might be expected in subsequent analyses of Nicaraguan obsidian artifacts.

The contexts of the northwestern Costa Rican materials are all late Middle Polychrome/Late Polychrome period (A.D. 1200–1520) and this also correlates well with the temporal placements assigned to the Nicaraguan specimens, and with the La Virgen phase (Middle Polychrome) placement given by Healy (1980: 285) for "three, and probably four" of the obsidian chips that he reported on from Norweb's testing. Only one fragment of a blade was reported from the same excavations. The low frequency of obsidian reported by Healy is comparable to the results obtained from the 1983 survey.

6 Compositional Characterization of the Nicaraguan Ceramic Sample

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Chemical characterization of Nicaraguan ceramics is based on instrumental neutron activation analysis (INAA) of 51 specimens from the 1983 Nicaraguan survey and other Nicaraguan ceramics that are part of the 1,238 samples in the Greater Nicoya ceramic data base (Bishop, Lange, and Lange 1988; Bonilla et al. 1987). Recent survey, excavation, and intensive ceramic analysis allow us to refine ceramic data interpretations, both in terms of the evolution of the local ceramic production traditions and in terms of the impact of foreign influences on forms and designs. This has been particularly important in allowing us to characterize Greater Nicoya in terms of northern and southern sectors (Figure 1.10). As noted elsewhere in this volume, some ceramic types or varieties have a distribution limited primarily to one sector or the other, while others are found in both, or are "pan-regional."

In addition to the characterization of locally produced ceramics, the ceramic-based subdivisions of Greater Nicoya also permit the stylistic and analytical assessment of ceramic specimens suspected of being imported from external sources. Our ability to quantify analytically previously intuitive speculations regarding ceramic trade has been one of the most significant results of the ceramic analysis program.

A ceramic paste analytical perspective for some of these interpretations, one that will permit recognizable "styles" of pottery to be attributed to general subregions of the Nicaraguan portion of Greater Nicoya, is the subject of the present discussion. A number of these new interpretations, some clearly defined and others somewhat more speculative, are presented in the cultural historical sequence in Chapter 7.

Prior to the inclusion of ceramics from the 1983 Nicaraguan survey, paste compositional patterns for Nicaragua relied heavily upon the pottery from Rivas and Ometepe Island. The incorporation of the survey's material allows us to expand our geographic coverage and marks what we hope will be a new beginning of archaeological and scientific study of the pottery from Nicaragua—an area of critical importance if we hope to understand the cultural development of lower Central America.

Structuring our discussion is the distinction drawn between the "northern" and "southern" sectors of the Greater Nicoya subarea (Lange 1984a). These heuristic designations are based upon differences in geographic distribution of material culture (eg. jade), settlement patterns, environmental resources, and ethnohistorical information, as well as the distribution of ceramic types. In general, the southern sector refers to northwestern Costa Rica while the northern sector denotes the Rivas Isthmus of Nicaragua.

Geological Background

Clays and the nonplastic materials naturally occurring in the clay or added to the clay during the production process are derived from natural mechanical and chemical weathering in the geological environment. The geological evolution of Greater Nicoya, including Pacific Nicaragua, has produced a complex environment against which to model ceramic production. The region has been subject to extensive crustal deformation and igneous activity from the Cretaceous period to the present. Within the northern sector of the region, which is the focus of this report, undifferentiated volcanic rock is dominant east of Lake Nicaragua (Figure 6.1).

Cretaceous and Eocene sediments constitute the primary geological feature of the Isthmus of Rivas, where they lie parallel to each other between the Pacific Ocean and Lake Nicaragua. Slightly northeast of these two features is a restricted occurrence of Quaternary alluvium and volcanic-derived sediments (Incer 1972). The soils and clays from Ometepe Island in Lake Nicaragua are produced from the weathering of undifferentiated Quaternary volcanic materials derived from the ejection of pyroclastics from the vents of Concepción and Madera volcanoes (McBirney and Williams 1965).

The weathering of a volcanic terrain can yield a readily identifiable compositional "fingerprint." However, the pattern may have a wide geographic

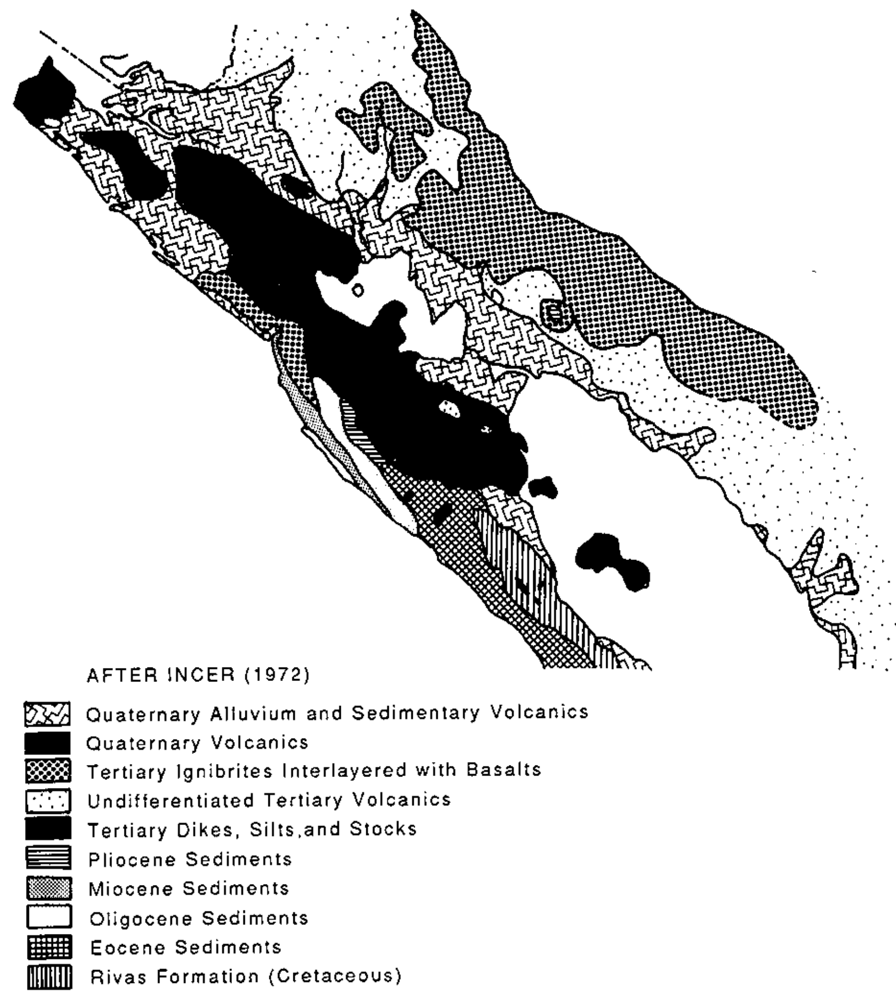

Figure 6.1. Surface geology of Pacific Nicaragua.

distribution, imparting a general "sameness" to the chemical characteristics of the clays and thereby limiting our ability to make subregional characterizations of ceramic production. On the other hand, depending upon the extent of control utilized during the ceramic production process, the presence of volcanic sands and miscellaneous pyroclastic materials may induce considerable ceramic compositional variation and blur what differences may exist among clay deposits. To the extent that the pyroclastic materials being added engender a distinctive profile (such as the tuff in Murrillo Appliqué [Figure 7.63a] and the high iron content in Papagayo Polychrome [Figures 7.51c-d, 7.52, and 7.53]) they may be as valuable as the clay itself in distinguishing a particular ceramic type from the rest of the assemblage.

Our present knowledge of the geochemical variation in Nicaragua ranges from general to absent depending upon the specific region under discussion. We have gained some insights into the relationships between the lower Central American geological environment and patterns of ceramic composition through our research in Costa Rica and through the petrographic analysis of thin sections of chemically analyzed ceramic specimens. Some of the latter included ceramic samples from Nicaragua. For the present, however, the level to which we can make specific inferences regarding the location of ceramic production is limited to large, poorly-defined subregions (Bishop, Lange, and Lange 1988: Figure 2.1).

The Greater Nicoya Ceramic Project Analytical Program

In order to better understand the cultural patterns of similarities and differences that led to the definition of northern and southern sectors in Greater Nicoya (Lange 1984a), an intensive program of ceramic compositional analysis was initiated at the Brookhaven National Laboratory in 1978 and has been continued as a program of the Smithsonian Institution's Conservation Analytical Laboratory. Questions pertaining to ceramic production and distribution were addressed using major, minor, and trace elemental data derived from instrumental neutron activation analysis (INAA) of over 1,200 ceramic sherds and vessels from Greater Nicoya (Bishop, Lange, and Lange 1988). This approach, noted for its great sensitivity and relatively low sample preparation time (Perlman and Asaro 1969; Bishop, Rands, and Holley 1982; Harbottle 1976, 1982), was considered appropriate in view of the potential "sameness" of the geological environment.

Details of the analytical procedures are given in Bishop, Harbottle, and Sayre (1982). Suffice it to say here that INAA involves the irradiation of a sample by neutrons in a nuclear reactor, which causes the interaction of neutrons with target nuclei. This leads to the formation of radioactive isotopes that give off acquired energy in the form of gamma rays. The gamma rays are of energies specific to the unstable state of a nucleus. The detection and counting of the emitted gamma energies can lead to quantification of many of the elemental concentrations that constitute the ceramic sample. Not all of the elements will be quantified with the same analytical precision. Accordingly, it is necessary to choose among the full set of resulting concentrations for those that are characterized with sufficient precision to be useful in addressing the archaeological objectives of the research.

In the present study, we have quantified only those isotopes whose half-lives are moderate- to long-lived. Of that subset, the following 15 elements were found to have been determined with acceptable analytical precision and were used for subsequent stages of group formation and evaluation: Rb, Cs, Ba, Sc, La, Ca, Eu, Lu, Hf, Th, Cr, Fe, Co, Sm, and Yb.

The Greater Nicoya data base includes the earlier analyses of 218 Nicaraguan samples drawn from the Rivas collections of the Peabody Museum at Harvard, Haberland's Ometepe Island pottery from the Museum für Völkerkunde und Vorgeschichte in Hamburg, and limited ceramic materials collected by Abel-Vidor from the western shore of Lake Nicaragua. The analyses of 51 samples from the 1983 survey provided the opportunity to analyze pottery with a much broader geographic distribution in Nicaragua and to evaluate some of our previously formed assumptions regarding the northern and southern affiliations of specific types and varieties. The new data contributed to the formation of Ceramic Paste Compositional Reference Units (CPCRUs) for Greater Nicoya. The following discussion is presented as a summary statement and is not intended to be exhaustive.

Groups of chemically similar pottery were derived during four stages of group formation and group evaluation:

1. Trial groups were formed initially using the Euclidean distance between sample compositional profiles as an objective measure for assessing intersample similarity. This procedure takes into account only the absolute elemental concentrations.

2. Once a group was formed, and if it was constituted with a sufficient number of members (eg. samples being two to three times more numerous than the number of chemical variates being used), samples in the group were evaluated as to their statistical likelihood of belonging to the group. This evaluation was carried out using the interelemental correlational characteristics of the group as well as the absolute concentrations. An individual sample's probability of belonging to the group, given its distance from the multivariate group center, was calculated using Hotelling's T^2, the multivariate extension of Student's t.

3. Samples which were found to lie outside of a stated confidence interval about a group were excluded and the group's characteristics were recalculated. Generally, an 80 percent confidence interval was used to refine the group membership. While this level of group containment may exclude some samples that belong to the group, it errs in the direction of being conservative (Bishop, Lange and Lange 1988: 20).

4. When no further samples could be excluded at the specified probability level, non-group members were evaluated, one at a time, as to their likelihood of belonging to the group. Comparison samples that were found to

lie within the confidence interval were added to the group and the evaluation process was repeated.

Chemically defined groups were sought that were free from compositional overlap with any of the other groups thus formed. For those groups with sufficient membership, far greater confidence exists to allow more rigorous statistical evaluation. Several smaller groups were formed whose integrity relies as much on internal typological or provenience homogeneity as it does on relative chemical similarity. In all, 39 groups were formed, 10 of which contain over one-half of all of the analyzed specimens and which represent the major Greater Nicoya ceramic types. Our interpretation of subregional raw resource variation and its relation to patterns of ceramic production and distribution in Greater Nicoya is extrapolated from these 10 primary groups. Detailed discussion of all of the groups, including those of secondary status, is in preparation. More detailed discussion of the stages of group formation and evaluation of these primary Greater Nicoya CPCRUs is given in Bishop, Lange, and Lange (1988).

We begin discussion of the compositional units with reference to the chemical variation observable in the larger groupings of Greater Nicoya ceramics that contain appreciable numbers of sherds with Nicaraguan provenience. Of the ten major CPCRUs, six groups (GN11, GN12, GN15, GN22, GN23, and GN24) have the most importance for the Nicaraguan study (our reference GN or Greater Nicoya group number is consistent with that used by Bishop, Lange, and Lange [1988]). Some Nicaraguan pottery has compositional resemblance to two primary southern sector, or Costa Rican reference units (GN01 and GN04). Minor or secondary northern sector CPCRUs—subject to less rigorous evaluation—also include Nicaraguan ceramics (GN numbers 2, 3, 13, 17, 22, 25, 26, 30, 32, 33, 35, 36, and 38). Nicaraguan pottery, therefore, occurs in 20 of the 39 recognized reference units.

Our objective in this paper is not so much to demonstrate the multivariate exclusive separation of the reference units as it is to discuss the compositional patterns that underlie the chemical "fingerprints" for pottery produced in Nicaragua. We begin, however, by showing the northern sector Nicaraguan-containing CPCRUs in contrast to the Mora and Galo Polychrome reference units of the southern sector (GN01 and GN04). While they represent only two of several southern sector-oriented compositional units, these Mora inclusive groups graphically demonstrate the strong pattern of compositional differentiation between pottery produced in the northern and southern sectors of Greater Nicoya. Mean elemental concentration values and their associated standard deviations for representative CPCRUs are given in Table 6.1.

Projected onto the first two axes derived through a principal components analysis of the pooled units (Figure 6.2), the major variation in the sample

Table 6.1. Primary Chemical Paste Compositional Reference Units.

	GN11	GN12	GN15	GN22	GN23	GN24		GN04
	n = 132	n = 50	n = 49	n = 28	n = 58	n = 19		n = 122
Ca	2.60 (31)	2.16 (21)	1.65 (18)	2.65 (32)	3.10 (38)	2.60 (61)	*	2.53 (26)
Sc	23.4 (11)	21.9 (9)	17.1 (10)	33.3 (8)	34.5 (10)	23.3 (10)	*	31.2 (9)
Cr	12.4 (38)	17.5 (24)	22.0 (23)	20.6 (17)	21.9 (24)	10.5 (11)	*	127.0 (18)
Fe	6.28 (9)	5.59 (10)	4.20 (10)	9.44 (13)	10.1 (10)	6.86 (10)	*	7.17 (8)
Co	13.6 (35)	17.9 (31)	16.7 (29)	24.9 (47)	40.1 (46)	16.1 (42)	*	25.7 (29)
Rb	38.4 (10)	61.0 (37)	70.7 (16)	37.3 (64)	41.1 (69)	52.7 (46)	*	35.2 (50)
Cs	1.37 (26)	1.19 (28)	2.54 (29)	0.815 (42)	0.850 (41)	0.789 (69)	*	1.21 (46)
Ba	971. (38)	1180. (29)	1010. (24)	836. (43)	970. (37)	1370. (30)	*	817. (52)
La	14.4 (13)	16.0 (14)	16.3 (7)	19.8 (26)	27.6 (20)	33.5 (25)	*	11.6 (15)
Ce	21.8 (30)	33.1 (17)	32.5 (10)	32.5 (37)	61.9 (42)	54.9 (26)	*	19.3 (25)
Sm	4.21 (18)	4.69 (29)	4.70 (12)	3.37 (26)	5.74 (29)	5.80 (24)	*	3.51 (17)
Eu	1.25 (10)	1.03 (16)	1.03 (10)	0.819 (20)	1.39 (22)	1.32 (30)	*	1.09 (9)
Yb	2.98 (12)	3.14 (13)	2.88 (12)	1.59 (23)	2.58 (19)	2.69 (22)	*	2.45 (14)
Lu	0.442 (15)	0.464 (14)	0.444 (16)	0.289 (19)	0.408 (25)	0.421 (26)	*	0.375 (15)
Hf	4.78 (9)	5.77 (8)	4.51 (15)	6.15 (9)	6.46 (11)	7.16 (12)	*	2.99 (12)
Th	3.19 (11)	3.76 (9)	3.99 (9)	4.87 (5)	5.00 (13)	5.88 (15)	*	1.59 (17)

Mean elemental concentration for selected CPCRUs. Concentrations listed in parts per million except Fe which is listed in percent. Number in parenthesis is one standard deviation expressed as percent of mean value. GN04, at right, is a Southern Sector CPCRU.

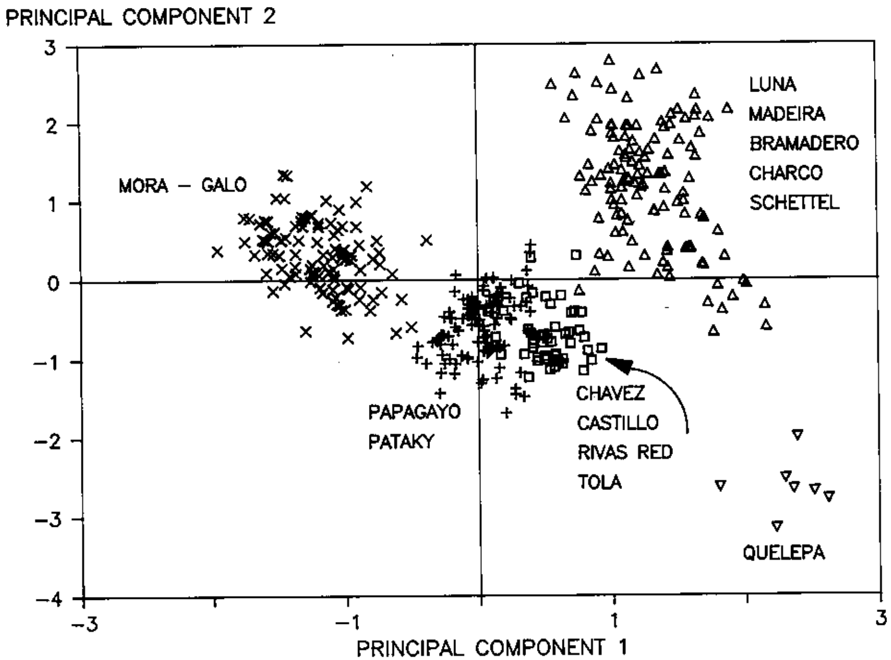

Figure 6.2. Bivariate plot of principal components 1 and 2 derived for Northern and Southern Sector CPCRUs. Component loadings given in Table 2.

set is displayed along principal component 1, and reflects high elemental loadings of most of the considered elements (Table 6.2). To the left side of the figure, the southern sector CPCRUs are shown with a single plot marker. Two elements are especially notable for differentiating northern from southern sector pottery: chromium and thorium (note concentrations in Table 6.1). Although a single element is seldom sufficient to characterize different production regions, it has been shown that if Greater Nicoya pottery is determined to have over 50 parts per million of chromium or less that 3 parts per million of thorium, it most likely was made south of the Rivas region. Confidence in such an attribution, of course, increases when multi-elemental patterns provide corroboration.

The center and right hand side of the plot are dominated by samples from the northern sector—samples whose provenience is heavily weighted toward Nicaragua. In the center of Figure 6.2 are samples from the CPCRUs GN11 and GN38, constituted by members of the Papagayo and Pataky Polychrome types. Slightly to the right of that large cluster are members of

Table 6.2. Principal Component Loadings for Northern and Southern Sector CPCRUs.

	COMP 1	COMP 2	COMP 3
Sc	-0.159	0.886	0.134
Cr	-0.715	0.415	0.319
Fe	0.086	0.909	0.013
Co	0.051	0.844	0.175
Ba	0.318	-0.236	-0.157
La	0.831	0.362	-0.109
Ce	0.765	0.431	-0.088
Sm	0.755	0.036	0.352
Eu	0.476	0.166	0.721
Yb	0.453	-0.454	0.639
Lu	0.507	-0.349	0.564
Hf	0.837	0.056	-0.407
Th	0.839	-0.012	-0.472
Proportion of variance explained			
	35.3	24.8	15.0

CPCRU 12, representing the Chávez White-on-Red, Castillo Engraved, Tola Trichrome, and Rivas Red ceramic types. Still largely separated on Component 1 but diverging higher on Component 2 are samples from CPCRUs GN22 and GN23. These are the primary reference groups containing the majority of the Luna, Madeira, and Bramadero Polychrome pottery. Toward the lower right hand corner of the plot are members of reference unit GN32, made up of non-typed ceramics from the Quelepa region of El Salvador and samples of Delirio Red-on-White recovered from the 1983 survey. Not differentiated in this plot—depicted with the same symbol as GN22 and GN23—are members of the Charco Black-on-Red and Schettel Incised group, GN24. The reference unit comprised of Vallejo Polychrome, GN15, is not represented by a specific marker, since it overlaps with other groups in the center of the plot relative to the first and second principal components.

Table 6.3. Principal Components Loadings for Northern Sector CPCRUs.

	COMP 1	COMP 2	COMP 3
Sc	0.723	-0.157	0.554
Cr	-0.045	-0.024	0.876
Fe	0.759	-0.129	0.54
Co	0.557	0.214	0.636
Ba	-0.007	0.191	-0.653
La	0.853	0.343	0.054
Ce	0.734	0.527	0.163
Sm	0.321	0.801	-0.011
Eu	0.437	0.835	0.021
Yb	-0.293	0.844	-0.263
Lu	-0.211	0.84	-0.109
Hf	0.864	-0.027	-0.066
Th	0.844	-0.076	-0.02
Proportion of variance explained			
	41.0	26.0	11.4

The inclusion of the southern sector Mora Polychrome reference units in Figure 6.2 permits compositional variation between the southern and northern sector groups to be especially well illustrated along the first component. Additionally, it provides a compositional background that will figure in the discussion of specific Nicaraguan provenienced specimens (see below). Not as distinctly different but chemically separable from other ceramics of the northern sector are the members of the Papagayo and Pataky compositional units (GN11). In order to illustrate more subtle compositional trends among the reference units of the northern sector, a separate principal components analysis was carried out that omitted the southern Mora and the northern Papagayo groups. The new principal component loadings for this northern subset of the data are given in Table 6.3; the data points for group samples are located in Figure 6.3 relative to the first two components.

The center line along the first component essentially separates the Charco-

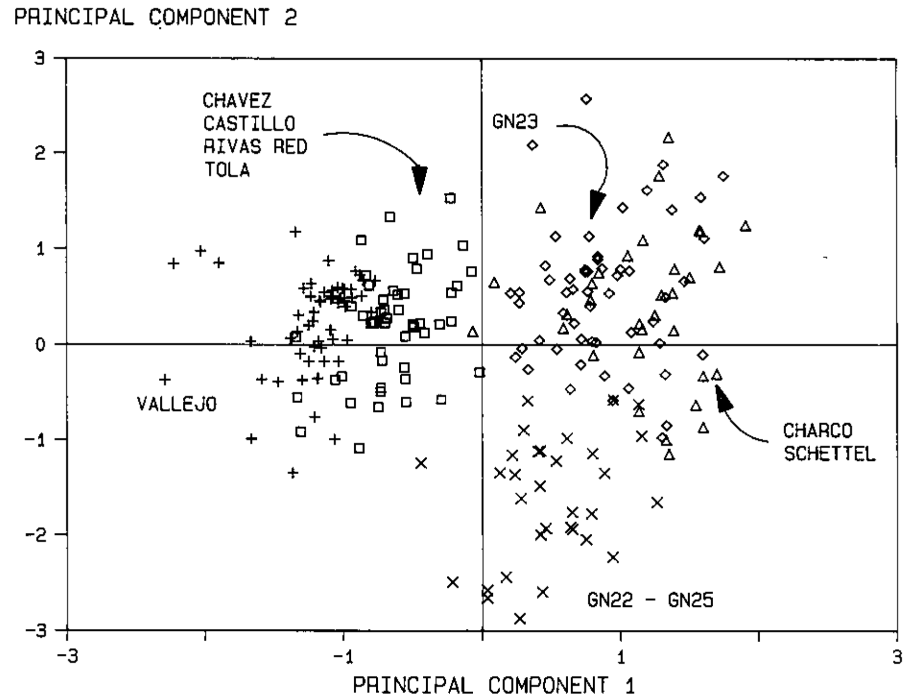

Figure 6.3. Bivariate plot of principal components 1 and 2 derived for Northern Sector CPCRUs. Component loadings given in Table 3.

Schettel (GN24) and Luna-Bramadero-Madeira groups (GN22, GN23) from those of the Vallejo (GN15) and Chávez-Tola etc. (GN12) groups. Compositional variation among the Luna, Bramadero, and Madeira units is shown along component 2, where GN23 has positive scores on component 2, while the groups consisting of similar typological specimens, GN22 and GN25, score low. This separation reflects the significantly higher rare earth elemental concentrations in GN23. Vallejo Polychrome, GN15, lies to the left of the plot, overlapping with some pottery of the Chávez, Castillo, Rivas, and Tola types.

Somewhat greater divergence of the Vallejo Polychrome samples relative to components 1 and 3 is illustrated in Figure 6.4. In this plot, the Charco-Schettel groups, GN24 shows its distinctive variation located toward the lower right hand corner. The upper right hand quadrant of Figure 6.5 contains the groups comprised of Luna, Bramadero, and Madeira.

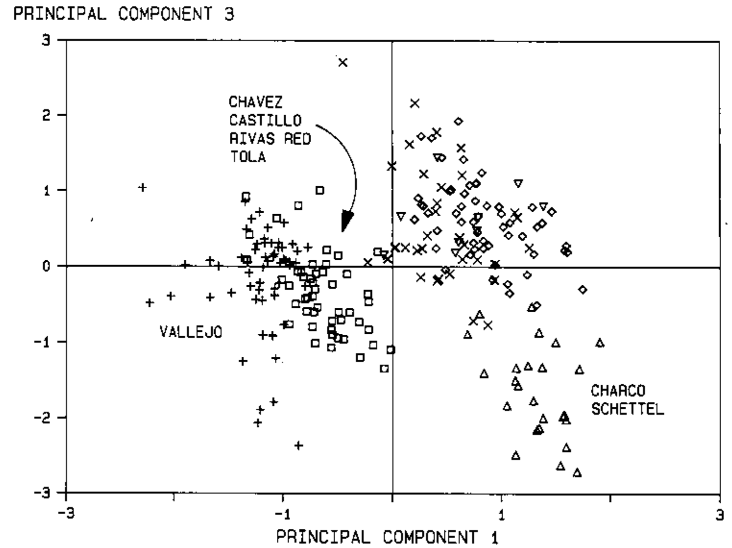

Figure 6.4. Bivariate plot of principal components 1 and 3 derived for Northern Sector CPCRUs. Component loadings given in Table 3.

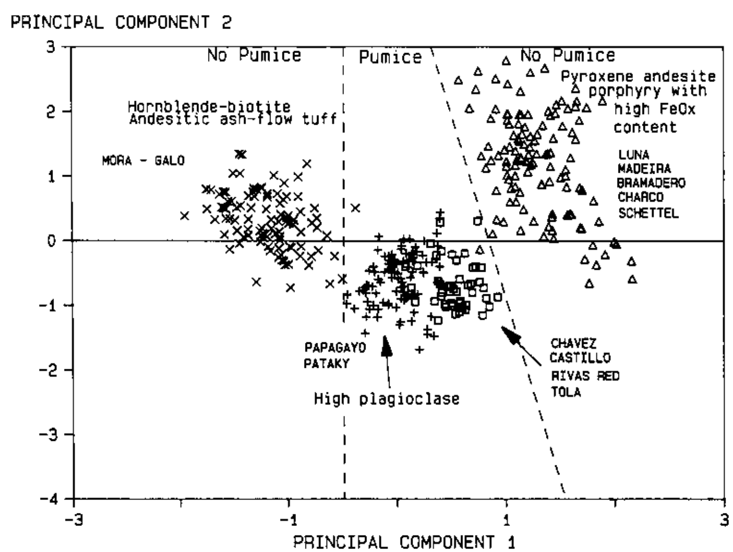

Figure 6.5. Bivariate plot of principal components 1 and 2 derived for Northern and Southern Sector CPCRUs. Component loadings given in Table 2; petrographic characteristics of represented CPCRUs added.

Northern and Southern Sector: Primary CPCRU's

Figures 6.2–6.5 have illustrated the major compositional trends observed among the major reference units characterizing the pottery produced in the northern sector of Greater Nicoya. A description of the typological characteristics of each major CPCRU and its geographical distribution follows. Sample size is indicated by the two numbers given in parentheses following the Greater Nicoya reference groups designation: the first number indicates the number of samples with a Nicaraguan provenience while the second is the total number of samples in the group. The correspondence between Nicaraguan provenience and compositional reference group is summarized in Tables 6.4 and 6.5. Selected survey samples are illustrated in Figures 6.6, 6.8, and 6.9.

GN01 (2, 64): One of the two Nicaraguan specimens in this southern sector group is a Galo Polychrome (Figure 6.6i) sherd and the other a non-typed polychrome. Both are recognizable as pottery that is rare in northern sector sites. With only one exception, the 64 specimens in this reference group are representatives of the Galo and Mora ceramic types (Appendix 2, GN01, GN04). Geographical distribution ranges from Isla del Caño off the southern Pacific coast of Costa Rica, to the central valley at Barrial de Heredia, and the Atlantic watershed (Figure 6.7).

GN04 (2, 122): Similar to GN01, this is a primary southern sector reference unit. Two 1983 Nicaraguan survey specimens are included in this group; one is of the Mora Polychrome (Figure 6.8h–i) ceramic type, and the other is of the distinctive Santa Marta variety. Group membership is strongly of southern sector types; geographical distribution is southern sector to Isla del Caño, the Central Valley, and the Atlantic watershed (Figure 6.7).

GN11 (42, 142): The largest northern sector unit in the Greater Nicoya data base, this reference unit is the primary focus for the grouped specimens of white-slipped Papagayo (Figure 7.51c-d, 7.52, 7.53) and Pataky Polychrome pottery (Figure 7.56c-d, 7.57a). Four white-slipped Vallejo Polychrome specimens (Figure 7.60b-d) also occur in this group, although most of the representatives of the type are found in GN15. This chemically-defined group is one of the most distinctive Greater Nicoya reference units. Attempts at subdivision have been unsuccessful; that is, no statistically significant partitions have been found in the group and, hence, no indication of chemical-typological covariation along ceramic varietal lines. The geographical distribution of the sampled pottery ranges from the northern sector, through the southern sector, and into the Atlantic watershed (Figure 6.7). In contrast to the generally orange-slipped groups, examples of which are

Table 6.4. Correspondence of Ceramic Sherds with Nicaraguan Provenience and CPCRUs.

CPCRU	TOTAL SAMPLES	NICARAGUAN SAMPLES
Southern Sector		
GN01*	64	2
GN04*	122	2
GN02	12	2
GN35	4	1
Northern Sector		
GN11*	142	42
GN12*	66	52
GN15*	49	15
GN22*	28	6
GN23*	66	27
GN24*	19	17
GN13	13	13
GN17	3	1
GN25	7	3
GN30	5	5
GN32	8	2
GN33	7	6
GN36	5	3
GN38	50	29
NO GROUP		80

* = Primary CPCRUs

Table 6.5. Compositional Attribution of 1983 Nicaraguan Survey Sherds.

ID #	CPCRU	SITE	TYPE	VARIETY
MSI016	GN12	Acahualinca	Leon Punctate	
MSI056	ng	Acahualinca	Vallejo? or Managua Polychrome	Mombacho?
MSI054	GN02	Agua Buena	Untyped	
MSI021	ng	Cerro de la Vaca	Ometepe Red-Slipped Incised	
MSI031	ng	Cerro de la Vaca	Untyped	
MSI033	ng	Cerro de la Vaca	Untyped	
MSI038	GN38	Cerro de la Vaca	Untyped	
MSI002	GN38	El Pachote	Papagayo Polychrome?	
MSI017	GN24	Finca de Cana	Charco Black-on-Red	Puerto
MSI034	GN15	La Ceiba Sur	Papagayo Polychrome	
MSI020	GN15	La Ceiba Sur	Vallejo Polychrome	Lazo?
MSI039	GN15	La Ceiba Sur	Vallejo Polychrome	
MSI028	ng	La Chanchera	Zoned Bichrome	Untyped
MSI046	GN38	La Vainilla	Untyped	
MSI055	ng	La Vainilla	Untyped	
MSI044	ng	Los Placeres	Delirio Red-on-white?	
MSI010	ng	Los Placeres	Leon Punctate	
MSI007	GN11	Los Placeres	Papagayo Polychrome	
MSI004	GN15	Los Placeres	Vallejo Polychrome	
MSI024	GN15	Los Placeres	Vallejo Polychrome	Mombacho
MSI025	GN38	Los Placeres	Vallejo Polychrome	Mombacho
MSI012	GN30	Luisitio	Zoned Bichrome	"Usulutan"
MSI035	GN30	Luisitio	Zoned Bichrome	"Usulutan"
MSI057	GN30	Luisitio	Zoned Bichrome	"Usulutan"
MSI019	GN12	Moyua	Chavez White-on-Red	Chavez
MSI022	ng	Moyua	Leon Punctate	
MSI005	ng	Moyua	Potosi Applique	Potsoi
MSI048	GN17	Moyua	Untyped	
MSI042	ng	Nejapa	Leon Punctate	
MSI013	GN38	Nejapa	Papagayo Polychrome	
MSI003	GN38	Nejapa	Tola Trichrome	Tola
MSI009	GN13	San Antonio	Bocana Zoned Incised	Bocana
MSI047	GN38	San Antonio	Chavez White-on-Red	Chavez
MSI011	GN32	San Antonio	Delirio Red-on-white	
MSI014	ng	San Antonio	Delirio Red-on-white	
MSI032	ng	San Antonio	Delirio Red-on-white	
MSI043	GN38	San Antonio	Delirio Red-on-white	
MSI051	GN32	San Antonio	Delirio Red-on-white	
MSI027	GN01	San Antonio	Galo Polychrome	
MSI037	ng	San Antonio	Leon Punctate	
MSI001	GN11	San Antonio	Papagayo Polychrome	
MSI036	ng	San Antonio	Tola Trichrome	Tola
MSI023	GN15	San Antonio	Vallejo Polychrome	
MSI030	GN38	San Antonio	Vallejo Polychrome	Mombacho
MSI026	GN15	San Cristobal	Papagayo Polychrome	
MSI058	ng	San Juan	Modern	
MSI006	GN30	Santa Marta	Zoned Bichrome	"Usulutan"
MSI029	ng	Santa Marta	Zoned Bichrome	"Usulutan"
MSI049	GN38	Tepetate	Bramadero Polychrome	
MSI015	GN13	Tepetate	Madeira Polychrome	Madeira
MSI018	GN11	Tepetate	Papagayo Polychrome	
MSI040	GN11	Tepetate	Pataky Polychrome	Pataky
MSI050	ng	Tepetate	Sacasa/Zapatera	
MSI052	GN38	Tepetate	Untyped	
MSI041	GN13	Tepetate	Vallejo Polychrome	Mombacho

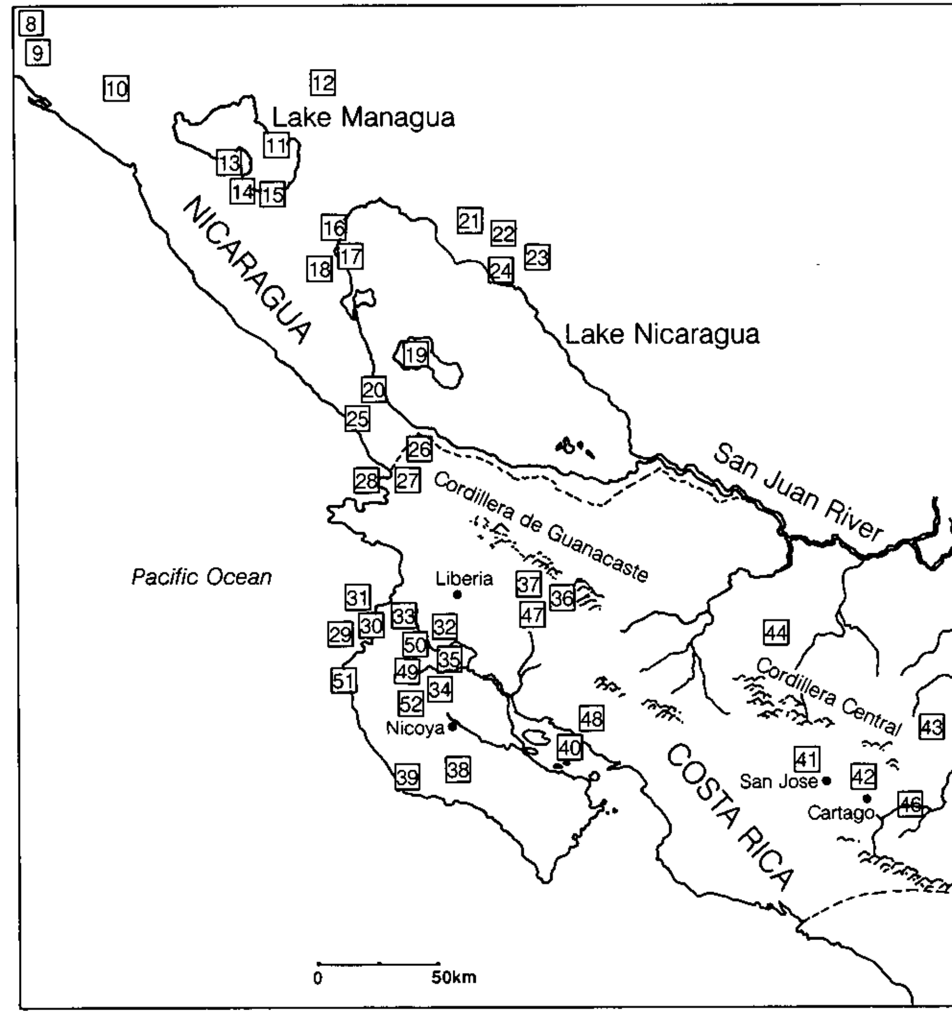

Figure 6.7a–b. Distribution of Sites with INAA samples discussed in chapter 6; (1) Quelepa (El Salvador); (2) Chalchuapa (El Salvador); (3) Ceren (El Salvador); (4) Cihuatan (El Salvador); (5) Las Vegas (Honduras); (6) Los Naranjos (Honduras); (7) Gulf of Fonseca; (8) NIC 19 (Santa Marta); (9) NIC 17 (La Chanchera); (10) NIC 13 (Luisitio); (11) NIC 11 (La Ceiba Sur); (12) NIC 12 (Moyua); (13) NIC 7 (Nejapa); (14) NIC 8 (Acahualinca); (15) NIC 9 (Los Placeres); (16) NIC 5 (Granada, Tepetate); (17) NIC 3 (San Antonio); (18) NIC 4 (El Pachote); (19) Ometepe Island; (20) NIC 1 (Finca de Cana); (21) NIC 25 (Agua Buena); (22) NIC 24 (La Vainilla); (23) NIC 23 (includes general Juigalpa area); (24) NIC 22 (Cerro de la Vaca); (25) Rivas (general area); (26) San Dimas; (27) Bay of Salinas (general survey and Las Marias site); (28) El Jobo; (29) Guacamaya; (30) Portrero; (31) Bay of Culebra (general survey and Nacascolo, Panama Salinas, Puerto Culebra, Vidor, Papagayo, Hunter-Robinson, Ruiz, and Jicaro sites); (32) Hacienda Tempisque and general Tempisque Valley survey; (33) general Sardinal Valley survey; (34) Guaitil (modern samples); (35) Mojica; (36) Mendez); (37) Guayabo de Bagaces; (38) Nosarita; (39) Nosara; (40) Gulf of Nicoya (general survey); (41) Barrial de Heredia; (42) Central Valley of Costa Rica (general survey); (43) Atlantic watershed (general survey); (44) Chaparron; (45) Isla Cano; (46) UCR 43 (Guayabo de Turrialba); (47) UCR 53 (San Pedro); (48) (UCR 94 (Las Pilas); (49) UCR 143 (El Llano); (50) UCR 39 (Torrecillas); (51) UCR 101 (Playa Grande); (52) UCR 44 (Ciclope); (53) Paxte.

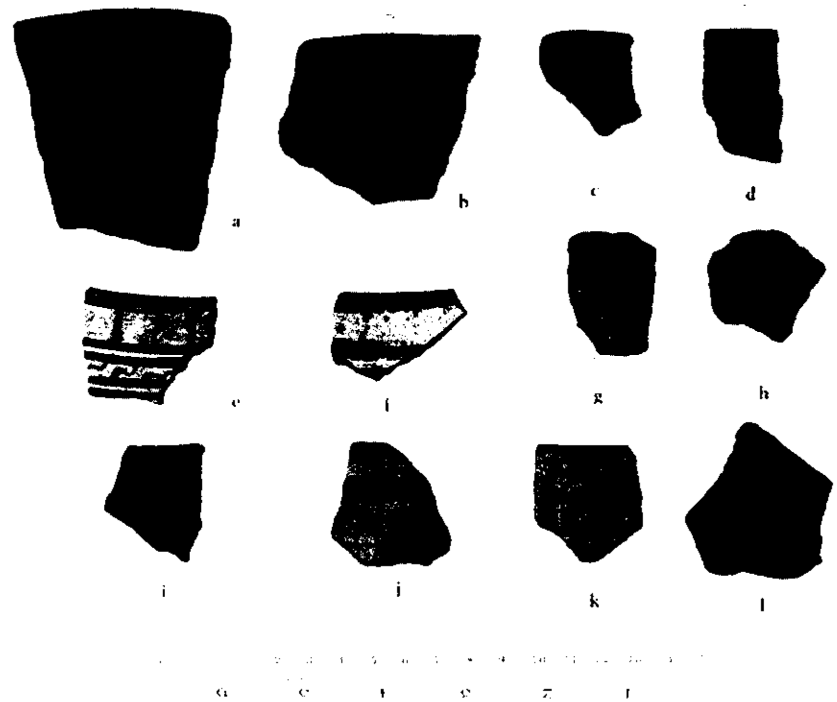

Figure 6.6. 1983 Nicaraguan survey, selected samples; (a) IO16, Leon Punctate; (b) IO21, Ometepe Red-slipped Incised; (c) IO17, Charco Black-on-Red; (d) IO24, Vallejo Polychrome, Vallejo variety; (e) IO39, Vallejo Polychrome, Vallejo variety; (f) IO39, Vallejo Polychrome, Vallejo variety; (g) IO44, Vallejo Polychrome, Mombacho variety; (h) IO10, Leon Punctuate; (i) IO27, Galo Polychrome, Jaguar Variety; (j) IO04, Vallejo Polychrome, Vallejo variety; (k) IO24, Vallejo Polychrome, Mombacho variety; (l) IO25, untyped.

relatively scarce in the northern sector, white-slipped pottery occurs frequently in the southern sector, probably as the result of trade (Bishop, Lange, and Lange 1988; Canouts and Guerrero 1988).

GN12 (52, 66): This distinctive compositional group contains all of the grouped specimens of Castillo Engraved (Figure 7.61b) and the Chávez White-on-Red (Figure 7.47b-c) ceramics. The latter ceramic type consists only of those with a Nicaraguan provenience. Chávez White-on-Red pottery with a southern sector provenience has been found to have a different compositional pattern. Tola Trichrome (Figure 7.46b-c) also has its main

Figure 6.8. 1983 Nicaraguan survey, selected samples, and comparative Greater Nicoya sherds showing visual similarities of group and nongroup samples; (a) IO33, Ometepe Red-slipped Incised; (b) IO07, Papagayo Polychrome; (c) IO43, Delirio Red-on-White; (d) IO14, Delirio Red-on-White; (e) IO32, Delirio Red-on-White; (f) IO51, untyped; (g) IO11, untyped; (h) R632, Mora Polychrome, Tambores variety (interior; member of CPCRU GN01); (i) RN61, Mora Polychrome, Tambores variety (interior), non-CPCRU.

representation in this group. While a few samples have a southern sector provenience, overall the ceramic types present an almost exclusive northern sector focus of production.

GN15 (15, 49): This group is made up of specimens of white-slipped Vallejo Polychrome (Figure 7.60b-d) with geographical distribution from the northern sector to the southern sector, including the western slope of the Cordillera of Guanacaste (Figure 6.7).

GN22 (6, 28): Representatives of the southern sector ceramic type of Bramadero Polychrome (Figure 7.62c) and northern sector types of Luna Polychrome (Figure 7.62a-b), and Madeira Polychrome (Figure 7.61c) constitute this compositional group. Geographic distribution is focused on the northern sector, but also extends into the southern sector (Figure 6.7).

GN23 (27, 66): As with GN22, the polychromes of the Bramadero, Luna, and Madeira ceramic types comprise this group. In comparison with GN22, this unit's geographical distribution is somewhat broader, as evidenced by one sherd of Luna Polychrome recovered from Isla del Caño (Figure 6.7). It is a moot point whether or not units GN23 and GN22 (above) represent different loci of production. The nature of their ceramic pastes, which show wide variation in the amount of iron oxides and ferromagnesium minerals (see below) and in the concentrations of rare earth elements, may represent slightly different weathering histories within a fairly localized area. If the two groups are merged into a single trial compositional group, the elemental variation becomes so broad that several samples in previously distinct groups are found to have high probabilities of group membership. Accordingly, GN22 and GN23 are retained as separate compositional units, related to one another in their pattern of divergence from other CPCRUs.

GN24 (17, 19): Most of these specimens are from the Zoned Bichrome period but include some later types, such as Charco Black-on-Red (Figure 7.45b-c) and Schettel Incised (Figure 7.43d). The geographical distribution of this group is almost exclusively in the northern sector (Figure 6.7).

The primary CPCRUs, consisting of sufficiently numerous samples to permit more rigorous statistical evaluation, and being chemically distinct and relatively "homogeneous" typologically, provide the basis for the characterization of compositional trends across the region defined as Greater Nicoya. In addition to these primary units, secondary Greater Nicoya CPCRUs can be recognized. In most cases, the samples which make up these secondary groups lie just outside of the confidence level used in defining the primary group and consist of the same ceramic types as the primary unit. A brief description of those groups that include Nicaraguan pottery is given below.

Northern Sector: Secondary CPCRUs

GN13 (13, 13): Although all members of this group have a northern sector provenience (8 of the 13 samples have been recovered from Ometepe Island), several types and all time periods are represented. As in GN15, representatives of the Vallejo and Papagayo types are present. Two Rosales specimens with an Ometepe provenience also contribute to this group. A northern sector affiliation for this group is unambiguous; however, the factors responsible for the group's chemical distinctiveness are unknown.

GN17 (1, 3): This "group" consists of two specimens that are outliers of the Vallejo Polychrome (GN15) group (Figure 7.60b-d), both with southern sector provenience. The one Nicaraguan survey specimen is not typed.

GN25 (3, 7): The three Nicaraguan specimens are part of a small group that consists of Bramadero Polychrome (Figure 7.62c), Luna Polychrome (Figure 7.62a-b), and Madeira Polychrome (Figure 7.61c). Among those with a southern sector provenience, one Luna Polychrome sherd was recovered from Isla del Caño, and one from near the Gulf of Nicoya (eastern shore).

GN26 (2, 9): These specimens are placed in a small compositional group that includes the southern sector Bramadero Polychrome and northern sector Luna Polychrome, Madeira Polychrome, and Vallejo Polychrome types. With the exception of two sherds from Rivas sites, the sherd proveniences are from the southern sector.

GN30 (5, 5): This is a group of non-typed, chemically similar pottery thought to date prior to A.D. 300. The entire sample was collected from sites that are in the northern half of the Isthmus of Rivas, beyond the northern limit of Greater Nicoya. Three of the samples carry an Usulután mode of decoration. Two of the samples, I012 and I057, have been identified by Robert J. Sharer as variants of Izalco Usulután, correct in base color and rim form; the eroded surface of I006 makes positive typological identification impossible. This group was compared against the Usulután samples (Bishop, Demarest, and Sharer 1989) in the Maya data base; no compositional agreement was found that would indicate a shared resource base. Instead, the composition of GN30 is closely similar to other reference units formed for Nicaraguan pottery. The Usulután mode of decoration appears to have been applied to pottery produced from local Nicaraguan raw materials.

GN32 (2, 8): The two Nicaraguan sherds are part of a small group consisting of sherds with proveniences in El Salvador and Honduras. Both sherds are of the Delirio Red-on-White type (Figure 6.8, c–e) and would seem to demonstrate trade/distribution southward from the Quelepa region of El Salvador.

GN33 (6, 7): The Nicaraguan survey sample represents the majority of specimens in this small group. Most of the sherds cannot be classified typologically. This, combined with wide geographic distribution for the pottery, makes archaeological interpretation of this group impossible.

GN36 (3, 5): Except for one sherd generally identified as Late Polychrome (based on the presence of white slip), this group consists exclusively of Papagayo Polychrome samples from both northern and southern sector sites. These samples fell just outside of the confidence interval used to define the major Papagayo-containing group (GN11).

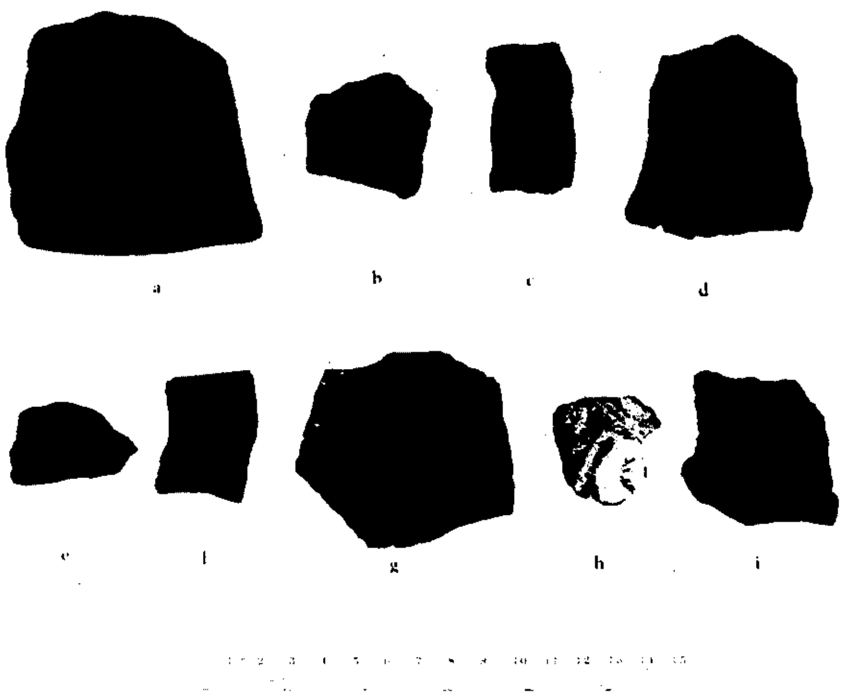

Figure 6.9. 1983 Nicaraguan survey, selected samples; (a) IO05 Potosi Applique, Potosi variety; (b) IO42 Leon Punctate; (c) IO36 Tola Trichrome, Tola variety; (d) IO03 Tola Trichrome, Tola variety; (e) IO09 Bocana Incised, Bocana variety; (f) IO47 Chavez White-on-Red, Chavez variety; (g) IO15 Madeira Polychrome, Madeira variety; (h) IO40 Pataky Polychrome, Pataky variety; (i) IO50 Sacasa Striated.

GN38 (29, 50): This compositionally broad but typologically restricted group consists primarily of Vallejo Polychrome and Papagayo Polychrome samples. Geographical representation extends from the Gulf of Fonseca, through the northern sector, and into the southern sector.

No Group Affiliation (80): There was a broad temporal and geographical range among the pottery analyzed from Nicaragua that could not be ascribed membership in any of the defined primary or secondary reference groups. If any pattern is discernible, it is that a disproportionate number of Zoned Bichrome and Early Polychrome specimens failed to be attributed to a reference unit. Viewed from the perspective of the total Greater Nicoya data base, we suspect that a lack of patterned relationship for samples from these

early periods indicates less refinement of a greater range of ceramic materials utilized at a larger number of production centers. However, support for this interpretation will require an extensive technological characterization program.

Southern Sector: Secondary CPCRUs

GN02 (2, 12): One of the two Nicaraguan specimens is untyped, and the other is a Potosí Appliqué sherd (Figure 7.48b-d). The rest of this secondary group is composed of southern sector types, with a geographical distribution in the southern sector as far south as Isla del Caño (Figure 6.7).

GN35 (1, 4): One Nicaraguan specimen of Galo Polychrome is chemically similar to other Galo Polychrome specimens recovered from Costa Rica. Based upon distributional evidence for the type, these specimens may represent the movement of southern sector pottery north into Nicaragua.

Petrographic Summary

The analytical results of the INAA program indicated some clearly-defined groups, but also revealed some questionable variation among uncontrolled variables. For example, in the case of two sherds that looked very similar in terms of surface finish and shared the same type/variety designation, one might be included in a group, while the other would fall outside of the utilized confidence interval and thus would be placed in the "Non-Affiliated" group. Clearly, variation in the nonplastic inclusions in the ceramic pastes could account for some of these results (Neff, Bishop, and Sayre 1988). Equally clear is that our generalized knowledge of the regional geology is inadequate to permit strong inferences to be made about the sources of observed chemical variation.

Recognizing the need to isolate geological factors that might be important in the modeling of subregional ceramic production, we initiated an exploratory program of petrographic thin section analysis. The purpose was twofold: (1) to provide data on the underlying mineralogical basis for the observed chemical variability through the identification of the nonclay materials in the ceramic paste, and (2) to provide information about the geological history of the minerals in the paste by identifying the kinds, sizes, associations, and the degree of mechanical or chemical weathering of inclusions.

Sampling for petrographic analysis was not extensive. In general, two or three sherds were selected from each of the primary CPCRUs; some of the secondary reference units also were sampled. The ceramic specimens selected were considered to be unambiguous compositional group members and have clear typological attribution. For large groups, such as those consisting of the Papagayo or Mora polychrome types, additional samples peripheral to the distribution were selected to see if discernable mineralogical differences might covary with the chemical divergence (Bishop, Lange, and Lange 1988).

Minerals identified through the petrographic examination included quartz, feldspars (including plagioclase), clinopyroxene, orthopyroxene, biotite, and hornblende. Especially important for the characterization of Greater Nicoya pottery was the recognition of three modes of occurrence for andesitic rock fragments. The first (denoted AND I) is an andesite ash flow tuff or ash flow containing a characteristic clear-glass groundmass accompanied by microlites of minute plagioclase laths and magnetite cubes. A second occurrence of andesite rock fragment (AND II) was in the form of andesite vitric-crystal (tuff?) with a brown glass. This category contains a distinctly higher percentage of light brown glass than AND I but a smaller percentage of plagioclase and magnetite microlites. AND II is considered to be silica-poor relative to AND I. The third category (AND III) is an andesite consisting of distinct grain sizes (porphyry) with a high FeOx content. This reddish-brown andesite contains dense, randomly oriented, well-formed, and twinned plagioclase laths within a groundmass of hematite.

Combining the mode of occurrence for the andesitic rock fragments with other petrological information, the results of the petrographic analysis of Greater Nicoya pottery can be summarized using three broad categories. Two of these categories are characteristic of pottery from the northern sector: one includes the samples from Nicaraguan groups GN12 and GN15 and is characterized by the presence of pumice fragments; the second category includes the compositional groups GN11, GN15, and GN 23 and consists of ceramics which contain pyroxene andesite porphyry with a high FeOx content. A final category consists of pottery containing clays rich with andesite ash flow tuff or flow materials, mineralogical characteristics that are not present in our chemically-defined Nicaraguan-focused groups.

The petrographic trends can be illustrated relative to the chemical data presented in the principal components plots discussed above. Inspection of Figure 6.5, representing the major compositional differences between the southern and northern sectors of Greater Nicoya, reveals that the plot is essentially divided into thirds, left to right. Pumice inclusions are common to abundant in the pottery represented in the center of the plot but absent in the groups on either side. Andesitic ash-flow tuffs, abundant hornblende, and biotite inclusions characterize the southern sector's distinctive Mora and Galo groups. On the right side of the plot, pyroxene andesite porphyry and darkly iron-stained minerals and clays are characteristic of the Luna-containing groups GN22, GN23, and GN25 and the Charco-Schettel group, GN24. In the center of the figure, pumice occurs in varying abundance,

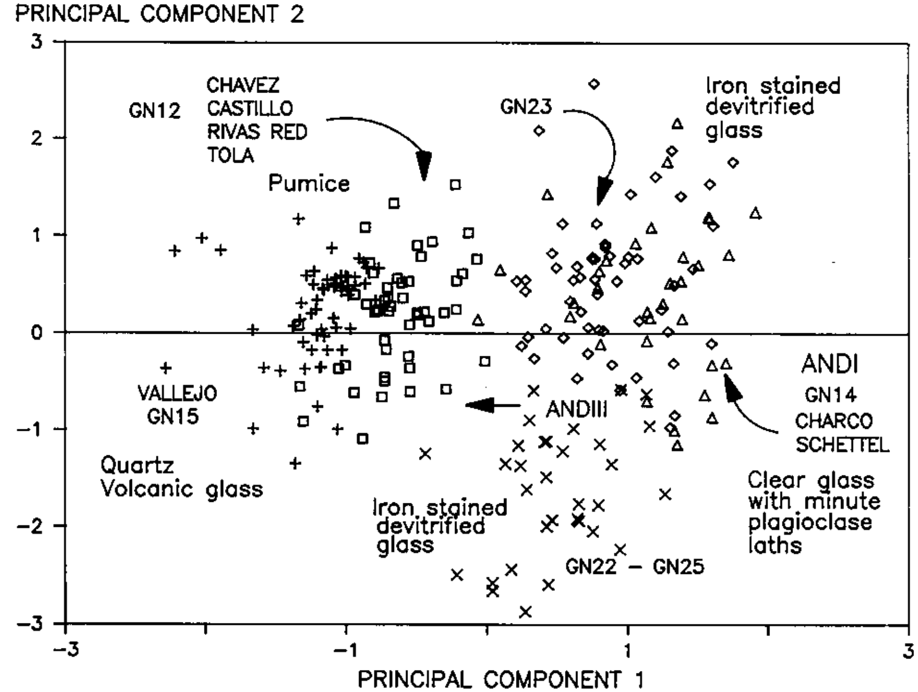

Figure 6.10. Bivariate plot of principal components 1 and 2 derived for Northern Sector CPCRUs. Component loadings given in Table 3; petrographic characteristics of represented CPCRUs added.

being moderate in Papagayo-Pataky dominated GN11, to abundant in the Chávez-Castillo-Rivas Red-Tola group (GN12). Reference unit GN11 (Papagayo-Pataky) is distinguished by its abundant plagioclase.

Figure 6.10 summarizes the volcanic-derived nature of the clays utilized in the production of Nicaraguan pottery in more detail, relative to the principal component analysis that excluded the Mora and Papagayo groups. The Vallejo Polychrome reference units GN15 and GN17 (not differentiated on the plot) contain pumice, clear glass shards, and quartz grains. The Vallejo groups are not only chemically differentiable from the pottery of GN12 (Chávez, Tola) but mineralogically as well, for the pottery of GN12 lacks the quartz grains. Toward the right-center of the plot, the AND III Luna-inclusive groups occur with their iron-stained, devitrified glass inclusions. Reference unit GN24, made up of pottery from the Charco and

Schettel ceramic types, is mineralogically separable from the Luna-inclusive groups by the lower abundance of clinopyroxenes of the augite series in its member samples.

Conclusions

The INAA analyses and characterizations reviewed in this chapter have contributed to (1) our interpretation of the Nicaraguan and Greater Nicoya ceramic data, and (2) the future analytical requirements for expanded research on ceramics from the area. Contributions to these separate but closely related objectives are summarized below.

Interpretation: The reality of the northern-southern sector differences has been reinforced. The "ceramic zones" that originally were defined on the basis of stylistic distribution and macroscopic examination of paste and temper characteristics generally have been borne out by the chemical and petrographic analyses. In addition, several broad compositional trends may be observed in the data, and we can begin to allude to geographic patterns within each sector.

To the extent that the mineralogical differences noted above are representative of the different CPCRUs, general northern-southern sector divisions were indicated in the characterization of each CPCRU. The northern sector ceramics generally are characterized by an abundance of volcanic glass shards or by pyroxene andesite porphyry with well-formed plagioclase in a hematite groundmass. Southern sector ceramics are characterized in more detail in Bishop, Lange, and Lange (1988). In the northern sector at least two distinct zones of production are inferred:

1. the region of the modern international border with Costa Rica, where Nicaraguan pottery from the Isthmus of Rivas can be identified and clearly distinguished from pottery produced in the south, whether on the Nicoya Peninsula, along the Pacific coast, in the Tempisque Valley, or in the Cordillera of Guanacaste; and
2. the northern Pacific coastal region, approximately from the area of Managua to the Gulf of Fonseca.

The occurrence in Nicaragua of pottery from Honduras and El Salvador to the north has been documented, as has the diffusion of technological information regarding the Usulután mode of decoration. Whereas in the past the occurrence of Usulután style decoration in Greater Nicoya was minimally seen as a chronological horizon marker, and at worst as an example of mesoamerican domination, we can now state that the limited sample tested thus far was produced in Greater Nicoya.

Evidence of the trade of ceramics from Costa Rica into Nicaragua, while quantitatively quite limited in the current data base, is demonstrated during the Early Polychrome period by the presence of Galo Polychrome in Nicaragua. The few Galo sherds analyzed were all from Costa Rica. The absence of larger quantities of Costa Rican manufacture is somewhat perplexing, since the stylistic influence is clearly from the southern Maya area, with striking visual similarities to Ulua Polychrome (Joyce 1985, 1988).

Trade from Nicaragua to Costa Rica is more apparent in the large quantities of Papagayo Polychrome, Vallejo Polychrome, and other types and varieties of Nicaraguan manufacture which are found throughout northwestern Costa Rica and even beyond, though in greatly reduced quantities. Other interpretive implications of the INAA data are presented in Chapters 7 and 8.

Analytical Techniques: The study of ceramic production and distribution through the chemical characterization of ceramic pastes is dependent upon the formation and evaluation of groups of similar pottery and the ability to separate these formed groups from others similarly formed. The sherd-specific discussion in this chapter was set within the context of all of the analyzed Nicaraguan ceramics and the distributional patterns previously established for the Greater Nicoya subarea (Bishop, Lange, and Lange 1988). Attribution of individual specimens to large compositional units followed by statistical evaluation strengthens the derived inferences.

Examination of the groups, including Zoned Bichrome period and some Early Polychrome period materials, reveals inclusions of large, pyroclastic materials (temper) which create excessive analytical background noise. In such samples, thin section analyses will be more productive. INAA was helpful in defining these groups to the extent that they did not cluster tightly in the earlier trial formulations of the CPCRUs.

Technologically, we have made the complete loop from lower power hand lens inspection of ceramics, to neutron activation, and back to microscopic analyses of thin sections. The different types of data have provided supplemental information and we have gained varying degrees of inferential confirmation concerning the pattern of ceramic production and distribution in Greater Nicoya. We conclude that petrographic distinctions among many of the principal northern and southern sector types and varieties can be discerned with "low-power" approaches (such as hand lenses) in many cases and thin section examination with a petrographic microscope in almost all others. Rather than overly depending on a single analytical technique, the greatest productivity has come in the interplay between the INAA and thin section data.

The opportunity to make such differentiations in the majority of cases without having to resort to techniques such as instrumental neutron activation analysis offers the potential for more rapid advancement of future studies of ceramic production and exchange in Greater Nicoya. This will permit relatively scarce analytical resources like INAA to be applied more selectively in those instances where extra analytical sensitivity is demanded by sharply focused questions.

This will also have the highly desirable outcome of facilitating transfer of primary analytical responsibility to archaeologists and analytical facilities within Nicaragua and Costa Rica.

7 Data Analysis

Lithic Overview

As a whole, the western Nicaraguan lithic assemblage recovered during the survey presents local solutions to local needs. These solutions certainly were not dominated by external cultures or technologies. Although there is some evidence of mesoamerican contact, it is a thin, late, and spotty veneer concentrated in the Managua-León area. Pacific Nicaragua is characterized by considerable regional variation in lithics, as shown by differences in raw material outcrops and use, in implement forms, and probably in functions.

The attempt has been made to convey regional variation by classifying sites into four zones. Lithic data are summarized by zone in Table 7.1 and by site in Table 7.2. The first two columns list the total number of artifacts and the number of non-obsidian artifacts per site. The quantity of non-obsidian (waste) is listed in column 3, followed by its mean weight in column 4 (the mean weight of debitage can be indicative of relative availability or scarcity of raw material). The number of obsidian artifacts is given in column 5, the number of percussion flakes in column 6, the mean weight of the percussion flakes in column 7, and the number of percussion cores from which they were derived in column 8.

Mesoamerican connections are indicated by the presence of prismatic blades (Figure 5.1). When the platforms (i.e., proximal ends) are preserved,