oaxaca near the contemporary community of Santiago Matatlán. During the Middle to Late Classic period (ca. A.D. 500-850), the site was one of the largest centers (other than Monte Albán) in the valley with over 1400 terraces housing at least 4000-5000 inhabitants. The site was first recorded in 1980 as part of the Valley of Oaxaca Settlement Pattern Project (Kowalewski *et al.* 1989), and was subsequently mapped and collected in greater precision in 1997 by Gary Feinman and Linda Nicholas (Feinman and Nicholas 2004a). Since 1999, Feinman and Nicholas have conducted 10 field seasons of residential excavations at the site, focusing on the horizontal excavation of eight domestic units/houses, representing both lower and upper strata of the population (Fig. 10). The excavations have yielded detailed records of how each of these residential units changed over time, generally over the course of three to four remodeling episodes (Feinman 2007; Feinman *et al.* 2002).

As selected by collaborators Gary Feinman and Linda Nicholas, our ceramic sample from El Palmillo consists of 259 ceramics drawn from collections now archived in the community museum at Santiago Matatlán (Table 6). Approximately 30 sherds were selected from each of the excavated 8 houses, with an attempt to include the range of common ceramic wares (*amarillo, café*, and *gris*) and vessel forms. The majority of these ceramics (N=220) date to the Middle to Late Classic, while a small number come from contexts dating somewhat earlier (Early to Middle Classic, N=39). No direct evidence of ceramic production (in the form of wasters) was encountered in this material. By sampling ceramics from houses across the socio-economic spectrum, we will be able to address such questions as whether the community of El Palmillo engaged in the exchange of utilitarian pottery during the Late Classic, or whether it was all locally produced, and whether wealthier households (represented by residences at higher elevations) had access to a greater diversity of pottery sources than did commoner households.

Table 6. Sample of ceramics from El Palmillo by terrace and ware

Context	*Amarillo*	*Café*	*Gris*	*Gris oxidada*	Total
T. 335	7	7	18	0	32
T. 507	7	3	21	0	31
T. 925	7	4	26	0	37
T. 1147/48	6	3	23	0	32
T. 1162	2	4	23	1	30
T. 1163	6	3	23	0	32
P. 11	6	7	22	0	35
St. 35	4	4	22	0	30
Total	43	35	178	1	259

● **Yaasuchi** (La Ciénega)

As part of his thesis research, Jeremias Pink (2014) analyzed a collection of materials from the site of Yaasuchi, located in the Valle Grande less than 15 km south of Monte Albán. In contrast to the larger communities discussed above, Yaasuchi was a hamlet or small village of less than 200 people during the Late Classic. Excavations at the site by Jason Sherman (2005) revealed two modest, Late Classic residential structures, **Structure 5B** and **Structure 6**, the latter of which was associated with clear evidence of ceramic production (Feature 1)(Sherman 2005:188-242; Fig. 11). **Feature 1** consisted of a roughly circular concentration (*ca*. 3 m in diameter) of reddish-brown soil with charcoal fragments, ash, burned earth, and large quantities of ceramics, including kiln wasters of *gris* and *café* pastes. The feature has been interpreted as an impermanent ceramic firing facility similar to that reported by Balkansky *et al.* (1997) and still in use in the valley today, which contrasts with the more formal kilns unearthed at Monte Albán and elsewhere (Markens and and Martínez López 2009). The ceramic collections from Yaasuchi therefore provide a critical point of contrast with the analyses proposed for other sites and collections, in both scale of production and settlement ranking within the valley.

Pink (2014) selected a sample of 311 Late Classic sherds from excavation and surface collections from Yaasuchi, from materials now archived by INAH, Oaxaca in the ex-Convento de Cuilápam (Table 7). The sample was devised as a stratified random sample of the predominate wares (*gris* and *café*) divided between Structure 5B, Stucture 6, and Feature 1. An additional sample was selected from surface collections taken from outside the vicinity of Structures 5B and 6; this sample was restricted the most common Late Classic ware, the G35 conical bowl.

The sample from Feature 1 is designed to assess the variety of wares and forms produced at the site, and to establish a signature for local production. Household debris from Structures 5B and 6 was selected to assess the extent to which these households were self-sufficient in their pottery needs and the extent to which they may have participated in larger exchange networks. Finally, the surface collections over the larger site are designed to assess the extent to which the Yaasuchi producers supplied the local community. As part of the Oaxaca Clay Survey, Pink conducted an intensive survey around the site of Yaasuchi to assess the availability of local clay resources. Trace-element analyses of these clays and a comparison with locally produced ceramics elucidate potters' choices regarding raw material selection and processing.

Table 7. Sample of ceramics from Yaasuchi by context and ware

Context:	*Café*	*Gris*	Total
F. 1 (firing feature)	31	34	65
Structure 5B	48	51	99
Structure 6	54	51	105
Surface	0	42	42
Total	132	173	311

● **Other Production Contexts**

In addition to the residential focus of the preceding sites, our sample included a limited number of sherds from three sites that appear to have been centers of ceramic production.

Located along the western piedmont 12 km to the north of Monte Albán, **Loma del Trapiche** was a center of ceramic production during the Late Classic. Winter and Nardín (1982) report on two kilns of Late Classic date encountered during salvage operations. Our sample comes from Feature 1, a large (2.4 m diameter) kiln, containing an abundance of large sherds which appear over-fired, with a whitish surface cast, and presumably represent production debris (perhaps used to cover the contents of the kiln during firing). Our sample of 25 Late Classic sherds includes three clear wasters exhibiting warping (Fig. 12a).

The site of **Cuilapan** is located just 6 km southwest of Monte Albán within the western Valle Grande. Salvage excavations at the COBAO School uncovered the remains of three cylindrical kilns, two dating to the Formative and one from the Late Classic period. No clear kiln wasters were encountered in these collections, and ceramics recovered from within the kilns may represent debris swept into a convenient pit left after the kilns were abandoned. However, since Cuilapan was an important population center from the Formative up to European contact, it was highly desirable to establish a chemical signature for pottery produced at this site. To that end, a sample of 31 sherds from three different kilns was selected for INAA; of these, only nine clearly date to the Late Classic.

The site of **San Agustín de las Juntas**, located along the eastern side of the Valle Grande 7 km southeast of Monte Albán, provides compelling evidence for intensive ceramic production. This mounded site was first identified during regional site survey as a potential producer of grey wares, based on the very high densities of MA I *grís* ceramics that covered the surface: survey teams complained that "*casi no se puede ver la tierra por los tepalcates*" (Blanton *et al.* 1982:254; Feinman 1986:356-357). Salvage operations in 1979 by Hébert Montaño confirmed its status as a major ceramic producer, with the excavation of kilns and thick middens of warped and twisted ceramic wasters (Winter 1984:195). During the Late Formative, San Agustín appears to have specialized in the production of fine paste gray *cántaros* and flat-bottomed bowls with incised bases (G-12). Continued production during the Xoo phase is indicated by the presence of kilns with Late Classic fill, and may have included the manufacture of G.35 bowls (M. Winter, pers. comm.). A total of 45 gray-ware sherds were selected from production contexts, and includes 13 obvious wasters of Formative date which establish a chemical signature for pottery produced from local clays (Fig. 12b), and six Xoo phase samples.

SAMPLE PREPARATION AND ANALYSIS VIA INAA

All exported samples were prepared for INAA in the OSU Archaeometry Lab. Ceramic samples were photographed (interior, exterior, profile), and a small portion of the sherd removed for analysis. Surface contamination on this piece was removed with a tungsten carbide burr or rotary file, the piece was rinsed with deionized water, dried, and pulverized.

All samples were characterized for a suite of 30 major, minor and trace elements, through a protocol of two neutron irradiations in the OSU TRIGA reactor and multiple counts of gamma activity. To quantify elements with short half-life isotopes, approximately 250 mg of pulverized material was encapsulated in high-purity polyethylene vials, and delivered via pneumatic tube to an in-core location with a nominal thermal neutron flux of 10^{13} n · cm^{-2} ·s^{-1} . The 7-s irradiation was followed by two separate counts of resultant gamma activity, one after a 15-minute decay (for Al, Ca, Ti, and V) and a second count after 2-hr decay (for Dy, Mn, K, and Na); both counts were for 540 seconds using a 25-30% relative efficiency HPGe detector. Beginning in April, 2013, this protocol was revised to a 20-s pneumatic tube irradiation, followed by a single count of gamma activity (540 s real-time) for short half-life isotopes after a 22-minute decay.

To quantify elements with intermediate and long half-live isotopes, sample materials were subjected to a 14-hr irradiation in the rotating rack of the reactor, a location which experiences a nominal thermal neutron flux of 2.3 x 10^{12} n · cm^{-2} ·s^{-1}. Again, two separate counts of gamma activity were acquired; the first count of 5000 s (live-time) began 6 days after the end of irradiation, while the second count for 10000 s followed a 4-week decay. These two counts provided data on As, La, Lu, K, Na, Sm, U, Yb, and Ba, Ce, Co, Cr, Cs, Eu, Fe, Hf, Nd, Rb, Sb, Sc, Ta, Tb, Th, and Zn, respectively. Element concentrations were determined via the direct comparison method; three replicates of the standard reference material NIST1633a (coal fly ash) and one of NIST688 (basalt) were utilized as standards. All data reductions were based on current consensus element libraries utilized by the Missouri University Research Reactor for archaeological materials (Glascock 2006). Finally, microphotographs of ceramic pastes were taken of the fresh break at magnifications of 50x, 100x, and 200x to record visual paste characteristics, including the color, size, angularity, and abundance of inclusions.

STATISTICAL ANALYSES

Based on the total sample of more than 1300 Late Classic ceramic vessels analyzed to date, we have identified multiple chemical composition groups representing different centers of ceramic production. Compositional reference groups were identified through the standard analytical sequence consisting of (1) preliminary group identification through bivariate and multivariate exploratory data analysis techniques, (2) group refinement to create statistically homogeneous core groups using a jack-knifed Mahalanobis distance statistic, and (3) re-evaluation of all samples for membership in refined compositional group based on multivariate measures of similarity. In order to assess the provenance of each group, we evaluated their fit with both production debris and natural clays. Individual clays and wasters were tested for membership in each of the ceramic composition groups, using the multivariate Mahalanobis distance (D^2) statistic, the assumption being that a high probability of membership reflects a match in composition.

Reference group definition. Each site was first examined individually, and obvious outliers and subgroups were noted. The goal was to identify a “main” group for each site since, according to the principle of local abundance, the most prevalent group probably represents local manufacture. All preliminary groups so defined were then checked for internal homogeneity using a jack-knifed Mahalanobis distance measure. In this test, also called “leave-one-out”, each case is removed one at a time and then statistically compared against the group composed of the remaining samples. If the group is homogeneous, the removal of a single sample will have minimal impact on its location and spread, and the jack-knifed case will have a high probability of membership in the remaining group. Samples with low probabilities of group membership are removed until a coherent composition group is attained. The resultant composition groups (or reference groups) are then compared against all other groups, to check for possible overlap.

Principal components analysis. Multivariate statistical evaluation of composition groups can be severely limited by small group size: the rule of thumb suggests that group membership should be at least three times that of the number of variables (or elements) used in the analysis. When this rule is violated, groups can become expansive or overly inclusive of dissimilar members, as group structure (based on inter-element correlations) is underspecified. Thus, principle components analysis (PCA) is often used to reduce the dimensionality of the data set and provide a new set of axes (components) for group evaluation and testing. These components represent weighted linear combinations of the elements, and are extracted to account for strong inter-element correlations or covariances representing major dimensions of geochemical variability. In the present data set, owing to the small sample sizes for some composition groups, within group distances were calculated based on principal component scores rather than element concentrations.

In order to identify geographically and geochemically sensitive dimensions of variation, a robust PCA was first calculated on clay samples, and then applied to the ceramic samples. The PCA was based on the log(10) values of 27 elements (Al, Ca, Dy, Mn, K, Na, Ti, V, As, Ba, La, Lu, Sm, Yb, Ce, Cs, Cr, Co, Eu, Hf, Fe, Rb, Sc, Ta, Tb, Th, Zn), working with a reduced set of clay and modern ceramic samples (N=301) which had been screened to remove samples with extreme element values relative to archaeological ceramic samples. In addition, a robust estimation procedure was used to calculate the variance-covariance matrix; this procedure is appropriate when the dataset contains outliers, as it effectively down-weights outlying values based on their distance from the multivariate group centroid (SAS 2013). The first seven principal components initially accounted for 90% of covariance structure; PCs beyond this number provided little explanatory power. These seven components were then rotated using a Quartimin (oblique) rotation in order to cluster variables onto these new axes; because the oblique rotation relaxes the requirement of orthogonality normal to PCA, the rotated factors share some variance and thus sum to greater than 100%. Total structure coefficients (correlations between the PC axis and original elements) are presented in Table 8. Regional distributions of principle component scores are illustrated in Figure 13.

Rotated Component 1 (accounting for 27.6% of the variance) represents the co-variation of the rare-earth elements (REE) along with some of the transition metals (Sc, Fe, Co, and Zn). High values for this component clearly track the geochemical contribution of the dioritic gneisses along the western edge of the valley.

Rotated Component 2 (8.8%) reflects covariation among all the first series transition metals (FSTM). Positive values are highest along the margins of the study area, particularly in the Mixtepec and Jalieza areas, but also along the eastern side of the Etla branch.

Rotated Component 3 (18%) accounts for covariation among Cs, Rb, Th, and Ta. Values are high in the eastern Tlacolula branch reflecting the influence of Tertiary andesites and ignimbrites, and extremely low in the area of meta-granite and meta-anorthosite in the Etla branch.

Rotated Component 4 (8.2%) tracks the contribution of high field-strength elements (Hf, Ta, Ti) in field clays, with high values for this component concentrating along the west-central portion of the valley and extending onto the valley floor.

Rotated Component 5 (15.9%) reflects the influence of calcareous sedimentary parent materials, with a high correlation with calcium. Positive values for this component extend through the center of the study area, but also reflect outcrops of sedimentary materials in other areas.

Rotated Component 6 (23.6%) tracks covariation among As, Rb, and Cs, a trio of elements associated with the geochemistry of Tertiary andesites. High values for this component extend from the eastern Tlacolula branch and south along the eastern side of the Ocotlán subvalley. In addition, positive values for this component are found along the valley floor in the Valle Grande, perhaps reflecting the movement of andesitic sands along the Atoyac River.

Finally, **Rotated Component 7** (12.2%) is strongly correlated with sodium. Negative values for this component track the presence of sedimentary parent materials (Rotated Component 5), suggesting a dilution effect by calcium, while positive values appear to track the alluvium throughout the valley.

Assigning samples to the most-likely reference group. All samples not utilized in the definition of reference groups as defined above were tested for membership in the established groups, the assumption being that a high probability of membership reflects a match in composition and a common geographic origin. For samples without a strong probability of group membership in any group, Discriminant Analysis (based on 27 elements) was used to assign samples to the most likely reference group. All samples that appeared to be non-local to a given site were also assessed by comparing their composition to that of reference groups using a profile plot of 27 elements. Element values were first normalized by dividing by the grand mean for the OCS samples, in order to put all elements on a common scale, and then ordered and plotted by geochemical group (major elements, transition metals, alkali elements, rare-earth elements, and high field-strength incompatibles). Individual samples were plotted against the mean values for reference groups, so that differences in the ratios of key elements could be readily evaluated and overall fit assessed.

Establishing provenance. In order to establish the geographic origin of ceramic composition groups, all clay samples and grid points were tested for group membership in each reference group. Probabilities of group membership were based on the 7 rotated OCS principal components, although comparable results were obtained using other metrics (see Pink 2014 for analyses of Yaasuchi ceramics). These probabilities were then mapped, to create a contour map indicating the most-likely area(s) of origin, and to identify the spatial scale of the source area. The result enabled us to determine whether the reference group matched a geographically localized clay signature, or whether the group matched extensive or multiple areas of similar clays.

Finally, for individual ceramic samples that could not be assigned to one of the reference groups, we attempted to identify locations(s) within the valley with the most similar clay compositions using our interpolated map of clay chemistry. First, the most likely fit was identified based on mean percent deviation between the ceramic sample and each grid point across a profile of 27 elements; profile plots were then used to assess the degree of fit with points identified as the most likely match. This strategy allowed us to suggest areas of provenance, even when we lacked a well-defined reference group for that area to serve as a statistical basis of comparison.

Table 8. Total structure coefficients for robust PCA of OCS samples, followed by Quartimin rotation

	Rot_PC1	Rot_PC2	Rot_PC3	Rot_PC4	Rot_PC5	Rot_PC6	Rot_PC7
% Variance:	*27.6*	*8.8*	*18.0*	*8.2*	*15.9*	*23.6*	*12.2*
Al	0.175	0.131	-0.161	-0.310	**-0.637**	0.060	0.306
Ca	-0.234	0.023	-0.087	-0.183	**0.966**	-0.068	-0.129
K	0.209	-0.278	0.342	0.021	-0.098	0.272	-0.173
Na	-0.023	-0.098	-0.318	-0.015	-0.204	-0.248	**0.942**
Sc	**0.732**	**0.714**	-0.072	-0.036	-0.386	0.184	0.174
Fe	**0.677**	**0.700**	-0.175	0.049	-0.454	0.153	0.252
Co	**0.510**	**0.770**	-0.186	-0.004	-0.369	0.155	0.446
Zn	**0.622**	0.480	-0.076	-0.249	-0.250	0.243	0.141
V	0.335	**0.855**	0.139	0.012	-0.118	0.235	0.010
Cr	0.260	**0.825**	0.141	-0.057	-0.169	0.245	0.064
Mn	0.280	**0.573**	-0.016	0.136	-0.202	0.411	0.355
Ba	**0.492**	-0.297	-0.177	0.354	-0.158	-0.171	0.208
La	**0.918**	0.075	0.101	0.309	-0.319	-0.098	0.132
Ce	**0.895**	0.175	0.079	0.329	-0.337	-0.071	0.158
Sm	**0.958**	0.265	-0.058	0.192	-0.378	0.005	0.190
Eu	**0.830**	0.128	-0.316	0.167	-0.439	-0.082	0.276
Tb	**0.939**	0.284	-0.031	0.137	-0.301	0.060	0.151
Dy	**0.955**	0.333	-0.002	0.162	-0.318	0.044	0.085
Yb	**0.940**	0.328	0.057	0.167	-0.245	0.085	0.008
Lu	**0.925**	0.345	0.120	0.176	-0.256	0.103	-0.025
As	-0.206	0.080	0.354	-0.196	0.009	**0.955**	-0.283
Rb	0.007	0.043	**0.765**	-0.122	-0.048	**0.527**	-0.379
Cs	-0.483	0.023	**0.580**	**-0.503**	0.050	**0.594**	-0.330
Th	0.044	0.043	**0.901**	0.233	0.003	0.198	-0.308
Ta	0.090	0.132	**0.698**	**0.495**	-0.005	0.105	-0.198
Ti	0.274	0.480	0.044	**0.520**	-0.222	-0.039	0.216
Hf	0.233	-0.121	0.344	**0.787**	-0.042	-0.017	-0.098

PROVENANCE RESULTS

Based on the distinctive composition groups apparent in our corpus of 1300 Xoo phase ceramics, at least 17 different areas were producing the Late Classic ceramics utilized by the communities investigated here (Fig. 14). Separation of these groups in multivariate space on canonical variates axes is illustrated in Figures 15-17. The composition groups can be lumped into five geochemical macro-groups reflecting parent materials: anorthosite of the northern Etla branch, gneiss of the Western Valle Grande (WVG), calcareous sedimentary rocks of the Eastern Valle Grande (EVG), andesite-derived clays of the southeastern Valle Grande (SEVG), and the ignimbrites and andesites of the Tlacolula branch.

(1) *Cremosa* ceramics. Our first two reference groups consist of *cremosa* ceramics (Fig. 18). *Cremosa* refers to the presence of whitish, plagioclase inclusions (either natural or added as temper), which come from the localized outcrop of weathered meta-anorthosite [pC(An)] north of Monte Albán. This area was utilized during the Formative period for the production of *crema* wares, and is still mined today as a temper source by the potters of Santa María Atzompa (Thieme 2001).

- **Monte Albán-Trapiche *Cremosa*** ceramics are enriched in Al and Na (Fig. 18) owing to the presence of the plagioclase inclusions, and have diluted (low) concentrations of most other elements. The Late Classic group overlaps strongly with Formative-era *crema* ceramics, suggesting little modification of the raw materials. The MA-Trapiche *Cremosa* group contains all the wasters and production debris from Loma del Trapiche. Four clays from the Atzompa area immediately north of Monte Albán (OCS_064A, OCS_064B, OCS_064D, and OCS_065) join with the MA-Trapiche *Cremosa* group, but both Loma del Trapiche and Atzompa would have had fairly direct access to these distinctive clays, given the distribution of the meta-anorthosite parent material.

- **High Fe *Cremosa*** group are similarly high in Al and Na, but are somewhat higher in iron and the rare earth elements (REE), suggestive of contributions from clays derived from the western precambrian gneiss. Two clays (OCS_190 and OCS_192) match this group; both are from alluvial deposits along the Río del Pueblo drainage to the west of San Lorenzo Cacaotepec. Rather than a different production source, we therefore suggest that this second composition group represents a somewhat different paste recipe involving gneiss-derived alluvial clays. Both composition groups (or paste recipes) were utilized for the full range of *gris, gris cremosa, café*, and *café cremosa* wares, although the High Fe paste was much more common in the production of *cafés*.

(2) Western Valle Grande groups. Five composition groups reflect the geochemical diversity of the western Valle Grande. All reflect the composition of gneiss-derived clays in that they are relatively high in the REEs, and low in Cs and Rb.

- The **NW Valle Grande** is a small composition group characterized by higher concentrations of Sc and lower concentrations of Rb and Th; the composition group also exhibits a positive Eu anomaly relative to other compositions groups from the western valley (Fig. 19). Clays with significant probabilities of membership in this group are located in the NW Valle Grande near the site of Cuilapan, including OCS_058, OCS_060, and OCS_263. We tentatively attribute the group to clays in the Cuilapan area, although only 1 out of 9 Late Classic ceramic samples found in association with the Cuilapan COBAO kilns are members of this group. Two wasters from Monte Albán (one Formative [MA_68] and one from the Late Classic [MA_88]) are associated with this reference group, and the group is well represented in kiln furniture at Monte Albán, suggesting that potters from Monte Albán may have accessed clays near Cuilapan as well.

- The **Yaasuchi Medium REE group** is abundant at Yaasuchi. Its compositional profile closely matches clay samples from the western Zimatlán valley, including a *barro negro* deposit less than 0.5 km from the site of Yaasuchi (YCS_308A, YCS_336A, and YCS_337B), suggesting that the most likely source of these ceramics was Yaasuchi itself (Pink 2014).

- The **Yaasuchi High REE group** is marked by extreme concentrations of the REE and a negative Eu anomaly. The most similar clay sample (OCS_046B) was collected from a buried clay deposit exposed in a road-cut about 1.5 km northeast of Yaasuchi, although the match is not close. However, the principal of local abundance (this group occurs primarily in the Yaasuchi collections) and group membership of a ceramic production waster from Yaasuchi both suggest that the High REE group was manufactured at Yaasuchi, despite the lack of local clay samples with a significant probability of membership (Pink 2014).

- The **Middle Atoyac/Zaachila** is a large composition group characterized by lower concentrations of REEs and slightly higher concentrations of Cs relative to other groups from the Western Valle Grande (Fig. 20). This compositional signature is consistent with alluvial clays near the Río Atoyac where REE-rich, gneiss-derived sediments from the Western Valle Grande are mixed with Cs-rich volcanic sediments from upstream in the Tlacolula Valley (Pink 2014). Clays with significant probabilities of belonging to this group were alluvial clays collected near the middle stretch of the Río Atoyac in the Southern Etla and Northern Valle Grande, including OCS_038 (7 km east of Yaasuchi), OCS_057 (1 km southeast of Zaachila), OCS_052B (5 km northeast of Zaachila), and OCS_186B (on the Atoyac below Atzompa). While a significant portion of this compositional group may represent Zaachila, the largest Late Classic center on the Atoyac, half of the Yaasuchi production wasters (n=3) excavated by Sherman (2005) belong to this group, and it was by far the most abundant in contexts most directly associated with the surface-firing feature (Feature 1) at Yaasuchi. This suggests that ceramics of this composition group were locally-produced at Yaasuchi (although with clays procured near the Atoyac) as well as at Zaachila.

- The **Monte Albán Gris** group consists largely of gray wares from the kilns at Monte Albán. Although none of the samples are clearly wasters, we attribute this group to Monte Albán based on its limited distribution at that site and from the association with clays from the immediate vicinity of Monte Albán, including Xoxocotlán (OCS_177), Monte Albán (OCS_178), and Atzompa (OCS_182). Its compositional profile is similar to the Middle Atoyac/Zaachila composition group, but has slightly higher calcium concentrations.

(3) The **Monte Albán-Eastern Valle Grande (MA-EVG)** composition group shows strong affinities to calcareous clays derived from sedimentary [Ki(lu-ar)] bedrock, in particular, the calcilutites characterized by high concentrations of calcium (Fig. 21). These parent materials underlie Monte Albán, but similar clays also extend for a considerable distance along the eastern Valle Grande, from San Agustín de las

Juntas south around Cerro Tilcajete. Significantly, 16 *gris* wasters from Monte Albán belong to this group, as do Formative-period ceramic wasters from San Agustin de las Juntas and samples from modern potters at San Bartolo Coyotepec. Thus, this composition group may represent production at several sites within a crescent-shaped source region stretching from Monte Albán, east to San Agustín de las Juntas, and south to Coyotepec. We note that calcium values vary from high in ceramics from San Agustín de las Juntas (especially in the Formative wasters), to relatively low in MA-EVG ceramics from the southern Valle Grande (including Xoo phase ceramics from Yaasuchi and Jalieza), suggesting that it may be possible to subdivide this group in the future.

(4) SE Valle Grande-Ocotlán composition groups come from the site of Jalieza, situated in a particularly complex area geologically, where sedimentary, volcanic, and even metamorphic parent materials interdigitate. Chemically, andesite seems to dominate, as these ceramics are low in calcium (Fig. 22), but two very different groups can be distinguished.

- The **Jalieza High Cr** group is (as the name suggests) distinctively high in Cr:Fe ratios relative to the rest of the valley. Clays most similar to this group are found in a narrow band stretching south across the Jalieza pass from OCS_094 at Sta. Cecilia Jalieza to OCS_224 east of San Martin Tilcajete. Generically, this group is similar to the Dainzú Café group, but can be readily distinguished by its elevated concentrations of Cr (e.g., Cr:Sc ratios).

- The **Jalieza Low Ca** group, in contrast, has substantially lower values of calcium than the fore-going. Similar clays are encountered from OCS_256 (Sto. Domingo Jalieza) south to Ocotlán de Morelos, suggesting that this group may have a slightly more southerly provenance than the Jalieza High Cr group.

- In addition, a small number of sherds from Jalieza can be matched to clays or grid points in the far southern end of the valley near Ejutla, based on a comparison of their compositional profiles. The Classic period site of San Joaquin (Feinman and Nicholas 1990) is one likely option; however, these samples are too few in number to form a distinctive group and they may well represent more than one source. Thus, they are lumped together here under the heading of "**Southern**".

(5) Tlacolula ceramics comprise at least seven distinctive composition groups, all characterized by relatively high concentrations of Cs, Rb, and As – a triad marking the influence of ignimbrites and andesites.

- **Dainzú Café** primarily occurs at Dainzú, but only one waster (DAN_104) from that site is assigned to this group (Fig. 23). However, clays extending from OCS_102 (Dainzú) south along the eastern side of Cerro Chavagua toward San Juan Teitipal are an acceptable compositional match, and link this group to the Dainzu area. In spite of its name, this compositional group was used to produce both *amarillo* and *café* wares; *ollas* and censors with solid handles are especially well represented.

- **Central Tlacolula** (formerly the Dainzú G-A group) is a large group comprising both *gris* and *amarillo* wares from both Dainzú and Lambityeco. All but one of the *gris* wasters from Dainzú and Lambityeco fall in this group. Although there are slight compositional differences between the wasters of these two sites, these are not strong enough to differentiate products of the two sites; thus, we suggest a single source area on the central alluvium of the Tlacolula sub-valley. We note that this area would also include the site of Gaii Guii, located between Dainzú and Lambityeco, and described by Fargher (2004) as containing ceramic production debris and massive middens of sherds believed to be associated with pottery manufacture.

- **E. Tlacolula (Yagul?) Low Th** is a small group characterized by higher concentrations of Rb and Cs, indicative of ignimbrite influence (Fig. 24). Its closest match is with clays north of Matamoros de Tlacolula: clay samples OCS_098, OCS_099, and OCS _100 join with this group in cluster analyses, although it is too small to test their multivariate probability of group membership. Although these clays would also have been accessible to Lambityeco, these ceramics are a minority group at that site; thus, we tentatively attribute them to Yagul or possibly Sta. Ana del Valle.

- The **El Palmillo-1** and **El Palmillo-2 (Low Sc)** groups both predominate at El Palmillo. Both groups are strongly enriched in Rb and Cs, in line with ignimbrite influenced clays found in the far eastern end of the Tlacolula subvalley (Fig. 24). The most similar clays to El Palmillo-1 occur along the SE piedmont of the Tlacolula arm, while those most similar to El Palmillo-2 are found somewhat further north. Given their prevalence (and proximity of clays) both can be considered local to El Palmillo.

- **Eastern Tlacolula High Cs** is a rather dispersed group held together by extreme concentration values for cesium, indicating a strong influence of ignimbrite. As Cs concentrations are highest in the far eastern end of the valley, this group may originate at **Mitla**, but the group dispersion may also indicate several communities and clay sources contribute to this signature.

- **Eastern Tlacolula High As** is of unknown provenance, although it is found exclusively at the site of El Palmillo. Although this group is too small to test for multivariate probability of group membership, clay samples from OCS_079 and OCS_097 join with this group in cluster analyses, suggesting a possible provenance near **Tanivet**.

INTERPRETATIONS

Our interpretations attempt to address (albeit in a preliminary manner) the questions posed at the beginning of this report.

(1) What was the economic role of Monte Albán during this time period? Is there evidence that the political capital was also a center of manufacture of domestic goods such as pottery, or that is was a hub for exchange transactions as a regional market center?

Evidence for ceramic production at Monte Albán during the Late Classic. Our sample of ceramics from Monte Albán includes production debris, along with a substantial number of sherds recovered from kilns which potentially (but not definitively) reflect ceramic production activities. In order to make sense of this corpus of material, it is helpful to divide the general category of kiln contents into several different classes of material representing different activities. For present purposes, we propose distinguishing between wasters, seconds, kiln furniture, and non-production related debris.

Wasters are sherds that show obvious evidence of bloating, blistering, warping, or severe cracking, resulting in damage that would make the vessels unusable or unsellable. Such vessels are discarded in the area of production, and so are considered the best marker of production. Not all ceramic pastes are equally prone to these defects, however. In particular, bloating and blistering result from the loss of volatiles (particularly carbon and the production of carbon dioxide) as vessels are fired to temperatures in the range of 700-900˚ C. Pastes with large or angular inclusions which provide pathways for moisture and CO_2 to escape are less prone to bloating; thus, they may be underrepresented in production debris by this criterion.

Kiln furniture are large pieces of broken or damaged vessels used to prop up or cover vessels in the kiln during firing. Such vessels provide strong evidence of ceramic production, but the vessels themselves could have been produced elsewhere and re-used; thus, their composition does not necessarily reflect local paste recipes. Kiln furniture may be difficult to distinguish from wasters (as defined above), but tend to show evidence of **over-firing** (warping and vitrification) and more importantly, evidence of **re-firing.** Multiple firing events are indicated when surface and paste characteristics reflect different firing conditions, or when zonal changes from reduced to oxidized are visible, especially when transitions are sharp and clearly defined (Rye 2006:115-118).

Most Late Classic ceramics are well-fired, with a uniform paste color, either oxidized or reduced (Fig. 25 A-B); relatively few contain a dark gray or black core indicating the incomplete burn-off of organics. Given these norms, a vessel with a reduced paste but an oxidized and vitrified surface could be the product of re-using a gray ware vessel in the open air and extreme heat at the top of the kiln. Conversely, a well-oxidized paste with a reduced surface could result from utilizing a previously fired *crema* or *café* vessel within the oven under conditions of insufficient oxygen (Fig. 25 C-D); some vessels indicate multiple changes in firing conditions, resulting in distinctive banding (Fig. 25 E-F). Pastes of these reutilized vessels are less likely to show bloating associated with wasters (when examined either macroscopically or microscopically), because carbon has been removed from the ceramic body in the initial firing. Note, however, that in reduced wares, bloating could occur on refiring, as removal of carbon may have been incomplete during initial firing, especially in iron-rich clays. Thus, recognition of kiln furniture requires a combination of attributes, include shape, size, firing, and paste characteristics.

Seconds, in contrast, are vessels with minor evidence of cracking or warping that would not affect the usability of vessel. Such a vessel may have been offered in the market at a reduced price, and its final destination and place of discard are therefore not necessarily indicative of local production. An isolated example of such a vessel cannot be taken as secure evidence of local ceramic production. For example, Faulseit (2013:65) reports that low levels of "wasters" were widely distributed across the residential terraces at Cerro Danush, but concludes that many were probably just imperfect vessels used despite their minor flaws (which included cracks or bubbles).

Finally, **non-production debris** is material thrown into the kiln after its abandonment; such pieces may represent household trash discarded in a convenient location and bear no relationship to earlier production activities. This trash consists of small to large pieces showing no evidence of misfiring or re-firing, nor are pieces necessarily well-oxidized. These vessels could have been produced elsewhere, and their composition does not necessarily reflect local paste recipes. We tentatively place in this category much of the ceramics from the two kilns associated with House 3 (PMA 72-73 Est. 3) at Monte Albán, as well as the kiln contents from Cuilapan COBAO.

Looked at from this perspective, there is solid, direct evidence at Monte Albán for ceramic production of *gris* vessels belonging to the MA-EVG group. All but one of our definitive wasters from the "*defectos de cocción*" collection fall in the MA-EVG group reference group, indicating a long history of producing ceramics of this composition (from MA Late I through MA IIIB/IV) (Table 9; for images of all wasters see Appendix I). The prevalence of this composition group in our site-wide collection of wasters is readily understandable, given that this composition group represents locally available calcareous clays derived from sedimentary [Ki(lu-ar)] bedrock, in particular, the calcilutites characterized by high concentrations of calcium.

In contrast, direct evidence for participation in the production of other wares is less strong for the Xoo phase based on our current sample. Within the kiln from Unidad Habitacional A, Elemento 1 (Table 10), we have one definite waster (MA_088) belonging to the NW Valle Grande group. The sherd exhibits a bloated, spongy paste, which appears well oxidized with a glassy texture under microscopic examination (Fig. 26). A second waster (MA_091) has an indeterminate composition which shares characteristics of both the MA-EVG and *cremosa* groups (and may be a mix of both pastes). This sample is a basal portion of a *cajete* with part of a second vessel fused to its interior surface; it has a partially oxidized paste and surface, a vitrified and spongy paste, but does not appear to be the product of refiring.

In addition, this kiln yielded a large number of vessels which are interpreted as "kiln furniture", in that they appear to have been fired more than once. These represent a variety of composition groups (provenances), including NW Valle Grande (N=5), Cremosa (N=2), High Fe Cremosa (N=2), and Middle Atoyac/Zaachila (N=2). None of these pieces exhibit paste bloating, although surfaces are well-oxidized and/or vitrified. Thus, it is possible that these vessels were acquired from off-site for domestic use, and then re-used as kiln furniture for ceramic production. However, the prevalence of the NW Valle Grande group in production debris suggests that these vessels were locally available and easy to come by.

Within the small kiln (F. 71) associated with House 3 (PMA 72-73 Est. 3), several large ceramic pieces at the top of the kiln were archived as potentially representing kiln furniture. While none of these pieces exhibit strong evidence of over-firing (no paste vitrification or surface blistering), the pastes of several vessels do exhibit evidence of having been fired more than once (Table 11). The most compelling cases are sherds with oxidized cores, but partially to fully reduced surfaces (MAX_93, MAX_96, and MAX_98), a pattern consistent with re-firing a well-oxidized piece in a reduced environment. Two of these belong to the NW Valle Grande group, and one to the MA Gris group.

Finally, there is indirect evidence for production of *gris* and *café* vessels belonging to the MA Gris group. This small composition group shows up only at Monte Albán, in the context of House 3 or in the debris of the small kiln (F. 71) associated with the house. This distribution suggests that the MA G-K group was likely produced on-site (although we have no production debris to substantiate that claim), and that production primarily served Monte Albán.

Table 9. Provenance of miscellaneous wasters from Monte Albán.

INAA ID	Provenience	Date	Composition Group	Comments	Interpre-tation	Form
MA_067	MA-93; CW_81-17	MA II	MA-EVG	warping, no bloating	waster	*cajete (G.12)*
MA_068	MA-93; A3-173	MA II	NW Valle Grande	incipient vitrification visible at 200X; possible blister	second?	*cajete (G.12)*
MA_069	MA-93; A3-624	MA IIIA	MA-EVG	warping, no bloating	waster	*cajete cónico con deseño inciso*
MA_070	MA-93; A3-412	MA IIIA	MA-EVG	warping, no bloating	waster	*cajete cónico con suporte solido*
MA_071	MA-93; A3-511	MA IIIA	MA-EVG	warping, no bloating	waster	*cajete cónico con deseño inciso*
MA_072	MA-93; A3-535	MA IIIA	MA-EVG	warping; vitrification/ bloating visible at 50X	waster	*cajete cónico con suporte solido*
MA_073	MA-93; K-70	MA IIIA	Mixed/ Indeter.	warping, no bloating	waster	*cajete cónico (G.35)*
MA_074	MA-93; A3-357	MA IIIA	MA-EVG	warping, bloating	waster	*cajete cónico con suporte solido*
MA_075	MA-93; A3-488	MA IIIA	MA-EVG	warping, no bloating	waster	*cajete cónico con diseño modelado*
MA_076	MA-93; Ed. I, 391	MA IIIA	MA-EVG	warping, vitrification and bloating	waster	*cajete cónico con suporte hueco*
MA_077	MA-92; PN-A87	MAIIIB/IV	MA-EVG	warping, bloating	waster	*cajete cónico?*
MA_078	MA-93; A3-364	MAIIIB/IV	MA-EVG	warping; vitrification and bloating visible at 50X	waster	*cajete cónico*
MA_079	MA-94; P6, Mont. III	MAIIIB/IV	MA-EVG	warping, blistering; vitrification visible at 200x	waster	*cajete cónico grande*
MA_080	MA-94; P6, Mont. III	MAIIIB/IV	MA-EVG	warping, blistering; vitrification visible at 200x	waster	*cajete cónico grande*
MA_081	MA-93; Area E, B.40	MAIIIB/IV	MA-EVG	warping, bloating?; vitrification visible at 100X	waster	*cajete cónico*
MA_082	MN, B113, C-27	MAIIIB/IV	MA-EVG	warping, bloating; vitrification visible at 50X	waster	*cajete cónico grande*
MA_083	MA-89; 25 Mayo, Bolsa 61	MAIIIB/IV	MA-EVG	warping, bloating; vitrification visible at 50X	waster	*cajete cónico grande*
MA_084	MA-90, P-S.2, 6	MAIIIB/IV	MA-EVG	warping; no bloating?	waster	*cajete cónico*
MA_085	MA-93; W. 9	MAIIIB/IV	MA-EVG	warping, cracking; no vitrification visible	waster	*apaxtle?*
MA_086	MA-93; Est. W2, B. 50	MAIIIB/IV	MA-EVG	warping, cracking; vitrification visible at 200X	waster	*cajete cónico*
MA_087A	MA-93; Est. W2, B. 50	MAIIIB/IV	NA	fused, stacked vessels	waster	*cajete cónico*

Table 10. Provenance and interpretation of production debris from Unidad Habitacional A (E. 1).

INAA ID	Composition Group	Description	Interpretation	Form
MA_087B	High Fe Cremosa	*crema* paste with oxidized and vitrified surface; no paste vitrification or bloating	refired kiln furniture	*Comal*
MA_088	NW Valle Grande	reduced paste with bloating and warping; surface oxidized and vitrified	waster, refired as kiln furniture?	*Comal*
MA_089	NW Valle Grande	well-oxidized paste and surface; warping, surface vitrification; incipient paste vitrification, no bloating	kiln furniture	*Apaxtle?*
MA_090	NW Valle Grande	well-oxidized paste and surface; warping; no paste vitrification or bloating	kiln furniture	*Comal*
MA_091	EVG-Cremosa mixture?	partially oxidized paste and surface; fusing with spongy paste	waster, not refired	*Cajete* base?
MA_092	Cremosa	oxidized paste with reduced surface; warping, cracking, surface vitrified; incipient paste vitrification but no bloating	refired in kiln; kiln furniture	*Olla* neck
MA_093	Cremosa	oxidized paste and surface; no paste vitrification or bloating	debris or possible kiln furniture	*Apaxtle*
MA_094	Atoyac/ Zaachila	oxidized paste and partially oxidized surface; no paste vitrification or bloating	debris or possible kiln furniture	*Cajete conico grande*
MA_095	Atoyac/ Zaachila	oxidized paste with reduced surface; no paste vitrification or bloating; clear evidence of refiring under different conditions at 30X	kiln furniture	*Cajete conico mediano*
MA_096	NW Valle Grande	oxidized paste and surface; no paste vitrification or bloating	debris or possible kiln furniture	*Cajete conico mediano*
MA_097	NW Valle Grande	oxidized paste and surface; no paste vitrification or bloating	debris or possible kiln furniture	*Cajete conico grande*
MA_098	NW Valle Grande	oxidized paste and surface; warping, surface vitrification; paste shows evidence of differential firing at 20X; no bloating visible at 200X	kiln furniture	*Comal*
MA_099	High Fe Cremosa	reduced paste and surface; no paste vitrification or bloating	debris	*Olla mediano*
MA_100	NW Valle Grande	reduced paste but oxidized surface; no paste vitrification or bloating	refired in kiln; kiln furniture	*Apaxtle o cajete*

Table 11. Provenance and interpretation of large pieces from the small kiln (F. 71) associated with House 3 (PMA 72-73 Est. 3).

INAA ID	Composition Group	Description	Interpretation	Form
MAX_093	NW Valle Grande	oxidized paste with partially reduced surface; no paste vitrification or bloating; no paste vitrification or bloating	possibly refired; kiln furniture?	*Cajete conico*
MAX_094	NW Valle Grande	reduced paste with strongly reduced surface; no paste vitrification or bloating;	possibly refired; kiln furniture?	*Cajete conico*
MAX_095	NW Valle Grande	solid café paste; no paste vitrification or bloating	debris	*Olla chica*
MAX_096	MA Gris	partially oxidized paste with reduced surface; no paste vitrification or bloating;	possibly refired; kiln furniture?	*Comal*
MAX_097	MA Gris	solid café paste; no paste vitrification or bloating	debris	*Cazuela*
MAX_098	NW Valle Grande	zonal firing: reduced surface over oxidized zone then reduced core; no paste vitrification/bloating	refired; possible kiln furniture	*Cajete conico*
MAX_099	High Fe Cremosa	solid gris paste; no paste vitrification or bloating	debris	*Comal*
MAX_100	MA Gris	solid café paste; no paste vitrification or bloating	debris	*Cajete conico*

In summary, using the preceding criteria for identifying on-site production, we have direct evidence that Xoo phase potters at Monte Albán produced ceramics from two different clay sources resulting in two chemically distinct composition groups: MA-EVG and NW Valle Grande. In addition, the criterion of local abundance suggests production of ceramics in a third composition group, the MA Gris. The identification of these composition groups as being the most likely representatives of ceramic production at Monte Albán is consistent with considerations of efficiency and competition which would favor utilization of clays closest to the production locale (Fig. 27). The MA-EVG group represents the most directly available clays and is numerically dominant in our current sample of wasters. It appears that these clays were a focus of Monte Albán, although perhaps in competition with San Agustín as indicated by the presence of Late Classic kilns at that site. Clays associated with the MA Gris ceramics are found directly east of Monte Albán, and are also well represented at the site (if not in production debris). Finally, clays used for the NW Valle Grande group are somewhat more distant and therefore would have been a less cost-efficient source of raw materials. While these clays do fall within a 7 km radius of Monte Albán proper (a distance that Arnold [1985:39-57] has argued represents the maximum distance that traditional potters are willing to travel to obtain raw materials), it is equally likely that some ceramics of the NW Valle Grande group represent imports from the vicinity of Cuilapan.

Notably, there is no clear evidence in our data set for the production of *cremosa* vessels at Monte Albán during the Xoo phase, and these vessels were more likely obtained from nearby communities. Vessels of these composition groups do, however, appear to have been re-used by local potters in the production process as kiln furniture. For example, MA_092 is an *olla* neck that shows cracking and surface vitrification; its well-oxidized paste in combination with a reduced surface suggests it was initially fired in an oxidizing environment but later refired in a reducing environment, perhaps as a prop inside the kiln. Conversely, MA_087B appears to have been exposed to high temperatures as a kiln cover; the sherd has an oxidized and blistered surface, but the intense heat and oxygen did not penetrate to the interior of the vessel wall, which appears to have been initially fired in a reducing environment. Two other *cremosa* vessels from this context (MA_093 and MA_099) show no evidence of deformation or over-firing and may be simple debris.

Evidence for ceramic consumption at Monte Albán during the Late Classic. Consumption patterns at Monte Albán are based on household debris from House 3, and from non-production debris swept into associated kilns (Features 5 and 71). The dominant ceramic groups represented include the two *Cremosa* groups which jointly account for 62% of the assemblage (Table 12). As noted above, the absence of Xoo phase production debris for these wares at Monte Albán (combined with the distance to available clay sources) makes it likely that most *cremosa* vessels are imports from Atzompa and/or Loma del Trapiche. If this is so, then local production at the site clearly lags behind imports in supplying the capital with basic ceramic goods.

Such a finding is consistent, however, with the apparent small-scale production of ceramics at Monte Albán. As described by Markens and Martínez López (2009), Late Classic ceramic production at Monte Albán appears to have been organized as a household industry, and only a few small workshops are known for the site. Further, the scale and intensity of production at these workshops appears to have been relatively low, in that no extensive middens of production debris are reported for Late Classic Monte Albán. This contrasts, for example, with Loma del Trapiche, where substantial middens of wasters relating to a single ware and restricted range of vessel forms suggest a high volume of production along with a high degree of product specialization.

Second in popularity are those ceramic composition groups deemed most likely to have been locally produced. Taken together, the MA-EVG, MA-Gris, and NW Valle Grande groups account for an additional 31% of the domestic assemblage. Further afield, definitively non-local ceramics from the Atoyac/Zaachila and Yaasuchi reference groups (along with outliers) account for less than 10% of the total.

Table 12. Provenance of ceramics from Monte Albán by context

Composition Group	House 3	Feature 05	Feature 71	Total Domestic	Percent of Total
Cremosa	30	2	24	56	35.0%
High Fe *Cremosa*	26	4	13	43	26.9%
NW Valle Grande	9	0	10	19	11.9%
MA *Gris*	2	0	17	19	11.9%
MA-EVG	7	1	3	11	6.9%
Atoyac/Zaachila	4	0	2	6	3.8%
Yaasuchi Med REE	0	0	1	1	0.6%
Other	1	0	4	5	3.1%
Total	79	7	74	160	100.0%

Overall, these data suggests that Monte Albán was a net importer of ceramics rather than a center of craft manufacture, to the extent that potters did not even fully supply the demands of their own households for ceramic goods. Again, this finding is consistent with the conclusions of Markens and Martínez López (2009) that ceramic production at Monte Albán was a limited household industry, and may not have met the needs of this large population center.

Comparison of Monte Albán with other Late Classic centers. In contrast to Monte Albán, our analyses suggest that the other communities in our study produced a much greater percentage of their own pottery, with a correspondingly lower dependence on the regional market system for obtaining basic goods (Table 13). At the high end, local production accounts for greater than 90% of the total assemblage at the provincial center of Dainzú, and over 70% of domestic assemblages from Jalieza. (Although we note that the high values for Dainzú may reflect the spatial scale of the main composition group, Central Tlacolula, which would make this pottery appear local.) Reliance on local pottery is lower in the eastern Tlacolula arm (61% at Lambityeco and 56% at El Palmillo), in part because we have been able to distinguish more sources in this area. It is also possible, however, that poor soils and low rainfall characteristic of the Tlacolula subvalley (Lind and Urcid 2010:49-51) required residents to diversify production of non-agricultural goods, including pottery.

Table 13. Provenance of Late Classic ceramics from all sites analyzed. (High-lighted cells indicate sources most likely to represent local production at each site.)

Ceramic Composition Group:	Jalieza	Yaasuchi	Monte Albán	Dainzú	Lambityeco	El Palmillo
Southern/Ejutla	3.7%	0.0%	0.0%	0.0%	0.0%	0.0%
Jalieza Low Ca	23.7%	0.0%	0.0%	1.7%	5.3%	0.0%
Jalieza High Cr	46.9%	0.0%	0.0%	0.0%	0.0%	0.0%
Atoyac/Zaachila	14.3%	43.8%	3.8%	0.8%	0.0%	0.0%
Yaasuchi Med. REE	2.4%	26.8%	0.6%	0.0%	3.5%	0.0%
Yaasuchi High REE	0.0%	12.8%	0.0%	0.0%	0.0%	0.0%
MA-EVG	2.9%	4.5%	6.9%	2.5%	4.4%	1.4%
Cremosa	0.0%	1.6%	35.0%	0.8%	2.7%	0.5%
High Fe Cremosa	0.0%	3.5%	26.9%	1.7%	0.9%	0.0%
NW Valle Grande	0.0%	3.5%	11.9%	0.0%	0.0%	0.0%
MA Gris	0.0%	0.0%	11.9%	0.0%	0.0%	0.0%
Dainzú Café	0.0%	0.0%	0.0%	42.0%	10.6%	2.3%
Central Tlacolula	0.4%	0.0%	0.0%	49.6%	50.4%	18.2%
Yagul Low Th	0.0%	0.0%	0.0%	0.0%	12.4%	0.9%
E Tlacolula High As	2.9%	0.0%	0.0%	0.0%	0.9%	9.5%
E Tlacolula High Cs	0.0%	0.0%	0.0%	0.0%	0.9%	10.9%
El Palmillo-1	0.0%	0.0%	0.0%	0.0%	2.7%	22.7%
El Palmillo-2 Low Sc	0.0%	0.0%	0.0%	0.0%	4.4%	30.9%
Indeter./Other	2.9%	3.5%	3.1%	0.8%	0.9%	2.7%
% Local	70.6%	83.4%	30.6%	91.6%	61.1%	53.6%

(2) What was the spatial scale and intensity of exchange interactions during the Xoo phase as viewed from a regional perspective? How far did ceramic vessels travel from producer to consumer?

All communities examined in this study were both producers and consumers of ceramics (Figs. 28-33), creating a network of exchanges with neighboring sites. Goods appear to have moved freely among adjacent zones, but the volume of exchange declined sharply with distance for most ceramic sources. By comparing provenance with provenience, it is possible to make some rough calculations of just how far these basic commodities were traveling. Values given in Table 14 indicate the average distance ceramic vessels traveled from producer to consumer, as well as the average distance that non-local ceramics traveled, as an indication of the size of the supply zone for each site.

Table 14. Distance ceramic goods traveled from producer to consumer by site.

Site	Mean Distance for All Ceramics (km)	Mean Distance for Non-local Ceramics (km)
Jalieza	4.6	17.1
Yaasuchi	5.7	9.6
Monte Albán	7.7	9.9
Dainzú	1.8	25.7
Lambityeco	8.1	16.4
El Palmillo	7.7	18.0

At the center of the regional system, Monte Albán appears to have been advantageously located in the midst of several ceramic producing communities. The capital relied heavily on five different ceramic sources, drawing from a core zone stretching from Loma del Trapiche in the north to Yaasuchi in the south, with a maximum distance of *ca*. 15 kilometers from producer to consumer. In our sample, there is no indication of ceramics entering Monte Albán from outside this core area, although the relatively low status of the household examined may not be representative of the larger, wealthier population. On average, ceramics imported to Monte Albán were transported less than 10 km, the smallest supply zone noted for urban centers in our study (Table 14).

Ceramic exports from Greater Monte Albán traveled much further (Fig. 34). It is noteworthy that the ceramic composition group (MA-EVG) for which we have the strongest evidence of production at Monte Albán is also the composition group that traveled the farthest within the valley. The prevalence of this composition group declines strongly with distance from the source, but it represents 2.5% of the Dainzú assemblage, 5.3% of the Lambityeco assemblage, and 1.4% as far away as El Palmillo. The *cremosa* composition groups (associated with Greater Monte Albán if not Monte Albán proper) display a similar pattern of long-distance travel, although they were not as well represented numerically. No other ceramic source areas display this popularity, yet the vessels thus transported appear to have been fairly ordinary, with a mix of *ollas* and *cajetes*, although thin-walled vessels such *botellones* and *cántaros* appear to be over-represented (see Appendix II for illustrations of vessels).

In contrast, ceramics from the provinces do not appear to have traveled over the same distances into the capital, as ceramics traveled outward from the capital to the provinces. Rather, while provincial centers were clearly in communication with the core, the bulk of ceramic trade occurred between neighboring regions, with the volume of exchange declining rapidly with distance. This pattern is illustrated in Figure 35, in which the distribution of ceramics made at Yaasuchi, Dainzú/Lambityeco, and El Palmillo is graphed as a percentage of local assemblages. Sites are ordered geographically on the horizontal axis to indicate the degree to which ceramics were exchanged among neighboring communities. The subregional scale of exchange is clear from these graphs, as is the degree to which ceramics moved freely within the valley.

3) Is the overall pattern of exchanges consistent with what we would expect with a hierarchically integrated market network? If not, in what key ways does it differ?

Economic geographers often characterize regional market systems in terms of geographic scale (the distance goods travel from producer to consumer), network (the volume of exchange among communities of equivalent economic rank), and hierarchy (the volume of exchange between centers and dependent communities or between higher and lower order market centers). As potential models for the Valley of Oaxaca, two ideal types can be usefully contrasted.

Interlocking market systems are characterized by both high vertical and horizontal integration, resulting in market systems of regional scale. Lower-order market centers are linked to multiple higher level centers in a nested hierarchy, creating a network of economic central places that efficiently moves goods both within and between zones (Minc 2006:86-87; C. Smith 1974, 1976). Because of this high degree of economic integration, goods are distributed widely throughout the system, resulting in exchange over greater distances and greater homogenization in the distribution of goods throughout the system (Minc 2006:87). At the same time, goods from higher order centers will be more widely distributed through dependent market centers, than goods produced in a lower-order center at the margin of the regional system, resulting in minor sub-regional variation. Such highly integrated, regional market systems are often associated with a strong, centralized authority that guarantees the stability, freedom of movement, and infrastructure (roads, judicial systems) necessary for such a system to function, but with minimal intervention or meddling in the operation of the market system (as through taxes, subsidies, infringements).

In contrast, **overlapping (or non-centralized) market systems** provide a fair degree of horizontal integration but display poor vertical integration (Minc 2006:84-85; C. Smith 1974:179-180). Market participants and goods are free to travel between adjacent market centers, but the scale of distribution is limited by the absence of a regional, hierarchical structure that would move materials between centers and their dependents, or among higher order centers. The result is a series of relatively small-scale, overlapping market zones with indistinct, fluid boundaries (Minc 2006:84-85; C. Smith 1974:179-180); neighboring communities have similar material assemblages, but the degree of similarity declines with distance. Such a system is typically attributed to political instability which prevents the development of a regional market hierarchy, or to a relatively weak or decentralized political authority, in which regional centers operate with a high degree of economic independence.

Our data suggest that by the Late Classic, exchange in the Valley of Oaxaca was more consistent with the second model, that of a non-centralized market system. The overall pattern is a series of overlapping market zones: a larger, core market zone serving the dense population of greater Monte Albán, with smaller market zones serving dependent communities (Fig. 36). Goods moved freely among adjacent zones, but the volume of exchange declined sharply with distance for most ceramic sources. The exceptions are ceramics most closely linked to production at Monte Albán or within Greater Monte Albán (ceramics of the MA-EVG and *cremosa* groups) which sometimes traveled long distances from producer to consumer. The mechanism underlying this long-distance movement remains a puzzle, as the goods transported appear rather ordinary and their equivalent would have been available much closer to home (see Appendix II).

The evolution of this system is unclear, as we lack solid information on its antecedents. Thus, it is difficult to claim that it reflects a devolution from a strongly centralized system. There are several indications, however, that Monte Albán had lost considerable economic power by the Xoo phase: the overall productivity of the capital as a center of pottery manufacture had declined through time, and the status or value of the vessels produced had declined from elite wares to basic domestic goods. Examining the capital's role through time, we note that:

- During the Terminal Formative (MA II or Nisa phase), Monte Albán was a major producer of *crema* vessels as demonstrated by Markens and Martinez-Lopez (2009); these high-status vessels appear to have been a focus of elite control and were widely distributed in the valley (Elson and Sherman 2007).

- During the Early and Middle Classic, Monte Albán continued to produce high-value gray wares, as indicated by the number of wasters of the carved G23 vessels encountered at the site (Fig. 37). How widely these products were distributed is currently unknown, but we do know that they were exported at least as far as Dainzú. Out of our small sample of Middle Classic G23's (DAN_036 – DAN_045) from that site, 80% match the signature of Monte Albán.

- By the Xoo phase, in contrast, ceramic production was limited to a few small operations at the periphery of the site (Markens and Martinez-Lopez 2009), and the quality of the vessels produced appears to be no different than the ordinary pottery widely produced in the valley.

At the same time, there are hints that subregional exchange systems may have expanded during the Classic. Although our data on the Early Classic is quite limited, we do have a small collection of Early-to-Middle Classic material from the site of El Palmillo. Comparisons between the earlier and later assemblages suggest a decline in the reliance on locally produced ceramics during the Late Classic (from 72% to 54%) and a correspondingly greater rate of exchange with neighboring communities (Table 15; Fig. 38). In particular, we note the increased interaction between El Palmillo and the Lambityeco/Dainzú area (which is not represented in the earlier assemblage at all, yet accounts for over 20% of the later assemblage), perhaps reflecting the rise of Lambityeco as a regional commercial center.

4) Finally, is there any evidence of divisions within the valley during the Xoo phase, indicating that political fragmentation created barriers to exchange? That is, do all parts of the valley share exchanges with Monte Albán, or do some sites appear to have been relatively isolated?

Our assessment of the volume of exchange among sites is based on overall assemblage similarity, as measured from the sources of ceramics represented and the relative abundance of each source. Here we use the Brainerd-Robinson (B-R) co-efficient, which ranges from zero (no similarity) to 200 (same sources in the same proportions).

In general, the degree of similarity among sites is quite low (Table 16), reflecting the dependence on local ceramics. Almost all B-R values are less than 50, indicating that pairs of sites share less than 25% of their ceramics. Sites are more similar to their nearest neighbors (as measured from straight-line distance), with a general decline in similarity with separating distance (Fig. 39). The highest B-R value is for Dainzú and Lambityeco (B-R=139), which are only 7 km apart. Part of their similarity thus reflects their close spacing, but part reflects the fact that we are unable to distinguish their ceramics as they both share in production of the Central Tlacolula composition group. Notably, no site stands out as being strongly dissimilar by this measure, given the geographic distances involved.

Table 15. Comparison of Early vs. Late Classic assemblages from El Palmillo

Ceramic Composition Group:	**Early to Middle Classic**	**Middle to Late Classic**
Southern/Ejutla	0.0%	0.0%
Jalieza Low Ca	0.0%	0.0%
Jalieza High Cr	0.0%	0.0%
Atoyac/Zaachila	0.0%	0.0%
Yaasuchi Med. REE	0.0%	0.0%
Yaasuchi High REE	0.0%	0.0%
MA-EVG	2.6%	1.4%
Cremosa	2.6%	0.5%
High Fe Cremosa	0.0%	0.0%
NW Valle Grande	0.0%	0.0%
MA Gris	0.0%	0.0%
Dainzu Café	0.0%	2.3%
Central Tlacolula	0.0%	18.2%
Yagul Low Th	2.6%	0.9%
E Tlacolula High As (Tanivet?)	15.4%	9.5%
E Tlacolula High Cs (Mitla?)	5.1%	10.9%
El Palmillo-1	28.2%	22.7%
El Palmillo-2 Low Sc	43.6%	30.9%
Indeter./Other	0.0%	2.7%
% Local	71.8%	53.6%

If we examine just the degree of interaction with Greater Monte Albán, we note again that exchange declines with distance from the capital. But in this case, the site of Jalieza has a notably low percentage of ceramics produced in the core zone given its distance from that source (Fig. 40). Although not clearly an outlier, the Jalieza assemblage contains only 2.9% of ceramics associated with Greater Monte Albán, in spite of being a large population center only ca. 20 km from that center. Further, all of these vessels fall in the MA-EVG composition group (which may have been produced in San Agustín de las Juntas as well as Monte Albán), and the assemblage contains no vessels from the *cremosa* composition groups presumably channeled through the Monte Albán market center. Instead, Jalieza has a slightly higher percentage of vessels (3.7%) originating from areas to the south near Ejutla. We note, however, that straight-line distance is a relatively crude measure of proximity in this mountainous landscape, and that a more accurate assessment of travel-time and its effect on interaction rates is being conducted as part of Sarah Walker's thesis research.

Table 16. Degree of similarity among ceramic assemblages relative to separating distance.
Unshaded cells: B-R coefficient indicating similarity between pairs of sites;
shaded cells: straight-line distance in km between pairs of sites.

	Jalieza	Yaasuchi	Monte Albán	Dainzu	Lambityeco	El Palmillo
Jalieza	0.0	44.9	20.2	12.6	25.6	14.7
Yaasuchi	14.9	0.0	41.2	13.4	22.7	9.1
Monte Albán	21.8	15.2	0.0	13.5	19.0	9.1
Dainzu	20.0	28.3	22.2	0.0	133.9	46.2
Lambityeco	22.0	33.2	29.0	7.2	0.0	65.8
El Palmillo	33.9	45.3	48.0	27.2	20.1	0.0

SUMMARY:

The results presented above are preliminary; more detailed analyses of inter-site interaction and intra-site consumption patterns will necessarily involve close collaboration among project participants. Overall, however, the results of this study provide no compelling evidence that the Zapotec state had dissolved into competing polities during the Xoo phase. Communities continued to interact with their neighbors and with the capital; goods moved freely (if not very far) from their source of origin and there is no indication that conflict impeded exchange among market zones. Yet the power and engagement of Monte Albán in the regional economic sphere appears to have been relatively weak. While Monte Albán depended heavily on producers within its immediate supply zone, exchange interactions with communities outside this core dropped off sharply.

To place these findings in perspective, we clearly need comparable data on trends leading up to this point in Zapotec history, as well as some knowledge of how the system continued to evolve in the post-Classic. To that end, we note that the success of this study in tracking intra-regional exchange rests on the relatively fine spatial resolution that we were able to achieve in sourcing ceramics using a regional, explicitly geochemical approach. Our field survey to characterize spatial variation in clay composition lays a solid foundation not only for this study, but for future analyses of Oaxacan ceramics.

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Figure Captions:

Figure 1. Distribution of Oaxaca Clay Survey sampling locations (shown in red) relative to the surficial geology of the Valley of Oaxaca. (Dashed line represents the approximate limits of the drainage basin.)

Figure 2. Mapping the chemical influence of different geological parent materials in Valley clays. A. Precambrian gneiss (high REE, Ba, and Mn); B. Cretaceous sedimentary rocks (high Ca); C. Tertiary andesites and ignimbrites (high Cs, Rb, and As).

Figure 3. Location of the main Late Classic sites within the Valley of Oaxaca sampled as part of this study (map from Pink 2014).

Figure 4. Locations of Xoo-phase kilns on the outskirts of Monte Albán (after Markens and Martínez López 2009: Fig. 14, imposed on GoogleEarth image).

Figure 5. General layout of House Pitayo-A at Monte Albán, with location of ceramic kiln (from Gónzalez Lincón 2003, Fig. 6.3).

Figure 6. Location of Late Classic houses within the site of Jalieza excavated by Christina Elson (Elson et al. 2007), from which our ceramic sample was drawn. Surface collections were taken from within the two areas of Late Classic Jalieza outlined by the solid line (*zona trazada*). (Base map courtesy of Christina Elson.)

Figure 7. Location of Late Classic terraces within the site of Cerro Danush, as mapped by Ronald Faulseit (Faulseit 2013: Fig. 4.4). Our INAA sample comes from excavations in Terrace S19 (Faulseit 2013: Fig. 6.9); note that ceramic wasters were abundant in these units.

Figure 8. ***Upper:*** Ceramic wasters from terrace S19 (DAN_096 – DAN_117). ***Lower:*** Vitrified pastes of ceramic wasters from terrace S19.

Figure 9. Location of excavations (areas B and C) within the site of Lambityeco yielding ceramics for this study.

Figure 10. Location of residential terraces within the site of El Palmillo as mapped by Gary Feinman and Linda Nicholas. Our INAA sample comes from excavations in the eight terraces denoted on the map in red. (Map from Feinman and Nicholas 2012: Fig. 5).

Figure 11. ***Upper***: Contour map of Yaasuchi showing locations of Late Classic domestic structures 5B and 6, and the surface feature for firing pottery designated as Feature 1 adjacent to Structure 6 (from Sherman 2005: Fig. 4.5). ***Lower:*** Ceramic production debris associated with Yaasuchi Feature 1 (photo courtesy of Jason Sherman).

Figure 12. A. Over-fired and warped pottery from Loma del Trapiche. B. Pottery wasters from the site of San Agustín de la Juntas.

Figure 13. Robust, rotated principle components analysis of valley clays.

Figure 14. Probable provenance of ceramic composition groups identified for the Late Classic.

Figure 15. Canonical variates separation of composition groups for Classic ceramics. Monte Albán - Eastern Valle Grande (MA-EVG) separates from similar groups on Canonical Variate 4. Greater separation among remaining groups is achieved at the regional level (see Figs. 9-11).

Figure 16. Canonical variates separation of ceramic composition groups associated with the Western Valle Grande. Five distinct composition groups are recognized, including two from the site of Yaasuchi, along with a group representing the central Atoyac drainage including Zaachila, a NW Valle Grande (NWVG) linked to clays near Cuilapan, and gray-ware produced at or near Monte Albán (MA Gris).

Figure 17. Canonical variates separation of ceramic composition groups associated with the eastern or Tlacalula branch of the valley. Solid symbols represent core group members, and open symbols represent cases assigned to that group by discriminate analysis. Four distinct composition groups are recognized, including two from near Dainzú, and two from the far eastern end of valley.

Figure 18. **A**. Compositional profile for cremosa reference groups. Both reference groups have relatively high concentrations of Al and Na owing to the presence of plagioclase, but they can be distinguished based on bimodalities in iron and the REE.
B. Clay mine used by modern potters of Atzompa. **C.** Microphotograph of typical cremosa paste showing white inclusions derived from weathered anorthosite. Small amounts of this mineral con strongly affect the composition of ceramics, enriching them in sodium.

Figure 19. Compositional profiles for reference groups associated with gneiss-derived clays. Relative to other groups they are relatively high in the REEs, Re, and Sc, but low in Cs and Rb.

Figure 20. Compositional profiles for reference groups associated with gneiss-derived clays moderated by alluvial deposition. They have a less extreme composition, but are still somewhat enriched in the REE, Fe, and Sc.

Figure 21. Compositional profile for the MA-EVG reference group associated with calcareous clays derived from calcilutite.

Figure 22. Compositional profiles for the Jalieza composition groups associated with clays derived from andesite.

Figure 23. Compositional profiles for the Tlacolula composition groups associated with clays derived from andesite.

Figure 24. Compositional profiles for the E Tlacolula composition groups associated with clays derived from ignimbrite. Their compositions are strongly enriched in Rb and Cs.

Figure 25. Late Classic vessel pastes and firing conditions. A-B. Typical, even paste color indicting controlled firing conditions from a single firing event, either oxidized or reduced; C-D. Vessels with oxidized cores but reduced surfaces; E-F. Vessels showing strong zonation in paste color indicating multiple firing events.

Figure 26. Late Classic wasters from Monte Albán. MA_088 has a composition clearly associated with the NW Valle Grande group, while MA_091 appears mixed, combining attributes of the MA-EVG and *cremosa* groups.

Comal waster with bloated paste and surface vitrification.

Fused vessels showing surface vitrification and paste bloating.

Figure 27. Known sources of clays matching Late Classic composition groups potentially produced at Monte Albán. The gray circle indicates a radius of 7 km surrounding Monte Albán, suggesting the probable maximum distance that potters would travel to obtain clays. Note that clays matching the MA-EVG, MA Gris, and NW Valle Grande fall within this radius; these ceramics are also best represented in production contexts at the site.

Figure 28. Sources of Late Classic ceramics at Jalieza.

Figure 29. Sources of Late Classic ceramics at Yaasuchi.

Figure 30. Sources of Late Classic ceramics at Monte Albán.

Figure 31. Sources of Late Classic ceramics at Dainzú.

Figure 32. Sources of Late Classic ceramics at Lambityeco.

Figure 33. Sources of Late Classic ceramics at El Palmillo.

Figure 34. Distribution of ceramics from Greater Monte Albán as a percent of Late Classic ceramic assemblage.

Figure 35. Exchange among other sites: distribution of ceramics made at Yaasuchi, Dainzu/Lambityeco, and El Palmillo, as a percentage of Late Classic assemblage. Sites are ordered geographically on the horizontal axis to indicate the degree to which ceramics were exchanged among neighboring communities.

Figure 36. Model for the organization of regional exchange during the Late Classic. A core zone (green) supplied Monte Albán, while a series of smaller, overlapping market zones served dependent communities.

Figure 37. MA IIIA *gris* vessels of the G23 type: wasters from Monte Albán (above) and exports to Dainzú (below).

Figure 38. Comparison of Early-Middle vs. Middle-Late Classic assemblages at El Palmillo.

Figure 39. Fall-off in similarity among Late Classic ceramic assemblages as a function of straight-line separating distance.

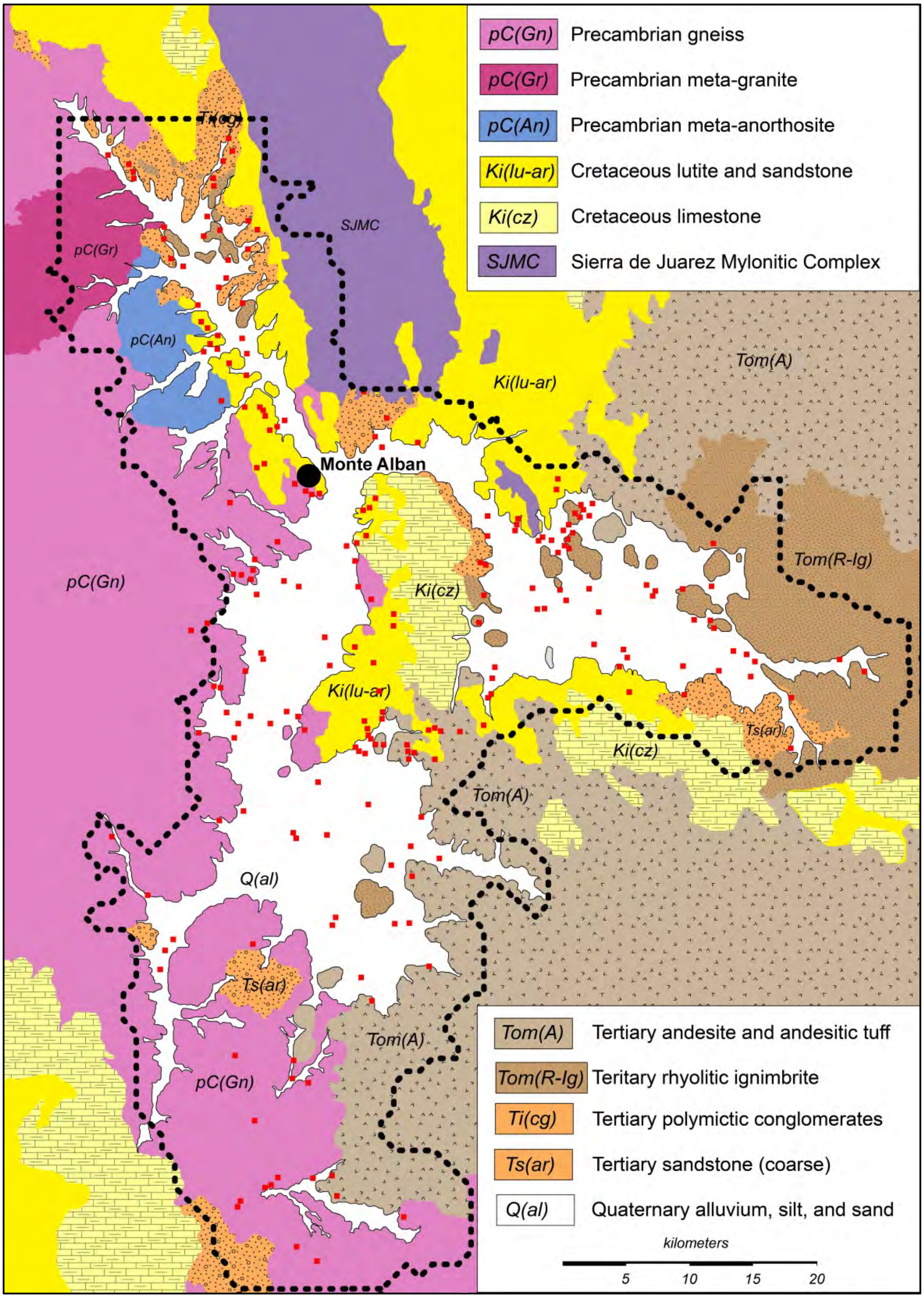
Figure 40. Percent of Late Classic assemblage comprised of ceramics from Greater Monte Albán, relative to distance from the capital in kilometers.

Trace-Element Analysis of Oaxacan Ceramics: Insights into the Regional Organization of Ceramic Production and Exchange in the Valley of Oaxaca during the Late Classic (AD 550-850)

Final technical report circulated to collaborators for analyses supported by NSF award 1005945:
Support of Coordinated, Regional Trace-Element Studies at the OSU-RC

Leah Minc and Jeremias Pink

October, 2014



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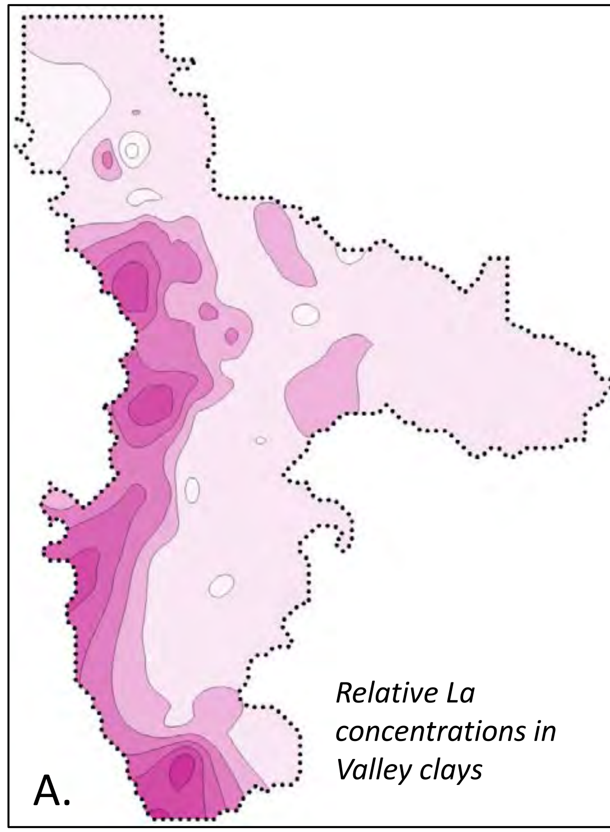
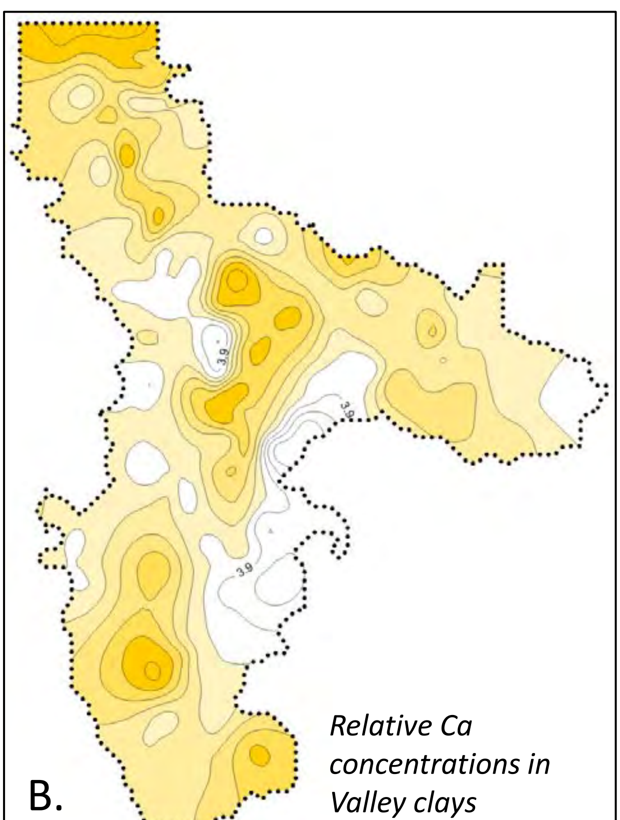
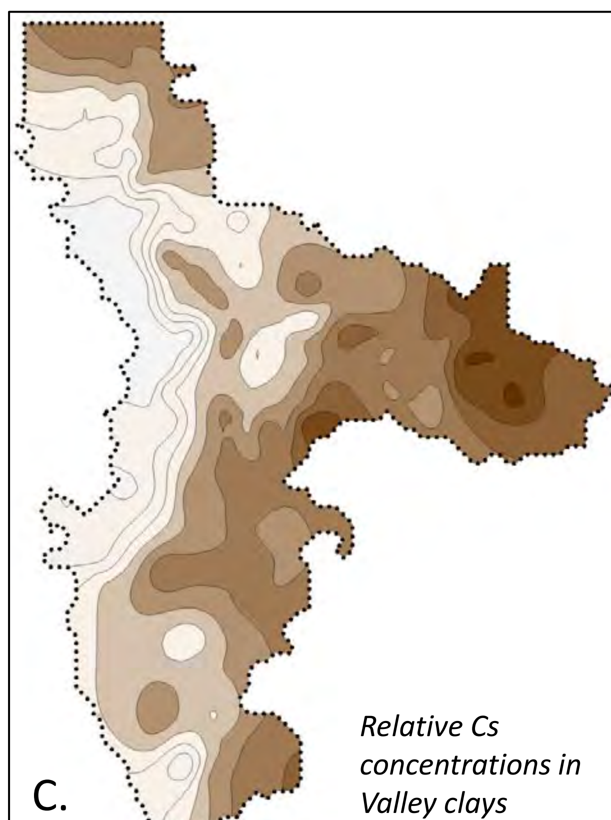
C. Tertiary andesites and ignimbrites (high Cs, Rb, and As)







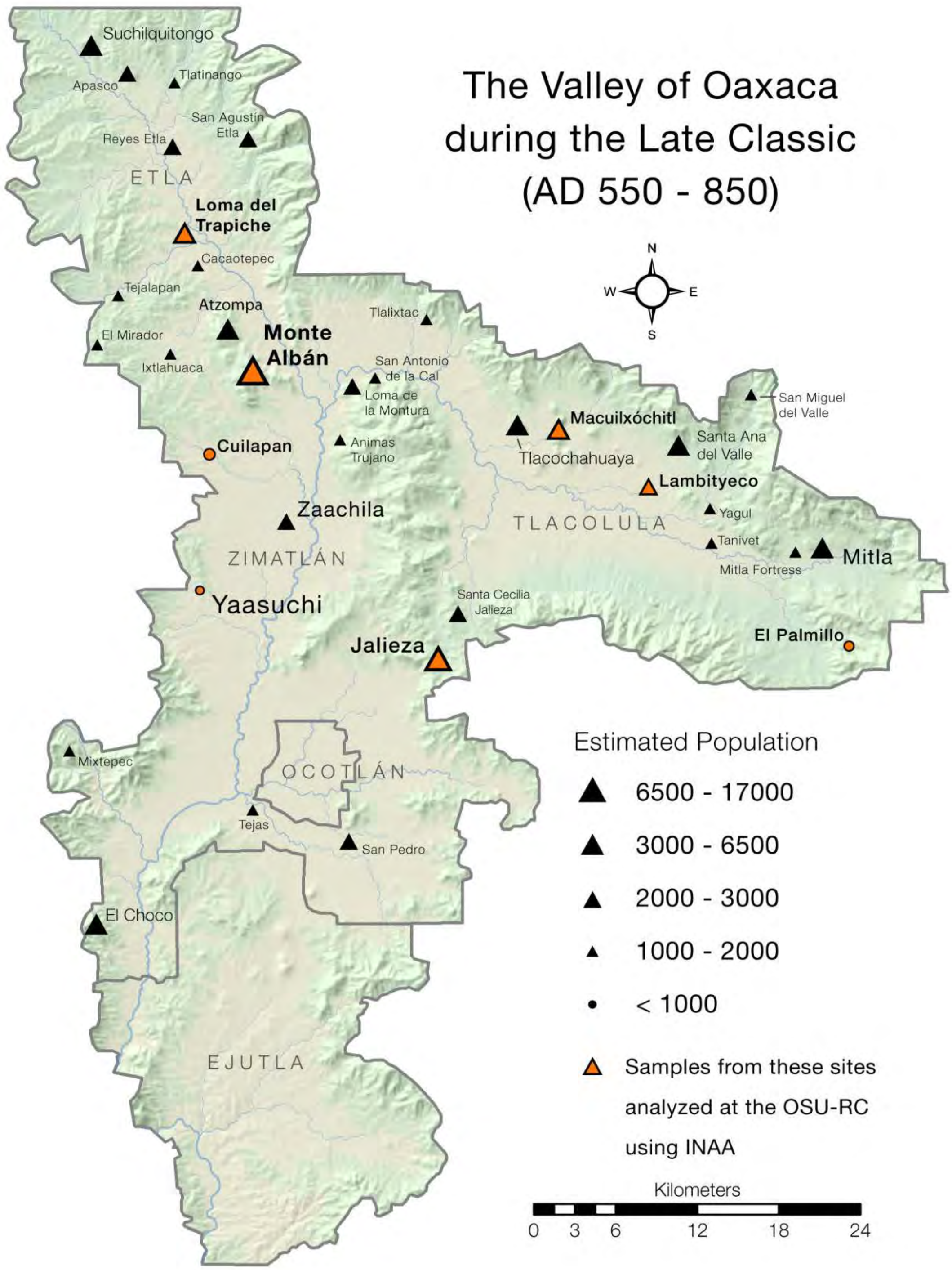


Figure 3. Location of the main Late Classic sites within the Valley of Oaxaca sampled as part of this study (map from Pink 2014).

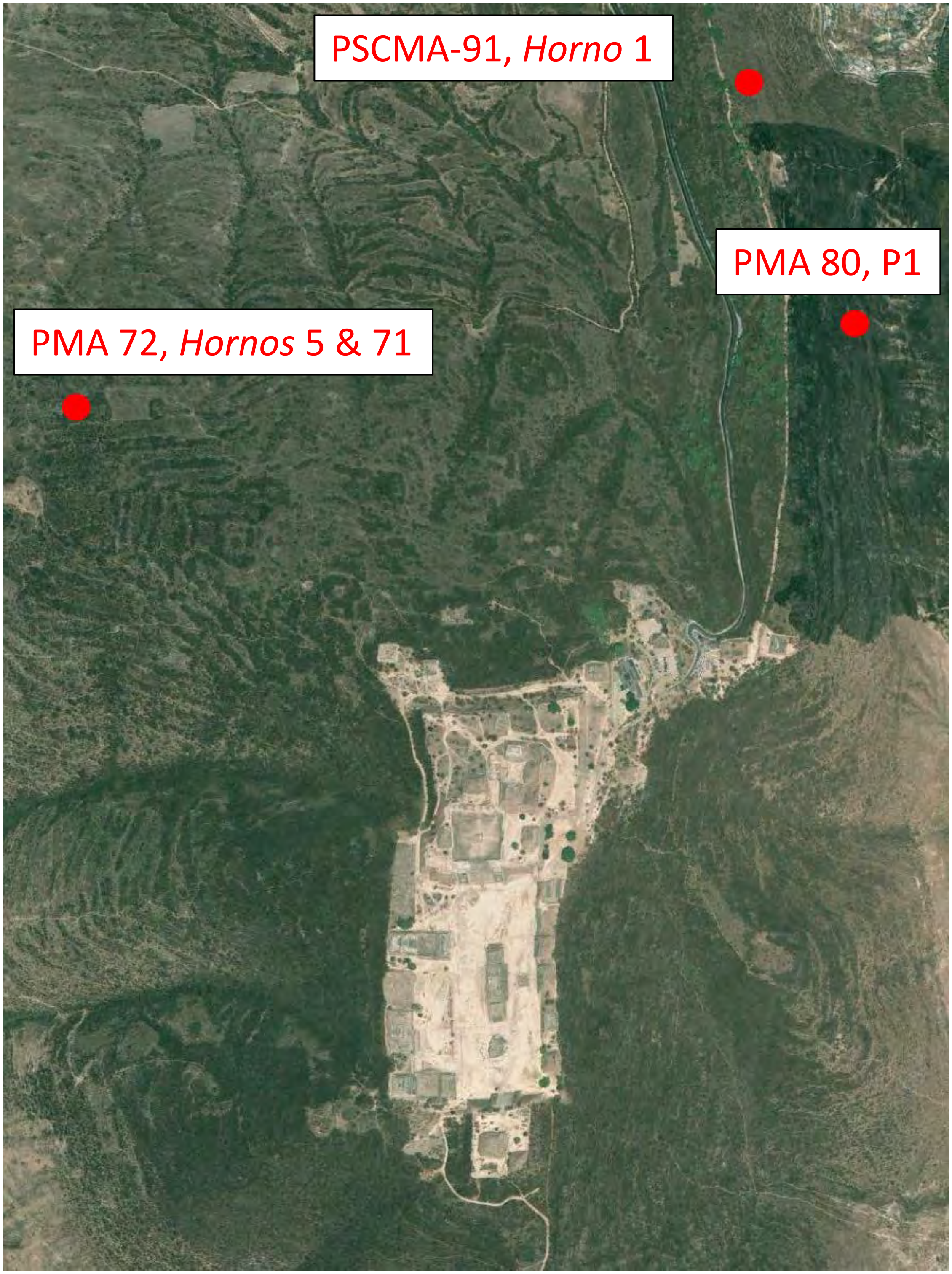


Figure 4. Locations of Xoo-phase kilns on the outskirts of Monte Albán (after Markens and Martínez López 2009: Fig. 14, imposed on GoogleEarth image).

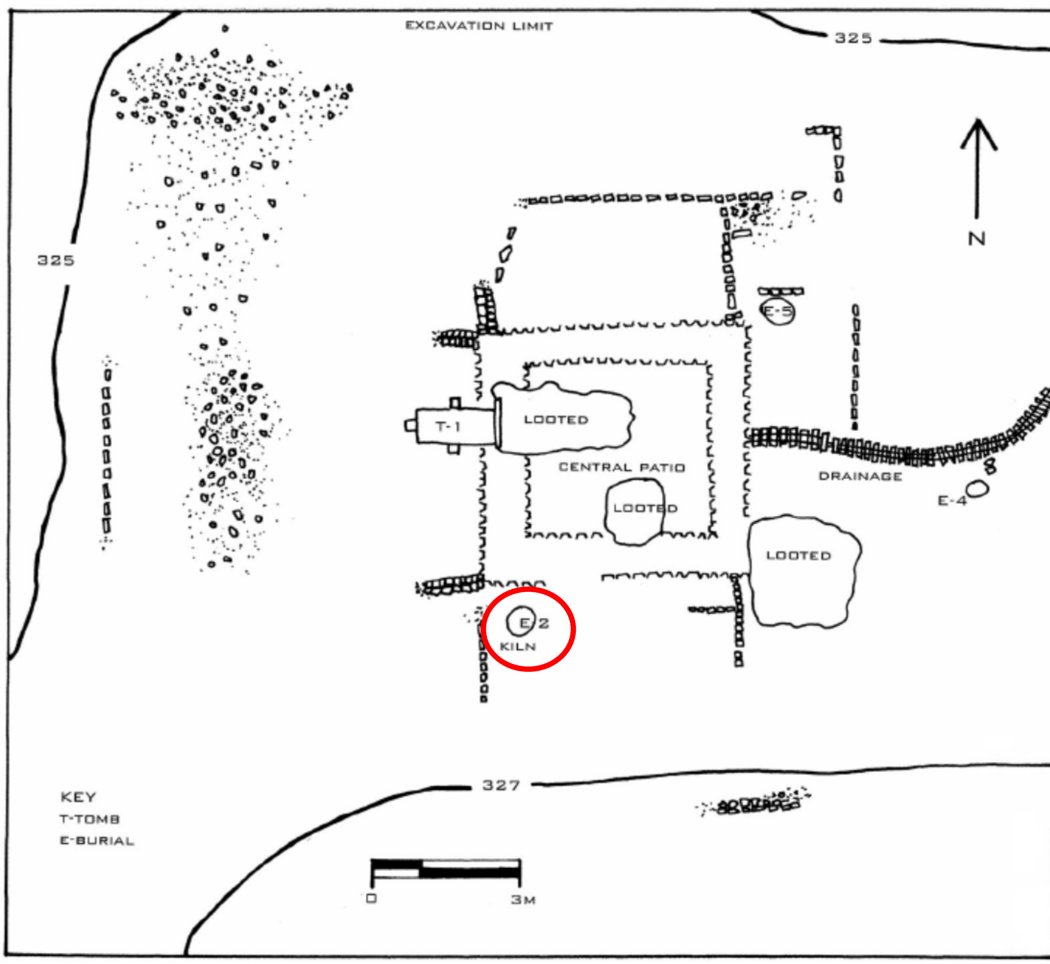


Figure 5. General layout of House Pitayo-A at Monte Albán, with location of ceramic kiln (from Gónzalez Lincón 2003, Fig. 6.3).

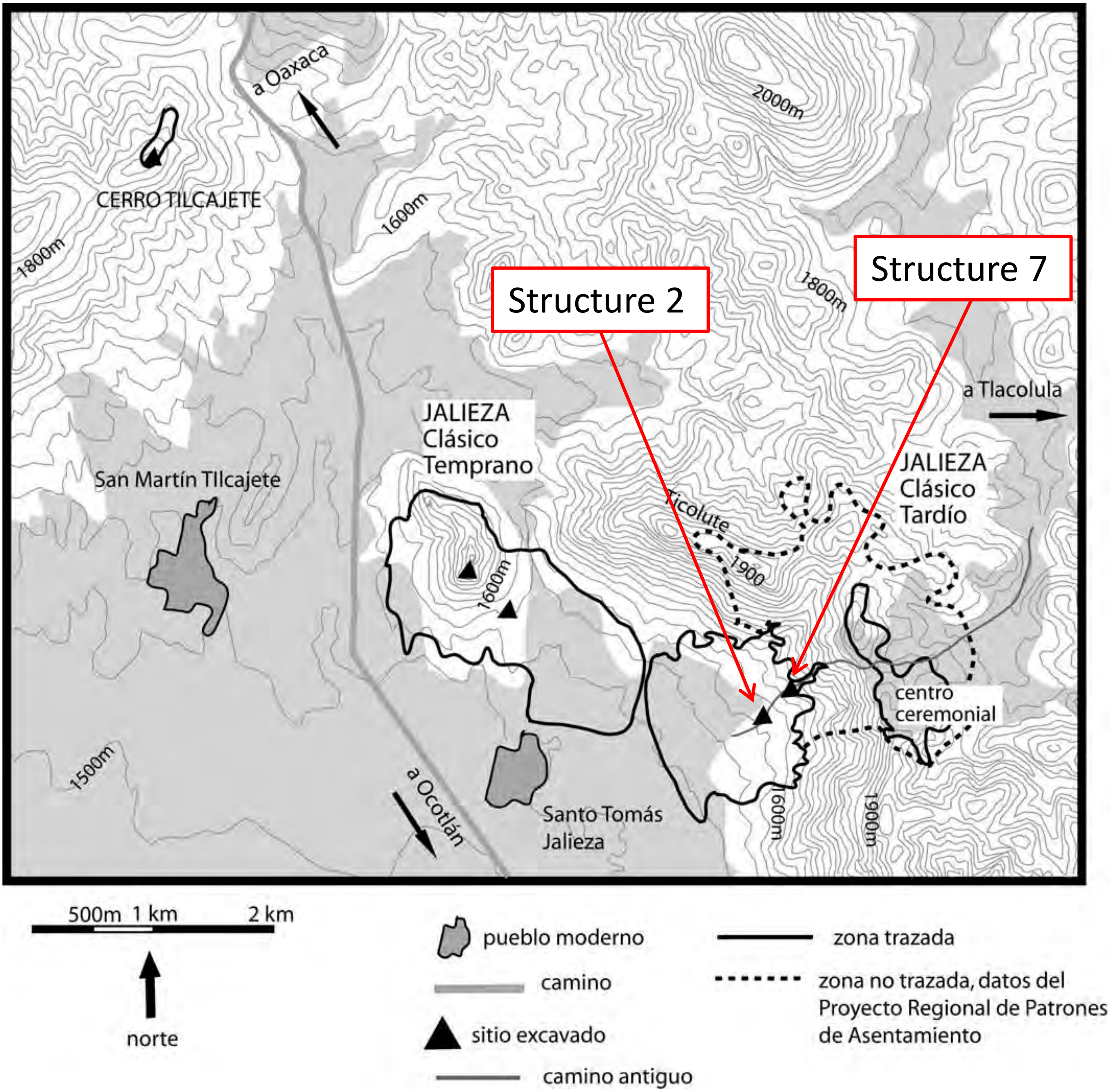


Figure 6. Location of Late Classic houses within the site of Jalieza excavated by Christina Elson (Elson et al. 2007), from which our ceramic sample was drawn. Surface collections were taken from within the two areas of Late Classic Jalieza outlined by the solid line (*zona trazada*). (Base map courtesy of Christina Elson.)

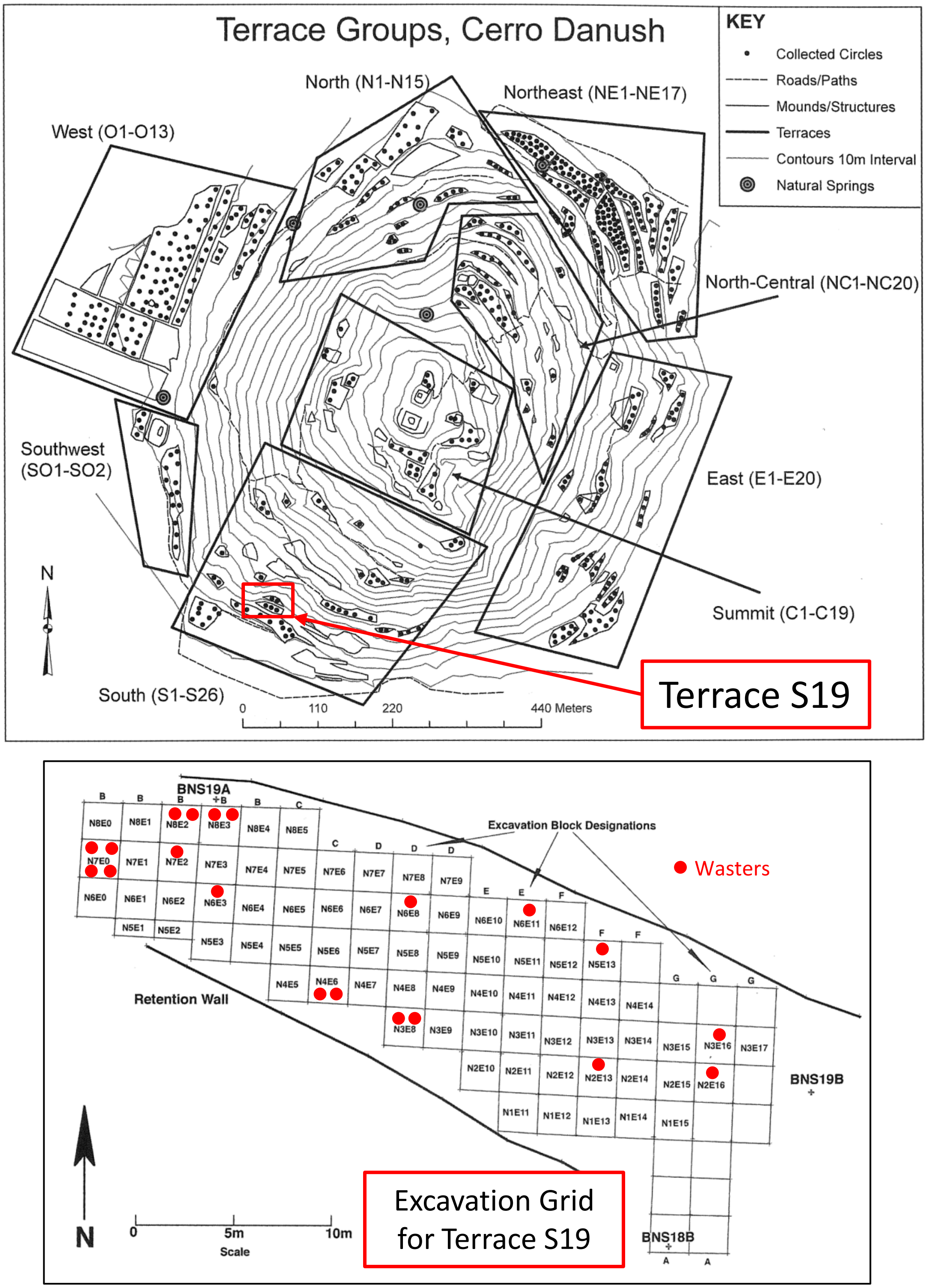
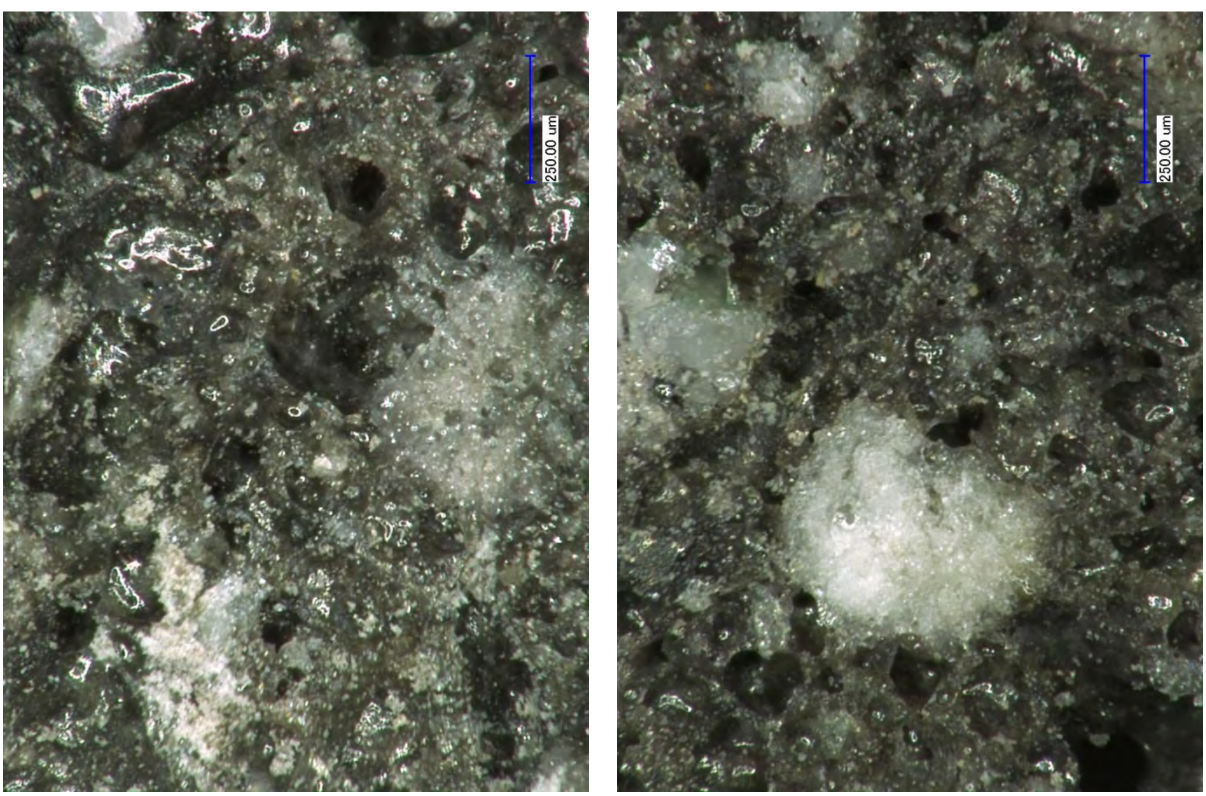


Figure 7. Location of Late Classic terraces within the site of Cerro Danush, as mapped by Ronald Faulseit (Faulseit 2013: Fig. 4.4). Our INAA sample comes from excavations in Terrace S19 (Faulseit 2013: Fig. 6.9); note that ceramic wasters were abundant in these units.

Figure 8. Ceramic wasters from terrace S19 (DAN_096 – DAN_117).



Vitrified pastes of ceramic wasters from terrace S19.

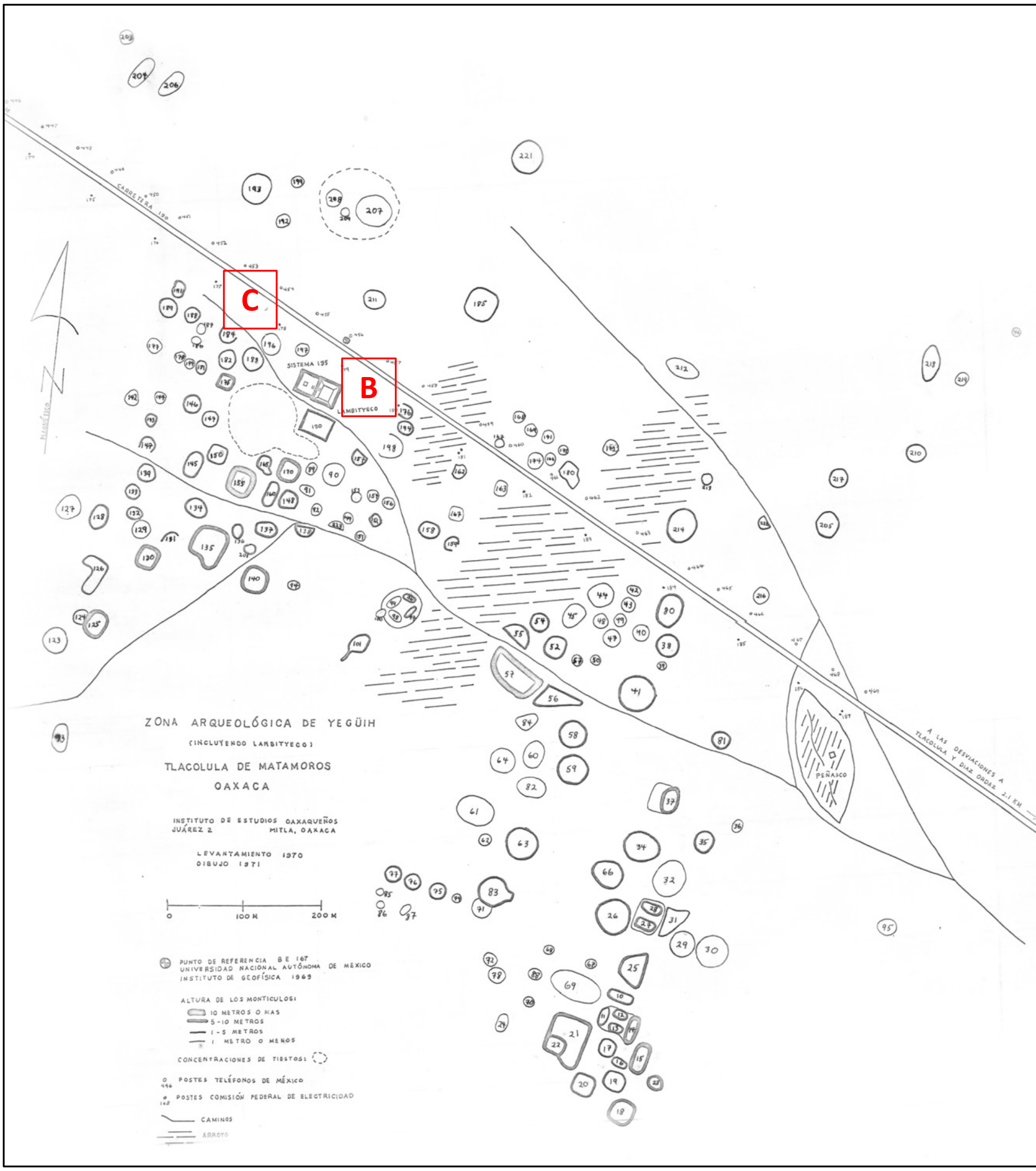


Figure 9. Location of excavations (areas B and C) within the site of Lambityeco yielding ceramics for this study.

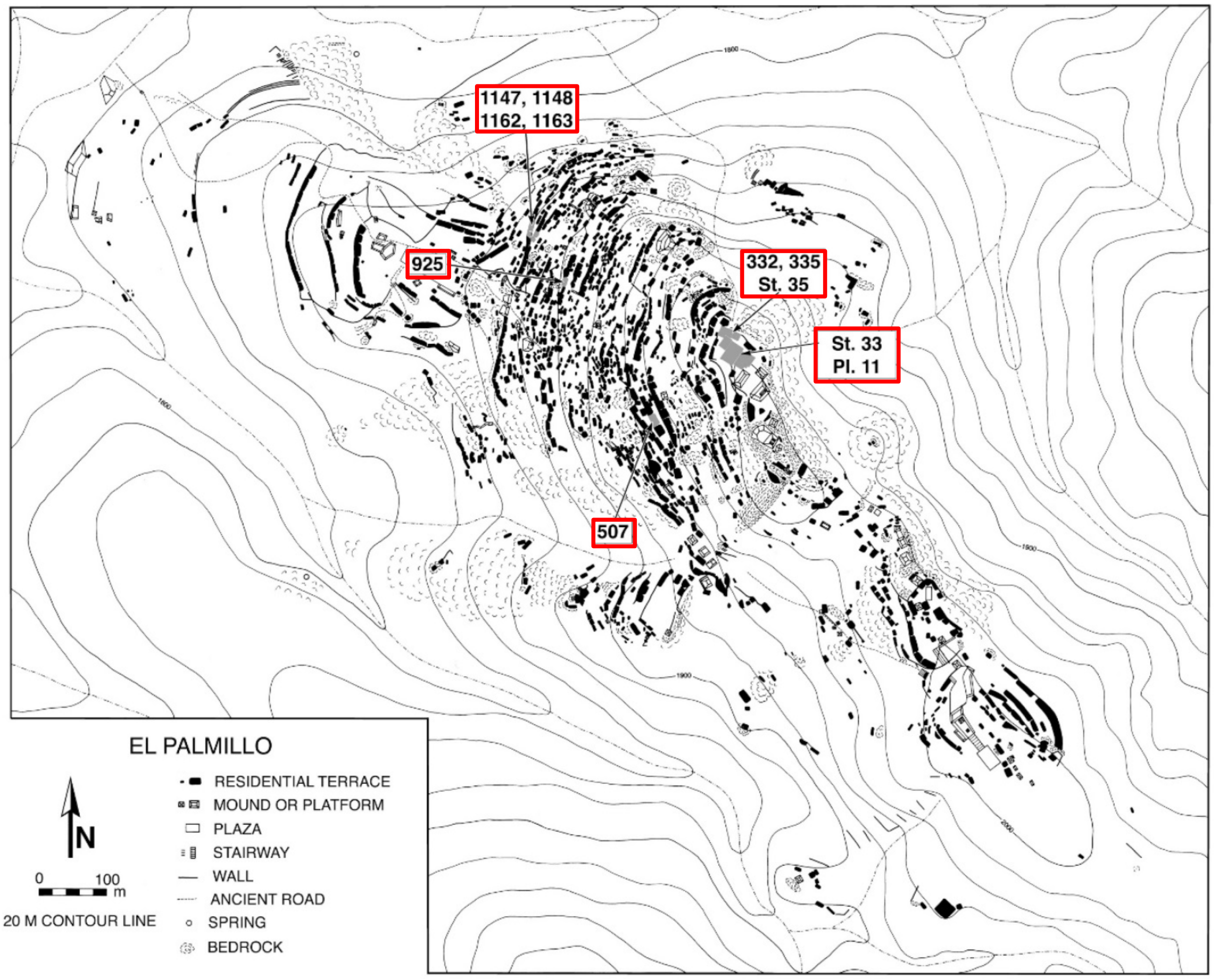


Figure 10. Location of residential terraces within the site of El Palmillo as mapped by Gary Feinman and Linda Nicholas. Our INAA sample comes from excavations in the eight terraces denoted on the map in red.
(Map from Feinman and Nicholas 2012: Fig. 5).

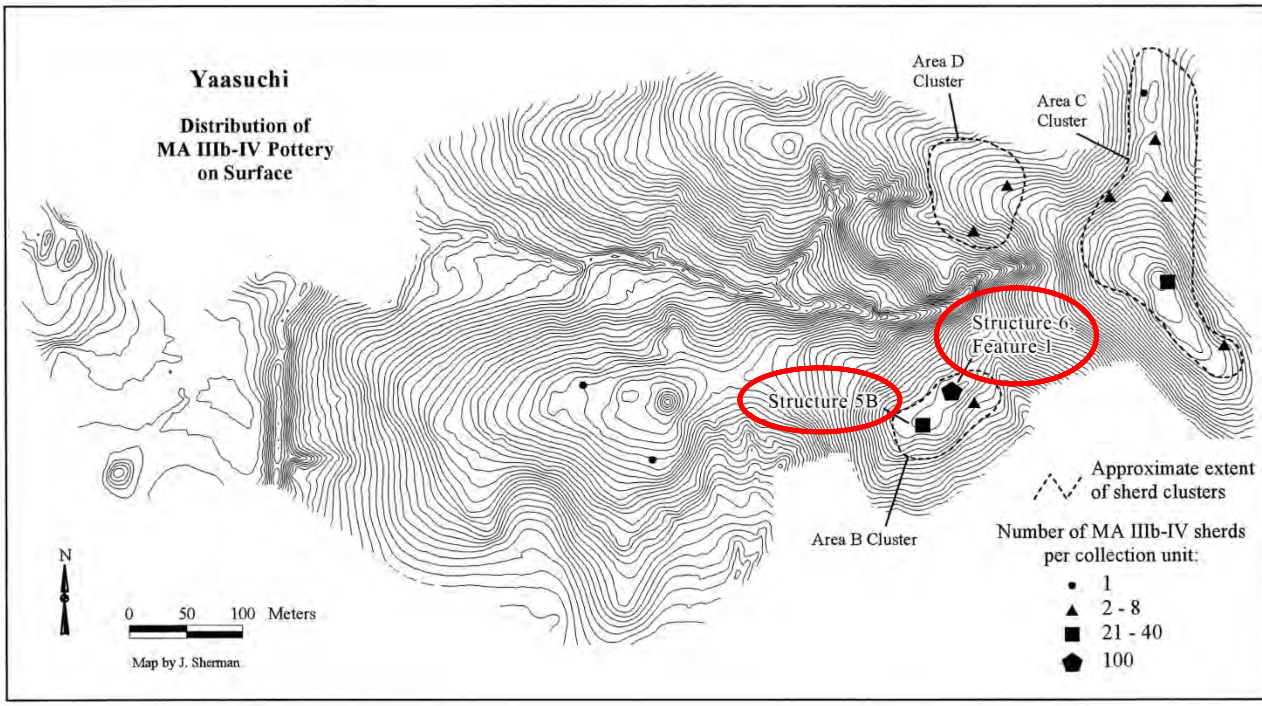


Figure 11. Contour map of Yaasuchi showing locations of Late Classic domestic structures 5B and 6, and the surface feature for firing pottery designated as Feature 1 adjacent to Structure 6 (from Sherman 2005: Fig. 4.5).

Ceramic production debris associated with Feature 1 (photo courtesy of Jason Sherman).

Figure 12a. Over-fired and warped pottery from Loma del Trapiche.

Figure 12b. Pottery wasters from the site of San Agustín de la Juntas.

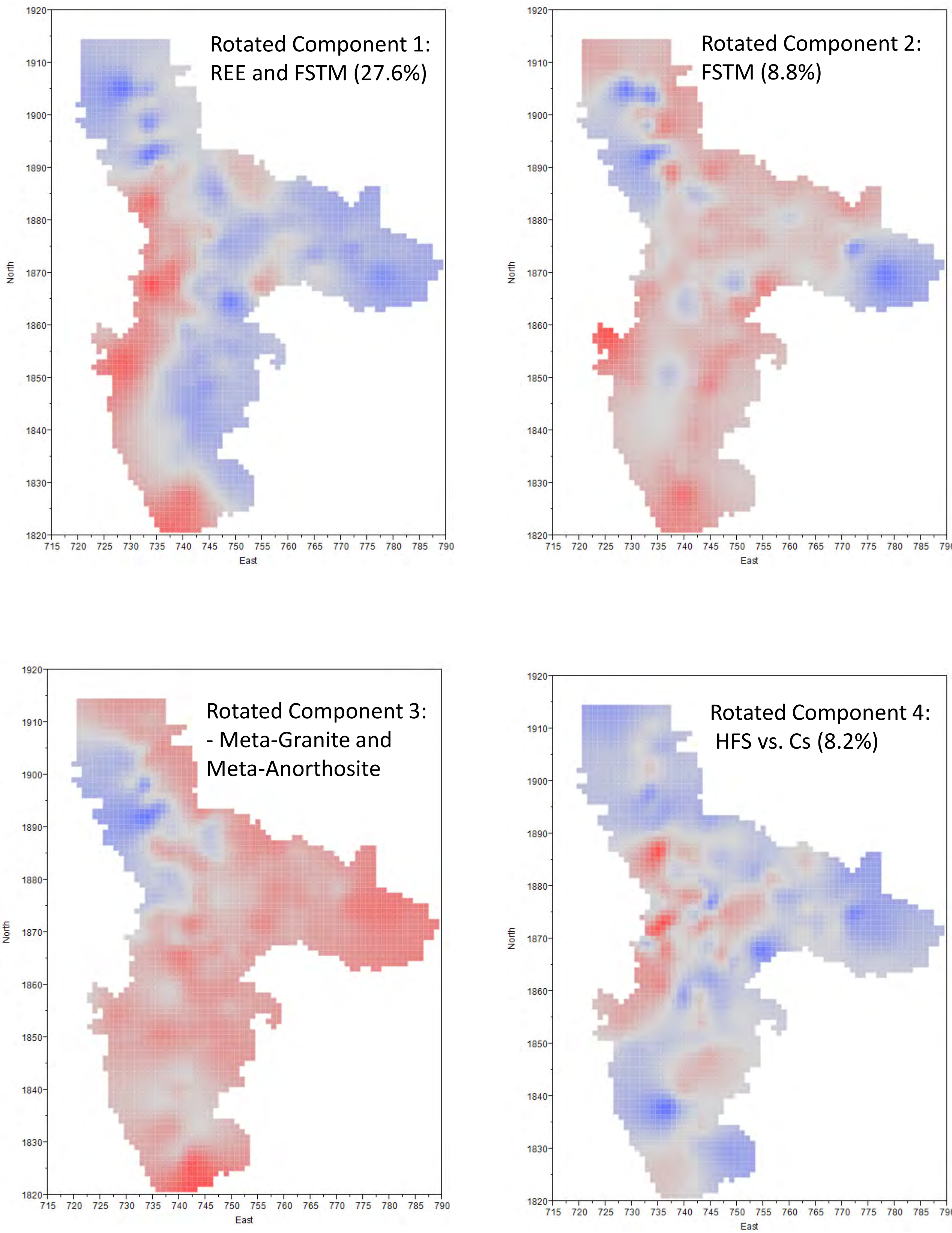


Figure 13. Robust, rotated principle components analysis of valley clays.

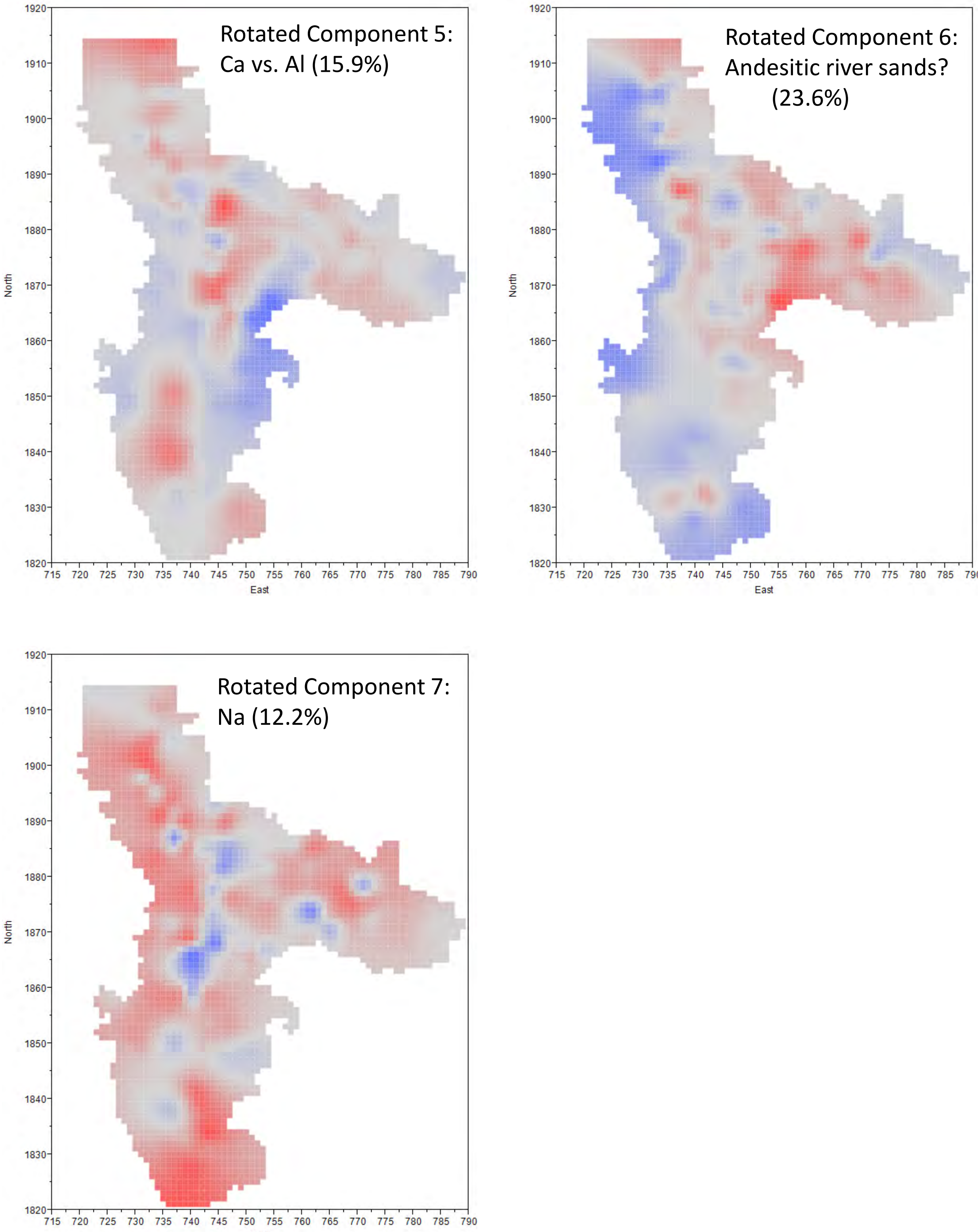


Figure 13, cont. Robust, rotated principle components analysis of valley clays.

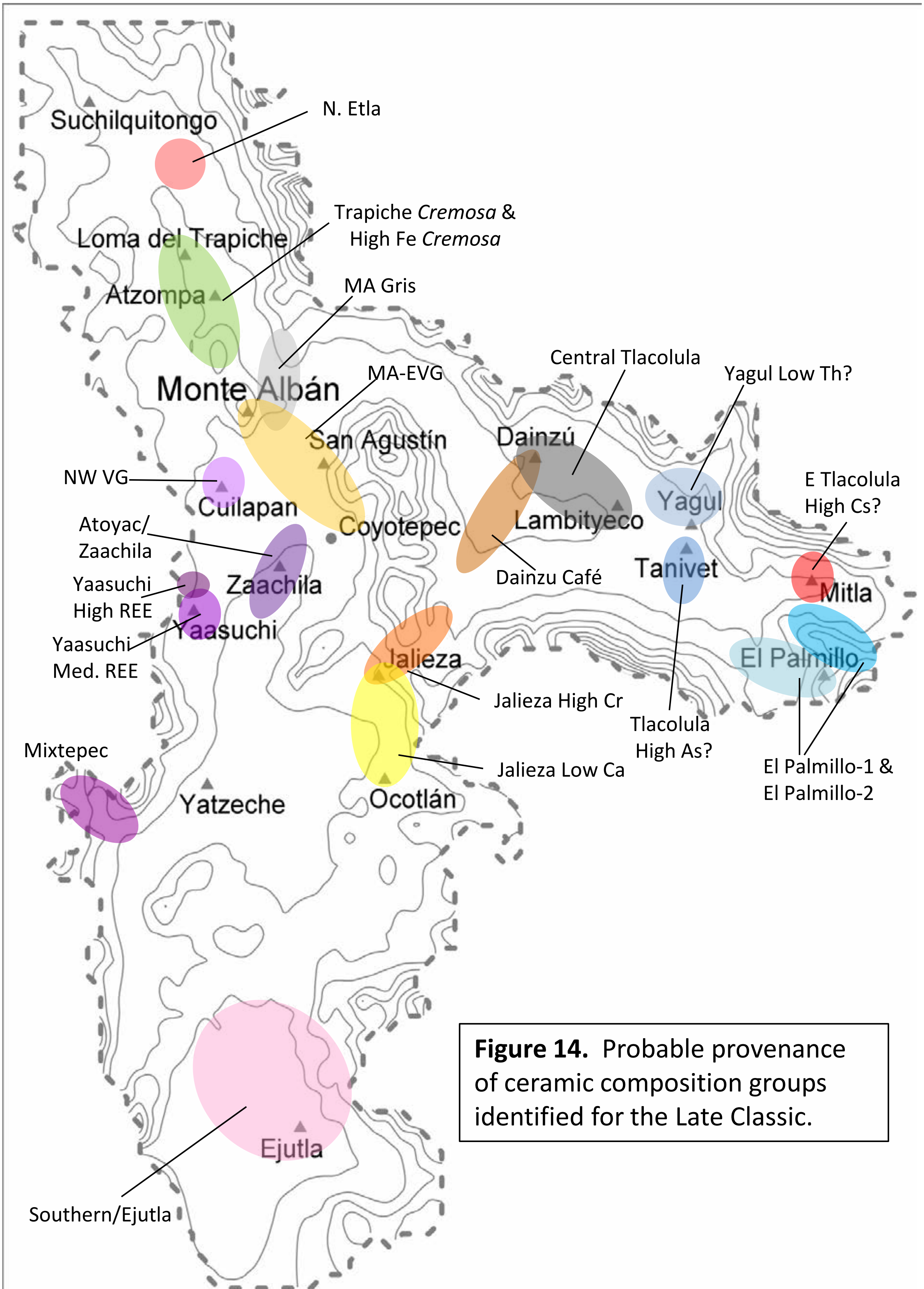


Figure 14. Probable provenance of ceramic composition groups identified for the Late Classic.

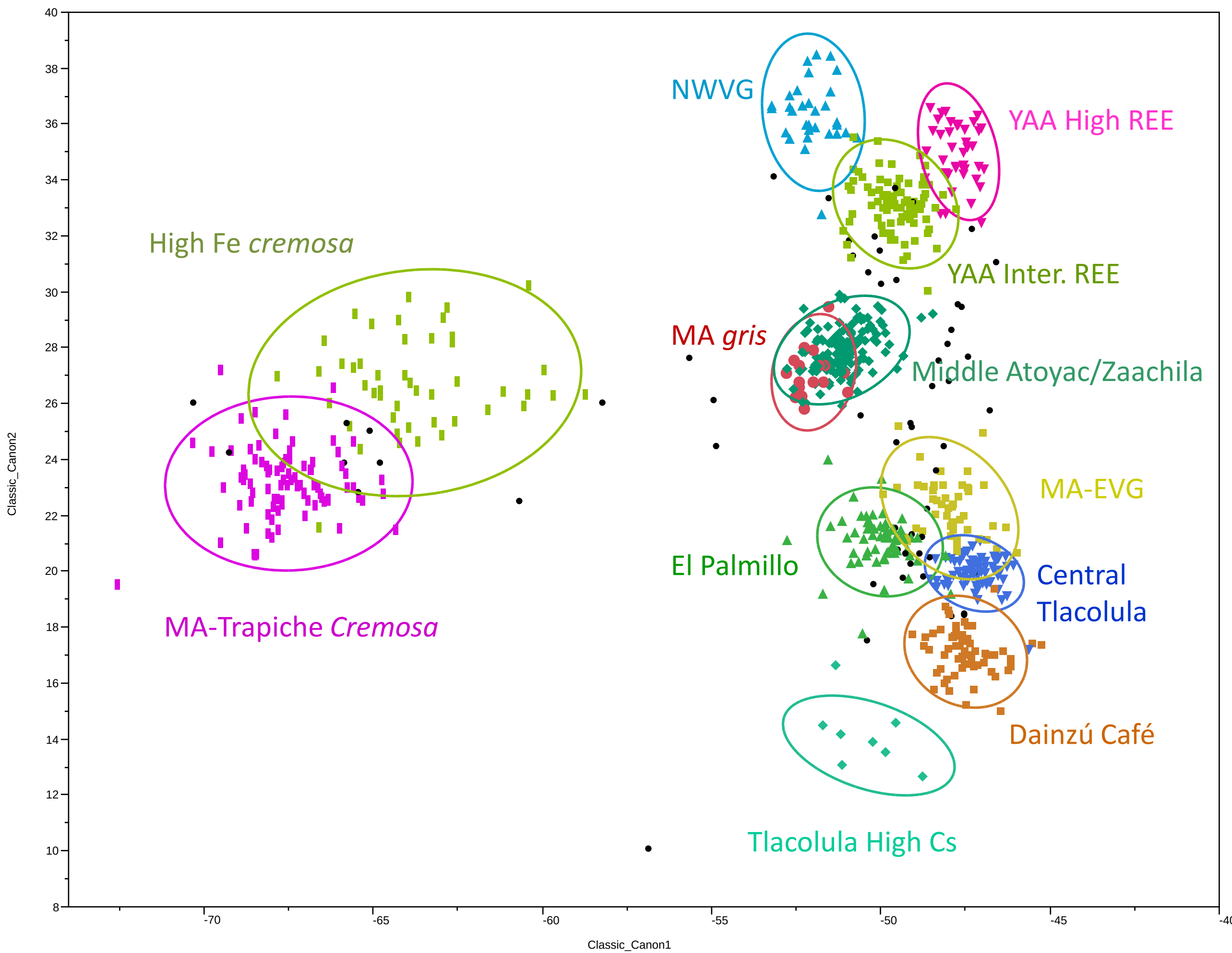


Figure 15. Canonical variates separation of composition groups for Classic ceramics. Monte Albán - Eastern Valle Grande (MA-EVG) separates from similar groups on Canonical Variate 4. Greater separation among remaining groups is achieved at the regional level (see Figs. 9-11).

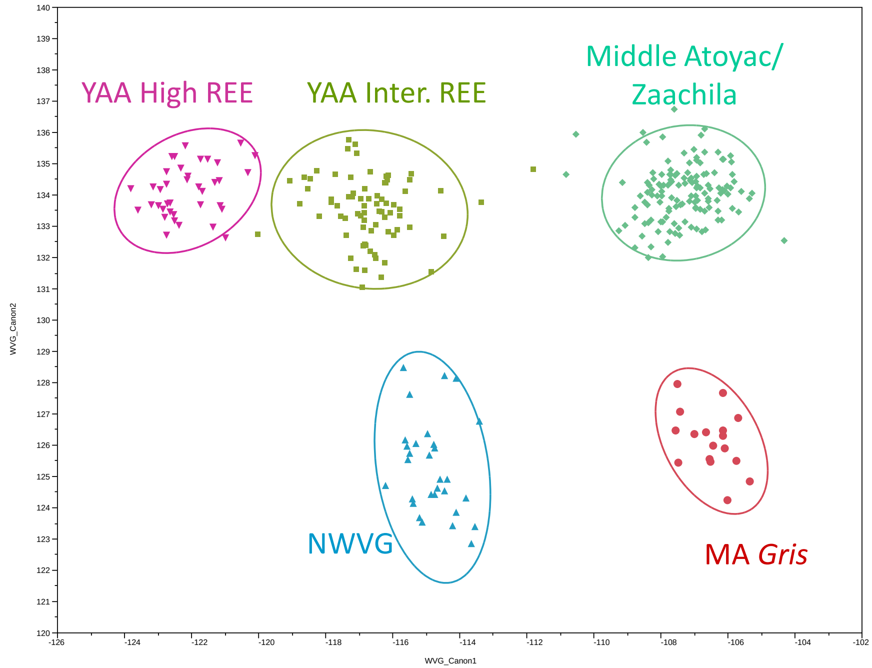


Figure 16. Canonical variates separation of ceramic composition groups associated with the Western Valle Grande. Five distinct composition groups are recognized, including two from the site of Yaasuchi, along with a group representing the central Atoyac drainage including Zaachila, a NW Valle Grande (NWVG) linked to clays near Cuilapan, and gray-ware produced at or near Monte Albán (MA *Gris*).

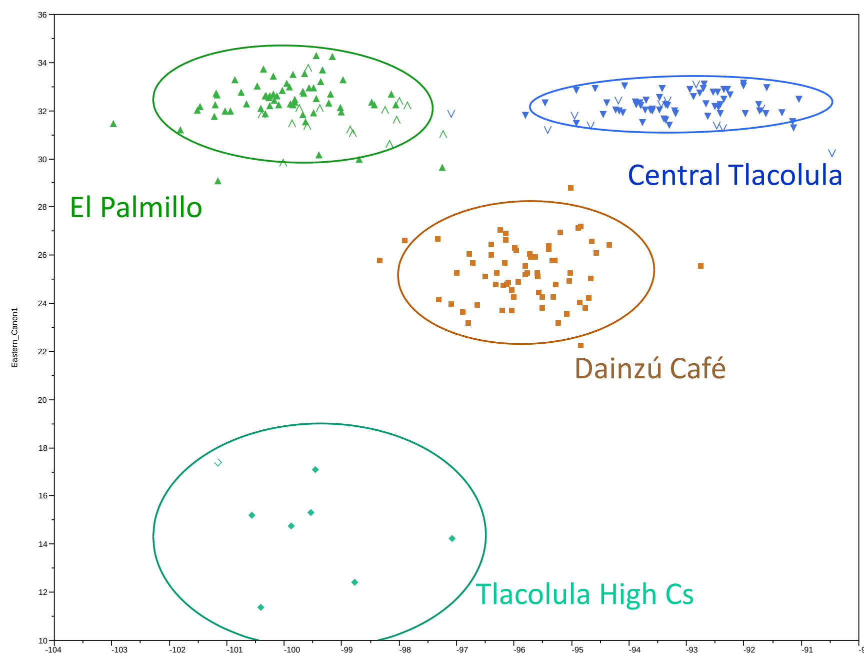


Figure 17. Canonical variates separation of ceramic composition groups associated with the eastern or Tlacalula branch of the valley. Solid symbols represent core group members, and open symbols represent cases assigned to that group by discriminate analysis. Four distinct composition groups are recognized, including two from near Dainzú, and two from the far eastern end of valley.

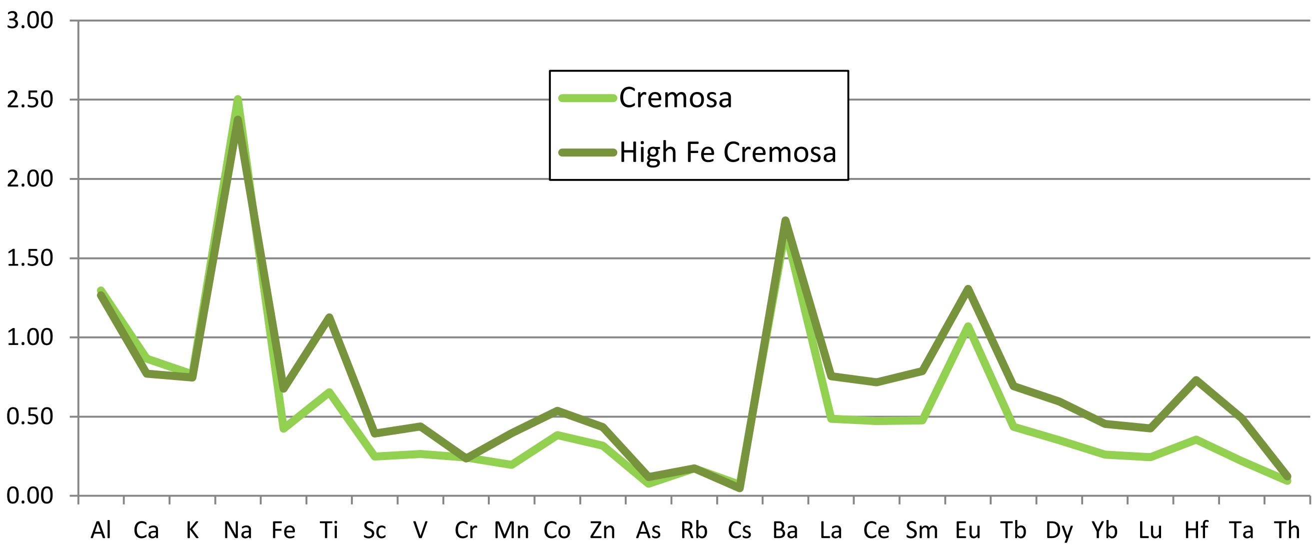
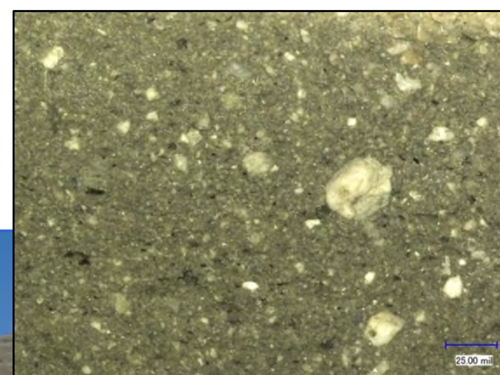


Figure 18. Compositional profile for *cremosa* reference groups. Both reference groups have relatively high concentrations of Al and Na owing to the presence of plagioclase, but they can be distinguished based on bimodalities in iron and the REE.



Microphotograph of typical cremosa paste showing white inclusions derived from weathered anorthosite. Small amounts of this mineral con strongly affect the composition of ceramics, enriching them in sodium.

Clay mine used by modern potters of Atzompa.

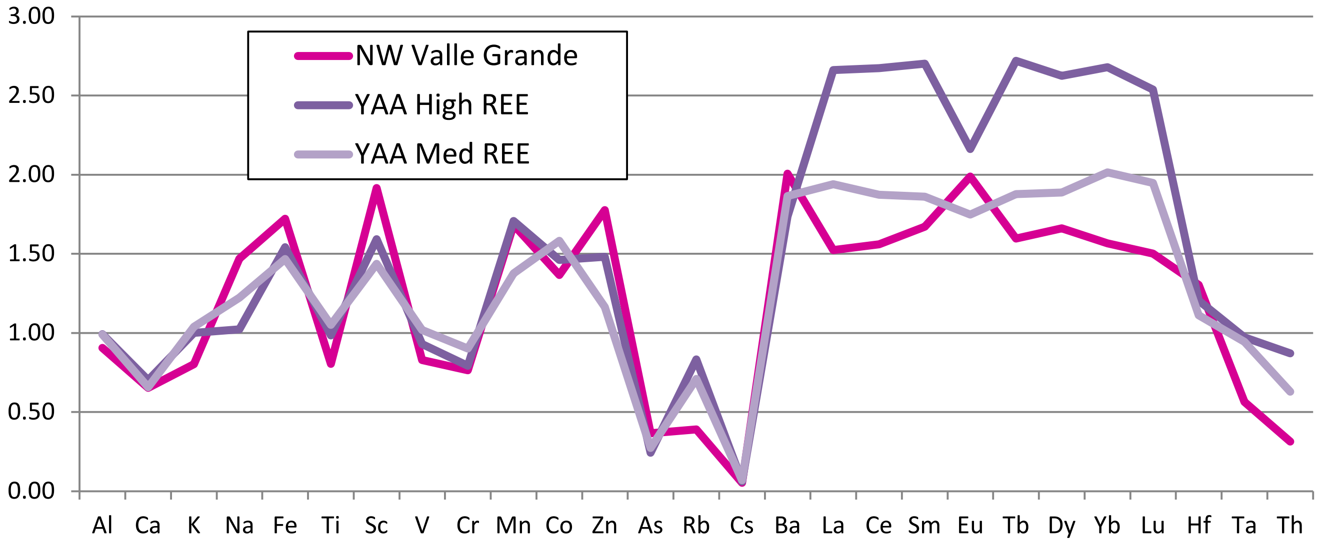


Figure 19. Compositional profiles for reference groups associated with gneiss-derived clays. Relative to other groups they are relatively high in the REEs, Re, and Sc, but low in Cs and Rb.

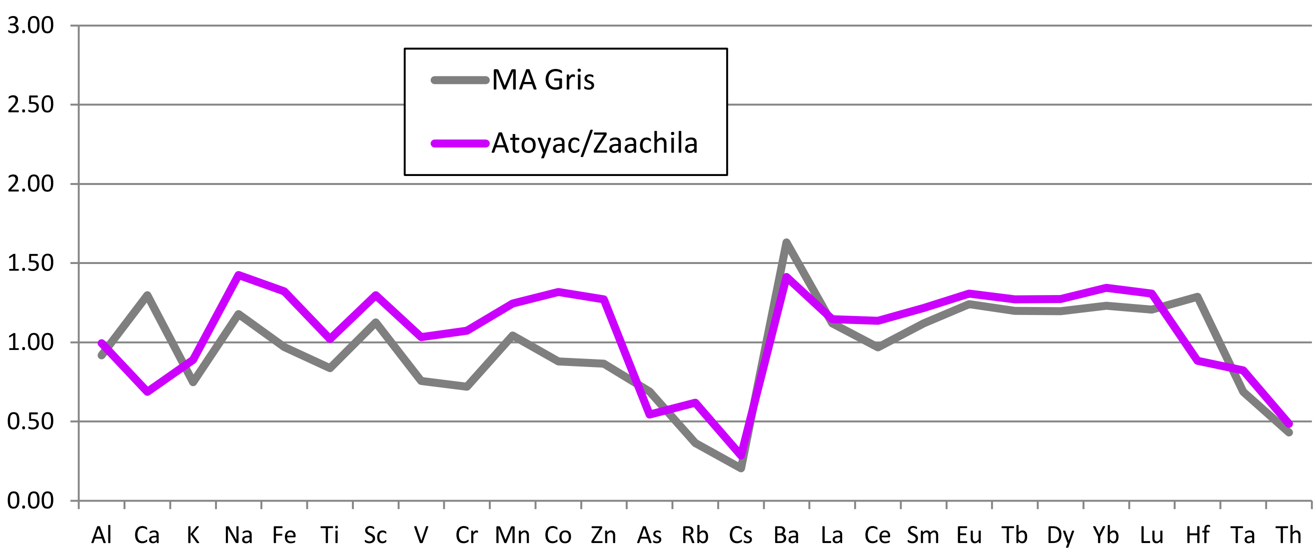


Figure 20. Compositional profiles for reference groups associated with gneiss-derived clays moderated by alluvial deposition. They have a less extreme composition, but are still somewhat enriched in the REE, Fe, and Sc.

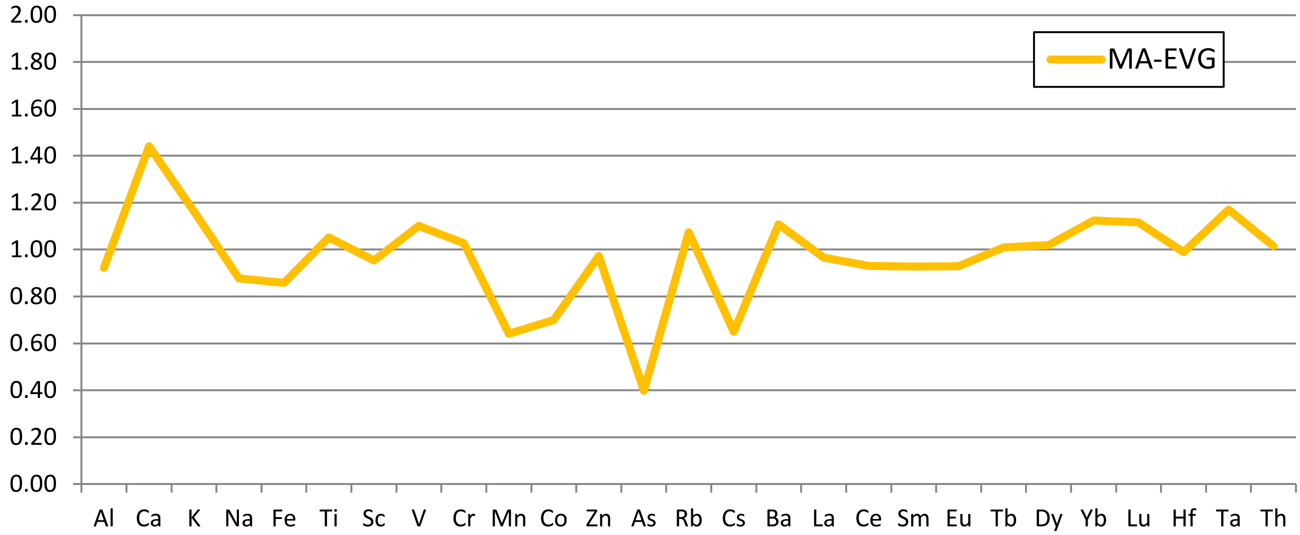


Figure 21. Compositional profile for the MA-EVG reference group associated with calcareous clays derived from calcilutite.

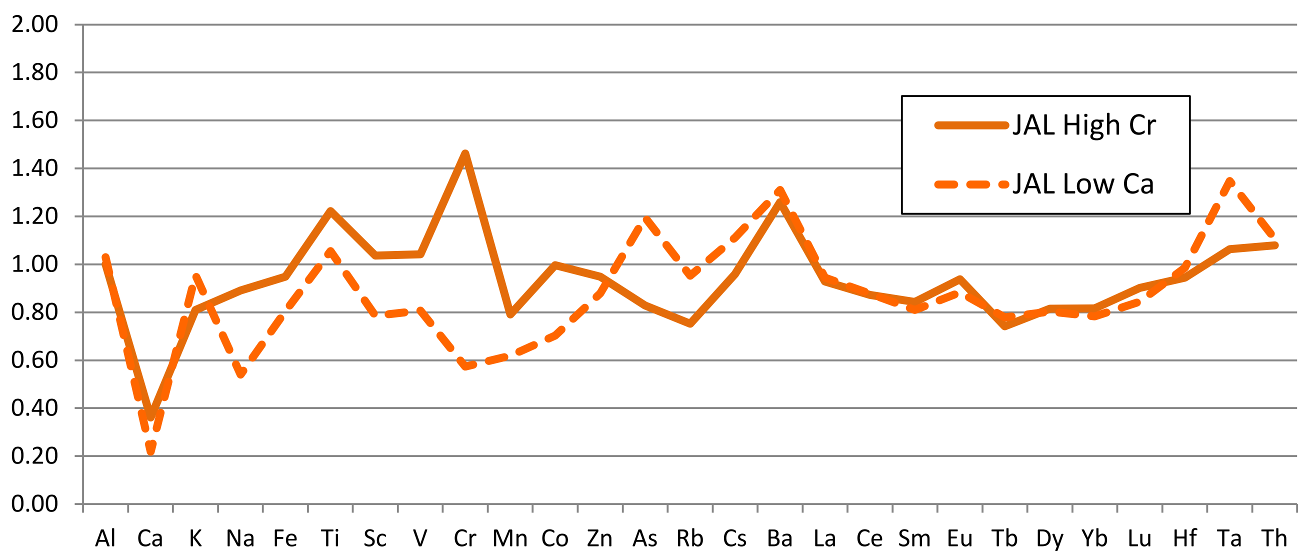


Figure 22. Compositional profiles for the Jalieza composition groups associated with clays derived from andesite.

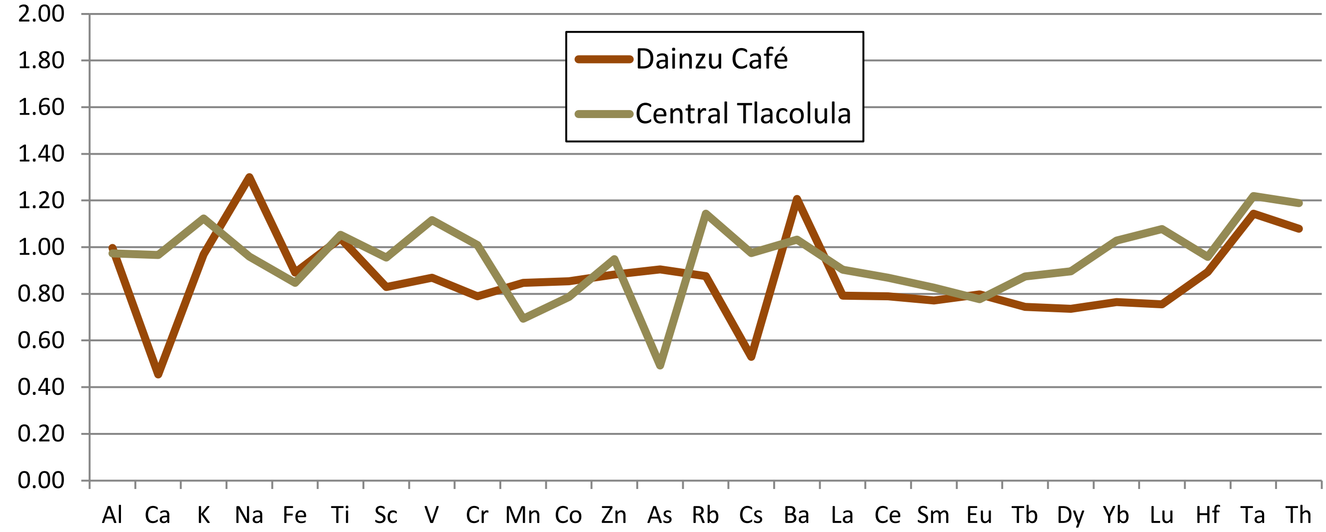


Figure 23. Compositional profiles for the Tlacolula composition groups associated with clays derived from andesite.

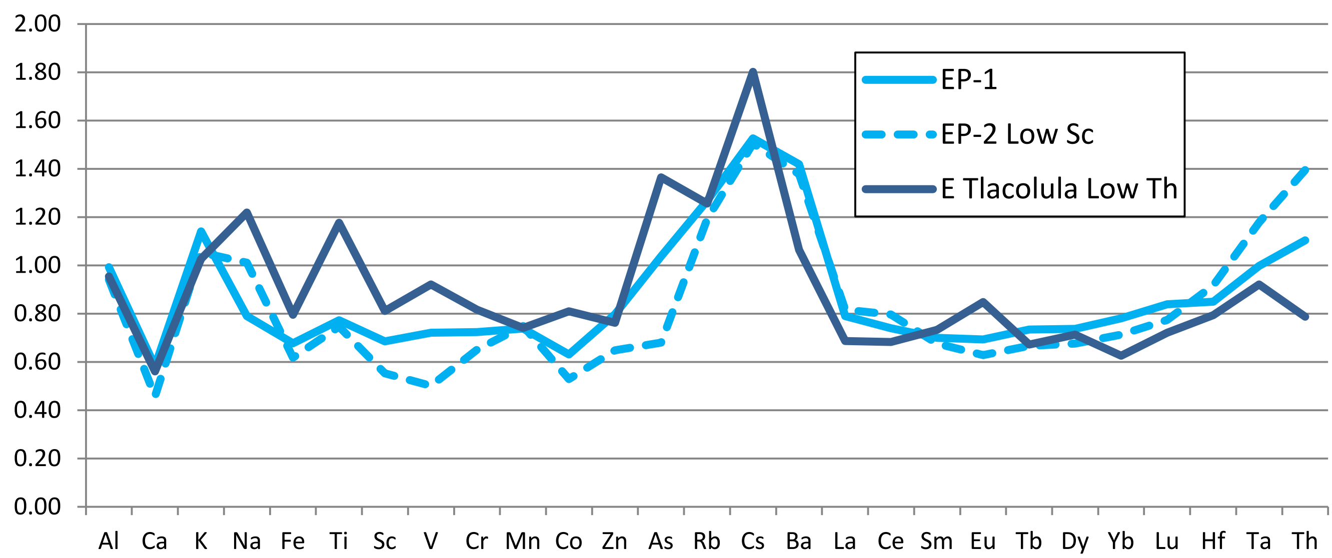
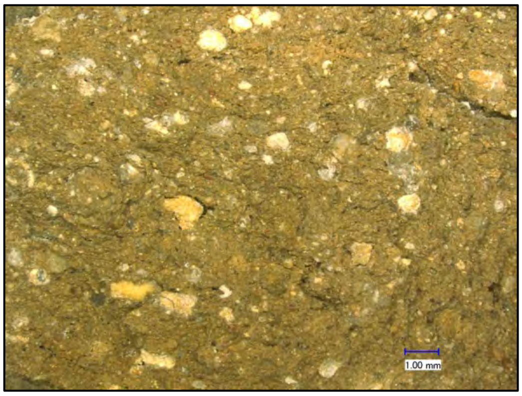
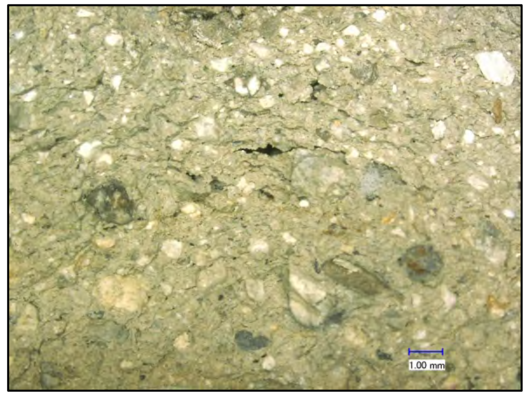


Figure 24. Compositional profiles for the E Tlacolula composition groups associated with clays derived from ignimbrite. Their compositions are strongly enriched in Rb and Cs.



A. MAX_097



B. MAX_099

C. MAX_093

D. MA_095 30X

E. MAX_098

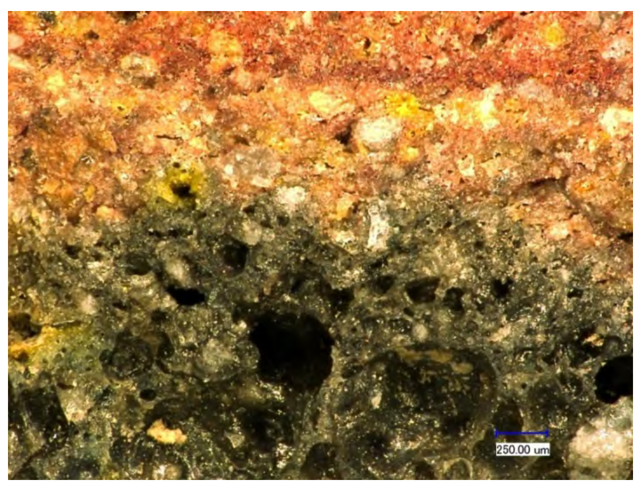
F. MA_089

Figure 25. Late Classic vessel pastes and firing conditions. A-B. Typical, even paste color indicting controlled firing conditions from a single firing event, either oxidized or reduced; C-D. Vessels with oxidized cores but reduced surfaces; E-F. Vessels showing strong zonation in paste color indicating multiple firing events.

MA_088. *Comal* waster with bloated paste and surface vitrification.

Paste vitrification (200X)

MA_091 (detail of fusing)



Paste vitrification (100X)

MA_091. Fused vessels showing surface vitrification and paste bloating.

Figure 26. Late Classic wasters from Monte Albán. MA_088 has a composition clearly associated with the NW Valle Grande group, while MA_091 appears mixed, combining attributes of the MA-EVG and *cremosa* groups.

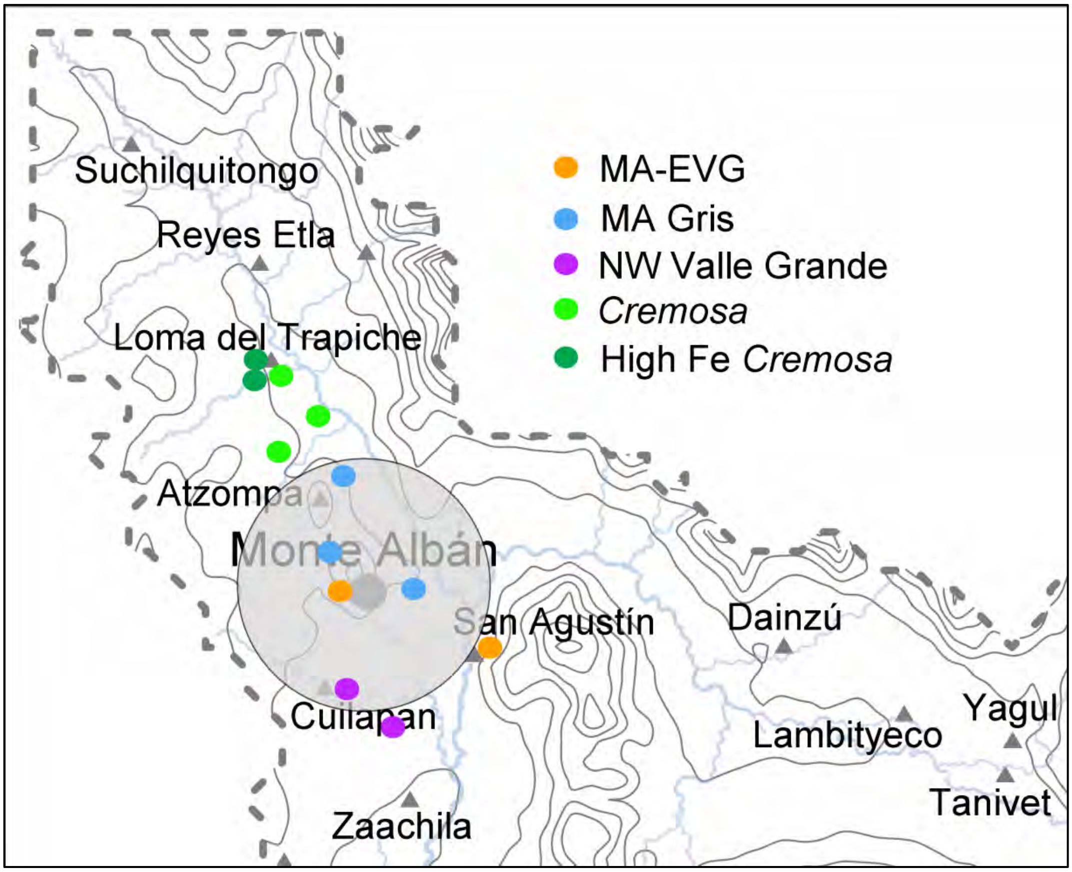


Figure 27. Known sources of clays matching Late Classic composition groups potentially produced at Monte Albán. The gray circle indicates a radius of 7 km surrounding Monte Albán, suggesting the probable maximum distance that potters would travel to obtain clays. Note that clays matching the MA-EVG, MA Gris, and NW Valle Grande fall within this radius; these ceramics are also best represented in production contexts at the site.

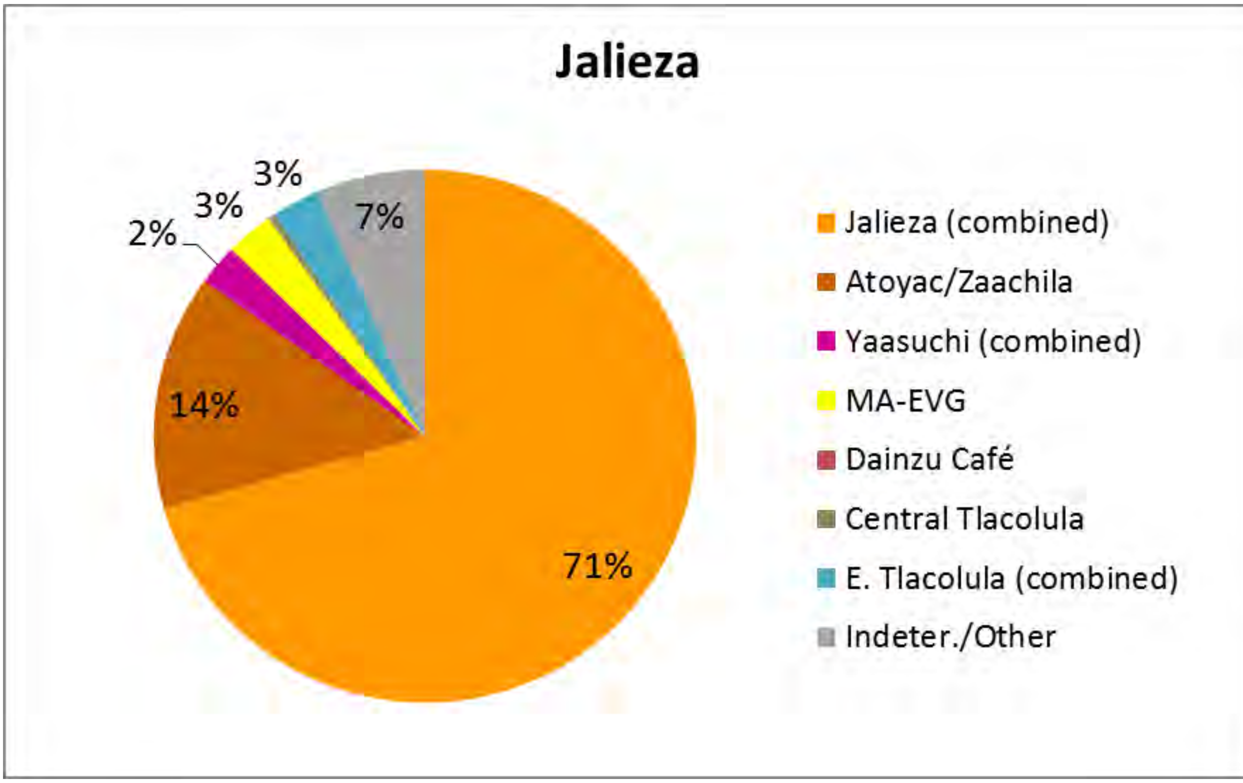


Figure 28. Sources of Late Classic ceramics at Jalieza.

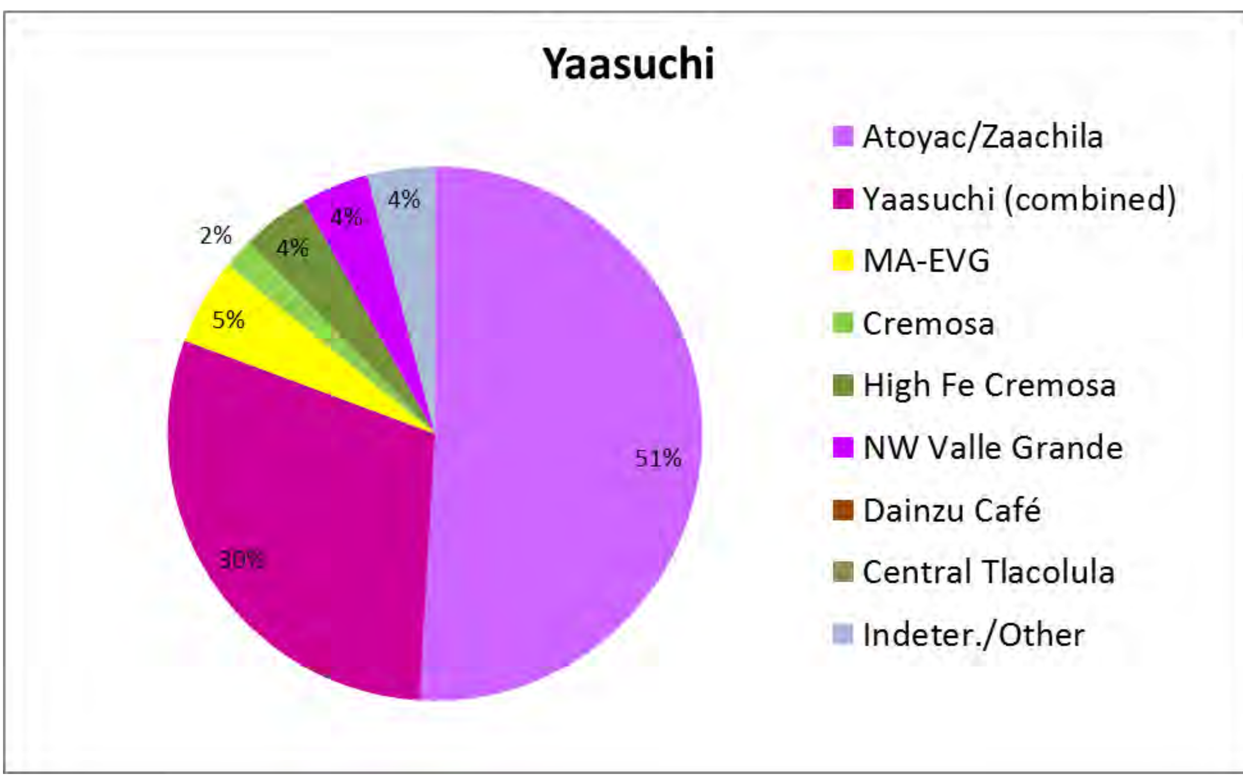


Figure 29. Sources of Late Classic ceramics at Yaasuchi.

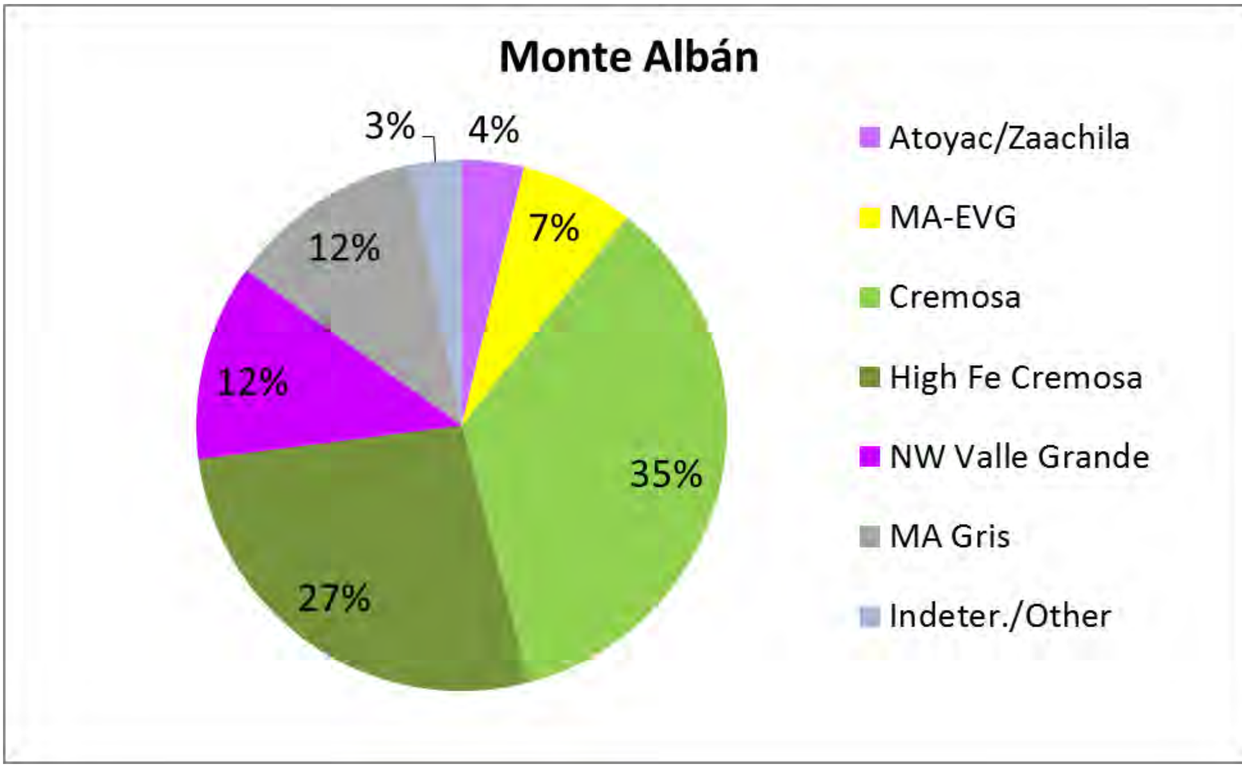


Figure 30. Sources of Late Classic ceramics at Monte Albán.

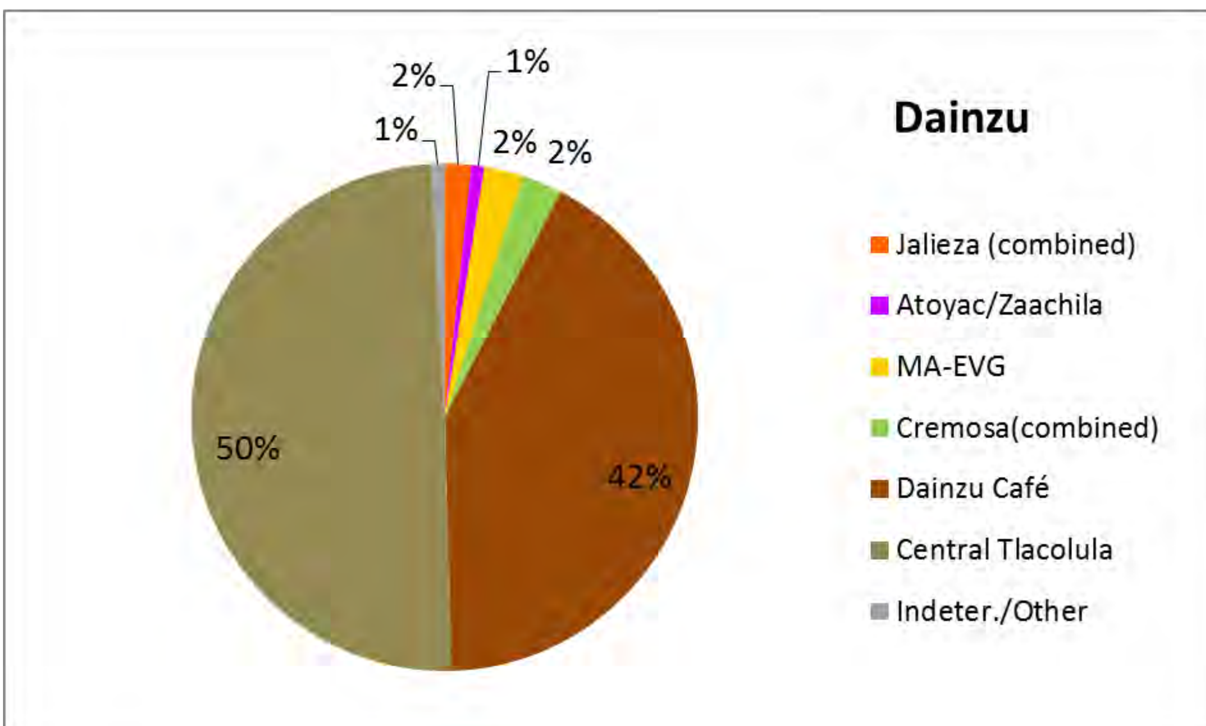


Figure 31. Sources of Late Classic ceramics at Dainzú.

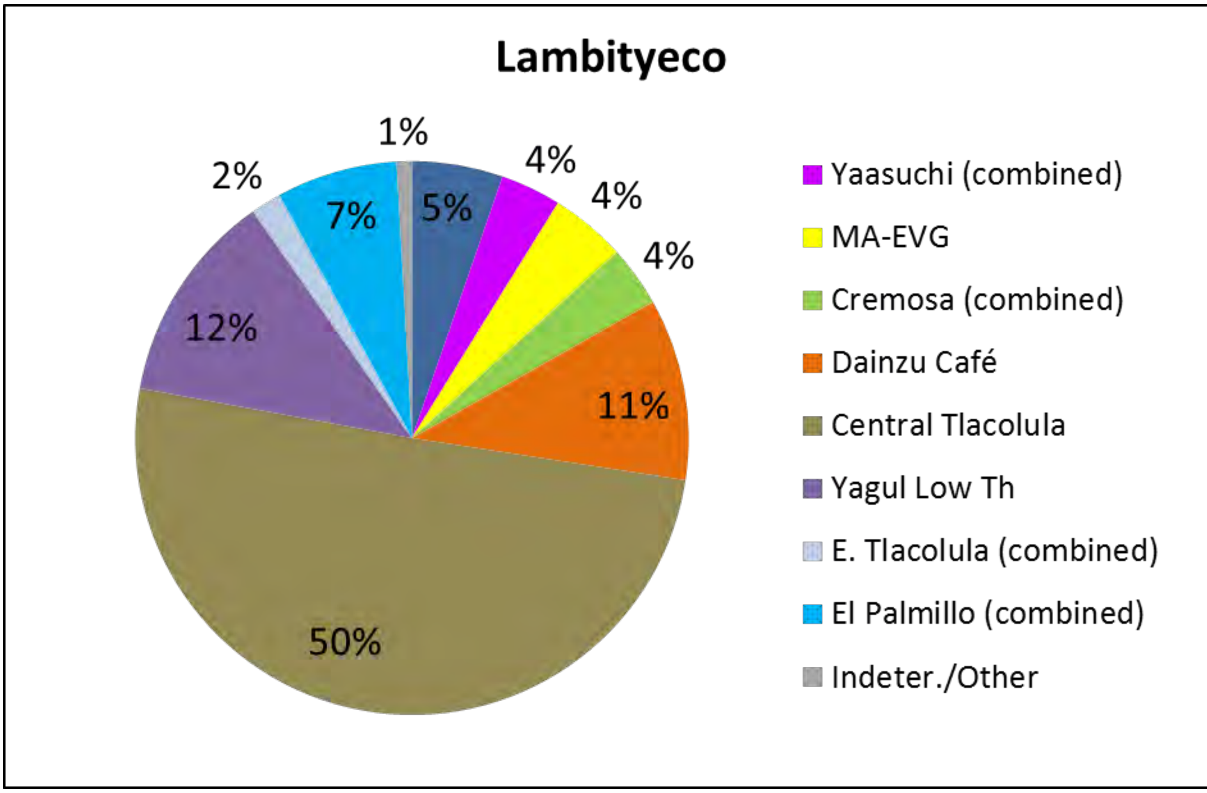


Figure 32. Sources of Late Classic ceramics at Lambityeco.

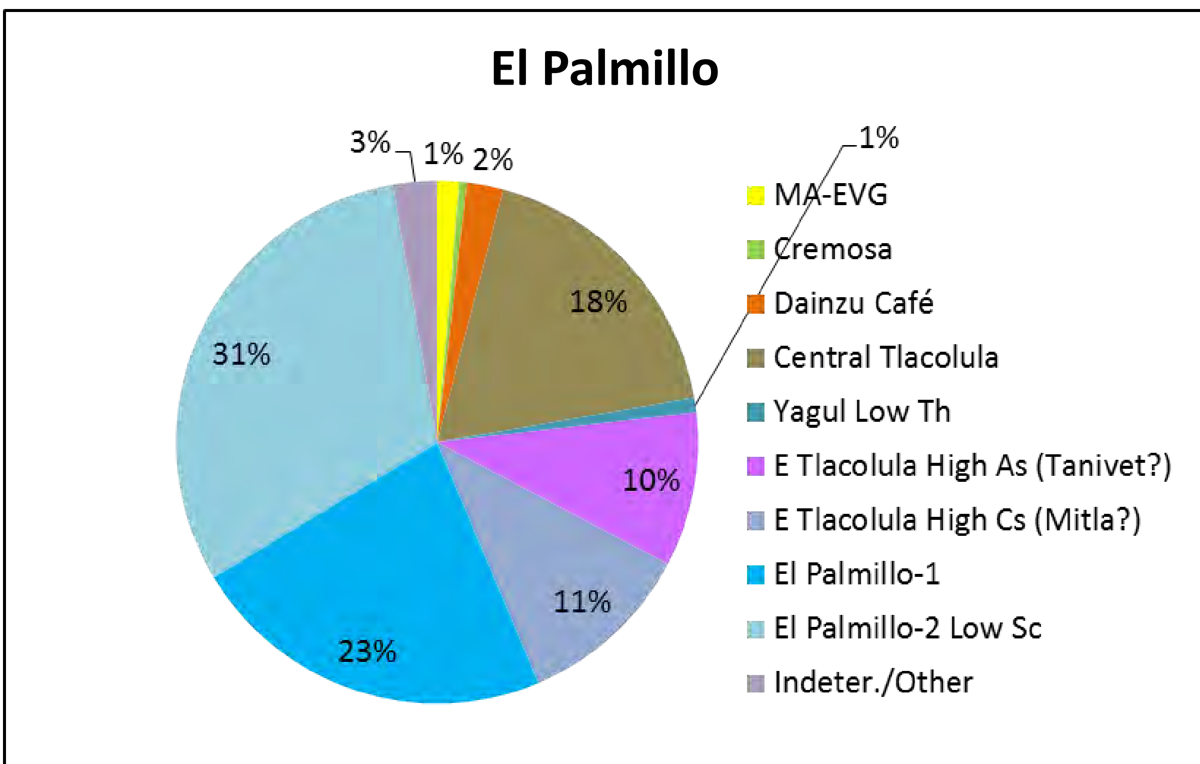


Figure 33. Sources of Late Classic ceramics at El Palmillo.

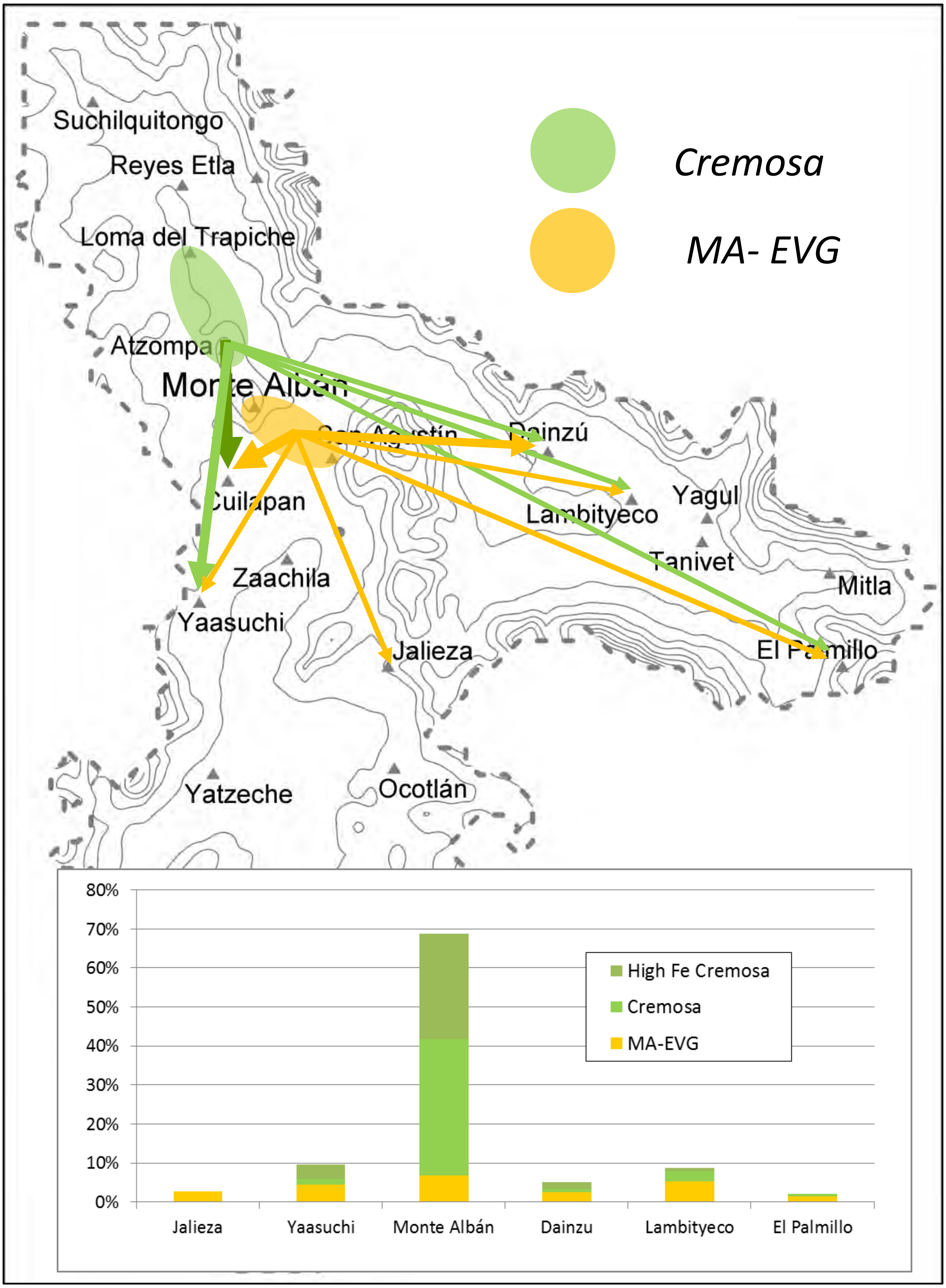


Figure 34. Distribution of ceramics from Greater Monte Albán as a percent of Late Classic ceramic assemblage.

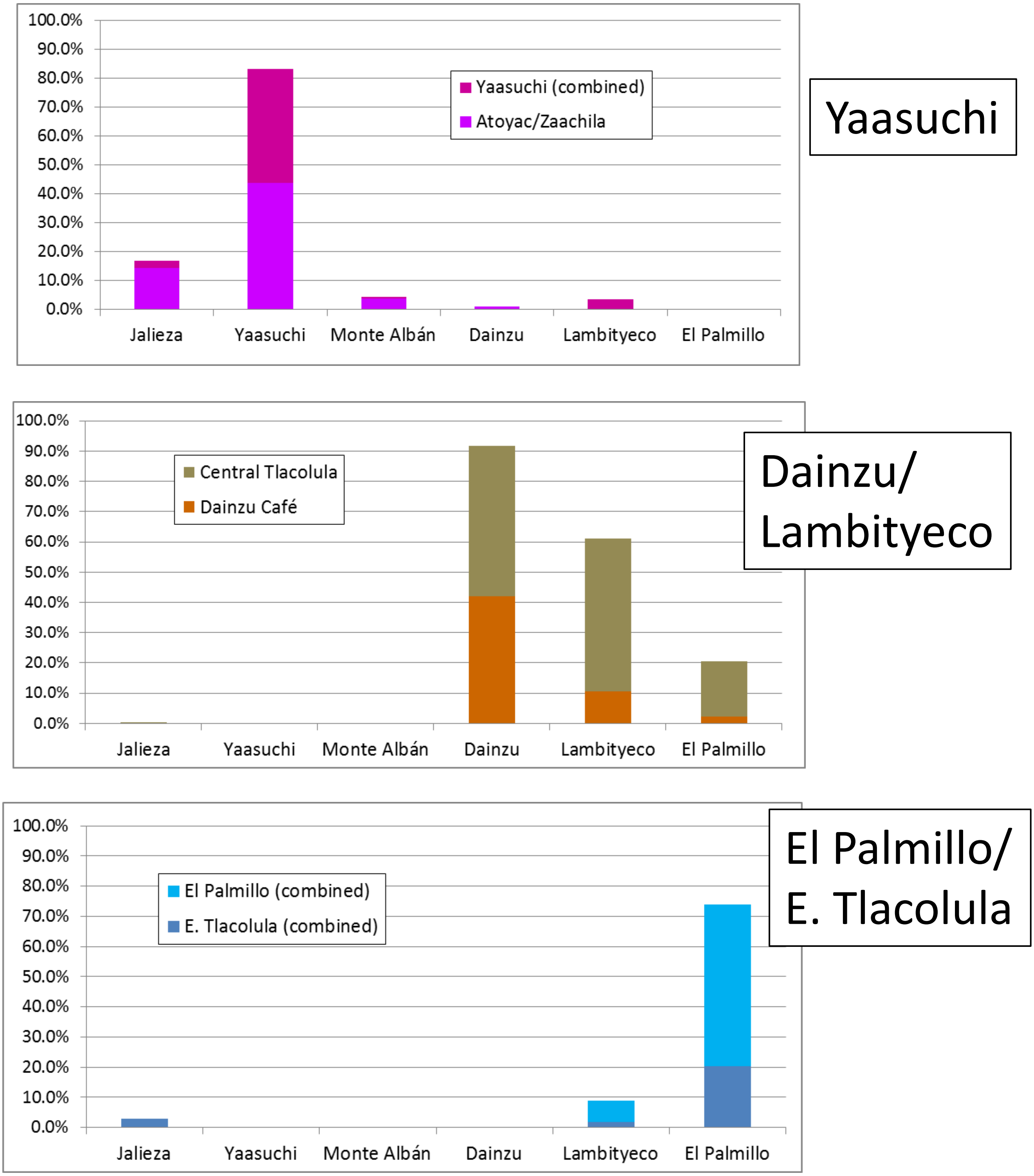


Figure 35. Exchange among other sites: distribution of ceramics made at Yaasuchi, Dainzu/Lambityeco, and El Palmillo, as a percentage of Late Classic assemblage. Sites are ordered geographically on the horizontal axis to indicate the degree to which ceramics were exchanged among neighboring communities.

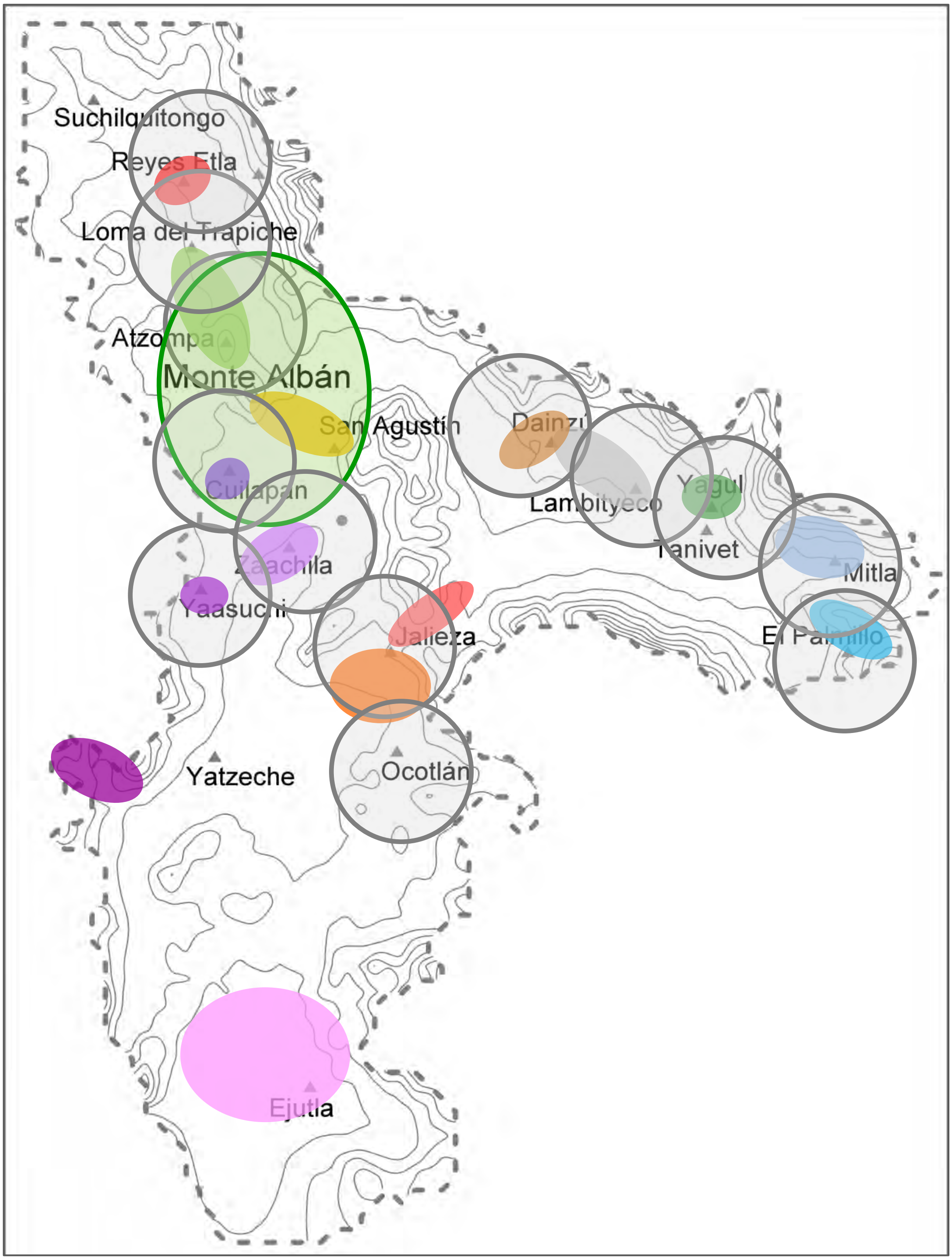


Figure 36. Model for the organization of regional exchange during the Late Classic. A core zone (green) supplied Monte Albán, while a series of smaller, overlapping market zones served dependent communities.

MA_072 exterior

MA_075 exterior

Figure 37. MA IIIA *gris* vessels of the G23 type: wasters from Monte Albán (above) and exports to Dainzú (below).

DAN_039

DAN_040

DAN_041

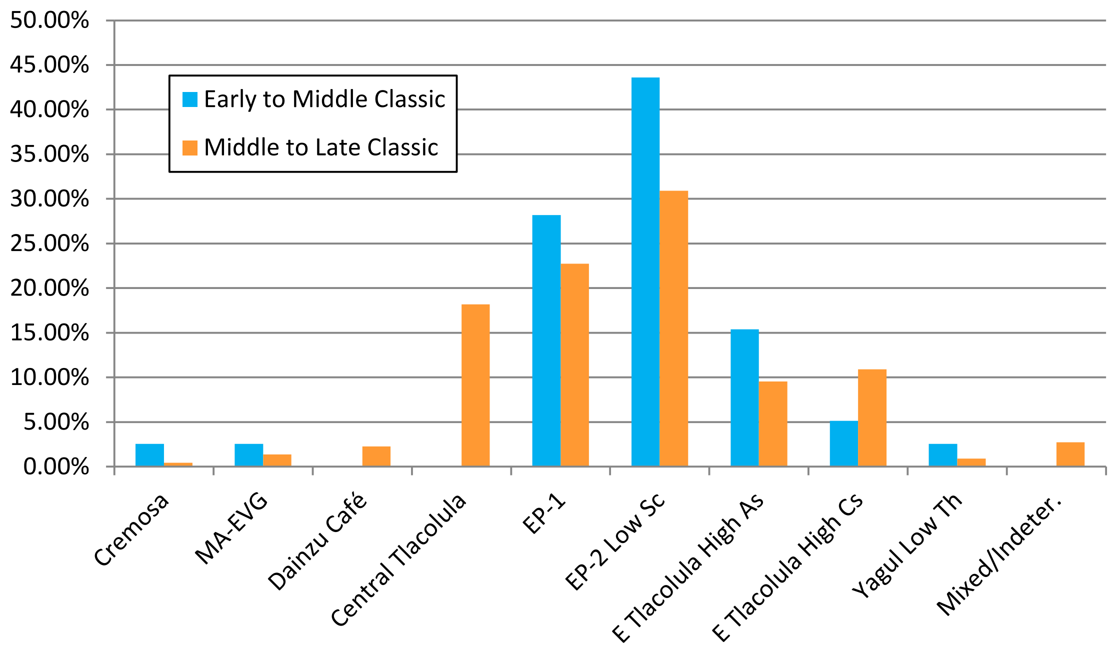


Figure 38. Comparison of Early-Middle vs. Middle-Late Classic assemblages at El Palmillo.

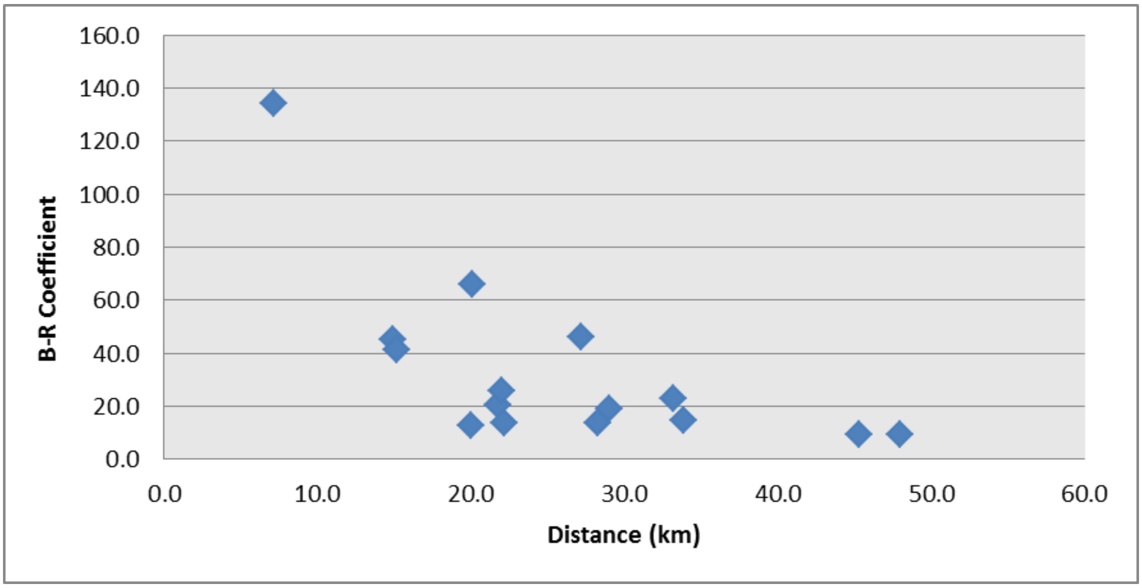


Figure 39. Fall-off in similarity among Late Classic ceramic assemblages as a function of straight-line separating distance.

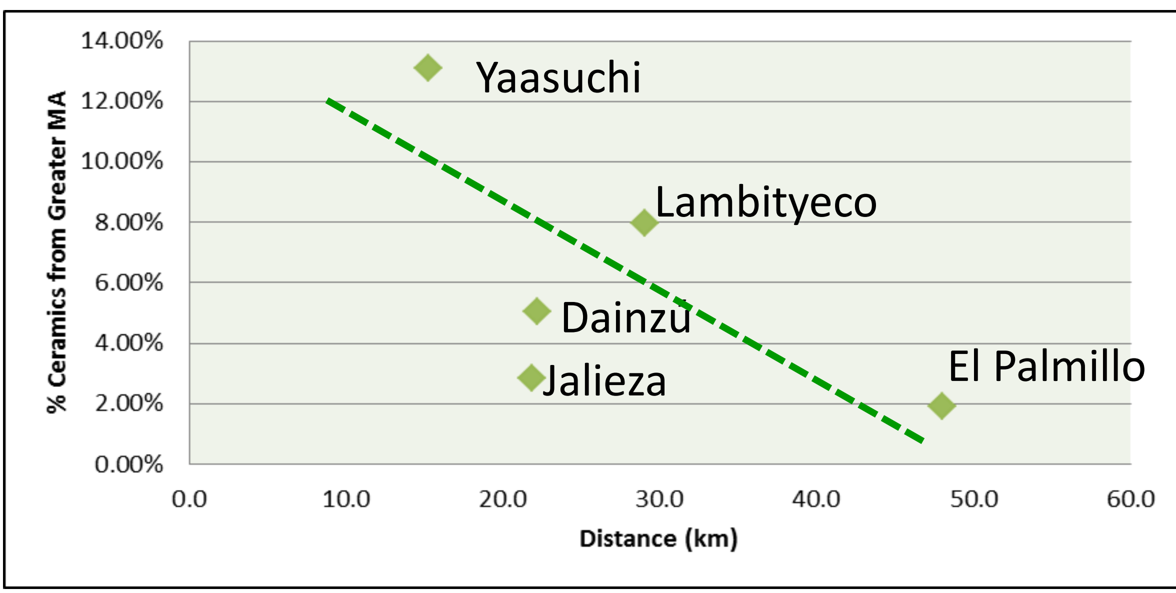


Figure 40. Percent of Late Classic assemblage comprised of ceramics from Greater Monte Albán, relative to distance from the capital in kilometers.

Appendix I:
Ceramic Wasters from Monte Albán

MA_067 – MA_100

Wasters and production debris archived as “*defectos de cocción*”

MA_067 interior

MA_067 exterior

MA_068 interior

MA_068 exterior

MA_069 interior

MA_069 exterior

MA_070 interior

MA_070 exterior

MA_071 interior

MA_071 exterior

MA_072 interior

MA_072 exterior

MA_073 interior

MA_073 exterior

MA_074 interior

MA_074 exterior

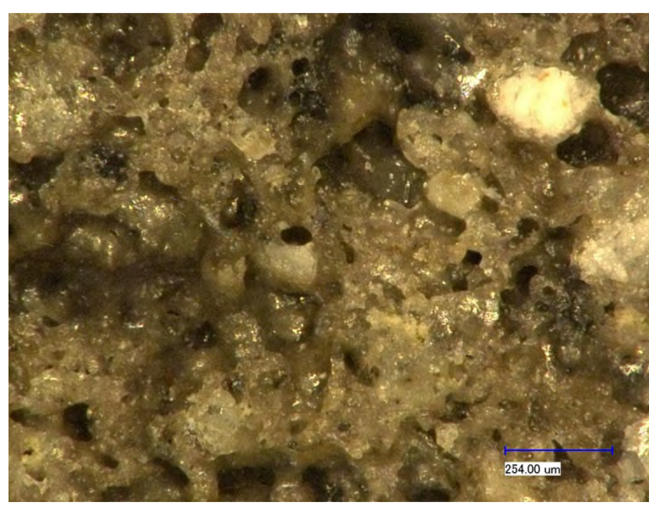
MA_074 spongy paste

MA_075 interior

MA_075 exterior

MA_076 interior

MA_076 exterior



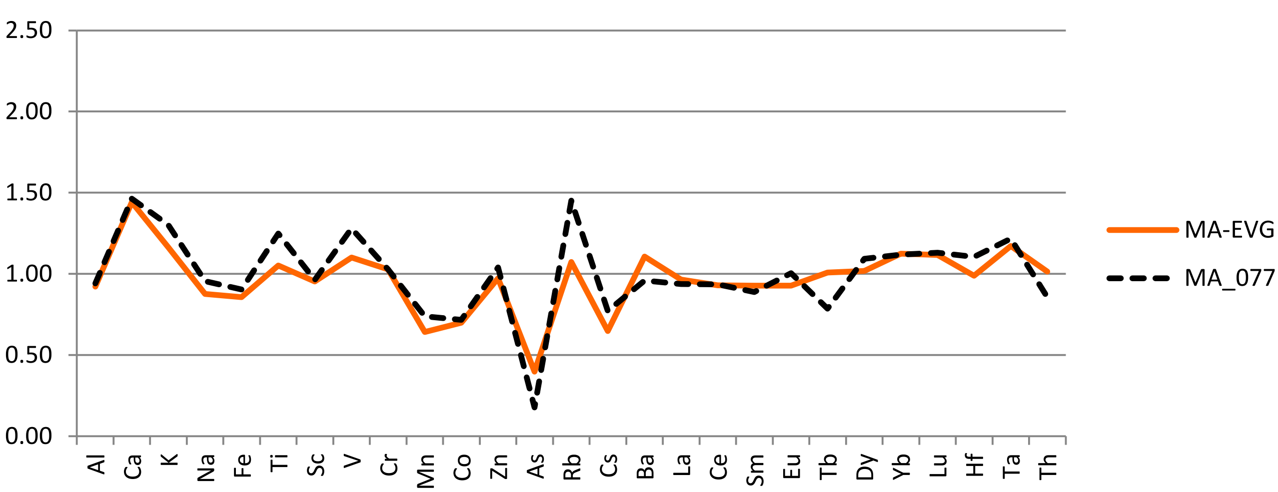
MA_076 spongy paste and vitrification (200x)

MA_077 interior

MA_077 exterior

MA_077 spongy paste

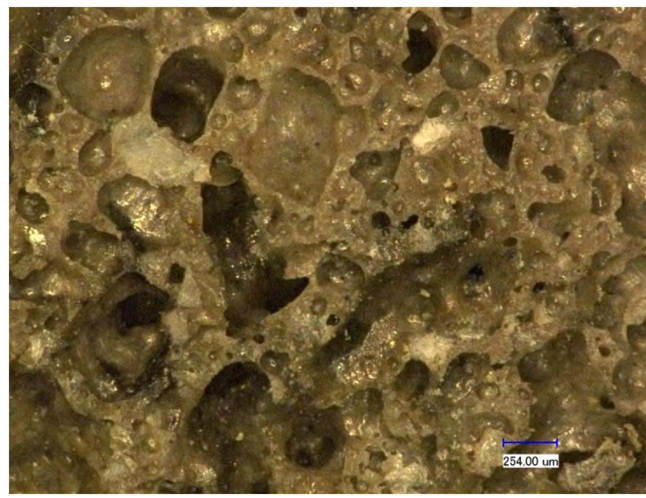
incipient vitrification (200x)



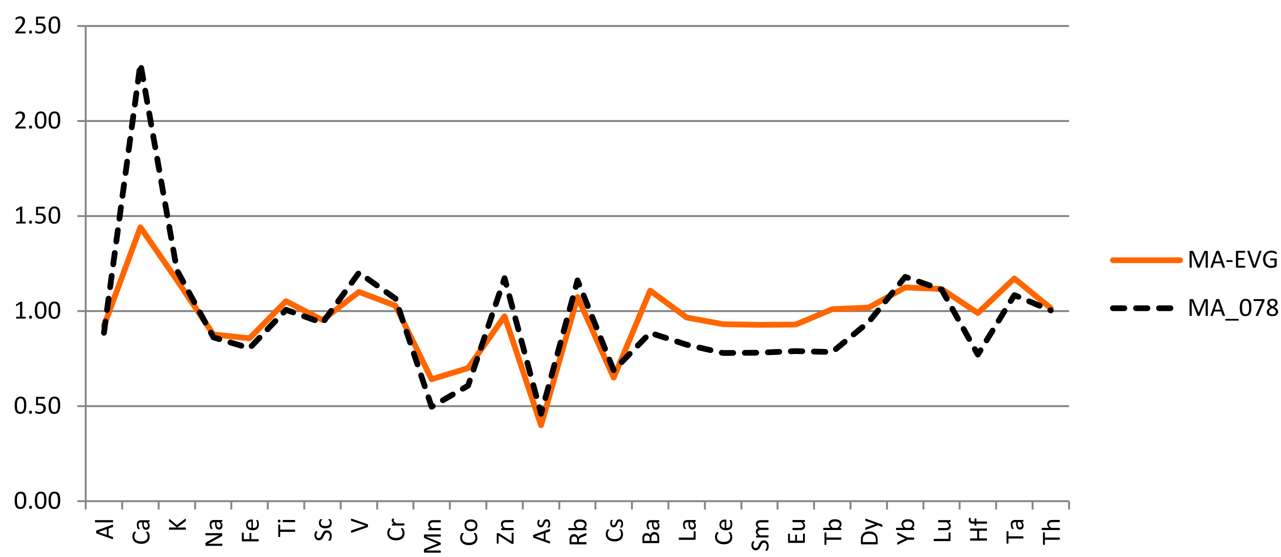
MA_078 interior

MA_078 exterior

MA_078 blister



paste vitrification/bloating (100x)

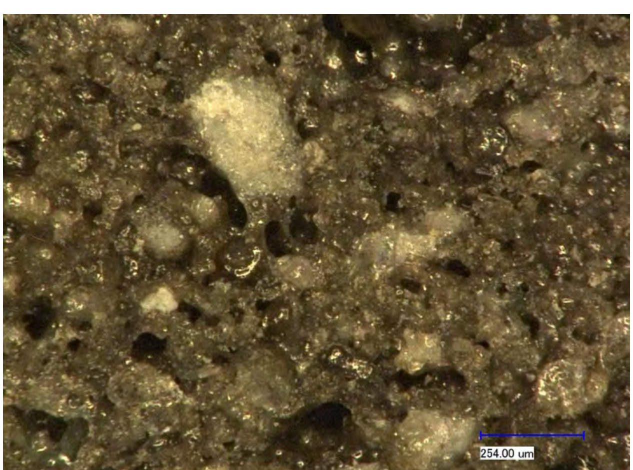


MA_079 interior

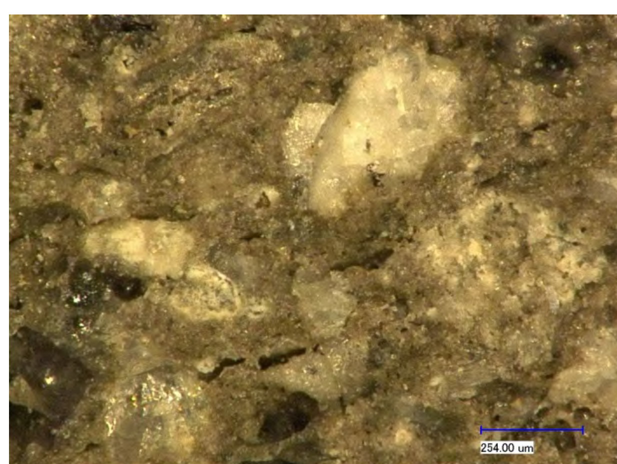
MA_080 interior

MA_079 exterior

MA_080 exterior



MA_079 vitrification (200x)



MA_080 vitrification (200x)

MA_081 interior

MA_081 exterior

MA_082 interior

MA_082 exterior

MA_081 collapsed support

MA_082 *burbuja*

MA_083 interior

MA_083 exterior

MA_083 spongy texture

MA_084 interior

MA_084 exterior

MA_085 interior

MA_086 interior

MA_085 exterior

MA_086 exterior

MA_085 cracks

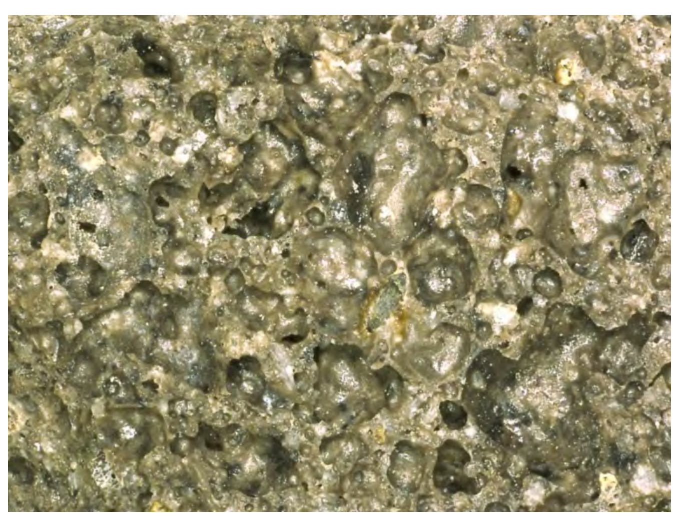
MA_086 cracks

MA_087A exterior

MA_087A profile

Fused, stacked vessels.

Paste vitrification
and bloating (50X)



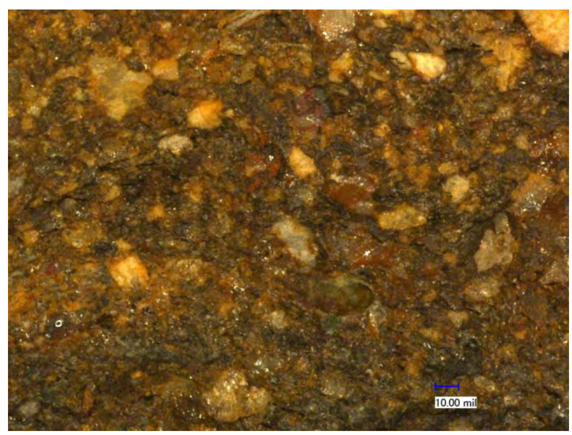
MA_087B – MA_100

MA-91, Pitayo-A, E. 1

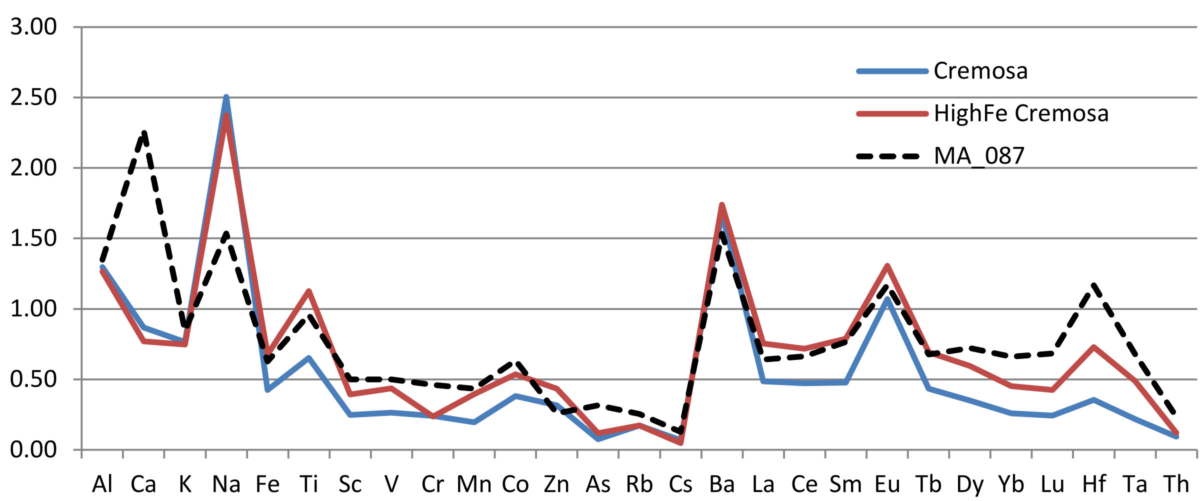
MA_087B interior

MA_087B exterior

Surface vitrification



Comal; refired kiln furniture (*crema* paste with oxidized, vitrified surface)



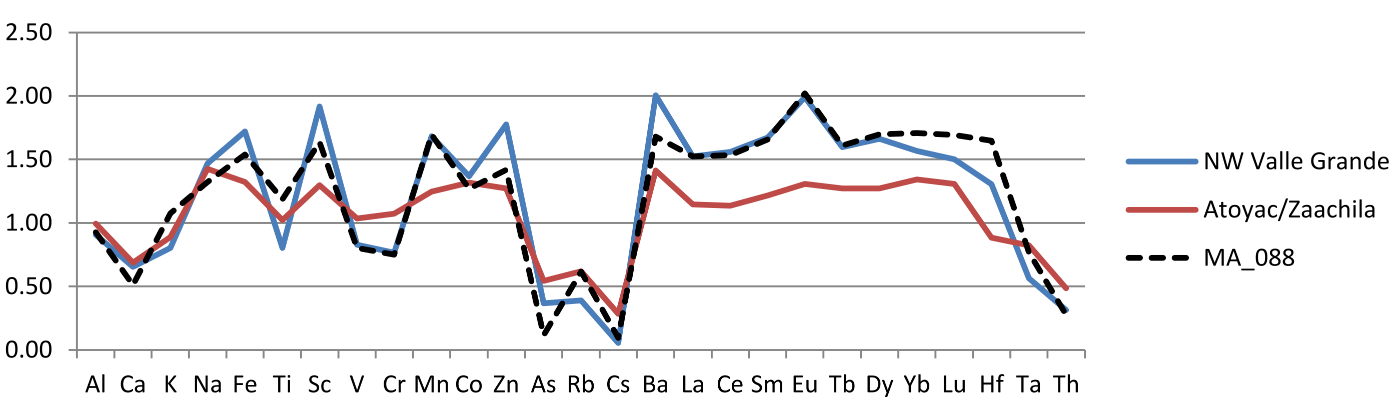
MA_088 interior

MA_088 exterior

MA_088 detail of spongy paste

Comal; waster or refired kiln furniture; reduced to oxidized paste with bloating and warping; surface oxidized and vitrified.

vitrification(200X)

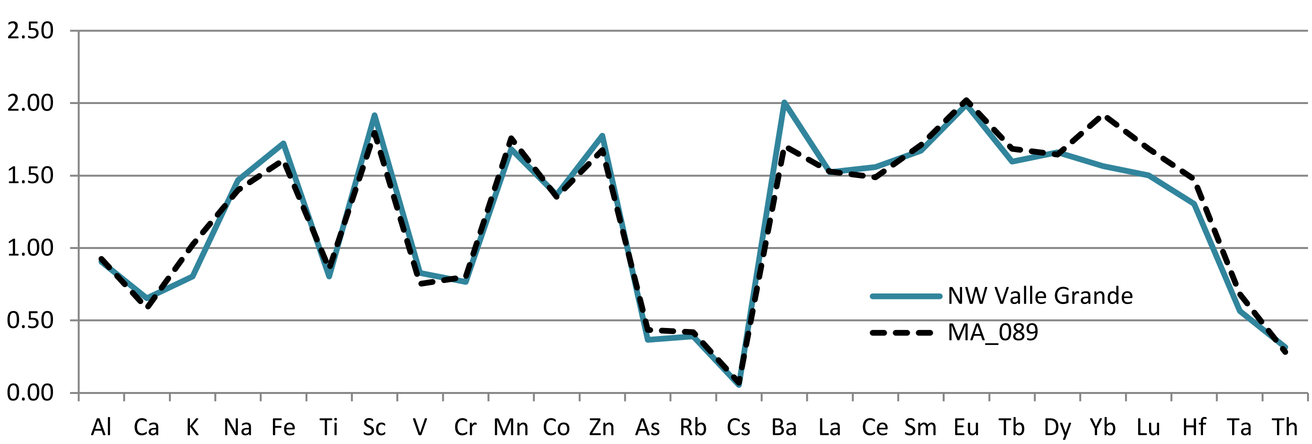


MA_089 interior

MA_089 exterior

Incipient paste vitrification and firing zonation (30x)

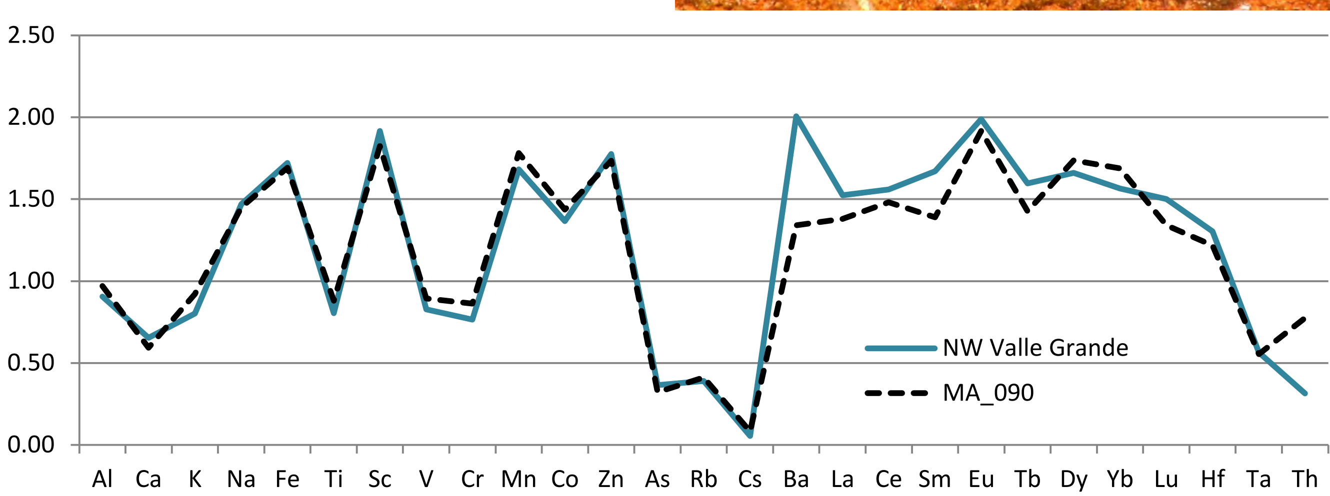
MA_089 surface detail



MA_090 interior

MA_090 exterior

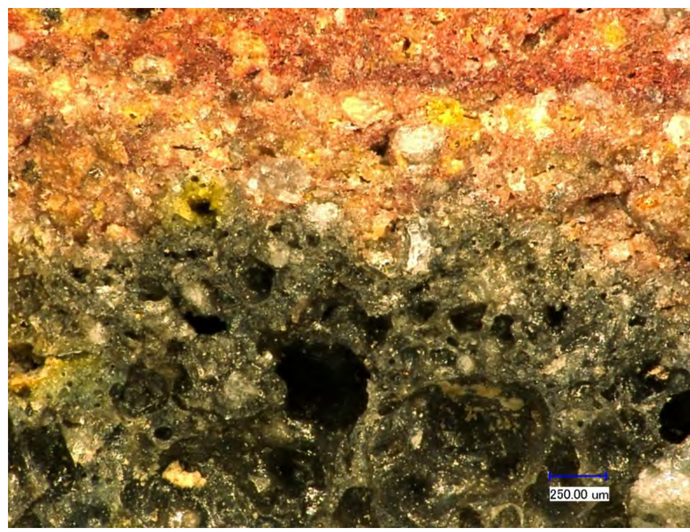
No paste vitrification (200x)



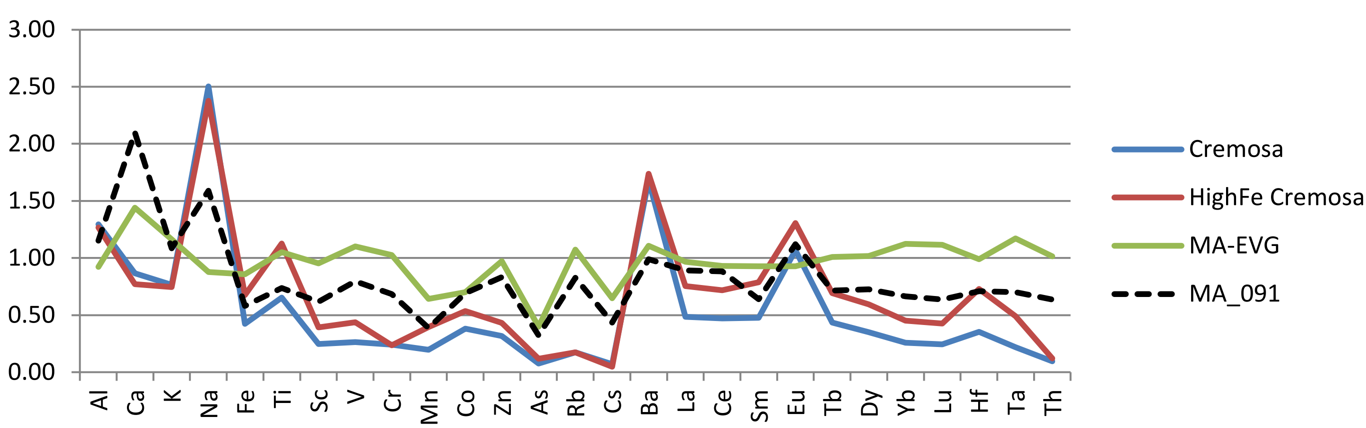
MA_091 interior

MA_091 exterior

MA_091 detail of fusing



MA_091 (100X)

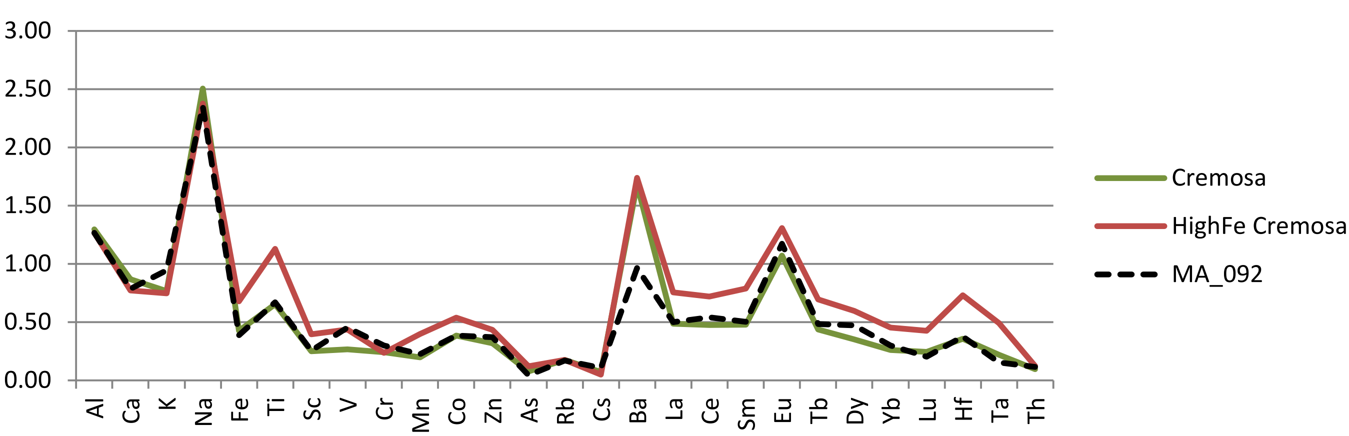


MA_092 interior

MA_092 exterior

MA_092 detail of cracks

Incipient vitrification (200x)



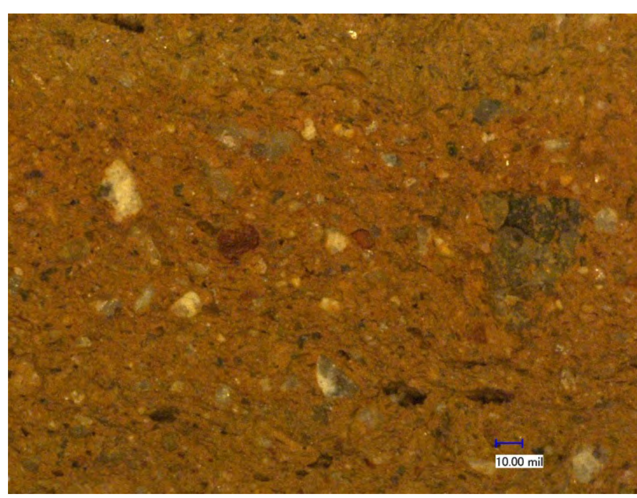
MA_093 exterior

MA_094 exterior

MA_093 interior

MA_094 interior

MA_093 50X



MA_094 50X

MA_095 exterior

MA_096 exterior

MA_095 interior

MA_096 interior

MA_095 30X

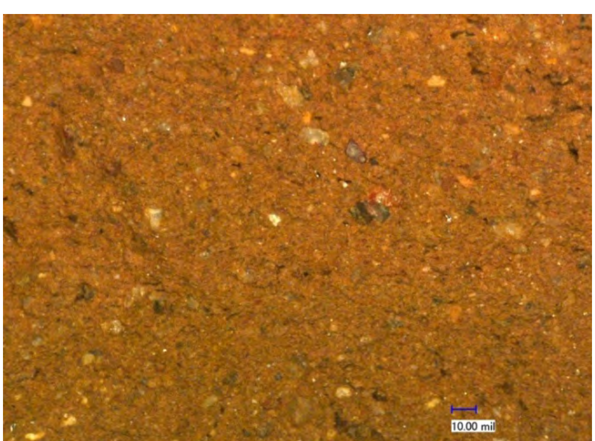
MA_096 50X

MA_097 exterior

MA_098 exterior

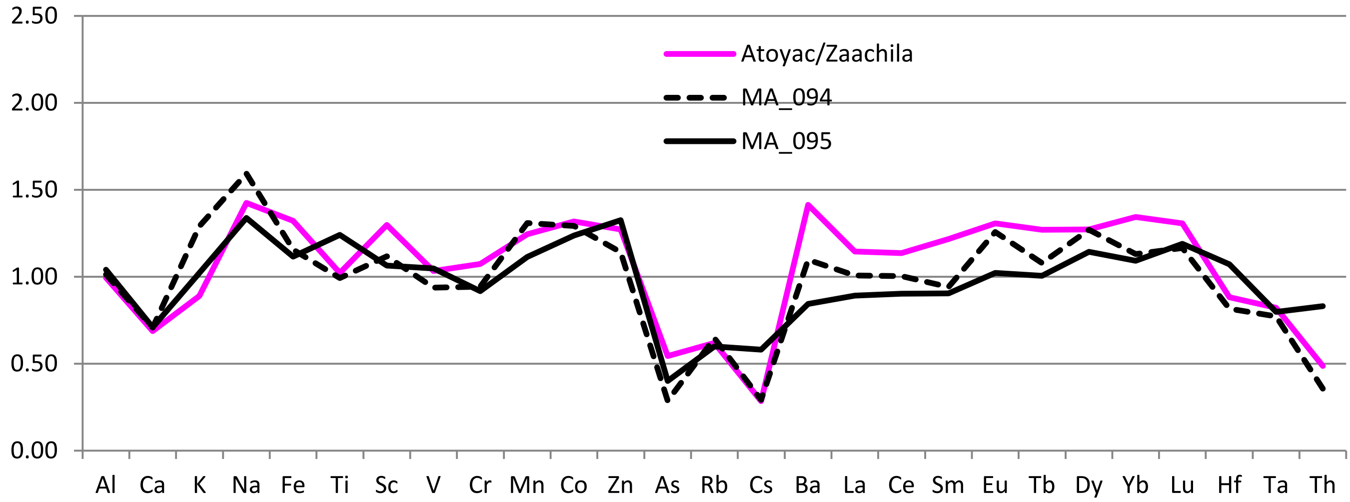
MA_097 interior

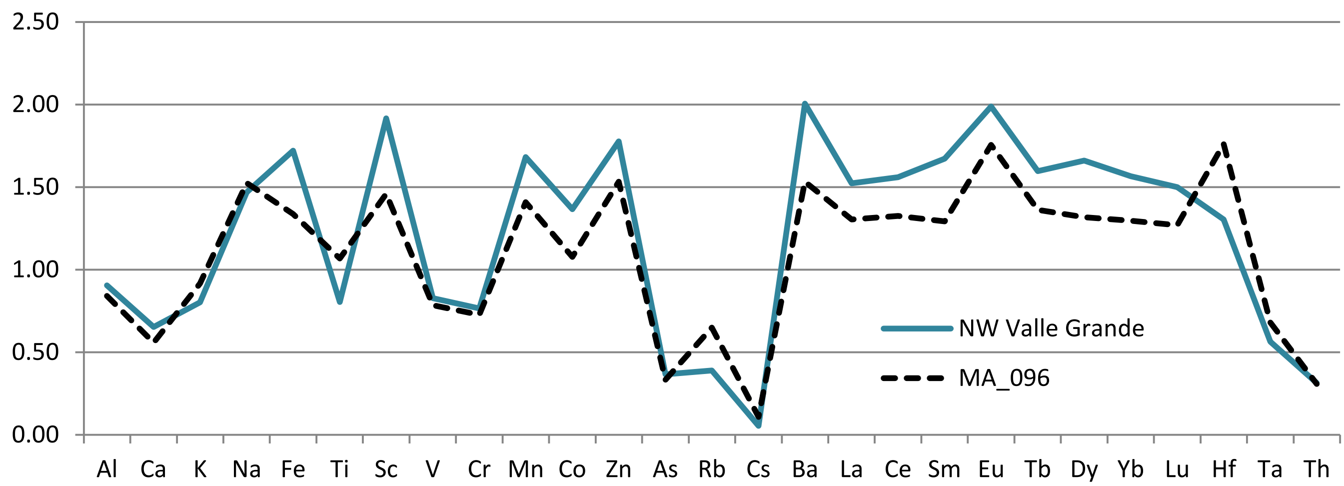
MA_098 interior

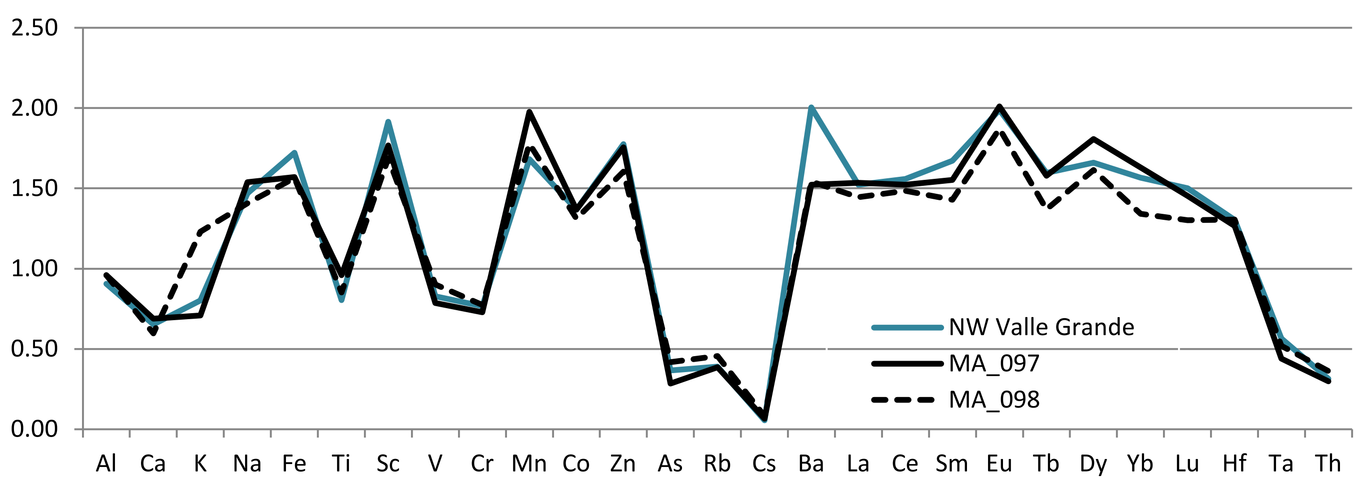


MA_097 50X

MA_098 20X


2.50
2.00
1.50
1.00
0.50
0.00
Atoyac/Zaachila
MA_094
MA_095
Al Ca K Na Fe Ti Sc V Cr Mn Co Zn As Rb Cs Ba La Ce Sm Eu Tb Dy Yb Lu Hf Ta Th


2.50
2.00
1.50
1.00
0.50
0.00
NW Valle Grande
MA_096
Al Ca K Na Fe Ti Sc V Cr Mn Co Zn As Rb Cs Ba La Ce Sm Eu Tb Dy Yb Lu Hf Ta Th


2.50
2.00
1.50
1.00
0.50
0.00
NW Valle Grande
MA_097
MA_098
Al Ca K Na Fe Ti Sc V Cr Mn Co Zn As Rb Cs Ba La Ce Sm Eu Tb Dy Yb Lu Hf Ta Th

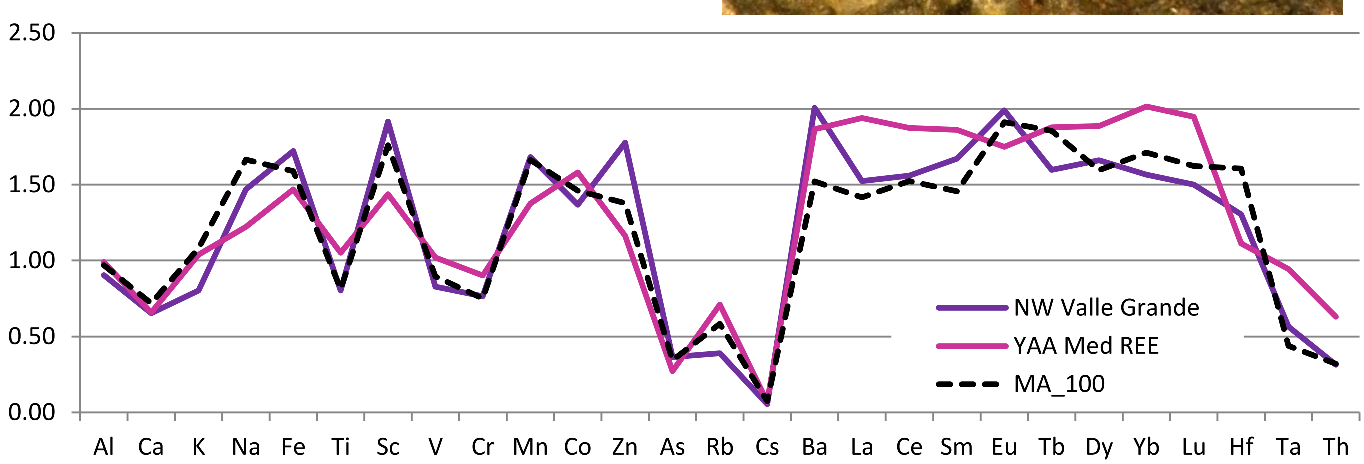
MA_099 exterior

No paste vitrification (200x)

MA_100 exterior

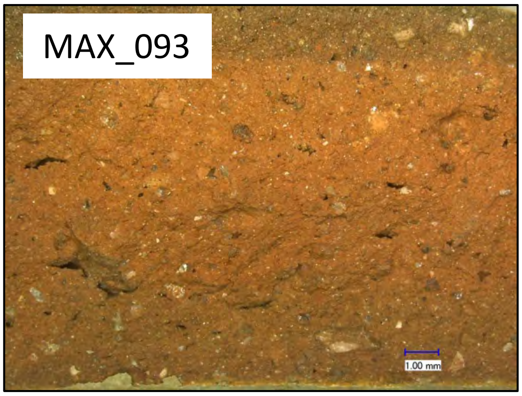
MA_100 interior

No paste vitrification (200x)

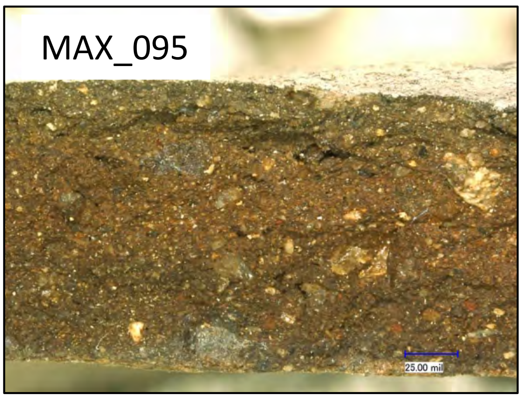


MAX_093 – MAX_100

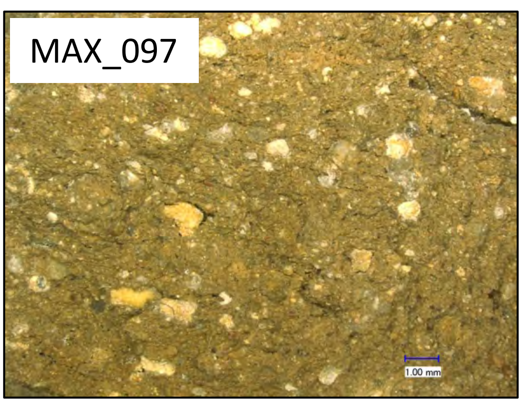
Fairly complete vessels from the upper part of large kiln (F. 71)

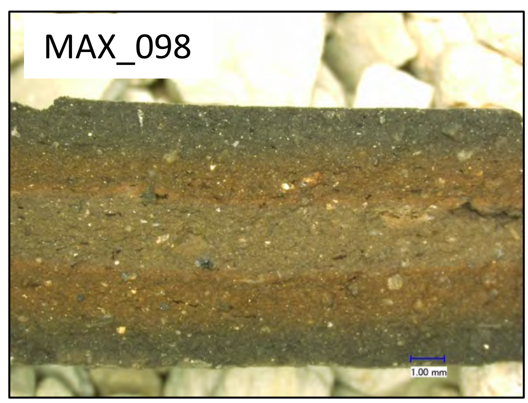

MAX_093
1.00 mm

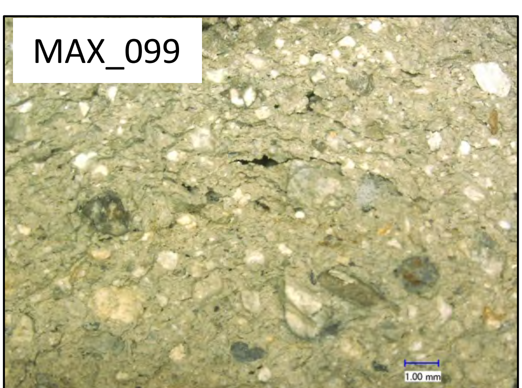

MAX_094
1.00 mm

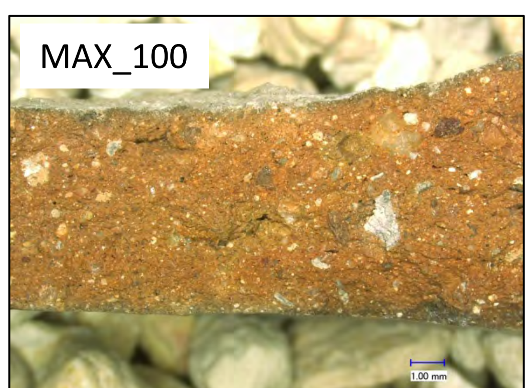

MAX_095
25.00 mil


MAX_096
1.00 mm


MAX_097
1.00 mm


MAX_098
1.00 mm


MAX_099
1.00 mm


MAX_100
1.00 mm


MAX_093

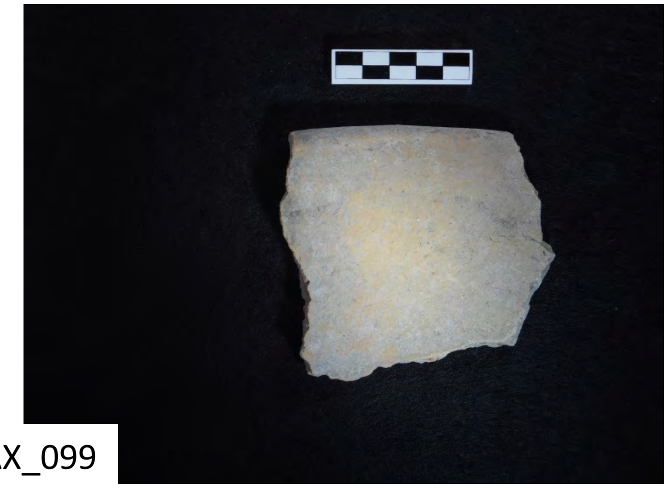

MAX_094


MAX_095

MAX_096

MAX_097

MAX_098

MAX_099


MAX_100

Appendix II:

Ceramic Exports from Greater Monte Albán

DAN_006 (Olla Sencilla)
High Fe *Cremosa*

DAN_019 (Olla Sencilla)
Cremosa

DAN_025 (Olla Sencilla)
High Fe *Cremosa*

Dainzú: Imports from Greater Monte Albán

DAN_052 (cántaro)
MA-EVG

DAN_121 (Cajete Cónico)
MA-EVG

LAM_048 (Cajete)
High Fe *Cremosa*

LAM_067 (Apaxtle)
Cremosa

Lambityeco: Imports from Greater Monte Albán

LAM_074 (Cajete)
Cremosa

LAM_107 (Olla)
Cremosa

LAM_031 (botellón)
MA-EVG

LAM_032 (botellón)
MA-EVG

LAM_042 (cajete cónico)
MA-EVG

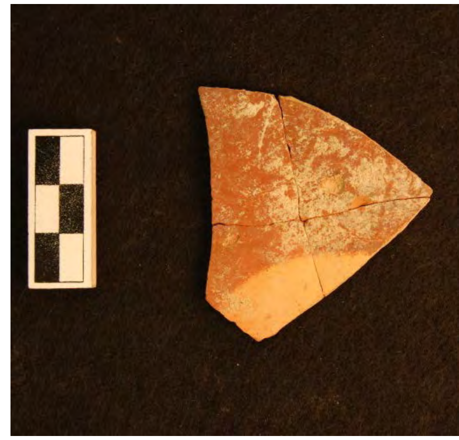
Lambityeco: Imports from Greater Monte Albán

LAM_049 (*cajete cónico*)
MA-EVG

LAM_050 (*cajete cónico*)
MA-EVG

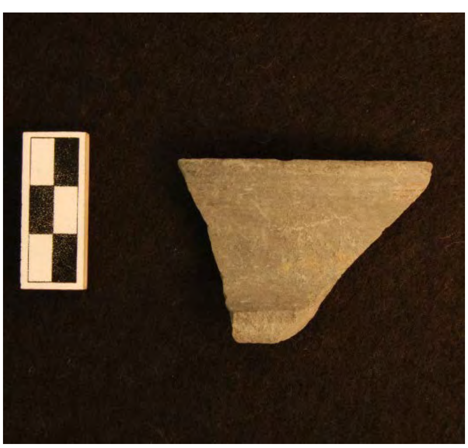
EP_123 (Cajete)
Cremosa

EP_138 (Cajete)
Cremosa



EP_016 (Cajete)
MA_EVG

El Palmillo: Imports from Greater Monte Albán



EP_145 (cántaro)
MA-EVG

EP_153 (cántaro)
MA-EVG

EP_192 (cántaro)
MA-EVG