CHAPTER

4

DETERMINING CERAMIC PRODUCTION: A VIEW FROM HONDURAS

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INTRODUCTION

Archaeological ceramic assemblages provide us with sets of data derived from the loci of consumption or discard. Often, however, information about the pottery's production and distribution can contribute even more significantly to the inferences we are able to make about the functioning of the social unit under study. When stylistically similar pottery is recovered from a number of proveniences -- different areas of the same site, different sites in the same region, sites in different regions -- the question arises as to whether the similarity is due to the material distribution or to cognitive sharing.

To address this topic, we often turn to paste compositional studies to evaluate the chemical similarity of the clay resource used to make the pottery. In New World archaeology, the method most frequently used is Instrumental Neutron Activation Analysis. The assumption is that ceramics made from the same clay source will be more similar chemically than pottery made from different clay sources. The primary analysis involves determing the elemental concentrations in various samples and numerically manipulating the elemental data to obtain groupings referred to as Chemical Paste Compositional Reference Units (CPCRUs) (Bishop and Rands 1982; Bishop, Rands, and Holley 1982). Once CPCRUs are constructed, statements can be made about the reference group specimens having been produced from resources in a restricted procurement zone. However, neither the resource itself nor the production locus is defined from this initial instrumental analysis.

During a recent workshop devoted to examining the legacy of Anna Shepard and the current status of technological analyses in the context of anthropological archaeology and social inference, two themes dominated: 1) the need for close collaboration between archaeologists and scientific analysts; and 2) the need for careful sample selection, definition of problem with the establishment of testable hypotheses, and a provision for the instrumental analytical output to be used as the basis for further inquiry rather than remaining as a descriptive statement of laboratory results. Within this framework -- the substantive issue of studying ceramic production and the methodological concerns of applying instrumental chemical analysis to archaeological pottery -- we will discuss a project that is "in progress."

GEOGRAPHIC FOCUS AND POTTERY FOR INVESTIGATION

Data sets from two regions in Honduras are included in the investigation:

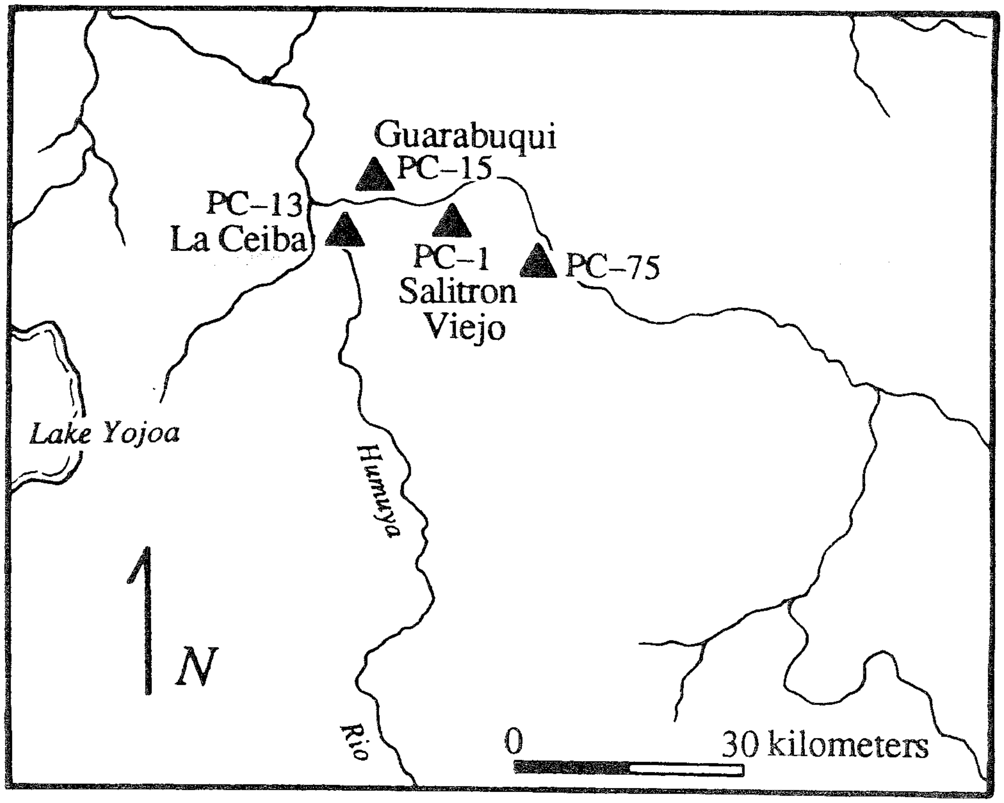
1. Pottery from the El Cajon project directed by Kenneth Hirth. This work was conducted in conjunction with the construction of the El Cajon hydroelectric power facility in north-central Honduras. Material was selected from four large sites which span the Late Formative through Late Classic periods (400 B.C.-A.D. 1000). These sites are Salitron Viejo (PC1), the dominant regional center, and three secondary centers: Guarabuqui (PC15), La Ceiba (PC13), and PC75 (Figure 1).

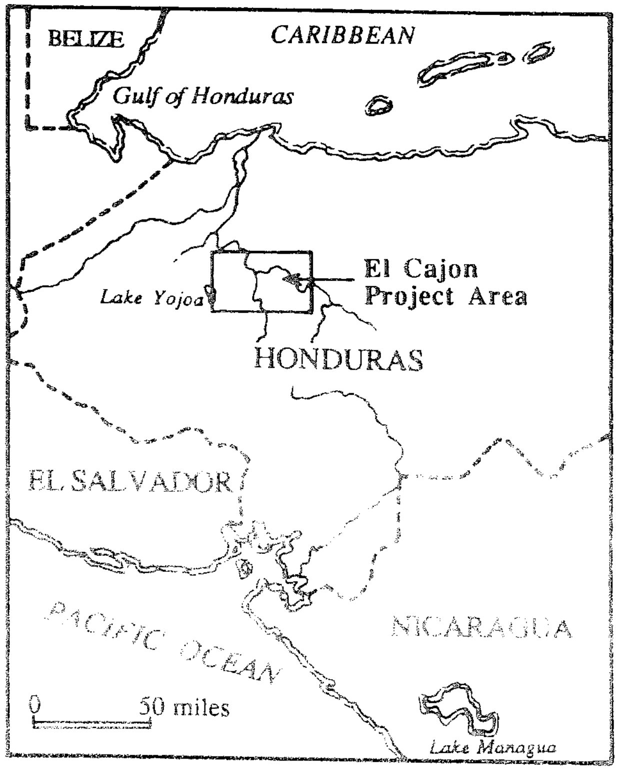
2. Pottery from the Sula Valley project directed by John Henderson. The Sula Valley contains the largest cultivable land mass in Honduras. Survey and excavation has been carried out at a number of sites with particular emphasis in those areas most threatened by encroaching development. Material (primarily Late Classic period) which had been analyzed by Beaudry during a Fulbright year was chosen from four central alluvium sites: Travesia (CR 35), the largest late Classic site; Villanueva (CR 212), a secondary center; El Plan (CR 178), a very small tertiary settlement; and LaMora (CR 70), either equivalent to El Plan, or a "suburb" of Travesia (Figure 2).

A ceramic category called "Bold Geometric Polychrome" has been recognized since early archaeological investigations in Honduras (Strong, Kidder, and Paul 1938; Strong 1948; Stone 1957; Glass 1966). The style is distributed in Northwest and Central Honduras and is characterized by various features: 1) an easily recognized set of design elements, primarily geometric with some stylized animal and "grotesque" representational shapes rendered in black and red on an orange slip; 2) a limited form inventory of large wide-mouthed storage jars and several bowl forms; 3) clear, bright orange paste with fine temper; and 4) a sharp, brittle fracture on fired pieces which emit a characteristic "ping" when tapped.

During the El Cajon project, stratigraphic excavations uncovered sizable quantities of "Bold Geometric Polychrome" as well as other vessels with similar forms and general paste characteristics but executed in other decorative modes (monochrome, bichrome, trichome). This expanded corpus suggested a developmental sequence within the same paste ware (Table 1).

(Beaudry, Bishop, Henderson, and Hirth) Figure 1: El Cajon Project Area Map.





(Beaudry, Bishop, Henderson, and Hirth) Figure 2: Sula Valley Project Area Map.

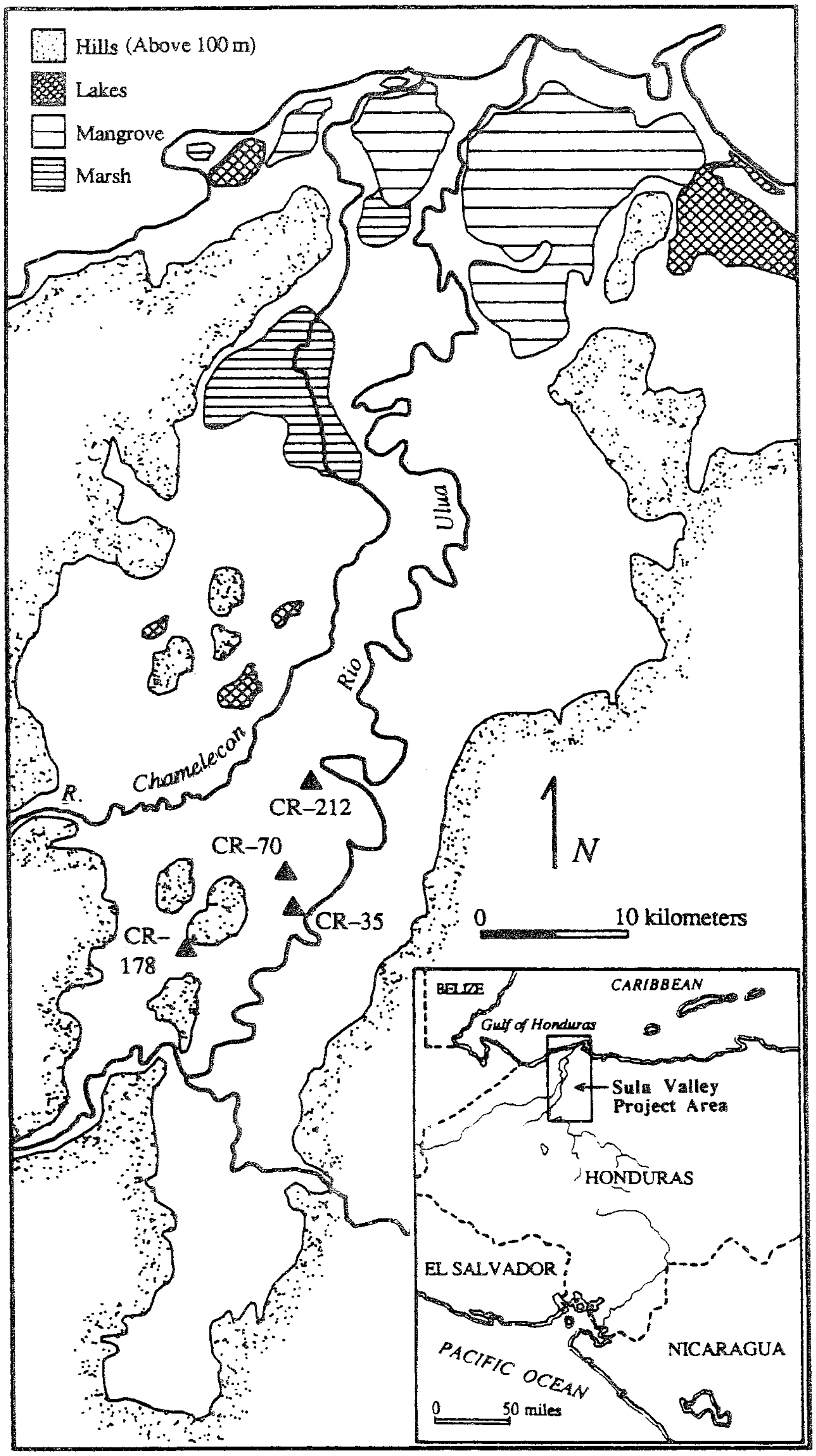


Table 1. Developmental Sequence of Sulaco Ceramic Group

Late Sulaco	A.D. 800-1000 (?)	Sulaco weak polychrome/black-lipped bowls
		Serpent fill/interior diagonal
Middle-Late Sulaco	(A.D. 700-900)	Incised white polychrome
Middle Sulaco	A.D. 600-800	Pendant U & textile design
Early Sulaco	A.D. 400-600	Bichrome/trichrome
Late Yunque/Early Sulaco	(A.D. 200-500)	Monochrome (including orange resist mammiform)

Consequently, during the First Honduran Ceramic Workshop in 1986, the taxon "Sulaco Ceramic Group" was proposed by Hirth and the various types, including the "Bold Geometric Polychrome," were placed in it. Also important was the recognition of misfired sherds within Salitron Viejo excavated lots, including some from the Sulaco group. The misfired material, not found as "wasters" in a kiln situation but mixed in with construction fill, suggested that at least some of the Sulaco Group pottery was made at Salitron Viejo.

With this indication that Salitron Viejo was one locus of production for the Sulaco Group pottery, a collaborative project was developed to answer a series of research questions.

RESEARCH OBJECTIVES

The work was conceived as a pilot test to evaluate the probability of Salitron Viejo's having been the main production area for Sulaco Group pottery used at Salitron Viejo and exported to other sites in the El Cajon region as well as to sites in the Sula Valley, outside the El Cajon region. "Bold Geometric Polychrome" has been recovered from additional areas outside the El Cajon region, such as Santa Barbara and the Comayagua Valley. However, Sula Valley material was selected as the first data set for the interregional part of the study because of the particular ceramic inventory in that region. There is another classified pottery type in the central alluvium of the Sula Valley, La Flores Polychrome, that shares designs and shapes with Sulaco but clearly is made from a different past that is not as finely tempered, is more friable when fractured, and is lacking Bold Geometric's distinctive "ping." This set of circumstances -- similar shapes and motifs with clearly distinguishable raw materials -- can be interpreted as resulting from a local attempt to duplicate the appearance of a scarce imported pottery. In this instance, it could be hypothesized that Las Flores (local Sula Valley manufacture) arose to fulfill the demand for the less available (imported from El Cajon) Sulaco. The other areas do not have as close an analog to the Sulaco Group, making the Sula Valley a more interesting comparative locus.

ANALYTICAL PROGRAM

Pottery Sample

A total of 130 sherds was analyzed, divided as shown in Table 2.

Table 2. Provenience of Sulaco Ceramic Group Specimens Analyzed

Region	N.
El Cajon Region	
Salitron Viejo (PC 1)	60
Guarabuqui (PC 15)	17
La Ceiba (PC 13)	5
PC 75	2
Sula Valley Region	
El Plan (CR 178)	25
Travesio (CR 35)	10
La Mora (CR 70)	7
Villanueva (CR 212)	2

Note: An additional 2 misfired, non-Sulaco Group sherds from Salitron Viejo were included in the analysis as control specimens.

The sample was weighted toward the El Cajon region and specifically Salitron Viejo because of that site's probable function as a production locus. The Salitron Viejo set included misfired Sulaco pieces, several misfired non-Sulaco pieces for comparative purposes and sherds representing the various decorative types seriated in the hypothesized Sulaco Ceramic Group sequence. This sampling strategy would allow an examination of resource utilization over time at the individual site. The Sula Valley sample, on the other hand, was selected to hold constant the design and shape variables on pottery from that geographic area. Several considerations influenced this sampling decision: 1) since design and shape in the Salitron Viejo Sulaco Group did vary over time, a larger sample from a restricted time period in the possible importing region would provide numerically more reliable data; 2) if Sulaco pottery production at Salitron Viejo had been organized for export as well as for local consumption, different producing units, specialized in making certain vessel shapes or decorative styles, could have used different clay sources. By limiting this possible source of variability in the data, interpretation would be facilitated.

Instrumental Analytical Procedures

Samples for neutron activation analysis were obtained from the selected pottery specimens by cleaning an area slightly larger than that of sampling location and extracting approximately 300-400 mg of the ceramic paste. All samples were taken with a tungsten carbide rotary file, which, in addition to its tungsten content, is known to contain appreciable amounts of manganese and cobalt and trace amounts of tantalum. When strong tungsten lines were recorded in the gamma spectra, the values for these elements were discarded.

The samples and accompanying standard material of known elemental content, NBS Standard Reference Material SRM 1633 (Coal Fly Ash), were encapsulated and irradiated for six hours at a neutron flux of 7.7×10^{13} $n/cm_2/sec$. Following a six day decay, each sample was counted for one hour using an intrinsic germanium detector (FWHM at 1333 ^{60}Co of 1.71 keV); data were collected on an 8192-channel Nuclear Data ND6600 multichannel analyzer. Subsequent data processing and reduction of the gamma peak data to elemental concentrations included corrections for pulse pileup and gamma peak interferences. The samples were allowed to decay for 30 days and then each sample was recounted for two hours using the same system (Blackman 1988). This configuration results in reliable determination of approximately 22 elemental concentrations. Analytical data and descriptive information are curated in the SARCAR facility of the Smithsonian's Conservation Analytical Laboratory and are available upon request.

Numerical Analytical Results

Numerical analysis of the 130 sherds was carried out using 14 of the elemental determinations which had acceptable analytical precision. In general, the data were submitted to cluster analysis using a complete linkage algorithm on a matrix of Euclidean distances. When summarized by a dendrogram, the largest clusters were isolated for further refinement. Samples outside of a 95% confidence interval were removed and the group properties recalculated. When a point of stability was reached, non-grouped specimens were evaluated, one by one, to see if they could be considered as group members, given their distance from the multivariate group centroid. Smaller groups were evaluated using a reduced number of variates. Finally, a few specimens that were highly divergent from all the others on several elemental concentrations were accepted as a group during the cluster analysis. The resulting groups are summarized in Table 3.

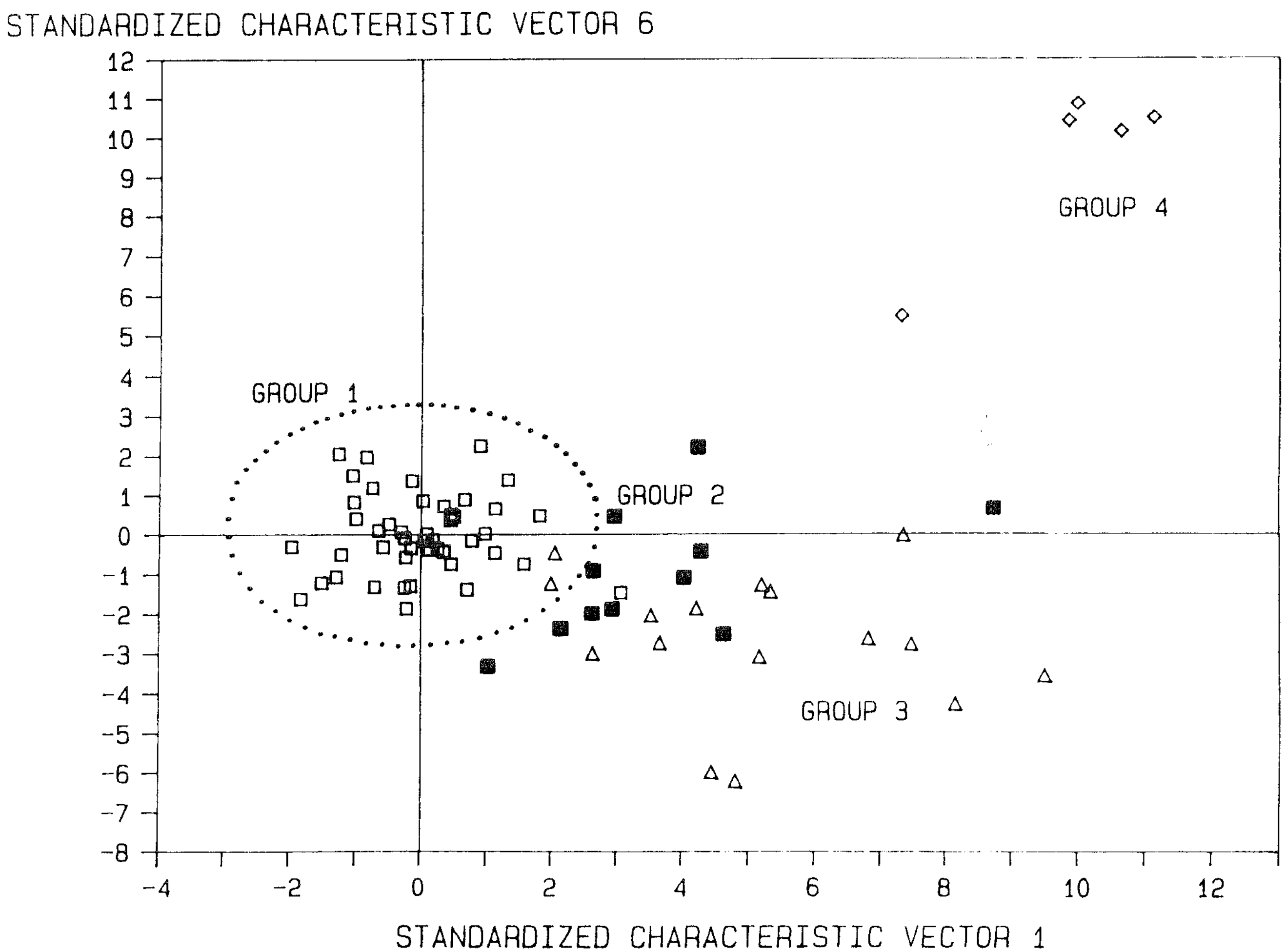
Table 3. Compositional Groups Resulting from Numerical Analysis of Elemental Concentrations

Group	N
1	47
2	16
3	12
4	5

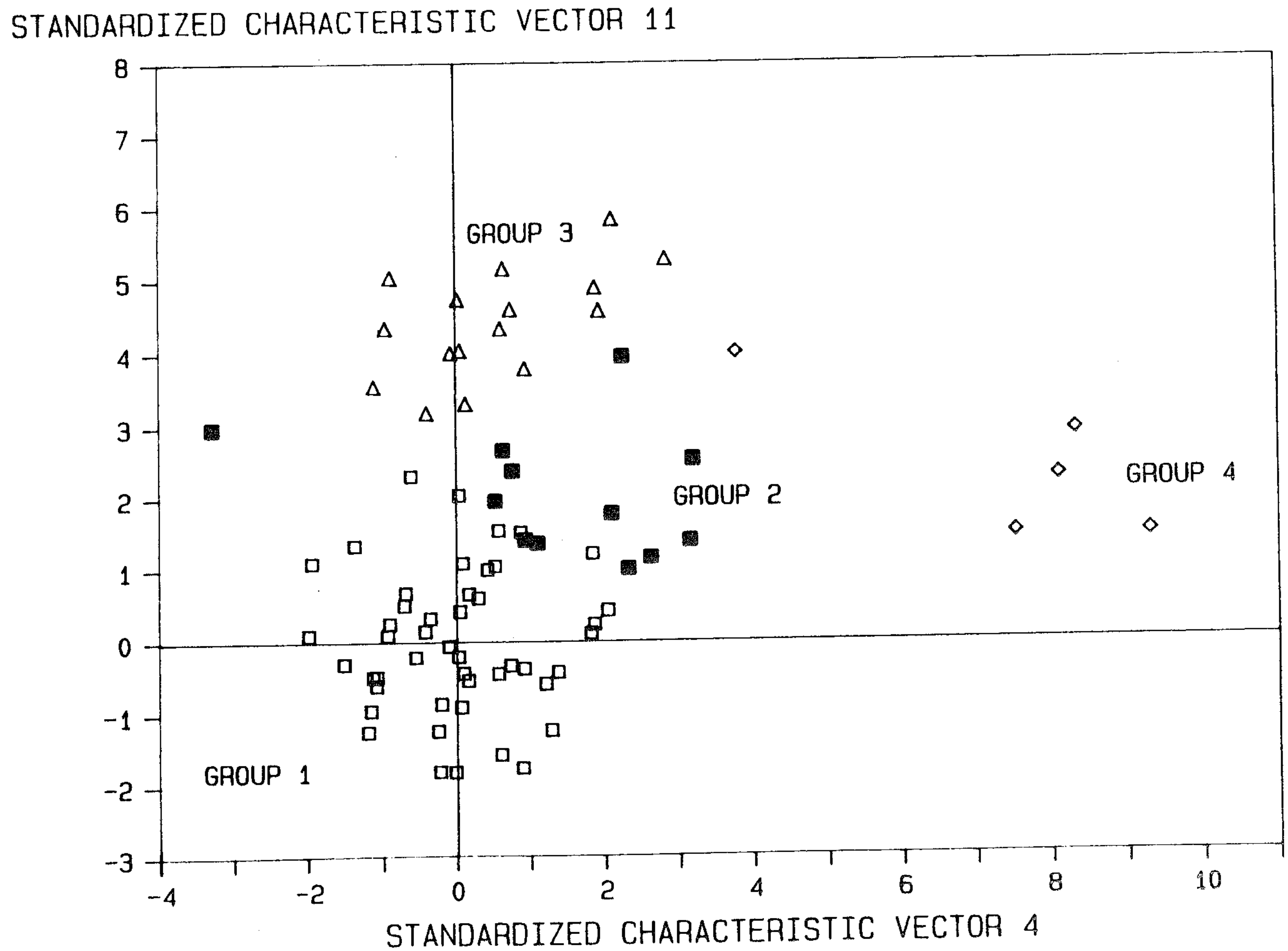
The small number of samples in three of the four groups makes robust statistical evaluation difficult. Accordingly, we will illustrate the tendencies for the groups to diverge one from another through reference to the correlational properities of the largest constituted group. From Group 1 we have extracted the eigenvectors (principal components) and have standardized them. The vectors are linear combinations of the original measurements wherein all of the interelemental correlations have been removed (see discussion in Bishop and Neff 1989). Figures 3 and 4 present the four compositional groups as they relate to each other relative to two vectors. When reviewing these figures, it would be remembered that the data are shown relative to only two out of the total of 14 dimensions used in this part of the evaluation. Groups which do not appear separated in two dimensions, are, indeed, separated in the higher dimensional space.

In Figure 3, Group 1 is contained within a 95% confidence interval. Even though, as mentioned, the spatial associations are represented on just two of the 14 dimensions considered, only two samples from Group 3 intrude into the Group 1 limits. The divergence of Group 3 from the Group 1 and Group 2 material (Group 3 tending toward the lower right side of the plot) reflects the importance of iron, scandium, and the rare earths in differentiating among the groups. Group 4 occurs well separated from the other samples in the upper right of the figure, reflecting its notable difference in sodium and cesium concentrations. In Figure 3, Group 3 overlaps with Group 2. However, using standardized characteristic vectors 4 and 11, the groups are more fully resolved (Figure 4). In both of the figures, Groups 1 and 2 are statistically separable but the close relationship between them is evident.

(Beaudry, Bishop, Henderson, and Hirth) Figure 3: Compositional Groups Relative to Vectors 6 and 1.



(Beaudry, Bishop, Henderson, and Hirth) Figure 4: Compositional Groups Relative to Vectors 11 and 14.



Thus, 80 of the 130 sherds analyzed were placed into reference units; 50 remained ungrouped. It is interesting to note that 16 of the ungrouped specimens showed highly individualistic concentration patterns. The other 33 cases were similar to the ranges of elemental concentrations found in Group 1. However, the multivariate analysis demonstrated that chemically they could not be considered as representing the same clay resource. At this point, we should mention that during the research steps on which we are reporting the analytical concept of the CPCRU is being utilized. this is the first stage of investigation before nonchemical considerations are factored in to arrive at Paste Compositional Reference Units (PCRU). That analytical grouping of ceramic samples "result(s) from merging two or more similar yet separable CPCRUs in order to achieve a new level of agreement with nonchemical data; (or) in another approach, all specimens not belonging to a specific site provenience, form class, or other cultural or mineralogical category are removed. In some manner, we are making the original, chemically 'homogeneous' class more homogeneous on some other level" (Bishop, Rands, and Holley 1982:305-306).

DISCUSSION AND ARCHAEOLOGICAL IMPLICATIONS OF ANALYTICAL RESULTS

Since the research concerned intrasite, intraregional, and interregional issues, the results will be discussed in that order. For ease of presentation, the design categories have been grouped and will be presented according to a general temporal placement.

Intrasite Pattern (Salitron Viejo) (Table 4)

Forty-three (72%) of the Salitron Viejo Sulaco material clustered into the four reference units:

Group 1: 19 (including 3 misfired sherds)

Group 2: 11 (including 5 misfired sherds)

Group 3: 8 (including 1 misfired sherd)

Group 4: 5

The remaining 17 Sulaco Group sherds did not group, indicating that other chemically different resources were also used for these vessels. The fact that the two misfired non-Sulaco Group sherds are ungrouped further

Table 4. Salitron Viejo Provenience Specimens Grouped into CPCRUs

Sylistic Types	CPCRU 1	CPCRU 2	CPCRU 3	CPCRU 4	Total Grouped	Un-Grouped	Total
Sulaco Weak/black-lipped bowls	6				6	2	8
Serpent fill/interior diagonal	1	1	1		3	3	6
Incised/white polychrome	2		1		3	2	5
Pendant U and knotted textile design	7	1	3		11	2	13
Bichrome/trichrome	2*	6*	2		10	2	12
Monochrome		1*		5	6	6*	12
Misfired, general Sulaco Group	1	2	1		4		4
Misfired non-Sulaco Group	1	2	1	–	4	–	4
	19	11	8	5	43	19	62

* Includes one misfired sherd

underscores the finding that a variety of chemically distinguishable resources were available to Salitron Viejo potters. (The possibility must also be considered that temper is contributing to the variablility being seen. That issue was not addressed at this stage of the work because of the relatively fine paste of the Sulaco Group materials.)

As mentioned, Group 4 showed a very distinct composition: one that was very different from other units. These five Salitron Viejo provenience specimens are all monochromes of two low frequency varieties: 1) pottery with a distinctive "tangerine" paste and surface treament, and 2) pottery decorated with a resist technique. Other than with Group 4, there is no clear indication of a correlation between a chemically derived group and the seriated stylistic classification. There is a suggestion, however, that compositional Group 2 relates to the earlier style types and the CPCRU 1 was more dominant in later periods. A temporal pattern for CPCRU 3 cannot be outlined because of the small sample size. In summary, after the monochrome period, about 75% of the Salitron Viejo provenience Sulaco Ceramic Group was locally produced from three restricted resources; the rest was made from chemically divergent resources either at Salitron Viejo or elsewhere. Toward the end of the Sulaco Group sequence there seems to have been more reliance on the Group 1 resource along with the continued use of variable resources that don't cluster chemically. This may signal a different pattern of production organization than in earlier times. Throughout the sequence, however, production was not hightly centralized nor controlled -- multiple producers made a variety of styles.

El Cajon Intraregional Pattern

Material from three other El Cajon region sites is included in the data set with the bulk (17/24) being from Guarabuqui. One-half of the regional specimens clustered into the various "local" Salitron Viejo CRCRUs; the division by group was not type-specific (Table 5). None of the El Cajon regional samples fit into Group 4, the deviant compositional group that contained the low frequency monochromes. One "tangerine" monochrome from Guarabuqui that could have been expected on stylistic grounds to associate with Group 4 remained ungrouped. The ungrouped half of the regional specimens could represent local production at these various sites or imports from production loci not represented in the present sample. The same tendency is noted as at

Table 5. El Cajon Regional Provenience Specimens Grouped into CPCRUs

Sylistic Types	CPCRU 1	CPCRU 2	CPCRU 3	CPCRU 4	Total Grouped	Un-Grouped	Total
Sulaco Weak/black-lipped bowls	2				2	2	4
Serpent fill/interior diagonal							
Incised/white polychrome	1				1	1	2
Pendant U and knotted textile design	1				1	4	5
Bichrome/trichrome		2	2		4	1	5
Monochrome		1			1	3	4
General Sulaco Polychrome	1		1		2		2
General Sulaco Group	–	1	–	–	1	1	2
	5	4	3		12	12	24

Salitron Viejo: utilization of the Group 1 resource continues into later periods while production from resources 2 and 3 ceases after the bichrome/trichrome decoration era. These data show that Salitron Viejo-made material was available to people living in the El Cajon region but other sources were also supplying the communities within the area -- a further argument against the hypothesis of central control of production and distribution of these materials.

Sula Valley-El Cajon Interregional Pattern

Four sites are represented in the Sula Valley sub-set with a majority of specimens coming from CR178, the small tertiary settlement. Fewer stylistic types are present in this sample with only one bichrome included among the predominantly polychrome types of the later periods. The finding that all but two of the grouped pieces cluster with Salitron Viejo CPCRU 1 corroborates the suggestion in the other data sets that clay resources at Salitron Viejo changed over time. If, at this stage of the analysis we had moved beyond CPCRUs to PCRUs where factors other than chemical homogeneity are considered, the lone Sula Valley piece in Group 2 as well as that in Group 3 would be removed. We believe that, in these cases, a statistical similarity should be overriden by archaeological considerations (Table 6).

As with the El Cajon regional subset, the presence here of a significant proportion of the Sulaco Group pottery made from the variable clay resources indicates a place of restricted production or controlled distribution. Sula Valley communities received some Sulaco Group pottery from Salitron Viejo but also had access to stylistically similar vessels made locally or imported from other than the identified Salitron Viejo resources.

SUMMARY

At this point in the research we have evidence that Sulaco Group pottery was not the product of highly centralized production system that utilized highly restricted clay resources. Salitron Viejo did supply some of the Sulaco Group pottery to communities within the El Cajon region and to sites in the Sula Valley, outside its region. However, almost half of the Sulaco Group speciments from the El Cajon region (outside of Salitron Viejo) and from the Sula Valley are made of chemically variable materials. Approximately 25% of the Salitron Viejo Sulaco Group material is of varying

Table 6. Sula Valley Provenience Specimens Grouped into CPCRUs

Sylistic Types	CPCRU 1	CPCRU 2	CPCRU 3	CPCRU 4	Total Grouped	Un-Grouped	Total
Sulaco Weak/black-lipped bowls						1	1
Serpent fill/interior diagonal							
Incised/white polychrome	14	1			15	11	16
Pendant U and knotted textile design	1				1	1	2
Bichrome/trichrome	1				1		1
Monochrome							
General Sulaco Polychrome	5				5	5	10
General Sulaco Group	2	–	1	–	3	1	4
	23	1	1		25	19	34

chemical composition.

We have now produced a description of these data with a minimum of interpretation. We expect to increase the number of analyzed specimens to determine with greater precision the chemical compositional groupings. We also need to address the issue of temper-related variability in the analytical results. Once the instrumental analysis is more definitive, we can then begin our real work -- integrating the results of this instrumental analysis into hypothesized reconstructions of the economic systems in prehistoric Honduras.

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