INTER-REGIONAL AND INTRA-REGIONAL SCALE COMPOSITIONAL VARIABILITY IN POTTERY FROM SOUTH-CENTRAL VERACRUZ, MEXICO

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Both long-distance and localized chemical relationships in pottery and their implications for studies of Gulf lowland exchange can be examined with instrumental neutron activation. New pottery samples from Classic period (A.D. 300–900) contexts in the western lower Papaloapan basin were subjected to chemical compositional analysis. The sample represents three groups, coarse utility jars, common orange slipped serving bowls, and fine paste, higher-value white slipped serving bowls. At an intraregional scale, four localities in the western basin were sampled, but not all proved to be compositionally distinct. A mangrove zone pottery group contrasts compositionally with groups from riverine farmlands to the west. At a larger interregional scale, pottery from neighboring geomorphological areas as well as distant alluvial systems up and down the Gulf lowlands yielded chemically distinct groups. Considerable intraregional trade is suggested, but little is evident at the interregional scale. The interregional analysis is the first integrated overview of Gulf lowland ceramic chemical compositions, and the intraregional analysis begins assessment of Classic period pottery production and exchange within the western lower Papaloapan basin. Methodologically, we use sand sources in the region to determine if differences in tempering of pastes are likely to account for differences in compositional groups.

Se analizan a través de activación neutrónica de elementos las relaciones locales y de larga distancia en cerámicas del período clásico (A.D. 300-900) procedentes de la cuenca oeste del bajo río Papaloapan, golfo de México. La muestra incluye tres grupos: ollas utilitarias burdas, cuencos comunes con baño anaranjado, y cuencos con baño blanco de pasta fina y de más valor por su escasez. En la escala intra-regional, se escogieron muestras de cuatro localidades del área pero no todas ellas resultaron distintas en su composición química. El grupo químico procedente del manglar contrasta con los de los terrenos agrícolas del oeste. A una escala interregional mayor, la cerámica de áreas geomorfológicamente vecinas, como las de los sistemas aluviales costeros más distantes, se distinguen en sus diferentes grupos químicos. El intercambio intra-regional es notable, pero es escaso a escala inter-regional en las muestras analizadas. Esta es la primera revisión integral de las composiciones químicas cerámicas de las tierras bajas del golfo e inicia el análisis intra-regional de la producción e intercambio de alfarería en la cuenca oeste del bajo río Papaloapan. Metodológicamente, evaluamos en muestras de arena de la región si la cantidad de desgrasante en la cerámica puede explicar las distinciones en la composición química entre los grupos.

In the Gulf lowlands of Mesoamerica (Figure 1), source attributions of pottery and assessments of exchange are in an early stage because the overall area is extensive and few chemical, mineralogical, and other assays of pottery, clays, and temper have been conducted. Nonetheless, a few studies exist that have examined: (1) broad Mesoamerican linkages indicating interregional trade (Blomster et al. 2005; Neff et al. 2006; Neff and Glascock 2002; Sayre and Harbottle 1979; Skoglund et al. 2006), (2) internal comparison of different pottery types within an assemblage (Harbottle and Bishop 1989), and (3) trade among neighboring areas such as the Cotaxtla and Blanco drainages (Skoglund et al. 2006) and within parts of the Tuxtla Mountains (Pool and Santley 1992; Stoner 2002).

This paper focuses on pottery from the western lower Papaloapan basin (WLPB) in south-central Veracruz with instrumental neutron activation

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Figure 1. Map of central Mesoamerica, showing sites mentioned in the text, most as sources of samples. Veracruz is outlined, and a gray box indicates the region from which new samples were drawn.

analysis (INAA), using both local and long-distance perspectives. We evaluate bulk chemical ceramic distinctions at various geographic scales using available comparative data within the Gulf lowlands and, within the WLPB, possible production and exchange of pottery among localities. We present the results at three geographic scales. First, we note the relationships of the WLPB samples (WLPB Macro group) to other ceramics in the Gulf lowlands and the adjacent highlands that are part of the Missouri University Research Reactor (MURR) data bank (MURR data include INAA analyses conducted at Brookhaven National Laboratory [BNL]). Second, we review a more localized scale that compares two adjacent drainages, the lower Blanco River in the WLPB and the lower Cotaxtla drainage to the west (Skoglund et al. 2006) (Figure 2). Finally, we report on chemical distinctions among pottery from sampled localities within the WLPB (Figures 3, 4, 5).

For the WLPB, we concentrate on the Classic period (A.D. 300–900) in order to complement Late Postclassic period (A.D. 1350–1521) information (Skoglund et al. 2006). The Classic period is of particular interest because it represents a peak of political activity at local centers just prior to the considerable Postclassic period disruption of settlements and cultural practices (Curet et al. 1994). The WLPB has diverse geomorphology including: modern dunes fronting the Gulf of Mexico, paleodunes that parallel the modern dunes inland, mangrove swamps and lagoons near the mouth of the Papaloapan River, the Tlalixcoyan River draining portions of the paleodunes and coastal plain, the Blanco River with headwaters in the Sierra Madre Oriental, and the Guerengo River, which reaches into the foothills of the Sierra Madre. The Tlalixcoyan, Blanco, and Guerengo eventually head eastward and debouche into the lagoons and mangrove swamp at the mouth of the Papaloapan River and its distributary, the Acula River.

Cerro de las Mesas, located in the Blanco delta (Figure 2), was the major Early Classic center (A.D. 300–600) dominating the entire WLPB (Stark 2003). It appears to have remained independent of the powerful highland state of Teotihuacan, despite Teotihuacan activities at Matacapan in the Tuxtla Mountains at the eastern edge of the lower Papaloapan basin (Santley and Arnold 1996; Santley et al. 1987; Stark and Curet 1994; Stark and Johns 2004). The WLPB realm was the origin of a distinct scroll style that, like the interlace style in north-central Veracruz, appeared as a prestigious style at Teotihuacan (Stark 1998, 1999a).

Around the beginning of the Late Classic period (A.D. 600–900) the focus of construction and political power shifted eastward in the Blanco delta to Los Azuzules, although Cerro de las Mesas was not abandoned. The delta area seems to have functioned as a capital zone, with several shifting foci of monumental construction (Stark 1999b). By the Late Classic period, the Cerro de las Mesas realm broke up, and major centers along the Guerengo River to the south and on the paleodunes to the north rivaled Los Azuzules. Nopiloa was the competing center in the Guerengo area, and Los Ajitos-Pitos was the dominant center controlling the paleodunes and possibly the Tlalixcoyan drainage. The mangrove swamp may have been independent as well, but the major Late Classic monumental complex there (in the Nacastle-Patarata settlement) was not as large as the other three, which were located in farmlands to the west.

Economic patterns also shifted during the Early to Late Classic transition. Evidence of concentrated

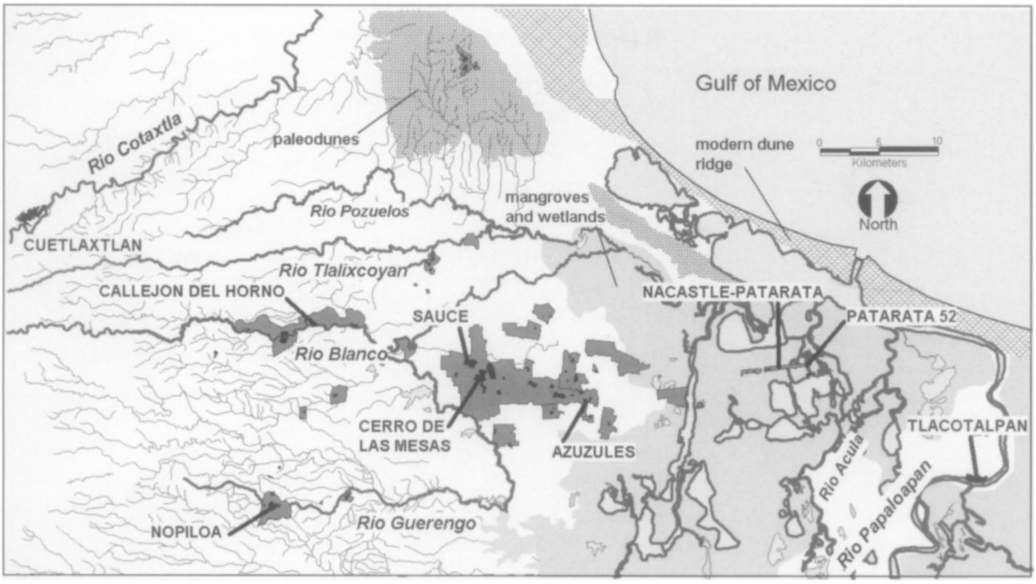

Figure 2. The western lower Papaloapan basin showing sites, rivers, and landforms mentioned in the text. Survey blocks are shaded dark, and areas of monumental construction are outlined within the blocks.

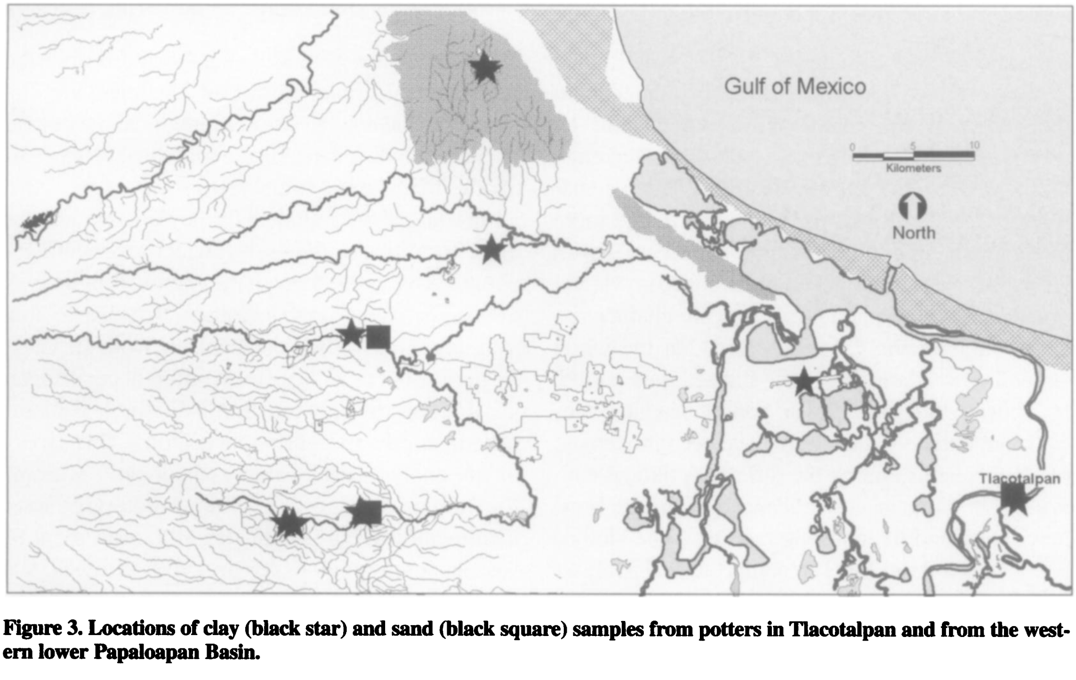

Figure 3. Locations of clay (black star) and sand (black square) samples from potters in Tlacotalpan and from the western lower Papaloapan Basin.

craft specialization (pottery production and obsidian blade knapping) appears at the Late Classic period centers (Stark 2006a; Stark and Garraty 2004), although none was evident earlier around Cerro de las Mesas. For example, two of the pottery bowl types we examine here suggest differential distributions that may be related to these changes in production and exchange. There is evidence that orange slipped bowls were produced around Los Azuzules during the Late Classic period (Stark and Garraty 2004), although they are so common that they also may have been produced elsewhere

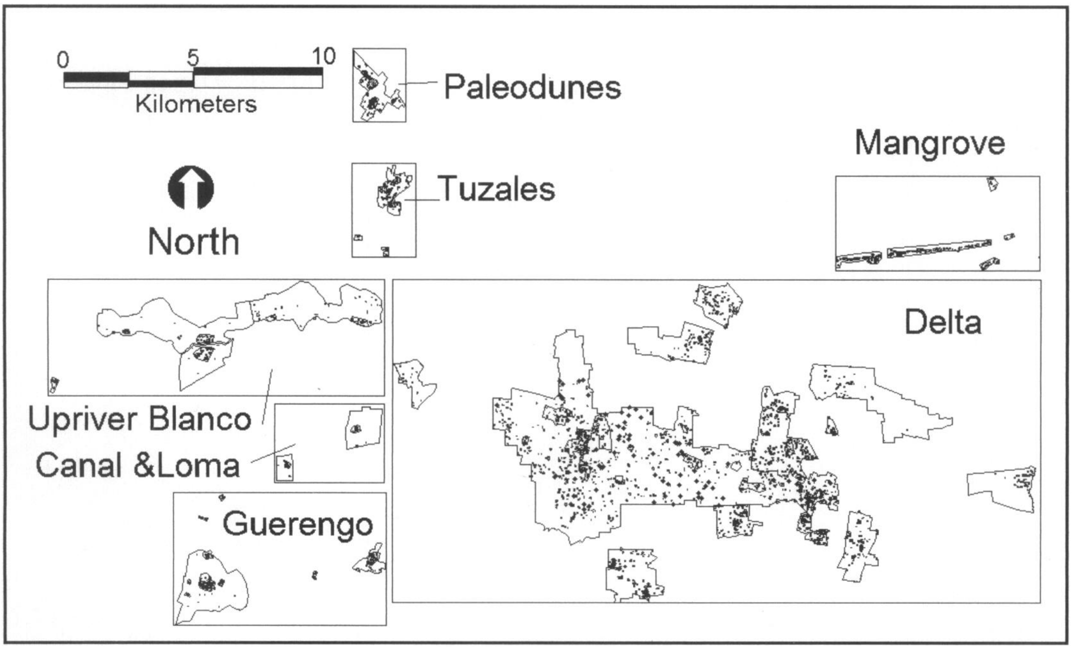

Figure 4. Compressed map showing each survey block to scale and indicating the archaeological features recorded. The blocks have been moved close to each other for the purpose of thematic plotting (see Figure 2 for their actual positions).

throughout the Classic period. Late Classic Blanco White decorated bowls are particularly abundant in the survey blocks near Nopiloa, which may be related to production of this type along the Guerengo (Stark 2006b). In contrast, the utility jars we analyze are larger, heavier, more abundant, and more likely to have multiple local production areas with less extensive circulation. Orange slipped bowls and orange slipped or plain utility jars are characteristic throughout the Classic period, but the white slipped bowls date only to the Late Classic period.

Thus, by the Late Classic period, despite political fragmentation, there may have been movement of some vessels among the different political entities on the basis of the indications of orange bowl production and the concentration of white slipped bowls in one drainage. The compositional analyses address this possibility and the degree of discrimination among localities in clay and ceramic compositions, which is particularly important for the Late Classic period when there are signs of political competition among centers in the localities sampled, along with indications of some reorganization of craft production in pottery and obsidian blades. As we explain below, we did not achieve a sufficient chemical discrimination to separate all of the intraregional localities that we had hoped because only two chemical groups were well documented, despite the selection of samples from four localities. We did, however, find evidence for intraregional movement of pottery, and we can indicate additional pottery categories that warrant future analysis.

In a larger geographical framework, we address other localities in the Gulf lowlands, providing a comparative assessment of the chemical signatures of vessels from diverse localities. Not all available samples in the MURR databank are from the Classic period, but even those from different periods can provide some insight into the distinctness of chemical signatures from different regions. This aspect of the analysis establishes considerable promise for compositional discrimination among Gulf lowland localities, but it indicates little movement of vessels among regions for the types sampled. We begin with these larger-scale comparisons and then narrow our focus within the WLPB.

Distinctions among Geomorphologically Separated Ceramics in the Gulf Lowlands and Adjacent Highlands

Comparisons of pottery up and down the Gulf lowlands can indicate how well different geomorphological regions can be distinguished chemically

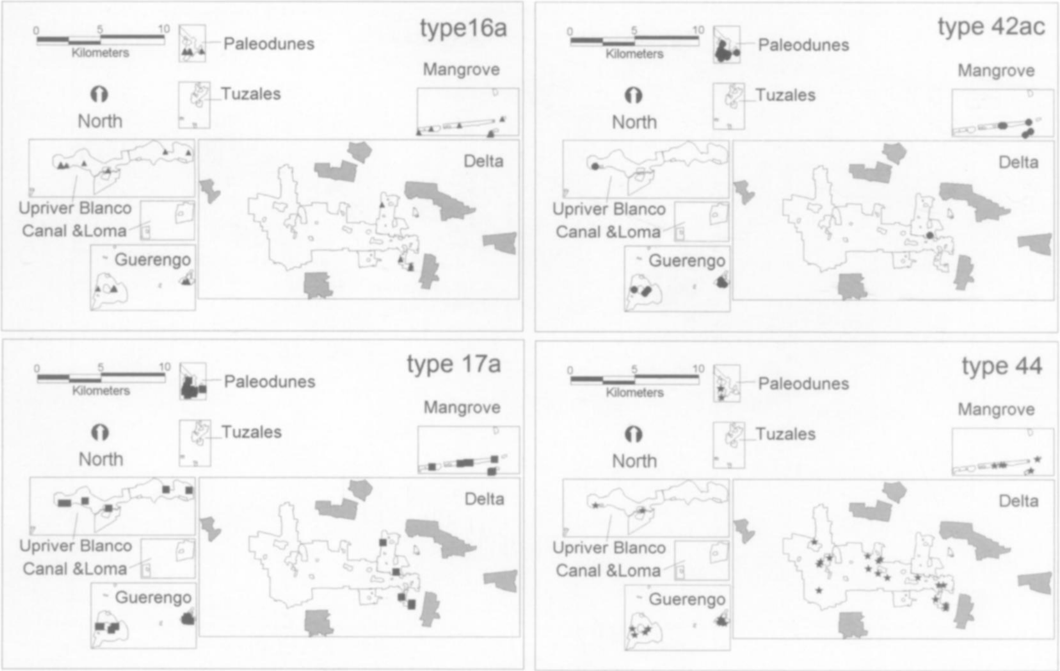

Figure 5. Four compressed maps, each showing the sampled collection locations for a different pottery type. See Figure 4 for the feature locations. Within survey blocks, the areas of monumental construction are outlined.

using INAA. Particularly for the alluvial coastal plain, sediment mixing from diverse parent materials presents considerable uncertainty regarding the geographic scale of compositional discrimination. Until more comprehensive sampling is done, however, we cannot rule out that additional samples from any one region will either overlap another region or register very differently from previous samples within the same region.

We draw upon samples in the MURR data bank from previous studies. The new samples we analyze are from the WLPB, forming a WLPB Macro group (discussed further below) in combination with previous Classic period samples excavated from the Patarata 52 residential mound in the mangrove swamp near the Papaloapan River mouth (located within the Nacastle-Patarata settlement also included in our new surface samples [Harbottle and Bishop 1989; Stark 1977, 1989]). This mangrove settlement has deeply buried Early Classic levels, but deposits above the water table predominantly date to the Late Classic. New samples from the WLPB include clays and sands and new analyses of modern potters' materials from Tlacotalpan (Figure 3).

Geomorphologically neighboring samples derive from the Late Postclassic center of Cuetlaxtlan (modern Cotaxtla) along the Cotaxtla River, the first drainage west of the Blanco (Figure 2). Skoglund et al. (2006) compared Late Postclassic pottery (A.D. 1350–1521) from the center of Callejón del Horno and its hinterland in the lower Blanco area of the WLPB (Lower Blanco group) to pottery from the lower Cotaxtla drainage (Cotaxtla group). They addressed a later period than our new WLPB samples. The eastern side of the lower Papaloapan basin includes the western Tuxtla Mountains, and MURR analyses include Coarse Orange from several Tuxtla Mountains Classic sites (Stoner 2002).

More geographically distant, predominantly Classic samples are from El Tajín in north-central Veracruz (six pottery types), Tuzapan, a site near Tajín (two types), and from the Pavón site in the Pánuco area of northern Veracruz (five types). Finally, part of the Puebla highlands adjacent to south-central Veracruz is represented by Postclassic sherds from Huejotzingo and Cholula (Neff et al. 1994).

A bivariate plot of chromium and cesium con-

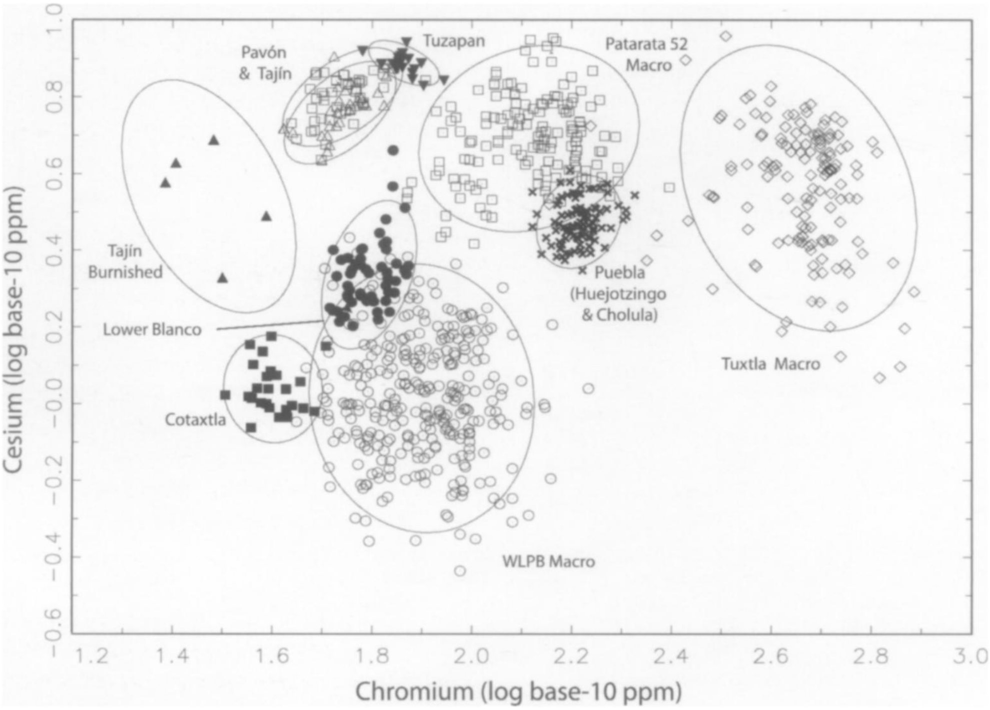

Figure 6. Plot of chromium and cesium base-10 logged concentrations showing the differentiation of WLPB and Patarata 52 pottery in relationship to other regional groups. Data presented for Tuxtla Macro (Stoner 2002), Puebla (Neff et al. 1994), and Cotaxtla and Lower Blanco (Skoglund et al. 2006) were generated at MURR. Data for Tuzapan, El Tajín Burnished, Pavón Panuco, and El Tajín were generated at BNL (Sayre and Harbottle 1979). Patarata 52 data were primarily generated at BNL (Harbottle and Bishop 1989); WLPB data were generated primarily at MURR, but also include BNL data. Ellipses represent the 90 percent confidence interval for group membership.

centrations suggests relatively good separation of pottery from these geographic and temporal categories (Figure 6). In addition, greater separation between the Puebla and Patarata 52 Macro groups can be seen in a bivariate plot of cerium and europium (Figure 7). The Pavón, El Tajín, and Tuzapan groups can be differentiated in a bivariate plot of manganese and scandium (Figure 8). One Zaquil Black Incised and seven undifferentiated "fine paste" samples assigned to the El Tajín group were recovered from the Pavón site, which seems to indicate long-distance movement of pottery between these two sites, but future research is necessary to determine the nature and extent of interaction. All pottery assigned to the Tuzapan and Pavón groups originated from their respective sites.

In southern Veracruz and Tabasco, San Lorenzo and La Venta were major Olmec centers, respectively, during the Early and Middle Preclassic periods (1200–900 B.C. and 900–400 B.C.) (Blomster et al. 2005; Methner 2000; Neff and Glascock 2002). Their sets of sherds separate well from the WLPB Macro group on a bivariate plot of chromium and rubidium concentrations (Figure 9). Likewise, pottery from San Lorenzo and La Venta is distinct from Patarata 52 pottery, and also from pottery produced in other regions, including Oaxaca (see Blomster et al. 2005; Neff and Glascock 2002).

An important implication of these distant comparisons is that geomorphologically distinct regions in the Gulf lowlands and some neighboring highland areas appear to be chemically distinct for the sampled pottery types, even though we have compared a range of time periods. Only additional assays that address more of the temporal and ceramic variation in each region can cement this observation. None of the newly analyzed WLPB sherds indicates trade among these distant coastal localities, but future analyses of more high-value decorated pottery might provide evidence of trade. For example, one promising Late Classic candidate

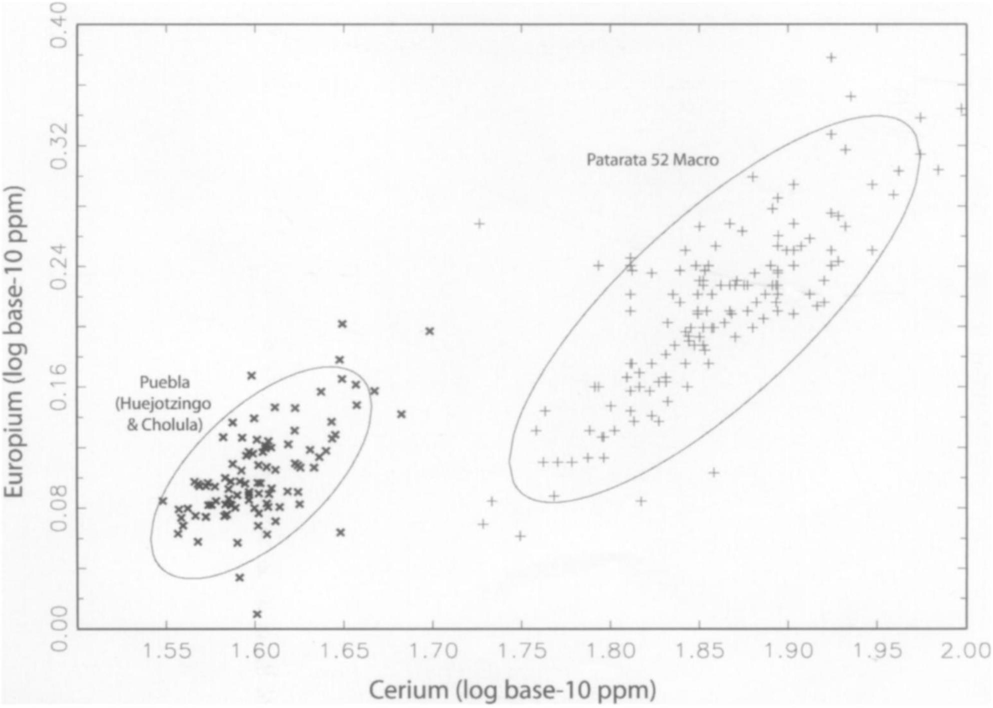

Figure 7. Plot of cerium and europium base-10 logged concentrations showing the differentiation of Patarata 52 pottery from the Puebla reference group. Ellipses are drawn at the 90 percent confidence interval.

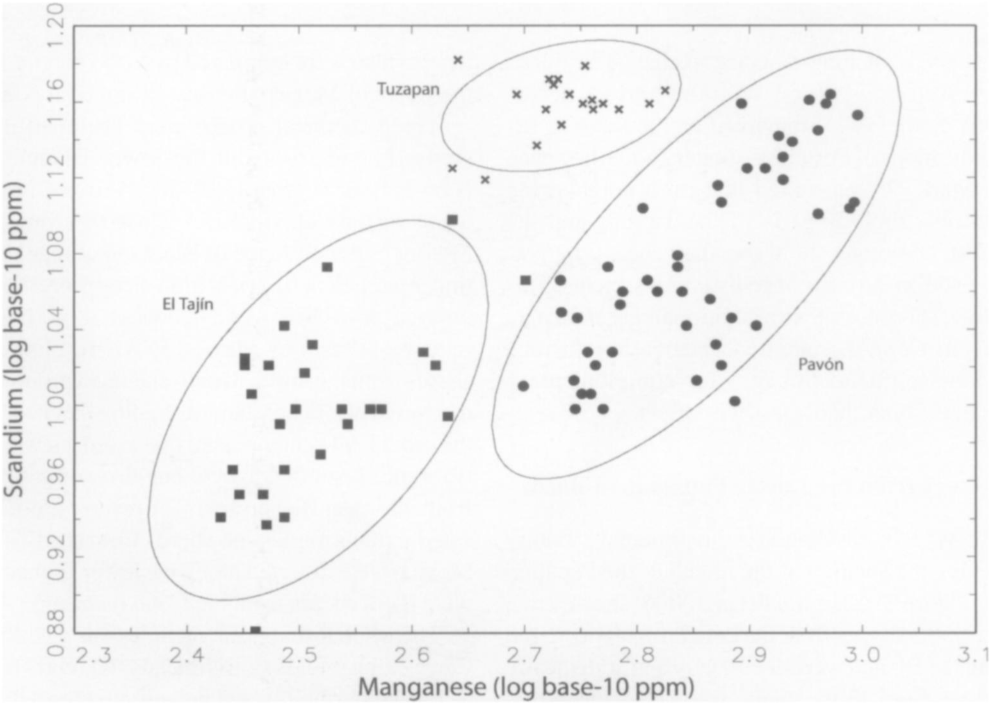

Figure 8. Plot of manganese and scandium base-10 logged concentrations showing the differentiation of the El Tajín, Pavón, and Tuzapan groups. Ellipses are drawn at the 90 percent confidence interval.

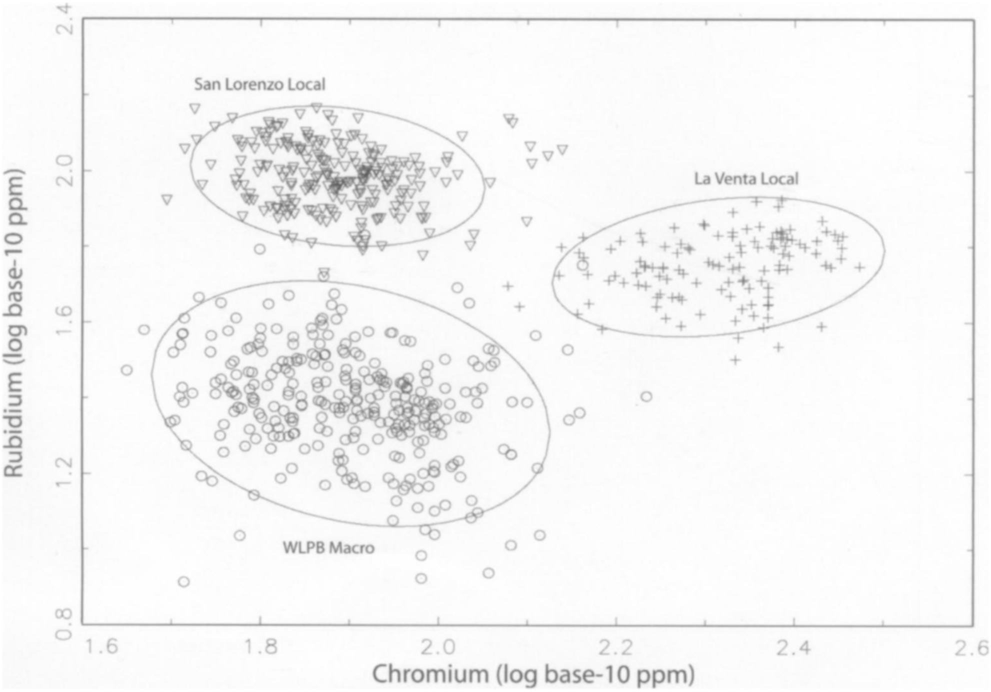

Figure 9. Plot of chromium and rubidium base-10 logged concentrations showing the differentiation of WLPB pottery from La Venta (Methner 2000) and San Lorenzo (Neff and Glascock 2002) reference groups. Ellipses are drawn at the 90 percent confidence interval.

for analysis of long-distance exchange is relief-impressed bowls (von Winning and Gutierrez 1996). Stark (1995) remarked on the scant stylistic indications of Postclassic pottery trade, however, and Stark (2006c) noted that even neighboring localities, such as parts of the Tuxtlas and the WLPB, do not yet show abundant coast-wise pottery trade on the basis of stylistic assessments. This finding, if borne out with additional research, may imply that long-distance trade relationships favored lowland-highland linkages for complementary products rather than coast-wise trade.

Pottery from the Lower Papaloapan Basin

In the WLPB, the Blanco is the principal tributary reaching the swamps at the mouth of the Papaloapan (Figure 2). Skoglund et al. (2006) showed that three pottery types from the Late Postclassic period along the Blanco were chemically and stylistically distinct from those characteristic at the Aztec provincial center of Cuetlaxtlan along the lower Cotaxtla drainage (Ohnersorgen 2001). Both locales also were compared to Aztec pottery from the Basin of Mexico, the seat of imperial power.

Three chemical groups were identified in the study: (1) sherds from the lower Blanco area (Lower Blanco group), (2) sherds from Cuetlaxtlan along the Cotaxtla River (Cotaxtla group), and (3) four imported Aztec III Black-on-orange sherds that matched a Tenochtitlan group previously assayed at MURR (see Nichols et al. 2002 for a review of Basin of Mexico INAA results). Two sherds from the lower Blanco chemical group were recovered at Cuetlaxtlan, suggesting that people at the provincial center not only received a few bowls from the Basin of Mexico, but also some vessels from the lower Blanco area. The reverse is not indicated in the sample—no sherds from the Basin of Mexico were detected along the lower Blanco, nor were there sherds from the Cotaxtla group.

The MURR data bank includes one sherd from Cerro de las Mesas (a BNL analysis) representing a Postclassic cholutecoid polychrome (possibly an example of Drucker's [1943:48] Complicated Polychrome). This type pertains to the widespread Postclassic Mixteca-Puebla ceramic style (several stylistic variants exist) (e.g., Lind 1994; Smith and Heath-Smith 1980). This sherd plots with the WLPB Macro group in the analyses discussed next, but not with the Postclassic Lower Blanco group, nor with the Huejotzingo and Cholula Mixteca-Puebla style polychromes from Puebla in the data bank (Neff et al. 1994). It appears likely to be a local vessel from the WLPB, but suggestive of a different chemical make-up than Skoglund et al.'s (2006) Lower Blanco group. Additional assays of Postclassic types are needed to more fully describe compositional variability and the possible provenance of pottery from this period.

Classic Period Pottery from Four Localities in the Western Lower Papaloapan Basin

The promising Cotaxtla-Blanco Postclassic comparisons led to our comparable attempt to distinguish chemical compositions and distribution patterns during the Classic period (A.D. 300–900), which saw the maximum occupational density in the WLPB. Surveys conducted intermittently between 1984 and 2002 intensively covered nearly 100 km^2 in several survey blocks, with feature-based records rather than a site approach, and with systematic collections that have provided the sherds for our analysis. Among the survey blocks the following locations were sampled in the ceramic chemical analysis: (1) within the Blanco River delta and slightly upriver along its banks; (2) at two locations along the Guerengo; (3) on the paleodunes south of the modern dune ridge, and (4) in the mangrove swamp, including the Nacastle-Patarata linear settlement where Patarata 52 is located (Figures 4 and 5). Samples of three ceramic categories (involving four types) were selected from each locality, as discussed below.

The distances among these localities are similar to that between the lower Cotaxtla River and the lower Blanco River, ranging from 15 to 42 km, in comparison with a distance of ca. 30 km between the lower Blanco and Cotaxtla. The western lower Papaloapan basin is a more complicated alluvial setting (Figure 2) than that of the Late Postclassic analysis, which involved two distinct drainages. Alluvial contributions to the WLPB are more likely to draw upon overlapping sedimentary sources.

There were reasons to hope for a chemical distinction of pottery from these localities, however. The Blanco River's headwaters are in the Sierra Madre Oriental near Orizaba. Extremely high dune ridges that front the Gulf of Mexico impede the egress of rivers, such as the Blanco, which turn toward the Papaloapan, which has a sufficient flow to maintain a constant channel opening. One smaller river just inland from the Blanco is the Guerengo, with headwaters in the foothills of the Sierra Madre Oriental. The Tlalixcoyan River parallels the Blanco on its north side, draining part of the coastal plain and the interior side of the paleodunes, emptying into the Alvarado Lagoon at the mouth of the Papaloapan River. All these rivers traverse an alluvial plain composed of sediments that may have diverse and possibly non-distinct origins.

An extensive series of lagoons and mangrove swamps lies inside the modern dune ridge at the mouth of the Papaloapan River. The Acula River runs through the mangrove swamp, bounding our main survey area in the swamp; the Acula parallels the Papaloapan and likely represents a distributary channel. Therefore, sediments near the Acula River are likely to have accumulated largely through deposition by the Papalaoapan River. The paleodunes likely comprise sands from a variety of offshore sources, but principally from the nearby Papaloapan River.

Consequently, it seemed possible that the diverse geomorphological factors across the region might yield chemically distinct raw materials and pottery in the four localities. Nevertheless, the distances among localities are not so great as to impede considerable movement of vessels. A given locality might yield sherds of one or more pottery types identical to those produced at, as well as recovered from, another locality. Unless all three of the pottery categories examined were equally widely traded, however, we should see some concentrations of chemical groups by locality, especially for the heavier utility jars that were harder to transport. Despite this promise of geographic differences in materials, the results did not distinguish possible local products for each of the four localities, with the exception of the mangrove zone, for which both clays and certain pottery types are chemically distinguishable.

Sampling for Analysis

Clay samples (11) and sands (3) were collected during the survey, although they represent only a modest beginning for sampling raw materials in the region. Additionally, we assayed six clay samples and two sands used by modern potters in Tlacotalpan (Stark 1984). Two of the clay samples also were analyzed previously at BNL. Tlacotalpan clays include vessel clays from downriver along the Papaloapan, kiln and mold dusting clay from the nearby swamp, and slip clay from upriver along the San Juan River, a tributary that reaches the Papaloapan River at Tlacotalpan from the east and that may include compositionally distinct sediments. The slip samples were reported by potters to derive from the municipio of San Juan Evangelista, 100 km in straight line distance from Tlacotalpan.

We selected rim sherds from collections with a strong representation of Classic period diagnostics (at or above the median of percentages of diagnostics, i.e., ≥ 25.25 percent, with percentages calculated only for collections at or above the median number of rims for all the survey collections, i.e., 68 rims or more). Sampling favored larger collections to enable selection of sherds from collections representing all the types being tested. Sherds had to meet the minimum size standards set by MURR (~ 1 x 1 cm).

Three categories were selected for study: (1) large, coarse-textured necked jars, especially red-orange slipped jars (type 16a) but also unslipped jars if necessary (type 42ac), (2) common orange slipped bowls (type 17a), and (3) rare Late Classic decorated bowls with a white slip, often a red-orange rim band, sometimes more opaque white over-painted designs on the sidewalls, and particularly fine finish and paste (Blanco White, type 44). The orange bowls and utility vessels were produced and used throughout the Classic period, in contrast to the white slipped bowls. Orange bowls have moderate to fine textured paste with sand temper. White slipped bowls have a fine paste with admixture of finely graded sand temper in low amounts. The utility vessels have a coarse or, rarely, medium paste texture with admixture of considerable amounts of sand temper of more variable sizes than the bowls. These paste characteristics are the same among all four localities (based on macroscopic and ten power observation). See Stark (2001) and Stark et al. (2001) for more discussion of Classic period pottery.

Coarse jars were least transportable and the most likely form to have been produced locally. Orange slipped bowls were more transportable, but, because of their common occurrence, possibly made in each locality and traded, as well. The white slipped bowls, because of their presumed special value and less-frequent occurrence, are the most likely to have been produced in one or a few localities and traded. The Guerengo drainage is a candidate a production area because of the higher relative frequencies of these bowls (Stark 2006b).

Two types of coarse textured jars with everted lips were sampled, preferentially red-orange slipped jars (type 16a) but secondarily unslipped jars if necessary (type 42ac). Because red-orange slips sometimes came only part way up the neck, some rim sherds that appeared unslipped may have been from red-orange slipped jars.

An attempt was made to select 80 rim sherds representing each of the three vessel categories, divided into 20 sherds from each of the four localities, totaling 240 rims. This aim could not be met for white slipped bowls because there were not enough collections with this relatively rare pottery meeting the minimum sample size and matching the requirement of a high percentage of Classic period diagnostics. In some cases even relaxing the requirements concerning the collection size did not produce the desired number of white bowl rims (in the paleodunes and the mangrove swamp) (Table 1).

Almost all sampling was from post-1988 survey blocks because many earlier collections stored in the Instituto Nacional de Antropología e Historia facility at San Juan de Ulua in Veracruz were destroyed by inimical environmental conditions. In the case of the white slipped bowls, however, most previously collected sherds were retained as part of a type collection. Therefore, several white bowl rims were drawn from the Central Block in the Blanco delta, surveyed in 1986–1988. Otherwise, the Blanco delta white bowl sample would have been considerably reduced. Some survey blocks were not sampled, for example, those covered in a subproject conducted by Stuart Speaker, to which Stark did not have ready access.

Figure 10 shows the rim and upper sidewall forms, including several variants. Each of the four ceramic categories is distinguishable in modal form frequencies, but the two coarse jar types overlap in two of their principle forms, with one distinguishing mode for orange slipped jars (Table 2).

Table 1. Count of Sherds Selected from Each Pottery Type and Locality.
The Blanco Delta and Upriver Areas Are Tallied Separately to Aid Spatial Analysis.

Locality	code 44 white slipped bowls	code 17 orange slipped bowls	code 16 orange slipped utility jars	code 42ac plain utility jars	Total
Delta Blanco	16	8	8	2	34
Upriver Blanco	2	10	8	2	22
Mangrove	12	20	12	8	52
Guerengo	20	20	7	13	60
Paleodunes	6	20	4	16	46
Total	56	78	39	41	214

Sample Preparation and Quantitative Analysis of the Chemical Data

Sample preparation and irradiation followed standard MURR procedures. Given that these details are extensively discussed in numerous other publications (e.g., Glascock 1992; Neff 1992, 2000; Neff et al. 1994), they are not repeated here.

The neutron activation analyses at MURR resulted in data for 32 or 33 elements in most samples. As, Ni, and Sb were below detection in several samples and were removed from consideration. Given the depositional context of some of the sherds (mangrove swamps and agricultural fields), elements such as Na, Ca, Fe, and Mn were closely examined to assess whether diagenesis including the addition of pesticides or fertilizers may have affected the analysis. These elements were within the range of previous studies from the region, and in general, the concentrations were comparable with other Mesoamerican ceramic studies.

As discussed above, 281 samples from Stark's earlier research at Classic period Patarata 52 were analyzed at BNL in the 1970s (Harbottle and Bishop 1989; Stark 1989). The Patarata 52 mound is part of the Nacastle-Patarata mangrove settlement recorded during the survey project and from which new surface samples were assayed. BNL data for Patarata 52 were intercalibrated to MURR data using conversion factors developed to facilitate interlaboratory comparisons of data. Given that data for fewer elements were generated at BNL, it was necessary to exclude Al, Ca, Dy, Nd, Sr, Tb, Ti, U, V, and Zr from the MURR-derived WLPB dataset. It is important to note, however, that the MURR data also were examined with these elements included; we determined that their exclusion from the analysis had little effect on the overall picture discussed below.

Log-transformed data were examined using principal components analysis (PCA) and through inspection of bivariate plots (see Neff 2000, 2002 for a detailed discussion of data reduction techniques). Samples were assigned to groups based on patterning observed in PCA and bivariate space. Mahalanobis distance probabilities confirm that the proposed group structure is viable.

Use of Mahalanobis distances usually results in a subset of specimens that cannot confidently be assigned to any group. As Neff et al. (2006) indicate, these specimens may be statistical outliers from one of the defined groups, may represent different pottery production practices or diagenic anomalies, or they may pertain to sources sampled so sparsely that they cannot be recognized as distinct groups. In the current study, specimens were left unassigned if they were marginal to all groups, if they showed compositional affiliations with more than one group, or if their inclusion in a group to which they apparently belonged obscured distinctions between otherwise well-discriminated groups. In most cases, the unassigned samples have less than 1 percent probability of membership in either WLPB group 1 or WLPB group 2, or they exceed 1 percent probability of membership in both groups. Although unassigned specimens are problematic, the approach taken herein is similar to that taken by most INAA laboratories and serves to minimize incorrect group assignments by leaving marginal specimens unassigned (Neff et al. 2006).

Compositional Results

Examination of the combined WLPB/Patarata 52 dataset resulted in the identification of multiple

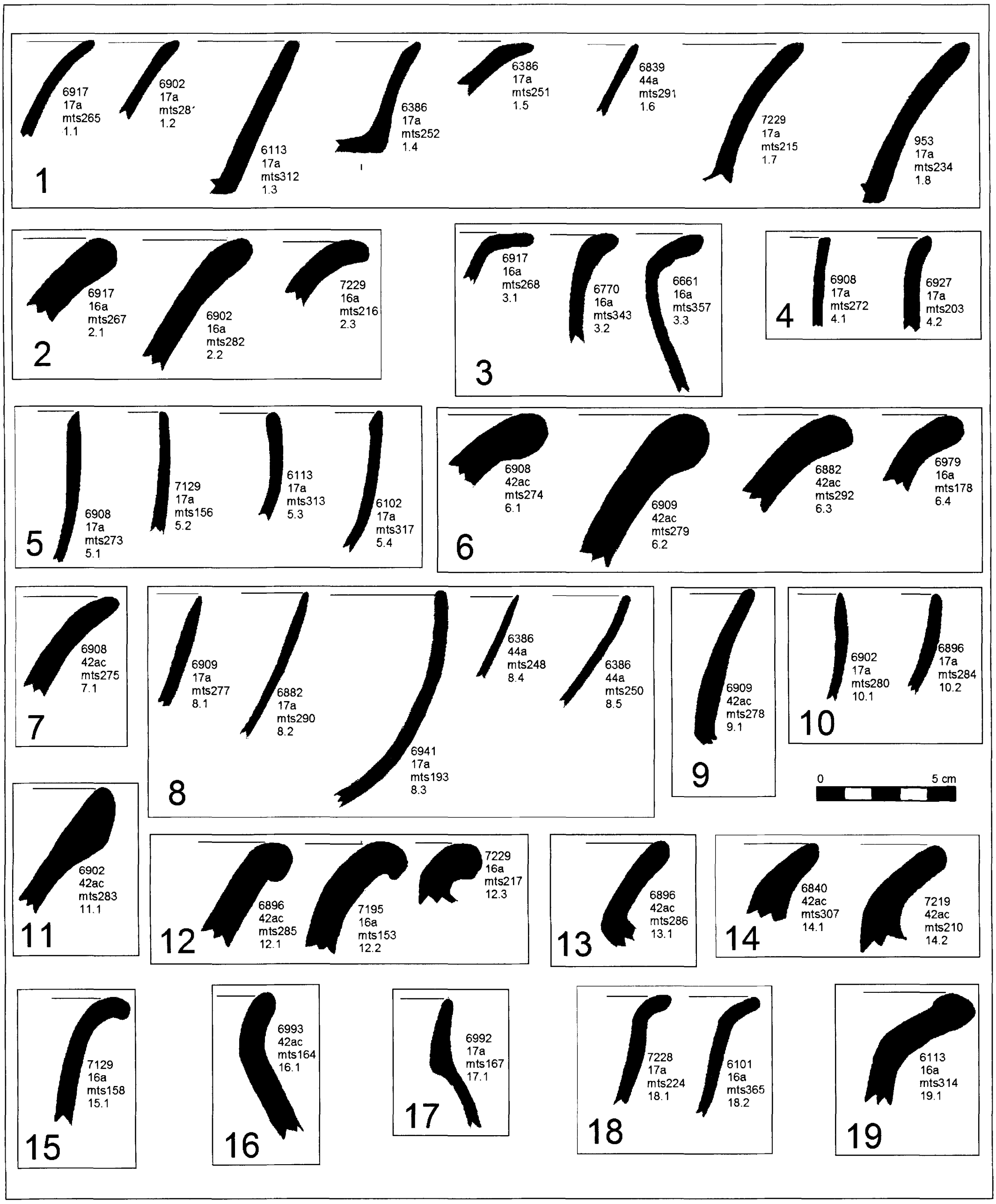

Figure 10. Pottery rim and upper sidewall forms. Each drawing lists, top to bottom, the collection number, the pottery code number, the MURR sample number, and the rim form classification number.

compositionally discrete groups. A bivariate plot of principal components 1 and 2 illustrates the basic structure of the combined dataset (Figure 11). Most pottery from the Classic Period WLPB contexts forms a relatively large group that we designated WLPB Macro to facilitate comparisons with pottery from other regions (e.g., Figure 6). Although the Lower Blanco group identified by Skoglund et al. (2006) undoubtedly represents local pottery production in the WLPB, it comprises only Postclassic period ceramics, and this group is distinct from the earlier WLPB pottery we analyze here. As expected, there is some overlap of Lower Blanco pottery with the WLPB Macro group (e.g., Figure

Table 2. Pottery Sample Tabulated According to Rim and Upper Sidewall Forms and Localities. Summary Modes in Boldface.

Locality	Type	Form Missing Data	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
Delta Blanco																						
White bowls	44	2								16												18
Orange bowls	17a	2	1				6					1										10
Orange jars	16a			3	2			1	1					1								8
Plain jars	42ac			1										1								2
Upriver Blanco																						
White bowls	44									1		1										2
Orange bowls	17a	1	4	1			2			2												10
Orange jars	16a			4				1						1						1	1	8
Plain jars	42ac													2								2
Mangrove																						
White bowls	44	3				2				7												12
Orange bowls	17a	3	3			1	2			4		6							1			20
Orange jars	16a	1						4						4		2	1					12
Plain jars	42ac	1						2						3		1		1				8
Guerengo																						
White bowls	44	3	1			1	1			13		1										20
Orange bowls	17a	2	8				3			4		2								1		20
Orange jars	16a	1		4										2								7
Plain jars	42ac	1		2				2	1					4	2	1						13
Paleodunes																						
White bowls	44	3	2							1												6
Orange bowls	17a	4	9			1	1			3		2										20
Orange jars	16a	1		2	1																	4
Plain jars	42ac	4						5	1		1		1	2	1	1						16
Summary																						
All 44 white bowls		11	3			3	1			**38**		2										58
All 17a orange bowls		12	**25**	1		2	**14**			**13**		**11**							1	1		80
All 16a orange jars		3		**13**	3			**6**	1					**8**		2	1			1	1	39
All 42ac plain jars		6		3				**9**	2		1		1	**12**	3	3		1				41
All 16a&42ac		9		**16**	3			**15**	3		1		1	**20**	3	5	1	1		1	1	80

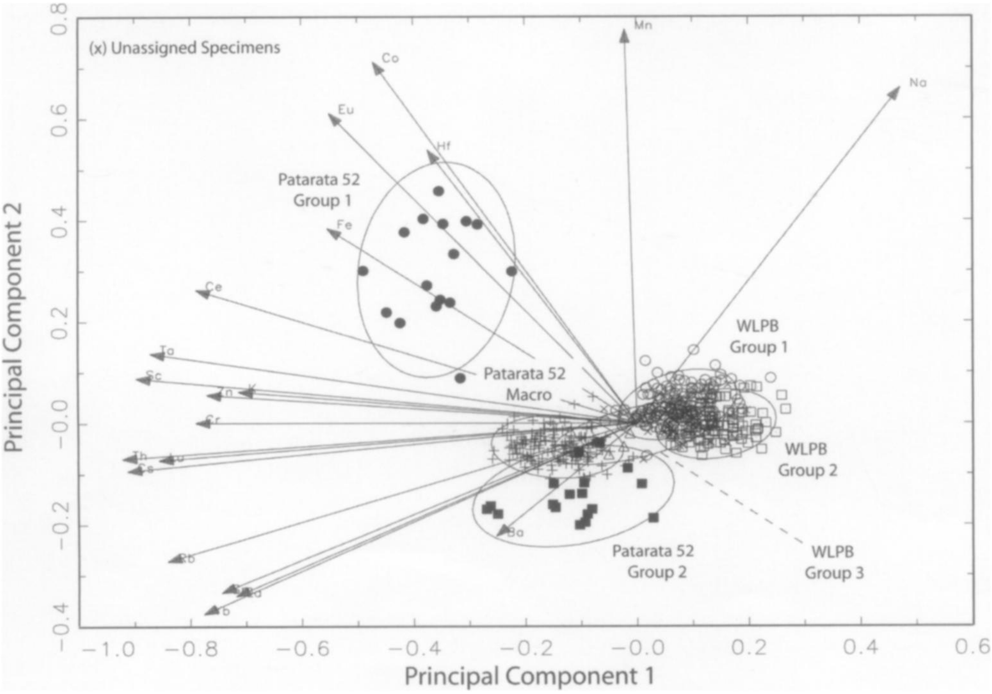

Figure 11. Biplot of principal component 1 and 2 based on correlation-matrix of the entire WLPB and Patarata 52 ceramic dataset. Ellipses represent 90 percent confidence interval for group membership.

6), and in fact cesium appears to be the main discriminating element. We suspect the reason for this distinction is that (1) Postclassic potters were selecting clays and sands from localized, specific sources in use for a shorter time span than the sources used throughout the longer Classic period, and (2) that there were some differences in paste preparation practices. Given that our focus is on the Classic Period pottery, the Lower Blanco pottery is not included in the following discussion.

The WLPB Macro group can be divided into three subgroups (WLPB groups 1–3). The distinction between WLPB groups 1 and 2 is marginal at best, and their multivariate distributions substantially overlap. Consequently, it is not possible to unambiguously separate groups 1 and 2 in bivariate or PCA plots (e.g., Figures 12, 13, 14). Better separation of groups 1 and 2 is achieved in a plot of principal components 1 and 3 (Figure 12) and in a bivariate plot of hafnium and lanthanum (Figure 14). Groups 1 and 2 contain roughly equal numbers of orange-slipped bowls (type 17), but approximately two-thirds of the unslipped jars (type 42c) are assigned to group 2 (Table 6).

In several attempts to identify patterning in the WLPB data, we focused on the fine-ware white bowls, type 44 (44, 44a and 44b). The fine-ware white bowls were generally higher in cesium and lanthanide elements than the utilitarian vessels, but it was impossible to achieve unambiguous separation of this type from the other pottery samples; most samples had high probabilities of membership in group 1 and what was tentatively identified as the "fine ware" group (and vice versa). Accordingly, the two groups were merged. One possibility for the overlapping membership in the fine ware and group 1 pottery is that the ceramics were made with compositionally similar clays, and that differential paste preparation practices, in particular the addition of temper to the orange-slipped bowls and coarse ware jars, diluted some elements. As a result, WLPB group 1 includes sherds from every type sampled, but especially prominent are the white slipped bowls, as 38 sherds were assigned to this group and only 4 to WLPB group 2 (Table 6). In addition to the WLPB samples analyzed at MURR, many samples from Patarata 52 (analyzed at BNL) were assigned to WLPB group 1 (see below).

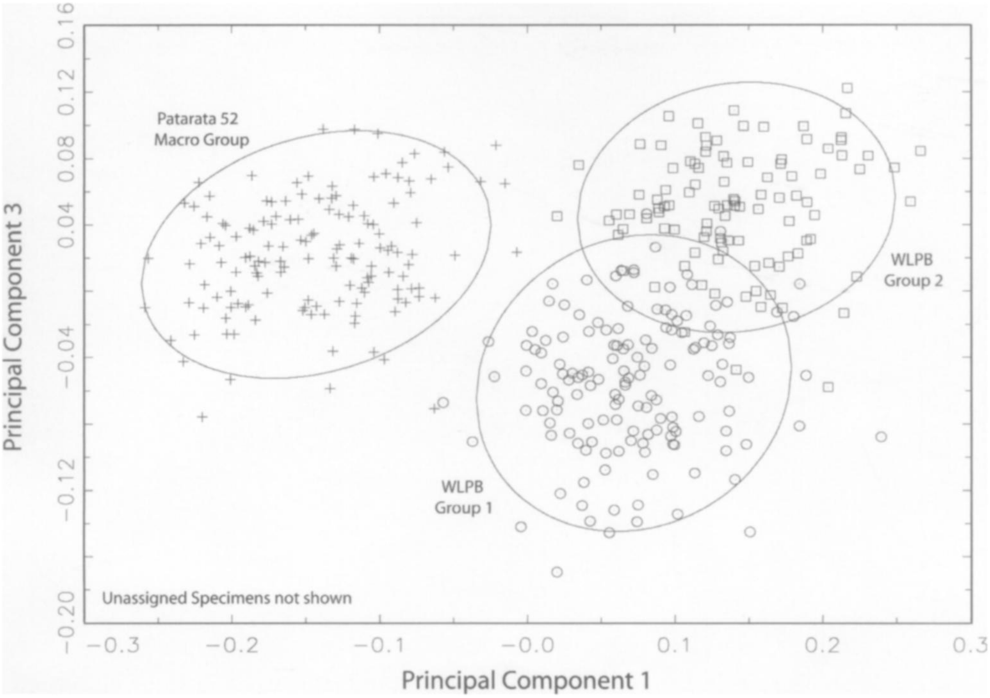

Figure 12. Plot of principal component 1 and 3 based on the correlation matrix of the entire WLPB and Patarata 52 ceramic dataset. Ellipses represent 90 percent confidence interval for group membership.

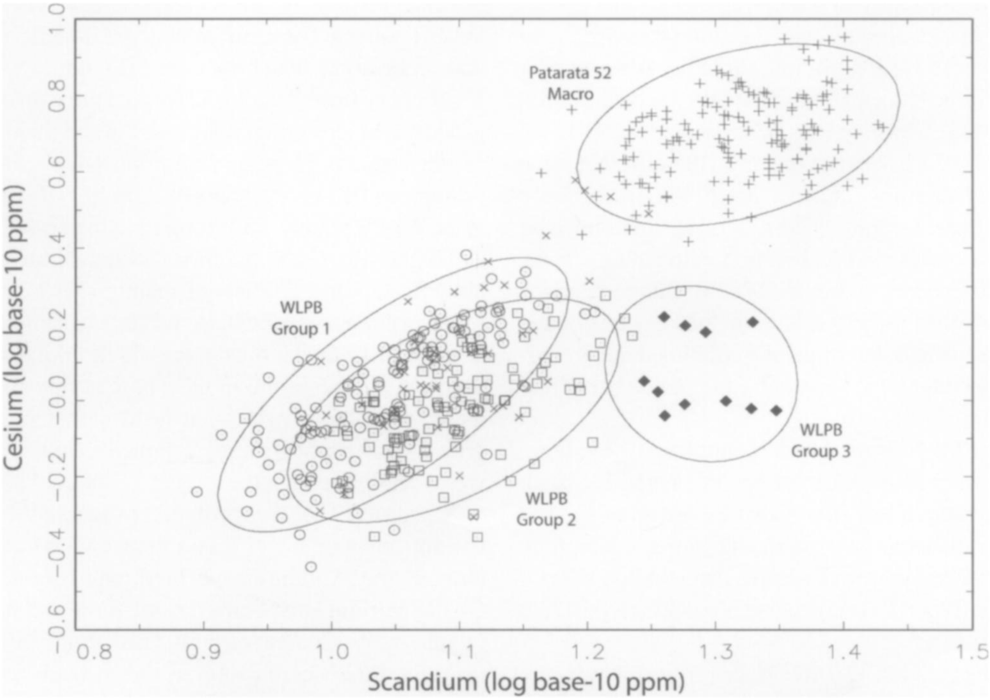

Figure 13. Plot of scandium and cesium base-10 logged concentrations showing the differentiation of WLPB groups 1, 2, and 3 from the Patarata 52 Macro group. Ellipses are drawn at the 90 percent confidence interval.

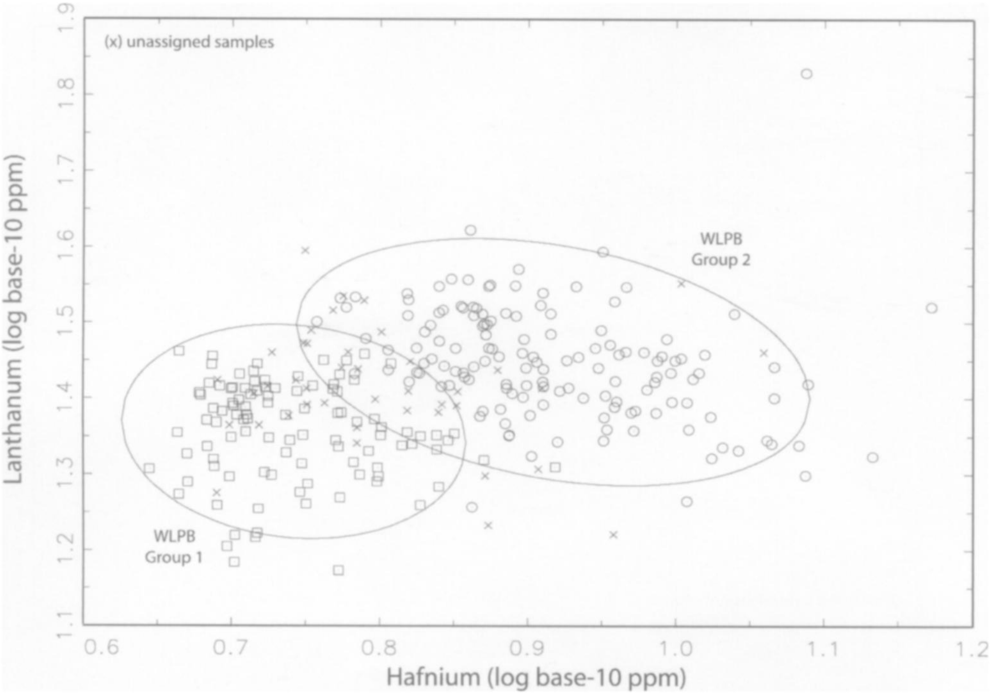

Figure 14. Plot of hafnium and lanthanum base-10 logged concentrations showing differentiation of WLPB groups 1 and 2. Ellipses are drawn at the 90 percent confidence interval.

The difficulty in separating the various groups is likely a consequence of the alluvial environment within the WLPB. Similar difficulty in separating pottery produced within alluvial systems has been reported elsewhere (e.g., Cogswell 1998; O'Brien et al. 1995). It seems probable in this case that some of the patterning (or lack thereof) is a consequence of different ceramic fabrics (fine, medium, and coarse pastes) in combination with subtle chemical differences within the WLPB. Future research with WLPB pottery should include a petrographic component to determine if a combined mineralogical and chemical approach can provide better resolution.

WLPB group 3, which is enriched in scandium, is distinct from other groups in Figure 13, but it comprises so few sherds that we are unable to say much about this group without additional sampling. WLPB group 3 sherds derive from orange-slipped bowls (type 17a) and coarse plain jars (type 42ac) (Table 6).

The Patarata 52 (P52) Macro group includes the majority of the excavated samples analyzed from the Patarata 52 mound and two new survey samples from the settlement of which P52 is part. There is a clear division between Patarata 52 pottery and WLPB pottery. These differences are illustrated in several bivariate data projections (Figures 15, 16, 17). Pottery from Patarata 52 formed three distinct groups: a Macro group comprised of the majority of the Patarata 52 pottery and two other groups designated P52 group 1 and P52 group 2. Relative to the WLPB pottery, P52 group 1 has lower sodium and higher Rb, Cs, K, and first row transition metals. P52 group 1 consists of mainly sherds from Mojarra Orange-gray, Coarse variant (10 samples), along with four daub samples, three clinkers or wasters, and a figurine mold. The fact this group includes wasters suggests that the Mojarra Orange-gray, Coarse variant sherds assigned to this group were locally produced.

P52 group 2 consists primarily of Tanare White, variant unspecified (12 samples), two Mojarra Orange-gray, variant unspecified, one Escolleras Chalk, variant unspecified, and three Mojarra Orange-gray, Coarse variant. This group differs from the P52 Macro group in that it tends to be diluted in transition metals (e.g., iron, cobalt, and manganese). The two dominating types for P52 group 1 and P52 group 2 have noticeably different

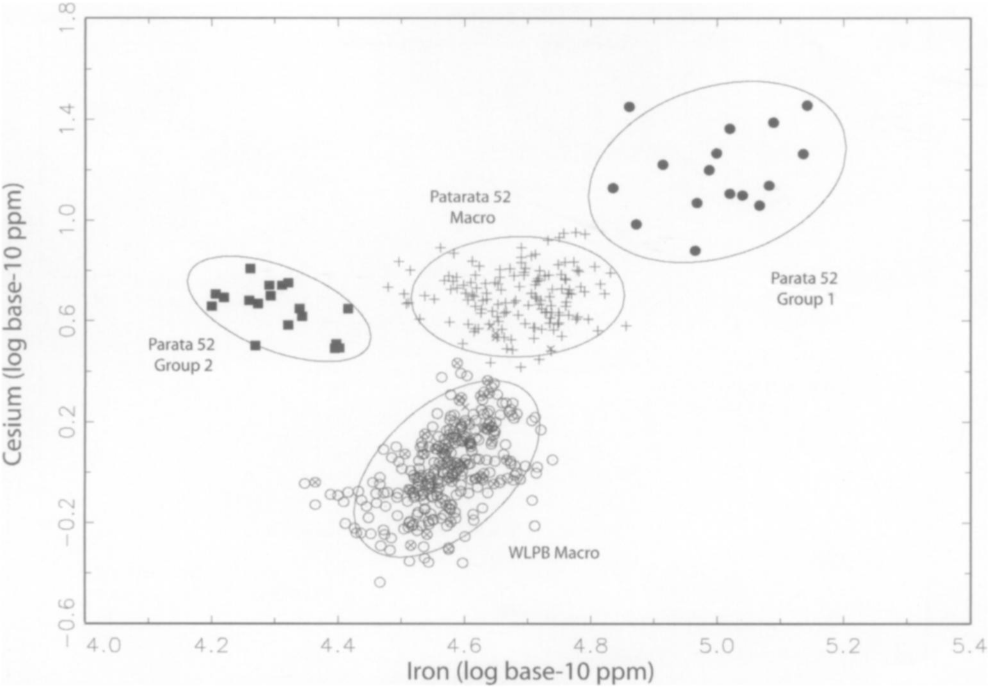

Figure 15. Bivariate plot of iron and cesium base-10 logged concentrations showing the differentiation of the WLPB Macro group from the Patarata 52 Macro group and two subgroups. The subgroups are distinct from the other regional reference groups shown above. Ellipses are drawn at the 90 percent confidence interval.

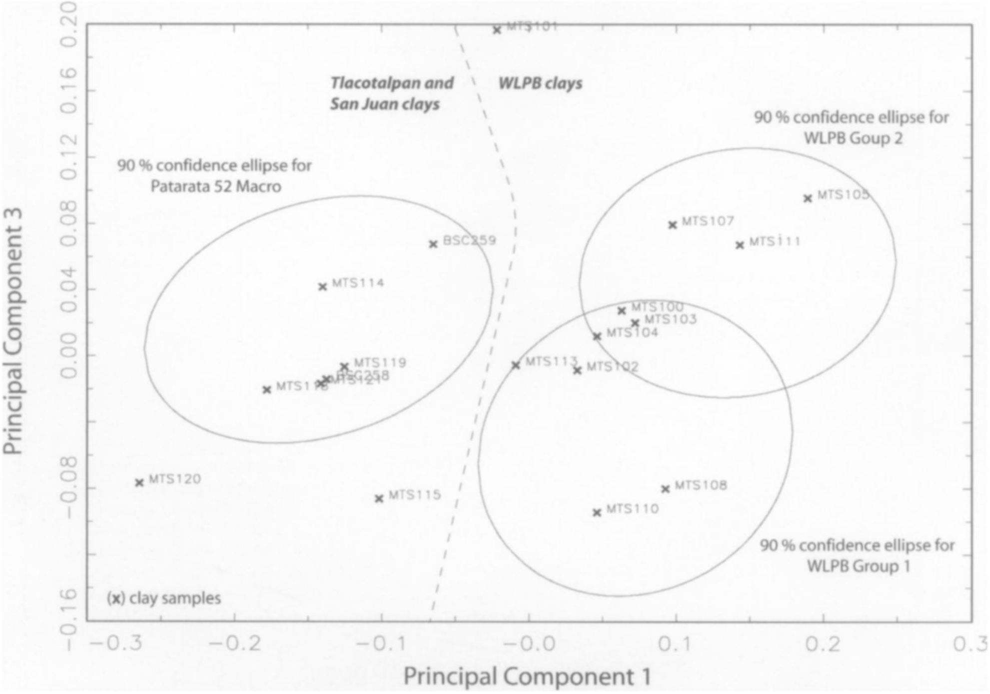

Figure 16. Plot of principal component 1 and 3 based on correlation-matrix of the entire WLPB and Patarata 52 ceramic dataset. Clays are projected against 90 percent confidence ellipses for the primary reference groups.

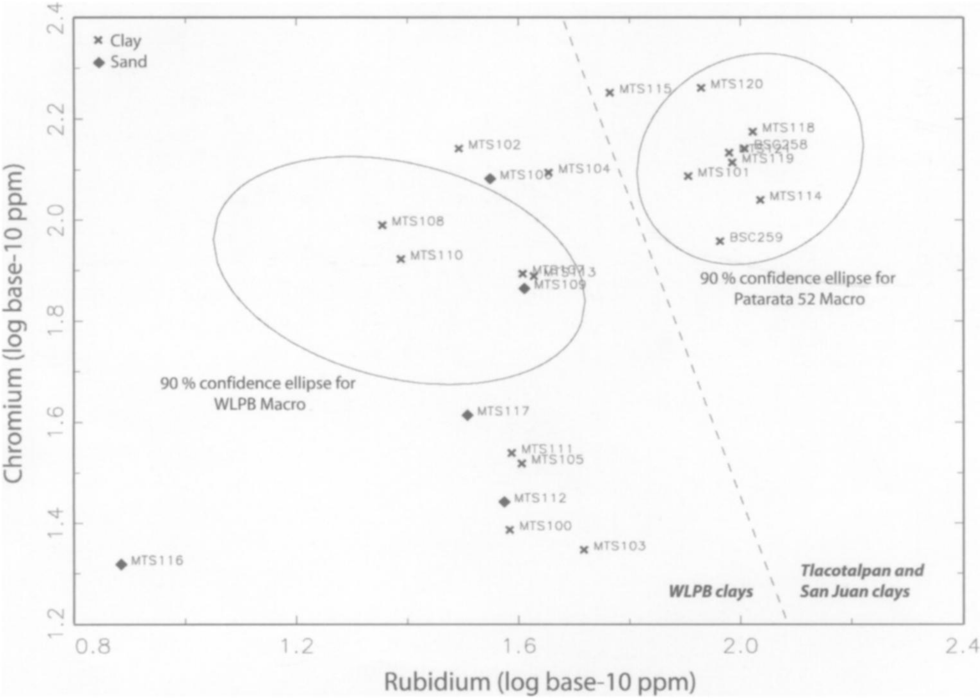

Figure 17. Plot of rubidium and chromium base-10 logged concentrations. Clays and sands are projected against 90 percent confidence ellipses for the Patarata 52 and WLPB Macro groups.

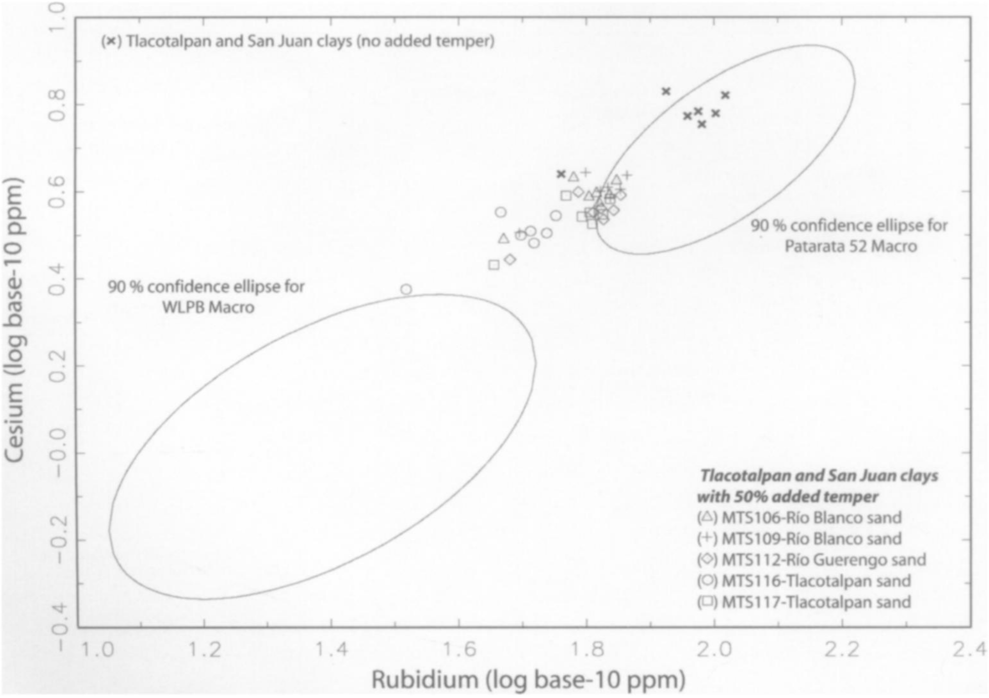

Figure 18. Plot of rubidium and cesium base-10 logged concentrations. Raw clays and clays tempered with 50 percent of each of the five analyzed sands are projected against the confidence ellipses for the Patarata 52 and WLPB Macro groups.

temper than other Patarata pottery. Tanare White has numerous clear sand particles, whereas Mojarra Orange-gray, Coarse variant, has dark, relatively large, widely spaced unidentified particles. In both cases, temper and/or clay differences may have established different chemical values, with a few other sherds, or other samples, such as daub, assigned similarly—perhaps because they contained some related sand particles.

We now turn to complex issues concerning sherds from pottery types sampled at Nacastle-Patarata that are assigned to the WLPB Macro group or the P52 Macro group, but not exclusively. Only two samples from the recent WLPB analyses were assigned to the P52 Macro group (one type 42ac utility jar and one type 44 white bowl), and both originated from surface collections in the Nacastle-Patarata settlement where Patarata 52 is located. All other Nacastle-Patarata sherds from these types and from the orange bowl type (type 17a) were assigned to the WLPB Macro group. Clearly, for the three new types analyzed, WLPB Macro assignments are highly characteristic, whether the sherds derive from the mangrove swamp or from the farmlands to the west.

Of the samples from the earlier BNL study of Patarata 52 pottery that were assigned to the WLPB Macro group, most were assigned to WLPB group 1. The sherds and types assigned to the WLPB Macro group are: 39 Acula Red-orange, Engraved variant; one Escolleras Chalk; 13 Mojarra Orange-gray, variant unspecified; six Prieto Gray-black; one Tlacotalpan Orange; and 18 Patarata Coarse, Plain variant (five Patarata Coarse, Plain variant, sherds were assigned to the Lower Blanco Postclassic group [Skoglund et al. 2006], the only Patarata 52 sherds assigned to that group). Notably, all Patarata Coarse (comparable to the type 42ac utility jars in the WLPB) and all Acula Red-orange, Engraved variant, sherds from Patarata 52 excavations were assigned to the WLPB Macro group, making them candidates for trade from the farmlands to the Nacastle-Patarata mangrove community.

Nevertheless, the range of types assigned to this group includes ultrafine pastes (Mojarra Orange-gray, variant unspecified, and Prieto Gray-black). Although only 16 percent of the sherds are involved, the assignment represents one of two striking anomalies. Mojarra Orange-gray, variant unspecified, pottery appears to have been manufactured at Patarata 52 (Stark 1989:102–112) as well as elsewhere in the Nacastle-Patarata settlement. Therefore, it seems unlikely that similar vessels were imported from farther west in the other WLPB localities, which makes the compositional results puzzling.

A related problem concerns Acula Red-orange, Engraved variant (ACEN). At Patarata 52 these bowls have distinctive designs, with running paneled animals. This type is similar in slip and forms to WLPB type 17a, but engraved animal motifs are extremely scarce in survey blocks west of the mangrove swamp. Thus it seems unlikely that the Patarata 52 ACEN bowls were manufactured to the west and imported to Nacastle-Patarata—a point to which we return below. The two anomalies warrant a detailed assessment of how raw materials relate to the compositional groups and the distinctness of the P52 Macro and WLPB Macro groups, which we test by modeling temper admixture.

Mahalanobis distance probabilities (Table 3) indicate that five ethnographic clays (MTS118, MTS119, MTS121, BSC 258, BCS259) obtained from Tlacotalpan potters are the best match to the Patarata 52 Macro group. In contrast, only four clays are likely candidates for WLPB groups 1 and 2. MTS108, MTS110, and MTS113 have high probabilities of membership in WLPB group 1 and MTS107 has high probabilities of membership in WLPB group 2. The two ethnographic slip clays that purportedly were obtained up the San Juan River in San Juan Evangelista have less than 1 percent probability of membership in any identified group. These associations of raw clays support the idea that the WLPB and Patarata 52 pottery was locally produced (although they do not indicate exactly where). In the case of Mojarra Orange-gray, Coarse variant, and Tanare White, variant unspecified (P52 groups 1 and 2), none of the clays appear to be good matches.

The ethnographic clays obtained from Tlacotalpan potters (used for vessels and for lining the kilns and dusting molds, some sampled in two different years) fall within the P52 Macro group in a biplot of principal components 1 and 3 (Figure 16), but a surface sample of several lumps of red clay from the Nacastle-Patarata settlement (MTS 101) does not. The slip clay samples from ca. 100 km up the San Juan River fall outside the ninetieth percentile confidence interval on the plot of principal

Table 3. Summary of Clays and Group Membership Probabilities. Tlacotalpan Modern Samples Are Described in Stark (1984) and Include Duplicate Samples Collected in Different Years as Well as BNL and MURR Analyses of the Same Samples in Some Cases.

			Mahalanobis Distance Probabilities		
MURR I.D.	Context	Description	WLPB Group1	WLPB Group2	P52 Macro
MTS100	North Blanco	Whitish-gray clay, possibly kaolinite	0	0	0
MTS101	Nacastle (mangrove)	Several lumps of red clay	0	0	0
MTS102	Vibora (paleodunes)	Reddish-brown clay with lumps and sediment	0	0	0
MTS103	Nopiloa (Guerengo)	Whitish-gray clay, possibly kaolinite	0	0	0
MTS104	Vibora (paleodunes)	Brown clayey sediment with lumps	0	0	0
MTS105	Nopiloa (Guerengo)	Whitish-gray clay, possibly kaolinite	0	1.1	0
MTS107	Piedras Negras, N bank Blanco	Brown clayey sediment with lumps	7.1	56.1	0
MTS108	Nopiloa (Guerengo)	Gray clayey sediment with lumps	54.4	.1	0
MTS110	Dicha Tuerta (Guerengo)	Black-brown clay with lumps	10.9	.1	0
MTS111	Dicha Tuerta (Guerengo)	Whitish-gray clay with lumps	.2	.2	0
MTS113	Tlalixcoyan (modern town)	Black-brown clay with lumps	34.5	8.7	0
MTS114	Tlacotalpan (modern town)	Light gray-brown clay for kiln lining and dusting molds	0	0	42.0
MTS115	Tlacotalpan (modern town)	Ethnographic yellow-brown clay used for slips, probably from San Juan River	0	0	.3
MTS118	Tlacotalpan (modern town)	Ethnographic medium gray clay for vessels	0	0	97.0
MTS119	Tlacotalpan (modern town)	Ethnographic medium gray clay for vessels	0	0	97.7
MTS120	Tlacotalpan (modern town)	Ethnographic yellow-brown clay used for slips, probably from San Juan River	0	0	0
MTS121	Tlacotalpan (modern town)	Ethnographic medium gray clay for vessels	0	0	86.9
BSC258	Tlacotalpan (modern town)	Ethnographic medium gray clay for vessels	0	0	91.2
BSC259	Tlacotalpan (modern town)	Ethnographic medium gray clay for vessels	0	0	87.1

Table 4. Total Count of Patarata Brookhaven National Laboratory Samples by Phase. The Portion of the Count Assigned to the WLPB Groups Is Given in Parentheses (Others All Patarata 52 Macro Group). Pottery Types Are Described in Stark (1989). Camaron Phase Is Early Classic Period and Limon Phase Is Late Classic Period.

Pottery or Clay	Camaron 1	Camaron 2	Camaron 3	Limon	Modern	Other
Tanare White, var. un.	1	2	6	3		
Tlacotalpan Orange, var. un.	1	1	2	3 (1)		
Acula Red-orange, Engraved var.	20[a] (19)	20 (20)				
Mojarra Orange-gray, var. un.	20 (3)	20 (2)	20 (5)	19 (3)		
Mojarra Orange-gray, Coarse var.	20 (3)	18 (3)				
Escolleras Chalk, var. un.	8	2 (1)		2		
Prieto Gray-black, var. un.	9 (1)	9	20 (4)	20 (1)		
Patarata Coarse, Plain var. (like type 42ac)	18[b] (18)					
Tlacotalpan Potters' Workshop					6	
Excavated Daub (P52, P37, P131, P56)					5	
Clinker or waster, P52						3
Figurine mold, P56						1
Tlacotalpan potters' clay for vessels				1		
Tlacotalpan potters' clay for lining kiln and dusting molds				1		

[a] One outlier sample not in any group.

[b] One sherd probably Camaron 1, but provenience not noted.

components 1 and 3 also (Figure 16), but they fall within or just outside the ninetieth percentile ellipse for a bivariate plot of rubidium versus chromium, and the previously mentioned surface clay sample falls within the ellipse on that bivariate plot (Figure 17). Thus, these two aberrant mangrove clay samples are closer to the P52 Macro group than to the WLPB groups 1 or 2.

Clays from along the Blanco River (MTS 100, MTS 107), from the paleodunes (MTS 102, MTS 104), and from along the Guerengo River (MTS 103, MTS 105, MTS 108, MTS 110, and MTS 111) fall within WLPB groups 1 or 2. Sands from along the Blanco River (MTS 106) and the Guerengo River (MTS 112) do not fall within the ninetieth percentile ellipse for a bivariate plot of rubidium and chromium (Figure 17), except for one Blanco sand (MTS 109).

To summarize, in most cases WLPB clays plot within or near the 90 percent confidence ellipses for the WLPB pottery and the Tlacotalpan clays plot within or near the 90 percent confidence ellipses for pottery from Patarata 52. Mahalanobis distance probabilities (Table 3) indicate that several of these clays can be attributed firmly to the P52 Macro group or to WLPB group 1 or 2. Tlacotalpan clays overall have higher probabilities for the P52 Macro group than the clays from the western localities have for the WLPB Macro group, probably because the Tlacotalpan clays are ethnographically selected for suitability for pottery; in contrast, clays from western localities were sampled by field crews and represent natural sediments in the area rather than materials specifically suited to pottery making. Clays that have less than 1 percent probability of membership in any of the groups are considered to be a "poor" match (Table 3). Clays that exceed 5 percent probability of membership generally can be considered a "good" match, whereas clays that exceed 50 percent probability in a group can generally be considered an "excellent" match with the group in question.

Although these data suggest that the differences between the WLPB and P52 groups are in fact

Table 5. Summary of Counts of Sherds, Clays, and Sands According to their Compositional Group and Locality.

	Pottery, Clays, and Sands				Pottery Only			
Locality	WLPB Group 1	WLPB Group 2	WLPB Group 3	Unassigned	WLPB Group 1	WLPB Group 2	WLPB Group 3	Unassigned
Delta Blanco	22	6	0	10	22	6	0	10
Upriver Blanco	2	11	0	13	2	11	0	9
Mangrove	24	8	3	18	24	8	3	17
Guerengo	30	13	0	23	30	13	0	19
Paleodunes	3	23	5	17	3	23	5	15

Table 6. Counts of Sherds According to Their Compositional Group and Type.

Type	WLPB Group 1	WLPB Group 2	WLPB Group 3	Unassigned	Total
44 white bowls	38	4	0	16	58
17a orange bowls	23	31	6	20	80
16a orange jars	11	11	0	17	39
42ac plain jars	8	14	3	16	41
Total	80	60	9	69	218
16a & 42ac	19	25	3	33	80

regional, it is possible that variable amounts of temper drive the differences between the P52 and WLPB Macro groups. Generally, the coarsely tempered sherds from Patarata 52 and from the surface collections in the Nacastle-Patarata settlement were classified with the WLPB Macro group, except for the two types dominating Patarata 52 groups 1 and 2, which suggests that temper (amounts and sources) plays a considerable role in determining compositional group assignments.

In order to ascertain whether variable amounts of temper could result in the observed differences between the P52 and WLPB Macro groups, we modeled the effects of temper on the five ethnographic Tlacotalpan clays that had high probabilities of membership in the Patarata 52 group. We also included the two ethnographic clays from San Juan Evangelista that projected favorably with the Patarata 52 pottery, but statistically were poor matches. Each of the seven clays was mathematically tempered with 10, 20, 30, 40, and 50 percent sand. A bivariate plot of rubidium and cesium (Figure 18) depicts the untempered clays, and each clay tempered with 50 percent sand, relative to the 90 percent confidence intervals for the two groups in question. If increased quantities of temper indeed affect group membership, then theoretically the Tlacotalpan clays tempered with higher quantities of sand should plot within (or very near) the 90 percent confidence ellipse for the WLPB Macro group, yet they do not. Given that it is unlikely that any of the pottery assigned to the WLPB Macro group contains more than 50 percent temper, we can conclude that increased amounts of temper are not responsible for the differences between the two groups. This suggests that the division between the two macro groups is driven by variability in clays, not tempers (although we admittedly have not analyzed all possible tempers in the area). This idea is also supported by the fact that each macro group contains both coarse and fine variant pottery. The results also indicate that the Tlacotalpan clays can be tied to the Patarata 52 Macro group, regardless of whether they were used to produce pottery with little or no temper or to manufacture coarsely tempered pottery.

Based on the INAA data for the clays and pottery, it appears that clays used to manufacture WLPB pottery are alluvial and compositionally similar across the WLPB area. Clays used to manufacture Patarata 52 pottery are likewise probably derived from alluvial sources, but from a different alluvial system, given that clays and modern pottery from Tlacotalpan and daub from Patarata 52 are assigned to this group. The Papaloapan has two primary eastern tributaries on the alluvial plain, the San Juan (at Tlacotalpan approximately) and the Tesechoacan, farther inland. In contrast, there are inputs to the western lower basin from rivers west of the Acula distributary, such as the Blanco and the Guerengo rivers. Thus, the P52 Macro group and P52 groups 1 and 2 appear to represent clays derived from a different geomorphological framework than those used to manufacture pottery assigned to the WLPB groups.

Having established that the differences between the Patarata 52 and WLPB Macro groups are likely a consequence of different clays from different alluvial systems, rather than variable amounts of temper, we can return to our discussion of the two anomalies with respect to compositional group assignments. Acula Red-orange, Engraved variant (ACEN) bowls were recovered from Patarata 52, but assigned to the WLPB Macro group. As discussed above, not only is ACEN pottery generally scarce to the west, but the running-animal motifs that characterize it at Patarata 52 are even scarcer. Thus, it seems unlikely that these vessels were manufactured in the WLPB, at least in the surveyed areas. There is a "substitute" red-on-orange decoration favored west of Nacastle-Patarata. A common bowl in the western WLPB has two or three, wide, exterior horizontal red bands on an orange slip (similar to type 17a, but with red decoration). Sometimes the red bands are sloppily delimited by an incised line.

Conceivably the ACEN animal bowls were produced in small household contexts in the Nacastle-Patarata residential mounds or others nearby, but given the major chemical differences in pottery and clay between the WLPB and Papaloapan, this scenario does not seem likely. Alternatively, it is possible that ACEN bowls recovered in the swamp contexts were produced in unsurveyed localities, perhaps to the southwest of the mangrove zone and south of the survey blocks to the west, provided that clays there are similar chemically to those in the WLPB Macro group.

Despite this possibility, there are still other signs that the chemical group discriminations are not entirely convincing regarding possible pottery production and distribution patterns. The assignment of 16 percent of the Mojarra Orange-gray, variant unspecified, sherds from Patarata 52 to the WLPB Macro group is problematic in view of evidence that this pottery type was produced at Nacastle-Patarata. Mojarra Orange-gray, variety unspecified, has an ultrafine paste, and is temperless or nearly so (as are Prieto Gray-black and Escolleras Chalk). Clearly, future chemical characterization of pottery from this region should focus on these ultrafine paste categories. We need to establish if sherds in the ultrafine orange and gray categories from the western survey blocks are assigned to the P52 Macro or WLPB group 1 or 2. There is a possibility of complementary exchange if utility vessels were produced to the west and predominantly imported to Nacastle-Patarata, as our results indicate, with ultrafine orange vessels produced in the mangrove settlement and exchanged to the western farmland inhabitants. Verification of this possibility will require additional sampling to determine how we should interpret the 16 percent of ultrafine orange sherds from Patarata 52 that appear anomalously to have been produced to the west, despite well-documented production at Patarata 52.

Implications of Results

The success of our compositional analysis varies with the geographic scale of comparison. At the largest scale, different alluvial systems appear to yield compositionally distinct pottery up and down the Gulf lowlands. At a more restricted scale, both lower Cotaxtla and western Tuxtlas pottery contrast chemically with the P52 and WLPB Macro groups. Despite the promising results for distinguishing chemical groups related to provenance on the basis of Skoglund et al.'s (2006) Postclassic samples, INAA of Classic period pottery from the WLPB does not lead to the identification of distinct signatures for pottery types nor localities, at least for the pottery types and time periods in question, and at the scale for which we hoped (Tables 5 and 6). The WLPB Macro group associated with the western farmlands is distinct from the P52 Macro group associated with the mangrove swamp. The WLPB Macro group did not comprise subgroups related to drainages, however. Within the WLPB Macro group, group 1 pottery tends to be more abundant to the south and east, and group 2, more abundant to the north and west; nevertheless, this trend requires more extensive sampling to substantiate it.

Our interregional comparisons of Gulf lowland pottery provide a broad-scale view of compositional variability within this large area. The ability to discriminate such diverse temporal and regional INAA datasets provides a basis for optimism that additional provenance-based INAA research the Gulf lowlands can be successful, as has been demonstrated in other areas of Mesoamerica and elsewhere. It is important to note the continued analytical value of the BNL INAA data that were used in this study. Although some of these data were generated more than 30 years ago, their role in facilitating an understanding of compositional variability within and between the WLPB and Nacastle-Patarata settlement areas has been significant. Likewise, examination of the BNL data generated for El Tajín and Pavón indicates long-distance movement of pottery between these sites (or between these regions), suggesting possible directions for future research.

For the WLPB, because INAA chemical characterizations crosscut types and locations, patterns of production and distribution of pottery remain uncertain. Although during the Early Classic period the western lower Papaloapan basin likely was unified under Cerro de las Mesas, there is little archaeological evidence of concentrated and localized craft activity. In contrast, during the Late Classic period, when the region broke up into three or four polities, localized production becomes more evident for several crafts, including pottery. One of the probable localized crafts involved orange bowl production (type 17a) around the center of Los Azuzules (Stark and Garraty 2004). White slipped bowls (type 44) are particularly common along the Guerengo drainage, which might be a clue to production there (Stark 2006b). The mangrove community was involved in production of ultrafine orange paste vessels (Stark 1989:102–112).

Unfortunately, despite this production evidence, we cannot determine the accompanying distribution patterns because compositional groups do not correlate well with pottery types or localities, and because the WLPB samples did not include the ultrafine paste types (temperless or nearly temperless) that were featured in the Patarata 52 analysis. On the basis of comparison of the P52 Macro and WLPB Macro groups, we can suggest that analysis of the fine paste categories like Mojarra Orange-gray and Prieto Gray-black in survey areas to the west of the mangrove zone is one of the most promising directions for future work. These types are important contributors to the P52 Macro group, and trade of compositionally similar sherds westward to the other survey localities might be identifiable.

Evidence of Late Classic period craft specialization in the absence of distinct compositional groups for drainages may mean that distribution went beyond individual polity boundaries, perhaps extensively. During the Early Classic period, there were no obvious political impediments to vessel exchanges. Consequently, one reason for the lack of compositional groups that can be clearly associated with each locality may be a substantial amount of trade involving various categories of pottery. The presence of WLPB Macro sherds at Nacastle-Patarata suggests considerable movement of vessels, for example. Another likely reason is a lack of chemical distinctness among clays in these predominantly alluvial contexts within the western basin outside the mangrove swamp, as indicated by the clay samples examined to date. Petrographic studies of sand tempers may yield insights that the INAA analysis could not provide (e.g., Miksa and Heidke 2001).

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