

1989

STYLISTIC AND CHEMICAL VARIABILITY IN PLUMBATE POTTERY: AN INTERIM REPORT

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INTRODUCTION

Plumbate pottery, a common constituent of the archaeological record for the Late Classic and Early Postclassic periods in Mesoamerica, is an artifact that is ideal for yielding information on ancient production and exchange systems. As the most technologically advanced manifestation of the potter's craft in Precolumbian Mesoamerica (Shepard 1965), plumbate offers evidence of specialization in ceramic production. As the most widely distributed of all Mesoamerican ceramics, it yields evidence of economic relations between widely separated regions. Thus, a study of plumbate pottery is also a study of two important characteristics of complex societies, namely economic specialization and large scale long distance trade.

The recognition of the importance of this ware is not new, as it has received the attention of researchers at least since the time of Seler (1915), culminating with the seminal publication of Shepard (1948). Shepard was limited in her investigation by a paucity of excavated material. Nevertheless, her painstaking synthesis of the available data was interpreted from the perspective afforded by observed paste compositional variation and she was able to advance several hypotheses regarding plumbate production. Unfortunately, little substantive research on plumbate has appeared in the intervening years -- despite Shepard's clear warnings that most of her interpretations were subject to further verification.

With the greatly increased availability of plumbate pottery as a result of recent excavations and the development of new analytical techniques, it is now feasible to reexamine some of the problems that have persisted since the publication of Shepard's work.¹ The general question

addressed here concerns the mode of production of plumbate ware. Specifically, 1) in how many places may plumbate have been produced? 2) was procurement of ceramic resources localized within the production region? and 3) was production a highly controlled, centralized activity? In this paper, data derived from neutron activation analysis are used to evaluate these questions. The answers form the basis for several tentative inferences regarding economic specialization and exchange patterns.

RESEARCH BACKGROUND

The most obvious characteristic of plumbate pottery is the shiny surface, in color characteristically a shade of orange or a shade of gray, depending on the firing atmosphere. Some of the gray specimens have an extremely hard, partially vitrified surface. The shiny gray appearance of these vessels led early investigators to adopt the misnomer "plumbate," meaning lead-based (as with a glaze), as a class name for them. Shepard (1948) demonstrated that both special slip clay (high in alumina and very high in iron) and a special firing technique (a reducing atmosphere at or above 950°) were necessary to produce the distinctive, vitrified surface.

Within the broad class of pottery defined by the distinctive surface, Shepard discovered two subclasses by means of petrographic analysis. These were Tohil, or "typical" plumbate and San Juan plumbate. San Juan was distinguished from Tohil by the absence of glassy rock fragments in the tempering material and the presence of fine flakes of volcanic ash. Lumps of ferruginous clay or hematite were found to be common in San Juan plumbate, leading Shepard to refer to it as the "ferruginous"

variety. Stylistic differences between ferruginous and typical plumbate were pointed out, but a restricted sample of the former made it impossible to offer a detailed stylistic description of San Juan plumbate.

Shepard also summarized the archaeological evidence concerning the chronological relationship between San Juan plumbate and Tohil plumbate. The evidence related to chronology consisted of 1) numerous finds of Tohil plumbate in Early Postclassic contexts all over Mesoamerica (summarized in Dutton 1943) and 2) excavations during the 1930's, principally at Kaminaljuyú (Kidder, Jennings and Shook 1946) and El Baúl (Thompson 1948), which yielded San Juan plumbate without Tohil plumbate apparently in Late Classic contexts. Subsequent to the publication of Shepard's monograph, the New World Archaeological Foundation investigations at Izapa appear to have confirmed the suggested plumbate chronology. According to Lee (1973, 1978), excavations on Mound 125a, Group F encountered a series of whole vessel caches which demonstrate that stylistically, San Juan plumbate preceded stylistically Tohil plumbate at Izapa.

Besides these two basic classes, Shepard suggested that an intermediate class, tentatively named "Robles," may exist based on textural and stylistic anomalies she observed in the collection from Finca El Paraíso, Guatemala. Although no one has offered an explicit definition of Robles, many investigators have incorporated it into their typological scheme (e.g., Dutton 1958; Smith 1957, 1971; Smith, Willey and Gifford 1960; Lowe and Mason 1965; Rands and Smith 1965; Wetherington 1978b). Lee appears to be suggesting that Robles represents a distinct production center in the following statement: "while the importance of Robles is still not completely understood, it now appears to have been a rather local development more closely related to Tohil, but still to one side of the general plumbate evolution" (1978:288).

In view of the confusion surrounding both classification of plumbate and the relationship of classes to zones of procurement and production, a primary objective of the present study is to provide chemical evidence regarding the number and spatial restrictedness of procurement zones. That is, does statistical analysis of the chemical composition of a sample of plumbate potsherds suggest one, two, or more compositional groups? Also, to what extent do the groups derived by neutron activation analysis coincide with stylistic classes?

Even assuming that more than one compositional group is found in the plumbate sample, the question of single versus multiple sources still cannot be resolved

completely. The existence of multiple compositional groups could result from use of different clay sources, addition of several kinds of temper to clay from the same source, or to a combination of these two factors. This aspect of the question of single versus multiple sources requires data on the mineralogical properties of the paste of the various groups in addition to the data of neutron activation analysis.

If two or more groups are shown to be from the same source, then this could be explained as contemporaneous existence of different methods of material preparation, or as temporal development of methods of preparation. Although data bearing on the development of plumbate are limited, the accepted division of plumbate into two temporally successive classes (San Juan and Tohil) provides a broad outline for interpreting observed compositional variability.

Our neutron activation data also provide the basis for indirect assessment of the relative localization of procurement and the relative standardization of production activities. We do not have direct archaeological evidence of procurement or production, nor do we have raw clay samples from the inferred production region. However, we argue that homogeneity of chemical compositional structure derived by neutron activation analysis reflects both localization of procurement activities and standardization of the production process.

The distribution of plumbate in excavated collections led Shepard to hypothesize that all plumbate was produced somewhere on the Pacific slope of southwestern Guatemala and southern Chiapas. Recently, this hypothesis has been questioned by Bruhns (1980a). After discussing some shiny gray-surfaced pottery from Cihuatán, El Salvador, she concludes that there may have been several plumbate production centers located between central El Salvador and Veracruz. Although the definitional and classificatory decisions that lead Bruhns to this conclusion are largely beyond the scope of this paper, it must be emphasized that our analysis pertains to the class plumbate, as it was defined by Shepard and as it is utilized by most investigators. We specifically exclude from consideration a number of shiny gray wares whose manufacture is known to have taken place outside of the Pacific slope region and which bear little resemblance to plumbate other than in some aspects of macroscopic surface appearance.

METHODS AND RESULTS

To pursue these questions of plumbate production, neutron activation analysis was carried out on a selection

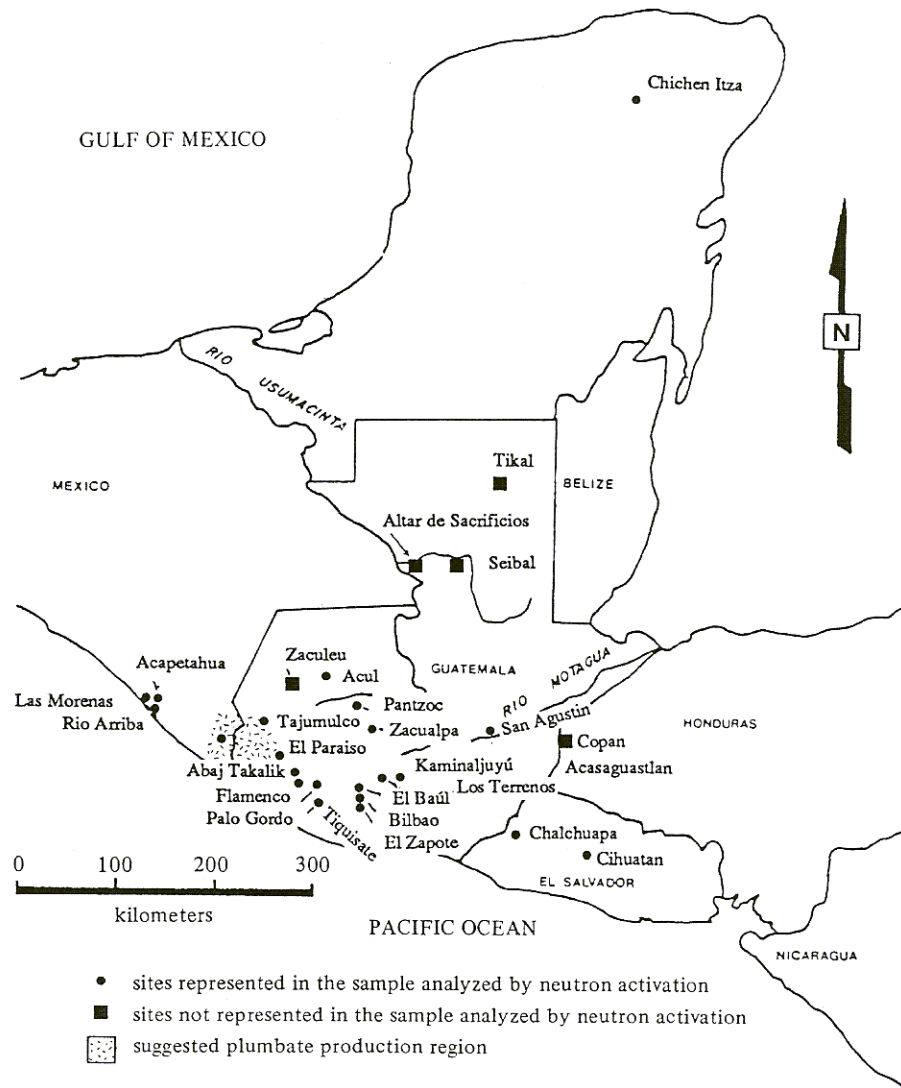


Figure 11.1 Map of southern Mesoamerica.

of plumbate ceramics. A variable number of samples from each of the sites represented on the map (Figure 11.1) has been analyzed, forming the basis for our initial assessment of the data. The cluster of sites along the Pacific coast Mexico-Guatemala border seen in Figure 11.1 is not an artifact of biased sampling, but represents the peak of plumbate abundance as it is known from archaeological surveys and excavations (Drucker 1948; Shook 1948, 1965; Thompson 1948; Lowe and Mason 1965; Rands and Smith 1965).

The principle guiding selection of sherds for sampling was that the data base should, within practical limits, represent the range of stylistic variation as well as

the range of geographic distribution of plumbate. We first located all of the plumbate sherds in the collections that were available to us (see Endnote 1). Then, we identified all sherds as either San Juan or Tohil plumbate on the basis of stylistic attributes. Rim form and overall vessel form were the main attributes used to assign sherds to one class or the other, although the presence of incised curvilinear abstract designs and the presence of effigy features were also used to identify Tohil sherds which did not exhibit evidence of rim form or vessel form. We could not assign any sherds to Robles because no one has ever provided an explicit class definition. When both San Juan plumbate and Tohil plumbate were represented at a

site, samples were taken of both. Within the major classes, we chose sherds representing the largest possible range of attributes of shape and decoration known to characterize the class.

This paper reports on a total of 138 analyses; another 50 samples have been processed but time did not permit their inclusion in this stage of data analysis. Since the data base is rapidly expanding, only a general overview of the plumbate composition will be presented here.

For such a relatively large geographic area as that being considered, the sample size is perhaps rather small. Nonetheless, given the very strong patterning that exists within the compositional data, it is expected that additional analyses will amplify, rather than alter our present conclusions.

Elemental abundances were determined by standard Brookhaven National Laboratory procedures (Bishop, Harbottle and Sayre 1981). Incomplete data for sodium and potassium required that we restrict numerical analysis to the 15 elements determined from long-lived isotopes. The elemental concentrations were transformed to log values (cf. Harbottle 1973) and submitted to average linkage cluster analysis of Euclidean distances between data points (Sneath and Sokal 1973). Early to emerge was the bifurcation of the data into groups stylistically attributable, for the most part, to San Juan and Tohil classes. Subsequent statistical analysis supported the initial divisions, leaving 35 samples that, for the moment, could not be assigned to either group.

It became clear upon inspection of the group membership that, although there was strong agreement, class assignments based on stylistic criteria did not exactly coincide with the two chemical compositional groups. While there were no stylistically Tohil sherds in the San Juan compositional group, 10 of the 45 samples in the Tohil compositional group were from sherds originally identified as members of the San Juan class. One of these was originally identified as a rim from a San Juan cylinder, but subsequent inspection showed that it is actually a rim from a wide-necked Tohil jar. The other 9 problematic sherds are plain bowls with modified (thickened or everted) rims. These bowls can be distinguished from San Juan plumbate bowls by the absence of basal molding and by differences in the techniques of rim modification.

Including these bowls within Tohil plumbate significantly broadens the class and alters our preconceived idea of its geographic distribution. Specifically, the impression that Tohil plumbate is nearly absent from the southwestern Guatemala-southern Chiapan coastal plain, where San Juan plumbate reaches its highest density (cf.

Table 11.1 Tohil and San Juan Plumbate Compositional Groups: Mean Oxide Concentrations

	Tohil (n=43)			San Juan (n=56)		
Rb	32.2	±	6.3	31.5	±	7.1
Cs	2.9	±	0.6	4.3	±	0.9
Ba	799.9	±	132.0	933.0	±	179.0
Sc	33.8	±	1.7	35.9	±	2.7
La	30.1	±	3.0	25.5	±	4.7
Ce	57.2	±	6.6	48.3	±	8.0
Eu	2.0	±	0.2	1.7	±	0.2
Lu	.52	±	0.08	.52	±	0.08
Hf	5.7	±	0.4	5.0	±	0.5
Th	7.5	±	0.5	9.8	±	1.2
Cr	22.2	±	1.8	33.5	±	3.7
Fe	7.8%	±	0.64	6.4%	±	0.64
Co	22.6	±	3.9	23.4	±	2.9
Sm	6.7	±	0.7	5.7	±	0.9
Yb	3.0	±	0.3	2.8	±	0.4
Log determinant of group covariance matrix	20.5			27.4		

Concentrations expressed as parts per million except iron which is in percent; all shown with ± 1 standard deviation ranges.

Shook 1965), now must be reconsidered. While the more well-known effigy and elaborately incised and carved Tohil vessels are not common on the coastal plain, plain bowls with modified rims are quite common. Therefore, the peak of geographic density of Tohil plumbate now can be seen to more closely coincide with that of San Juan plumbate.

Tohil plumbate is the more homogeneous of the two groups with group standard deviations of several elements below 8% (Table 11.1). San Juan is similar in composition, diverging only in a few elements, principally those referred to as the rare earths, and chromium and thorium. The basis for these differences is as yet unknown. Since a majority of the samples thus far analyzed were from pottery housed in the Museo Nacional de Arqueología y Etnología, Guatemala, complete examination of petrographic thin sections was not possible. As an interim solution we can, however, draw on Shepard's observations in interpreting the observed chemical variability. For example, Shepard found finer, more abundant volcanic dust in the San Juan plumbate class, which can be seen to correlate with the greater abundance of barium in the San Juan compositional group.

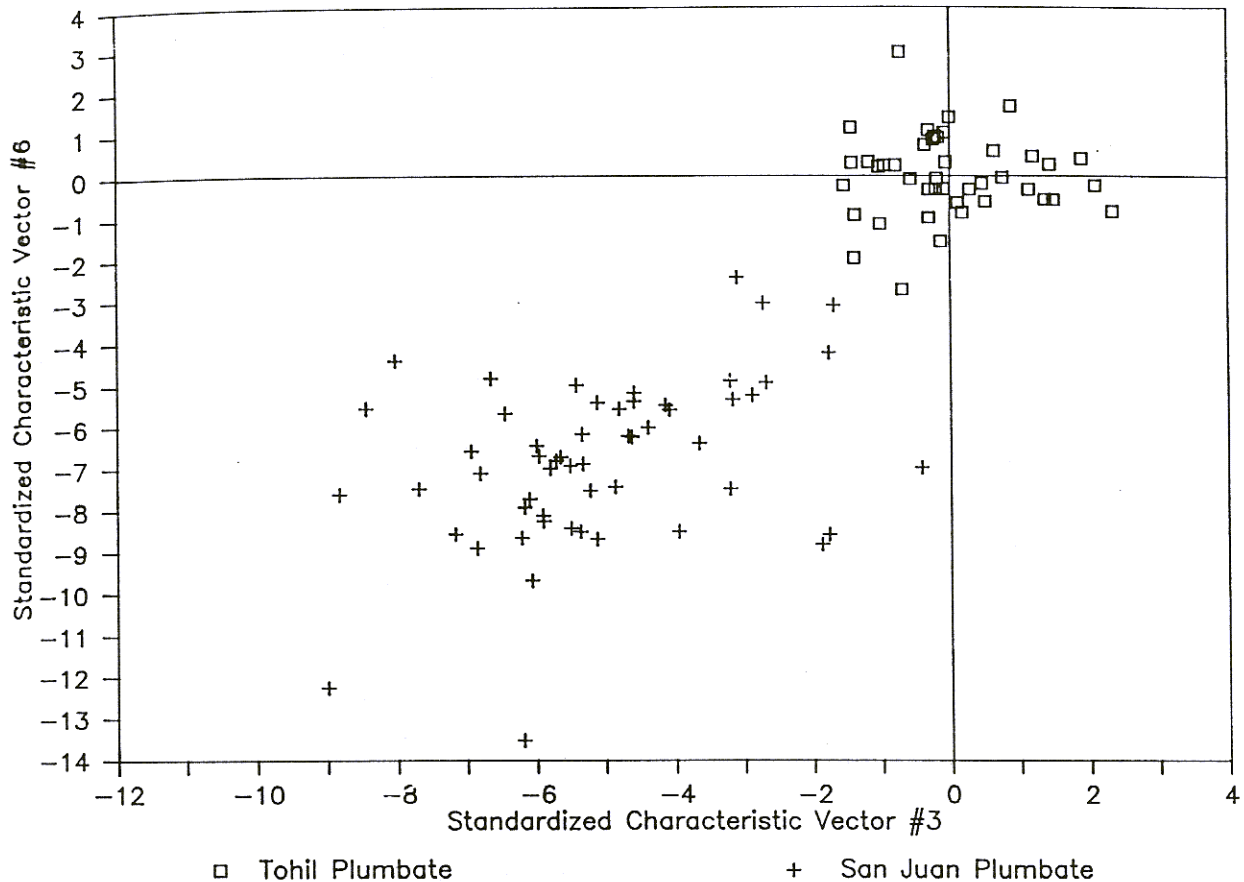


Figure 11.2 Standardized characteristic vector plot. Data points are shown relative to Vectors 3 and 6, derived from the Tohil plumbate compositional group. Vector 3 is composed primarily of Sc, Hf, Th and Yb while Vector 6 is weighted on Th and Fe.

For our chemical paste compositional groups, the statistical likelihood of group membership was calculated using Hotelling's T^2 , which is the multivariate extension of Student's t . Probabilities of group containment were derived letting each group provide the reference centroid. For each group, a sample in one group had probabilities greater than 10% of belonging in its group and less than 0.1% of coming from a population represented by the other group.

Characteristic vectors were also calculated, allowing a different perspective to be gained. Based upon a group's variance-covariance matrix, these are a set of linear combinations of the original variates. The latter provide a new set of reference axes each of which is orthogonal to (or independent of) any other axis. In addition, the origin of the vectors now occurs at the

multivariate center of a group. The characteristic vectors simply provide a new description of the distribution and do not alter the relative positions of the data points. The vectors thus derived for one group can be used to illustrate the relative position of a comparison group. Figure 11.2 displays the data relative to two such vectors that underlie the Tohil data. This is not a discriminant analysis plot, so the vectors are not chosen to separate the groups maximally. However, one may readily see that the Tohil and San Juan groups are almost fully separable in these two dimensions alone.

The other differences, including the slightly greater variability shown by the San Juan group, could be explained by the difference related to volcanic ash content. It is interesting to find that San Juan, Shepard's "ferruginous" variety of plumbate, actually has a lower total iron

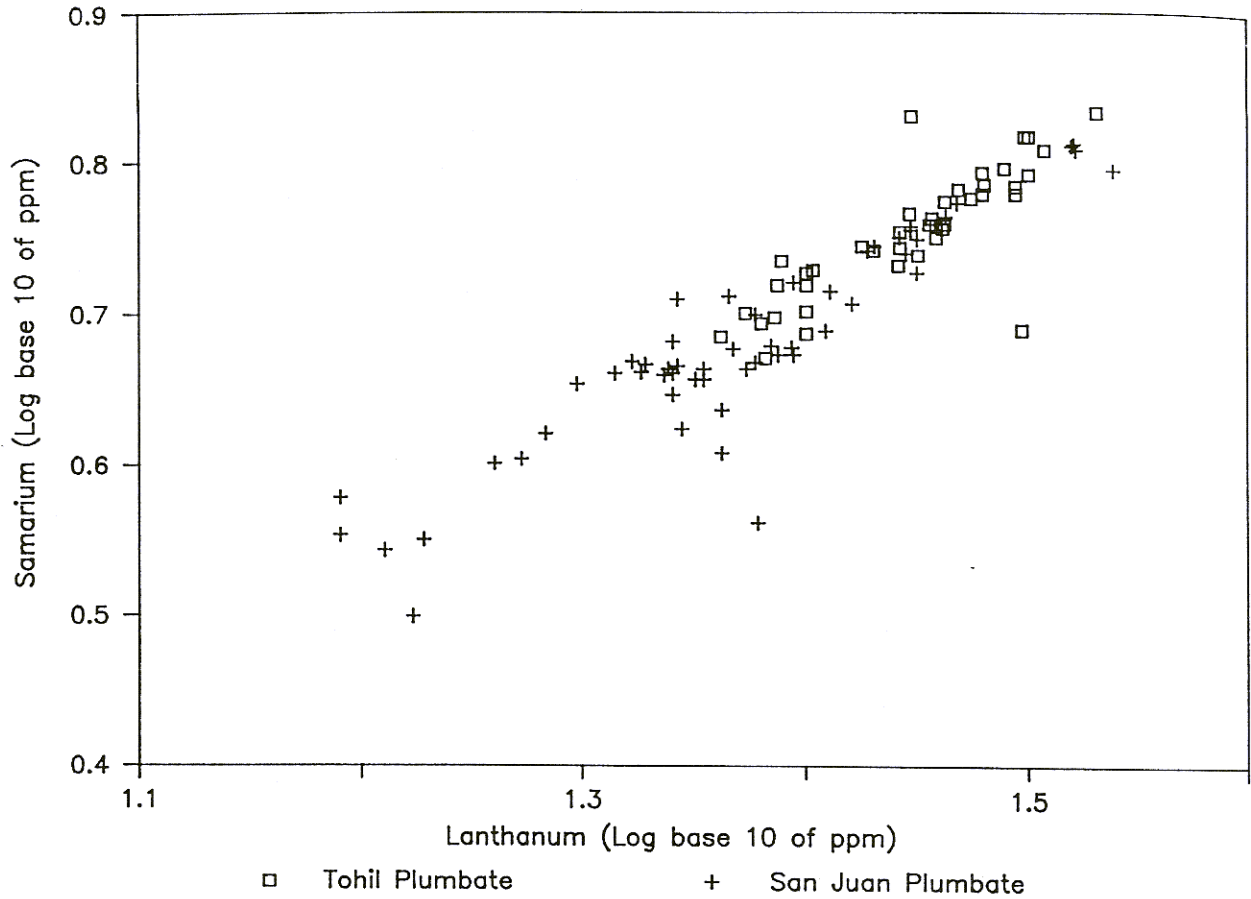


Figure 11.3 Correlation plot of San Juan and Tohil plumbate compositional groups. Data points are shown relative to Lanthanum and Samarium concentrations. Individual group 95% confidence ellipses are indicated.

content than does Tohil. The designation "ferruginous" therefore relates only to the observable iron-containing inclusions in the paste and should not be used to describe the paste *per se*. Higher iron content in the Tohil group may partly explain the more frequent occurrence of vitrified specimens in Tohil; for, as Shepard (1965:48) points out, ferrous oxide acts as a flux promoting vitrification in a reducing atmosphere of sufficiently high temperature.

Specimens of the San Juan class predominate among the samples currently excluded from statistical membership in either of the two main compositional groups. As the data set increases in size and additional variability is incorporated into the major groups, many of these now peripheral specimens most likely will be assigned. It

appears to be significant that no site-specific orientation is seen in the outliers. Nor are there any stylistic attributes or attribute combinations that occur with greater than expected frequency in the outliers. Thus, we are not viewing a situation that suggests a separate manufacturing site, but rather, individual chemical variation.

In summary, the clearest pattern in the compositional data is a partitioning of the samples into groups which correspond to San Juan and Tohil formal classes. There is no chemical basis for postulating a third class such as Robles. If there is a formal basis for an intermediate class or classes, it has yet to be found in our data. We suspect that it will be shown that both classes of plumbate exhibit significant formal variability in the dimension of time. However, the current system of two major classes

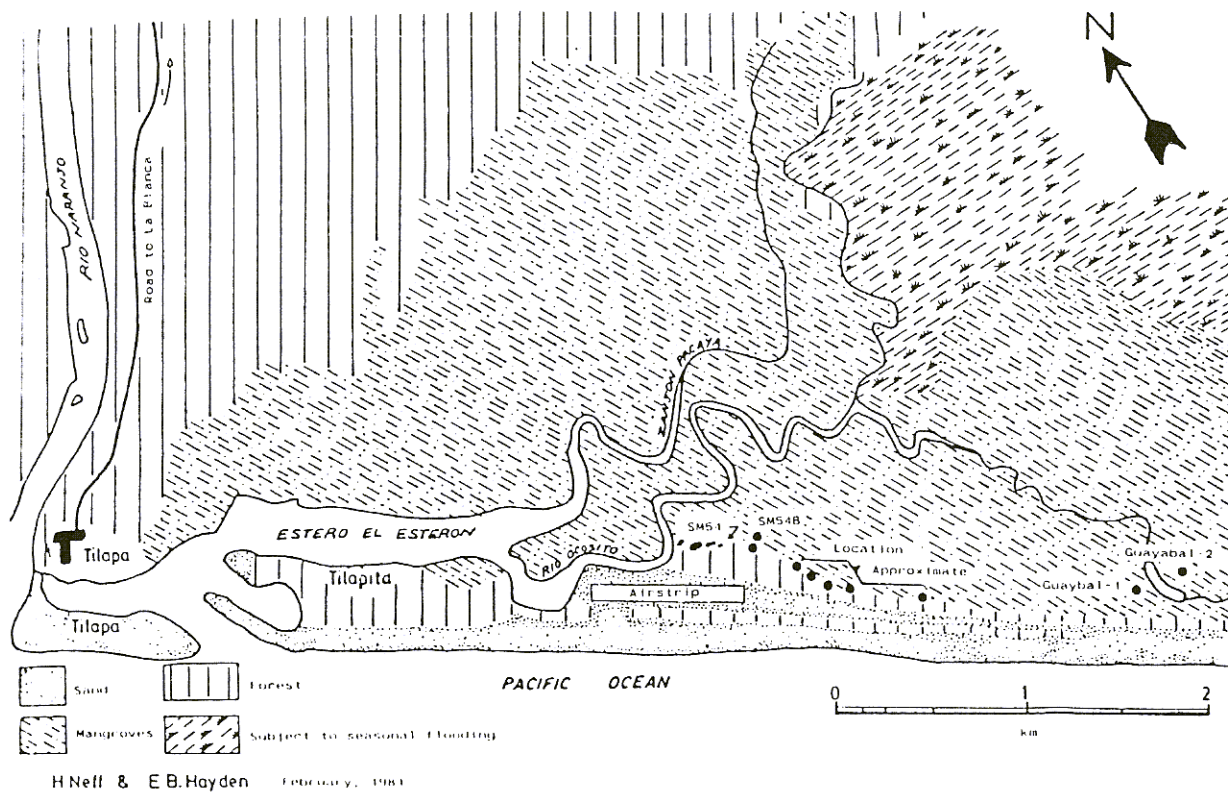


Figure 11.4 Map of the littoral zone near the mouth of the Rio Naranjo, eastern Soconusco region.

(each containing a series of formal subclasses) is the most parsimonious way to organize our samples of plumbate pottery.

The chemical data are consistent with an interpretation of a limited raw material procurement area and controlled production of the more pronounced differences between San Juan and Tohil. An example of the similarity between the two classes may be seen in the correlation plot of the analytical data for lanthanum and samarium (Figure 11.3). As with several other combinations of elements, the two groups lie on the same correlation line. One possible explanation would be that the slightly more homogeneous Tohil was made from the same clay as that used for San Juan but differing in type or quantity of ground up temper. Additional analyses coupled with petrographic examination should help determine the locus of these variations.

Given 1) that compositional and stylistic differences coincide, 2) the likelihood that San Juan and Tohil were

made of clay from the same source, and 3) that stylistically San Juan plumbate has been shown to precede Tohil in time, the compositional difference may be explained best as a shift in methods of preparing raw materials. Considering the geographic distributions of the two classes, the most plausible interpretation is that San Juan and Tohil represent a single tradition of ceramic manufacture from the Pacific slope of the southwestern Guatemala-southern Chiapas. If we include the plain bowls that were compositionally Tohil, Tohil and San Juan co-occur in our sample most frequently in a narrow strip of land roughly paralleling the Rio Naranjo, Rio Suchiate, and their tributaries from the coast to about 2000 m elevation.² As mentioned above, this is also the region where plumbate is most common in excavated sherd lots. (Figure 11.4 indicates the locations of sites with plumbate within a well-surveyed portion of this region.) These several lines of compositional and distributional evidence would seem to warrant rejection of

the separate geographic origins hypothesis in favor of the hypothesis that both San Juan and Tohil plumbate were made somewhere within this region.

The compositional homogeneity of the two plumbate classes, especially Tohil, suggests not only a single source for the clay, but that the source was fairly localized. One may also cite Shepard's observation concerning the essential uniformity of the ceramic pastes and the need for a slip clay which would vitrify under reducing conditions (Shepard 1948:143). The necessary association of particular raw materials with a particular technology imposed greater constraints on the spatial organization of production than either special raw material or a special technology would have alone.

We lack direct archaeological evidence of plumbate production at any one locality, although there are theoretical and empirical reasons to believe that the zone of procurement/production would have been fairly close to the coast. First, fine sedimentary clay sources would be expected to lie close to the coast because current velocities diminish downstream, especially where rivers enter the barrier lagoon system, and the finest fraction of suspended sediment would be deposited where current velocities are lower. Second, recent findings at a site known as SM54 (Coe and Flannery 1967) and neighboring sites located along an extinct lagoon in back of the present beach near Tilapa, San Marcos (see Figure 11.4) provide some evidence for plumbate production (Neff 1981). This evidence can be summarized as 1) far greater abundance of plumbate at these sites than at any other known sites; 2) demonstrably greater time depth of occupation by people possessing plumbate at these sites; and 3) circumstantial evidence for ceramic manufacturing, consisting of fired, amorphous waste lumps of clay (it has not been determined yet if these lumps are plumbate in composition).

DISCUSSION

The results of neutron activation analysis combined with available distributional data permit us to make some observations about the organization of production and exchange of plumbate pottery. First, as argued above, both classes of plumbate probably were made within the Pacific slope region lying along the Rio Naranjo, Rio Suchiate, and their tributaries. From the neutron activation analysis results and other available data, we have inferred that plumbate was produced in only one or a few communities of this region. Limited archaeological evidence points to the littoral zone as the most likely location of producing communities (Figure 11.4).

If future research supports the above interpretation, then the occurrence of plumbate within the region, but outside the littoral zone could have been due to a regional exchange system organized around zonal specialization. Theoretically (i.e., according to a least effort formulation), communities would have specialized in producing goods from materials which were available close by. There also would have been an economic incentive to specialize in goods not available in adjacent zones. So, for example, a large part of the coastal plain would have specialized in growing staple foods, especially maize, and perhaps also in growing and processing cotton.³ The littoral zone inhabitants -- who could have had only limited farming in the mangrove swamps, salt flats, and sandy soil behind the beach -- would have specialized in the procurement of salt and perhaps the manufacture of plumbate pottery.⁴ In the wetter piedmont, the inhabitants may have specialized in growing other agricultural products, such as cacao, which requires more rain. In the steep canyons dissecting the escarpment of the highlands, a likely specialty would have been volcanic rock for grinding stones.

The plumbate compositional evidence also suggests a trend toward increased differentiation and specialization in the economy of the Pacific slope from the Late Classic through Early Postclassic periods. As discussed above, Postclassic Tohil plumbate is compositionally more homogeneous than Late Classic San Juan plumbate. A decrease in the compositional variability in the ceramic products of a region (increased standardization) over time may mean that access to resources and the production process itself were becoming more rigidly controlled and, inferentially, that ceramic production was becoming an increasingly specialized pursuit for groups with access to the requisite raw materials. The higher iron content of Tohil plumbate paste, which may relate to more consistent vitrification, can be seen as a refinement of plumbate technology, possibly the result of experimentation by specialists seeking to perfect their products.

Similar inferences of specialization from standardization/homogeneity of ceramic products have been made by a number of investigators (e.g. Rathje 1975; Irwin 1977, 1978; P. Rice 1978, 1980, 1981; Rye 1981). Rye, for example, suggests that evidence of specialized production could be sought in "aspects of pottery production such as raw materials (range of materials decreasing with time), forming techniques (range of techniques narrowing and process sequences simplifying), and types of vessel (number of forms decreasing and standardization increasing)" (1981:125). Besides standardization, specialized production is often assumed to entail an increase

in the volume of output (Rathje 1975; Van der Leeuw in Rice 1981).

Irwin's (1978) work is perhaps the most persuasive example of this kind of inference because the end point of the sequence he analyzes is an ethnographically known pottery industry, that of Mailu Island off southeastern Papua New Guinea. This industry, which carries on the stylistic tradition of prehistoric Mailu pottery, is "technologically, stylistically, sociologically, and spatially homogeneous" (Irwin 1978:409). Irwin's archaeological evidence indicates that pottery in the region became more standardized around the same time that the Mailu potters acquired a pottery monopoly (i.e., coincident with the establishment of specialized production).

Rathje (1975) and Rice (1981) introduce some complexities into the equation of standardization with specialization. In particular, they argue that, while increasing ceramic specialization produces an archaeologically observable trend toward increasing *technological* standardization, stylistic attributes do not necessarily become more standardized. In Yucatan, the trend toward "cost control mass replication" (as inferred from standardization) leads eventually in the Late Postclassic period to local stylistic variety resulting from the use of interchangeable parts (Rathje 1975:431). According to Rice's (1981) model, stylistic and technological attributes follow different standardization trajectories, and the trajectories vary for different functional classes.

Considering the observable trends in plumbate stylistic and technological attributes, a more complex formulation of the inference of specialization seems warranted. As pointed out above, compositional homogeneity is comparatively higher in Tohil plumbate, suggesting increasing specialization. In contrast, even an impressionistic comparison of San Juan plumbate and Tohil plumbate style indicates that variety actually *increases* in some aspects of style. In San Juan plumbate, a relatively small number of simple incised and carved motifs appear in decorative bands on a relatively small number of vessel shapes. Tohil plumbate style combines standardization of vessel shapes and decorative techniques (although some plastic techniques, such as modeling and molding are used with increasing frequency) with a great variety of effigies and incised abstract motifs. That the potters who made Tohil plumbate were conscious of the individual creative aspects of their craft is indicated by the signatures found as potter's marks on many whole Tohil vessels. Creativity, a variety-producing element in ceramic manufacture, seems to have been constrained by such things as standardized guidelines for preparing raw materials, a limited repertoire of vessel shapes, and a limited

ited repertoire of techniques for decorating the surface of the wet clay.

Another anomalous aspect of the process of increasing specialization in plumbate production is that total output volume appears to decline, while investment of labor per pot appears to rise. These changes may relate to a shift in relative emphasis on different functional classes between the Late Classic and the Early Postclassic periods among plumbate potters. In any case, the implication is that an adequate model of the evolution of ceramic specialization would have to allow for the possibility that specialized production and mass production do not always go hand-in-hand; there is a complex interplay of stylistic, technological and functional changes, and the archaeologically observable outcome may vary from one situation to another.

Part of the reason why the complexities of ceramic evolution have not been entirely appreciated before is that the process is usually viewed from the perspective of changes in whole pottery assemblages, which are generally mixtures of products of a number of pottery making groups. Focusing on the products of a single pottery-making group may be a more profitable approach. Of course, this approach is more difficult since it is not always possible to isolate the products of one group within an assemblage. For this reason, easily identifiable pottery classes which have been shown to pertain to a single production center (such as plumbate) are particularly appropriate sources of data for the study of the evolution of ceramic specialization (cf. comment by Kolb in Rice 1981).

Changes in exchange mechanisms are often viewed as correlated (sometimes causally) with increasing specialization. Irwin (1978), for instance, argues that Mailu islanders became specialized potters at the same time they became specialized traders; trading networks were expanding in southeast New Guinea at the same time that ceramic specialization was established on Mailu Island. Rye (1981) similarly argues for the area of New Guinea he studied, that since pottery was a major long-distance trade item, "increasingly localized specialization would be circumstantial evidence of involvement" in long-distance trade networks. In Yucatan, as Rathje (1975) notes, the inception of long-distance marine-based trade during the Postclassic period made long-distance exchange of bulky items, like pottery, a feasible economic endeavor. This change in transport technology, "would have created a new mass market potential for all varieties of trade items" and the mass market potential would have led to "the mass distribution of pottery produced in quantity by cost-control techniques (i.e., by specialized

production). In her analysis of Valley of Guatemala White Ware ceramics, Rice (1978) argues for a relation between changes in exchange patterns and changes in the mode of ceramic production throughout the Formative period, as ceramic production became increasingly specialized.

Certainly the long-distance exchange mechanisms responsible for the distribution of plumbate outside its manufacturing region change between the Late Classic and Early Postclassic periods. Late Classic San Juan plumbate only occurs in archaeological assemblages in southern Mesoamerica. Outside of southwestern Guatemala and southern Chiapas, it is found only in low frequencies which appear to decline monotonically with distance from the implied source area. San Juan is not notable for its high frequency in grave offerings or caches.

Early Postclassic Tohil plumbate was traded much more widely than San Juan plumbate: finds have been reported from all corners of Mesoamerica and Central America, from Panama in the south to Yucatan, Central Mexico, and Nayarit in the north. The large number of whole Tohil vessels in museums throughout Mesoamerica, as well as some documented excavations, attest to its frequent occurrence as whole vessels in caches or grave offerings. From these distributional and contextual data, it can be inferred that 1) long-distance trade in plumbate took place on a much larger geographic scale during the Early Postclassic period compared with the Late Classic period and 2) there was a shift in the socioeconomic context of plumbate long-distance trade between the Late Classic and Early Postclassic periods.

While we can infer the shift that occurred between the Late Classic and Early Postclassic periods in the production and exchange of plumbate pottery, it is more difficult to explain why these changes occurred. Probably none of the authors discussed above would advocate a prime mover explanation for the development of specialization. The eclectic approach is explicitly advocated by Irwin who states, "given the archaeological evidence, the most plausible model is one of multiple causation . . ." (1978:411). In other words, a variety of selective pressures may favor increased ceramic specialization.

Among the selective pressures that may favor specialized ceramic production are the following: 1) technological or organization changes in exchange systems (Rathje 1975; Irwin 1978; Rice 1978, 1981; Rye 1981); 2) locational characteristics of subsistence resources and ceramic resources relative to human populations (Arnold 1975; Irwin 1978; Rice 1978); 3) political factors, such as concentration of power in the hands of a particular group

(Irwin 1978; Rice 1978, 1981); 4) population growth (Arnold 1975; Rathje 1975; Rice 1978, 1981). To this list of possible causes for changes in the plumbate industry can be added Shepard's (1948) suggestion that the abrupt disappearance of Tohil plumbate from the archaeological record could be due to depletion of the clay source. The process of resource depletion may have been responsible for the changes associated with the transition from San Juan plumbate to Tohil plumbate as well: the apparent anomalies of decreased output volume and increasing labor input per vessel which accompanied increasing compositional standardization may reflect increasingly efficient use of resources. The increasing scarcity of plumbate vessels combined with the greater investment of labor in Tohil plumbate may have acted to drive the exchange value of plumbate up, resulting in the archaeologically observable increase in areal distribution of plumbate and its more frequent occurrence in ceremonial offerings.

This partial list of the various causes advanced to explain the evolution of specialized production should not be construed as implying that no general theory accounts for observed variability. The position taken here is that all the causes mentioned above involve some shift in the relation of people to resources. The clearest example is Rice's and Arnold's arguments that population growth, combined with locational characteristics of subsistence and other resources leads to the original establishment of ceramic specialization. The causal connection between new exchange networks and specialization exists in the fact that new exchange networks may open up a new source of basic (subsistence) goods which can be exploited by producing non-subsistence goods (such as pottery) and using them to procure basic goods. Depletion of ceramic resources would cause change in ceramic production once the economic strategy of a particular group becomes focused on ceramic production and exchange: depletion of resources relative to population favors any change which increases the efficiency of exploitation of the resource (cf. Boserup 1965).

The general importance of explaining specialization and long-distance trade derives partly from their ubiquitous association with other attributes of complex societies. A theory about the evolution of complex societies would have to show that observable variability in all of the definitive characteristics of such societies is best predicted by the theory espoused. The plumbate data base presents the opportunity to test a number of alternative hypotheses about relationships between independent and dependent variables in the evolution of ceramic specialization and long-distance trade. Therefore, the

analysis of temporal variability in plumbate production and exchange would contribute toward a general theory of the evolution of cultural complexity. Although we have argued that a materialist-selectionist theory accounts for temporal variability in plumbate production, more conclusive results should be sought. Among the kinds of data required are greater chronological control, knowledge of the location and extent of raw material sources used by plumbate potters, and a more thorough general understanding of the Late Classic and Early Postclassic occupations in the pertinent regions.

ADDENDUM

Since this paper was written in 1981, the first author completed his dissertation on plumbate at the University of California Santa Barbara. A larger analyzed plumbate sample (about 450 specimens of plumbate and related wares) contained a third compositional group, designated "Guayabal," which is apparently confined to the littoral zone near SM54 (see Figure 11.4) and which seems to precede San Juan and Tohil in time. Among the amorphous clay lumps from SM54 were one specimen similar in composition to San Juan plumbate and one similar in composition to Guayabal plumbate.

ENDNOTES

1. We are grateful to Lic. Francis Polo Sifontes, ex-Director General of the Instituto de Antropología e Historia, Guatemala, and to Lic. Dora de Gonzalez, Director of the Museo Nacional de Arqueología y Etnología (MNAE), Guatemala, for allowing us to sample plumbate sherds in the MNAE. We also thank Dr. B. Voorhies, Department of Anthropology, University of California, Santa Barbara (UCSB), for allowing us to sample sherds from the Drucker Collection, formerly held in the Smithsonian Institution, Washington, DC and recently acquired by UCSB. Aspects of the investigation were carried out under the auspices of the US Department of Energy.

2. In the analyzed sample, San Juan composition sherds co-occurred with Tohil composition sherds at the follow-

ing sites in the southwestern Guatemala-southern Chiapas Pacific slope region: La Victoria, La Primavera, Izapa, Santa Romelia, Tajumulco and El Paraíso. Outside this region, San Juan and Tohil co-occur (in our sample) only at El Zapote and Tiquisate, both of which lie on the coastal plain to the east of the study area. Based on stylistic criteria alone, both classes have also been identified at Kaminaljuyú.

3. One of Mark Johnson's (personal communication) findings at the site of Flamenco, near the upper edge of the coastal plain near Retalhuleu, was an extremely high concentration of spindle whorls within one of the houses he excavated. This can be construed as evidence for cotton processing at this location.

4. Coe and Flannery's (1967) discussion of micro-environments in the Ocos area indicates that all of the microenvironments likely to have been available to the inhabitants of SM54 and adjacent sites (i.e., beach sand and low beach scrub, mangrove forest, salt flats, and madresal) would have been unsuitable for agricultural pursuits. In discussing the lower Papaloapan mangrove zone, Stark (1977:21) includes land suitable for agriculture as one of the resources of the zone. However, the only suitable land consists of islands elevated sufficiently above the water table, i.e., river levees and archaeological sites. The location of SM54 (immediately behind the beach) does not afford easy access to elevated land within the mangrove zone or to inland areas suitable for farming.

Although many kinds of terrestrial and aquatic fauna are available in the littoral zone, the Late Classic and Early Postclassic inhabitants apparently did not exploit them: during extensive surface collection and posthole digger testing at SM54, no evidence of vegetal food processing (e.g., grinding stones) or of exploitation of terrestrial or aquatic fauna (e.g., shell or bones) were recovered. In addition to the limited evidence of pottery manufacture, the only other evidence of economic activities recovered from SM54 and adjacent sites were a number of artifacts thought to be associated with salt processing.