OBSIDIAN SOURCES AND ELEMENTAL ANALYSES OF ARTIFACTS IN SOUTHERN MESOAMERICA AND THE NORTHERN INTERMEDIATE AREA

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Obsidian sources, and the proportions of those sources represented in site collections, are known poorly in the southeast mesoamerican periphery. The Honduran sources of La Esperanza and Güinope are described and "fingerprinted" chemically, and their utilization is explored in selected sites in Honduras, Nicaragua, and Costa Rica. Although prehistoric Nicaraguans and Costa Ricans used obsidian from sources as far away as Honduras and Guatemala, most of their cutting tools were made from local materials, using informal manufacturing techniques. The analytical results indicate two sources of new types of obsidian have yet to be found; they may lie in western Nicaragua.

Los fuentes naturales de obsidiana, y como ellos estan representados en colecciónes de sitios arqueológicos, no son bien conocidos al suroeste de Mesoamerica. Datos descriptivos y quimicos de los fuentes hondureños La Esperanza y Güinope son presentados. Tambien, la llegada y uso de la obsidiana de estos fuentes en sitios arqueológicos en Honduras, Nicaragua, y Costa Rica son considerados. Aunque los indios prehistóricos de Nicaragua y Costa Rica usaron obsidiana de Honduras y Guatemala, de fuentes a larga distancia, hicieron la mayoría de sus artefactos para cortar de materiales locales, con un têcnico no complicado. Los datos indican que por lo menos hay dos tipos de obsidiana en la zona con fuentes todavía desconocidos; tal vez queden en el oeste de Nicaragua.

The major natural sources of obsidian in Mesoamerica, lying in central Mexico and in the Guatemalan highlands, have been analyzed for their major and trace elements, and each has a distinctive chemical "fingerprint" (e.g., Asaro et al. 1978; Stross et al. 1983). Obsidian artifacts from numerous mesoamerican sites have been analyzed, and the percentages of the various sources, in different phases, have contributed important information on resource exploitation and trade networks.

In contrast, obsidian sources in the southeastern periphery of Mesoamerica have been neglected, and obsidian artifacts from sites in this area and lower Central America have not been analyzed regularly to determine sources. Here, we describe two sources in southern Honduras and present the results of analyses of obsidian from selected sites in Honduras, Nicaragua, and Costa Rica.

The Honduran source of La Esperanza has been mentioned in published literature, but not always accurately. The Güinope source has not been described before. The data indicate at least two sources of obsidian have yet to be found in situ; they may lie in western Nicaragua.

OBSIDIAN SOURCES

The La Esperanza Obsidian Source

The La Esperanza obsidian source is located in the southwestern highlands of Honduras, in the Department of Intibuca (Figure 1). The source was first reported by Lunardi (1948). About a decade

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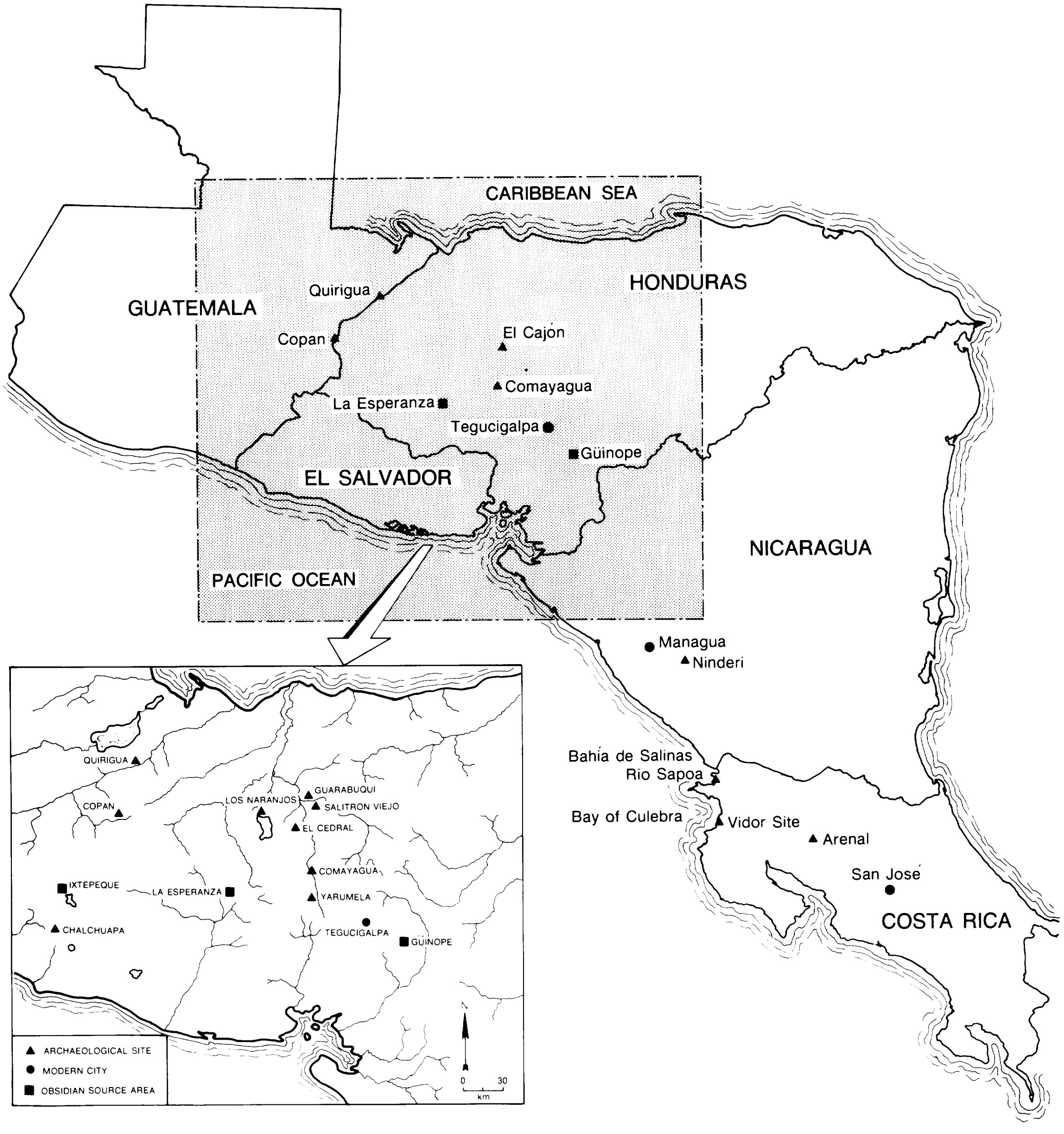

Figure 1. Southern Mesoamerica and the Northern Intermediate Area. Inset map, at same scale, identifies archaeological sites and obsidian sources.

later Plowden examined sites in the La Esperanza area over a period of a few years. He was joined in 1962 by Bullen, and the two published an article on their findings (Bullen and Plowden 1963), apparently unaware of Lunardi's work. Although they did not realize there was an obsidian source at La Esperanza, they did find evidence of occupation and obsidian use extending from the Paleoindian through the Classic periods, and perhaps later. A fluted base of a finely flaked biface, likely a Clovis point, is evidence of Paleoindian occupation of the area, and probably indicates use of the La Esperanza obsidian source at that time. The abundant prismatic blades and polychrome ceramics at various sites in the La Esperanza area indicate source utilization at least during the Classic period, and likely during the Preclassic and Postclassic periods as well. The "narrow-stemmed points" Bullen and Plowden (1963:385) attribute to an early ceramic horizon at site Ib-22 are very

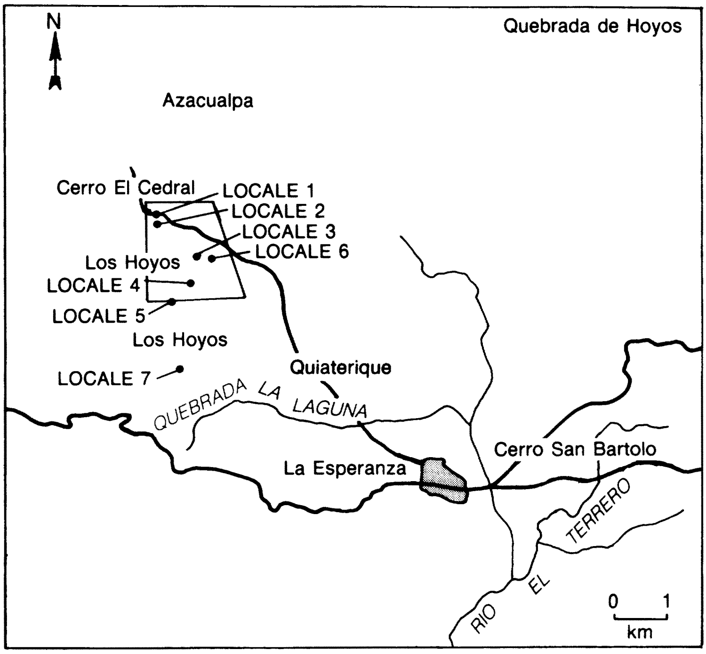

Figure 2. Obsidian locales at the La Esperanza obsidian source, southwestern Honduras. Roads are indicated by darker lines.

similar to the "pointed stem, ovate blade" bifaces common in western El Salvador, dated to the Postclassic period (Sheets 1978:23:Figure 2b2-3). They may have erred occasionally in assuming that some aceramic lithic sites were preceramic. That would lead to an overassignment of collected materials to the Archaic period, and an underrepresentation of later use and manufacture.

Some of Bullen and Plowden's reasoning errors may have been duplicated by Coe and Flannery (1964), who surface collected a small locality within the huge El Chayal obsidian outcrop–workshop complex in Guatemala. Noting the lack of ceramics and prismatic blades, they concluded the industry probably was aceramic, hence preceramic, and thus either Paleoindian or Archaic. The lack of clear Paleoindian diagnostic artifacts led them to conclude that the workshop was probably Archaic. The assumption that the full artifact inventory of a society would be deposited at a specialized quarry and performing workshop is unwarranted, and the bulk of the artifacts they collected more likely date to the Late Classic and Postclassic, millennia later than Coe and Flannery suspected (Sheets 1975).

More recently, the Proyecto Arqueológico El Cajón continued exploring obsidian exposures and technology in the La Esperanza area. In 1980 Dennis Coskren and Vito Veliz located and collected obsidian samples from an outcrop in a road cut near Cerro El Coyote, 2 km west of Quiaterique (Figure 2, site 7). Chapman (1982) independently reported large quantities of obsidian in the low hills of El Cedral, 4 km northwest of the town of La Esperanza. A local informant look her to the area called "Los Hoyos," where she saw evidence of prehistoric subsurface mining of obsidian. Because of Chapman's (1982) report, the El Cedral area was surveyed by project members in 1983. Obsidian outcrops, quarry, and mining areas, as well as several production workshops and utilization areas were identified in the El Cedral region. The survey of the La Esperanza source area is described more fully by Sorensen and Hirth (1984). Their results are summarized here.

Survey of the El Cedral hills by Hirth and Sorensen identified six sites where obsidian was either outcropping or was worked (Figure 2). Obsidian nodules ranging from 1 to 30 cm in diameter were observed over more than a kilometer along a road running along the eastern flank of El Cedral. Evidently they had washed downslope and were exposed along the road cut and in small *quebradas* draining the hillside. A local informant indicated that water-worn cobbles can be found in small drainages around the entire base of El Cedral.

The prehispanic mining area at the summit of El Cedral, known locally as Los Hoyos (Figure 2, locale 5), first reported by Chapman (1982), was examined more closely. The mines consisted of narrow vertical shafts that directly descended onto the top of the obsidian flow. More than 30 shafts and shallow shaft depressions were observed at site 5, which covers an area approximately 1 ha in size. No attempt was made to either map or record accurately all of the mines because of limited time and the danger of falling into shafts partially covered by a thin veneer of humus, sticks, and leaves. That hazard is the reason why local inhabitants avoid using the area for grazing or agriculture. It is likely that there are more than 100 mine shafts in the area. Large piles of obsidian debitage were identified immediately adjacent to the mines, where initial reduction was carried out. Local informants reported a second, similar mining area on the top of Cerro El Coyote, near site 7 (Figure 2).

A lithic analysis by Sorensen (Sorenson and Hirth 1984:41) indicated that a wide variety of tools were manufactured at or near the Los Hoyos source, including rough cores, bifaces, unifaces, and polyhedral blade cores. The waste materials located at sites 4 and 5 have the same characteristics as workshops at El Chayal, Ixtepeque, and Otumba, where large waste piles include primary flakage, abandoned percussion cores, and some broken bifaces and preforms (Coe and Flannery 1964). No evidence for the production of finished tools was found at either the mines or the workshops.

The Güinope Obsidian Source

The Güinope obsidian source is located in the Honduran Department of Paraiso, near the town of Güinope, 35 km southeast of Tegucigalpa (Figure 1). To our knowledge the Güinope source has not been reported previously in the anthropological literature, and still remains to be surveyed in a comprehensive manner. Dennis Coskren, of the El Cajón Archaeological Project, visited the area in 1980, to investigate informal reports to the Instituto Hondureño de Antropología e Historia that an obsidian source might be located near Güinope.

Obsidian samples were procured by Coskren from river gravels near the bridge that crosses over the Quebrada Grande, 1.75 km west of the modern town. Obsidian was abundant along the floor of the *quebrada,* occurring as exposed, water-worn cobbles ranging from 1 to 15 cm in diameter. No attempt was made to locate the original source of the obsidian, but Coskren felt it probably was to the south. Rough percussion flakes, small flake cores, and some debitage were identified along the *quebrada,* but nothing that resembled a production workshop was encountered during this brief visit.

Further survey during the summer of 1987 by Hirth established that the dispersed source for this obsidian lies in the Cerro Grande area near Cerro Loma de Pie 3 km south of Coskren's original collection area. While no obsidian outcrops were identified during the survey, obsidian cobbles between 1 and 10 cm in diameter were noted in the soil matrix and in small *quebradas* over the 3 km^2 area between locale 1 and the Cerro Loma de Pie (Figure 3). Local informants, interested in exploiting the possible commercial potential of obsidian, report that no exposed in situ concentrated outcrop exists anywhere in the Güinope region. Obsidian apparently occurs only as rock debris left as erosional "float" from an ancient obsidian flow.

No conclusive evidence for prehistoric mining activities was found during the 1987 survey. No evidence for vertical shaft mines similar to those at Los Hoyos near La Esperanza were observed or reported by local informants. Rather, obsidian from the Güinope zone apparently was collected from colluvial and alluvial deposits from the Cerro Grande area. The outline of a trench approximately 15 m in length was observed at the base of Cerro Loma de Pie (locale 3). It exposed soils with a high proportion of obsidian, including cobbles larger than those available on the surface. Local informants were not aware of any historic or recent activity that could have resulted in that trench. It is possible that the trench could be prehistoric, and that trenching was used to obtain larger cobbles.

Lithic tools manufactured from obsidian were recovered sporadically throughout the survey area, but not in quantities or types that would indicate specialized production. Tools included large and

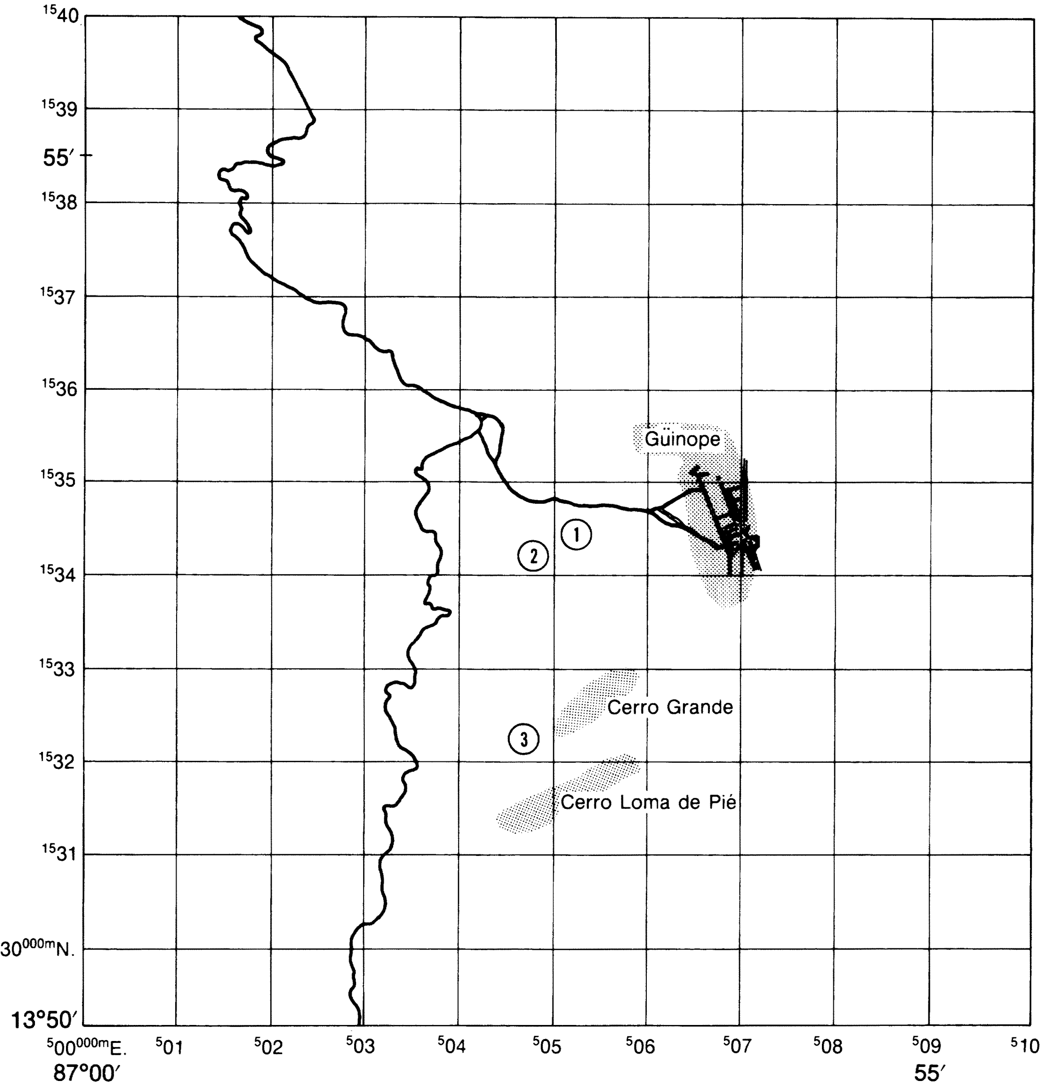

Figure 3. Three collection locales in the Güinope obsidian source, southeastern Honduras. Roads indicated; grid squares are 1 km^2.

small percussion flakes, percussion-flake cores, and unifacially retouched flake tools. No evidence was recovered that indicated either prismatic-blade manufacture or bifacial manufacture. It is important to note that the obsidian cobbles observed at Güinope rarely exceeded 10 cm in diameter, and therefore, obsidian-nodule size itself would not be an encouragement to core-blade technology. While a variety of percussion-flake cores and tools could be produced from the majority of Güinope cobbles, most are too small to be transformed into percussion macrocores and then into polyhedral cores for the pressure manufacture of prismatic blades.

Occurrence of Obsidian from the Güinope and La Experanza Sources in Central Honduran Archaeological Sites

Recent source analysis of obsidian from the El Cajón region in central Honduras (Hirth 1985, 1988) has established that Güinope and La Esperanza material composed a significant proportion of the obsidian assemblage for all periods for which analyses were conducted (Late Formative-Late Classic period). A total sample of 123 obsidian artifacts were analyzed using particle induced X-ray emission analysis at Western Michigan University, under the supervision of Steve Ferguson. Obsidian artifacts were analyzed for amounts of Sr, Rb, Zr, Mn, and Fe; provenience determinations were made by plotting relative amounts of these elements on ternary diagrams (3-pole graphs), and by then comparing them to source samples analyzed using the same technique.

Güinope materials occur in low frequencies in Late Formative deposits at the site of Salitron Viejo, where they constitute approximately 4 percent of the total sample (N = 28). The major obsidian source utilized during the Late Formative appears to have been La Esperanza, which constituted 70 percent of the analyzed collection.

Güinope obsidian rises in frequency during the Early and Middle Classic periods. At Salitron Viejo, Güinope obsidian constitutes 12 percent of the collection (N = 34) while at the site of La Ceiba it represents 36 percent of the analyzed sample (N = 69). While Güinope obsidian continues as an important source into the Late Classic, it occurs in slightly lower frequencies at the site of Guarabuqui. Here Güinope obsidian constitutes 5 percent of the analyzed Late Classic materials (N = 20).

An important characteristic of the Güinope obsidian used in these sites is that it only occurs as simple flakes and percussion tools. All prismatic-blade manufacture was carried out on cores from the La Esperanza, Ixtepeque, or El Chayal sources (Hirth 1988:Table 4). A complete analysis of the lithic assemblage, being conducted by Jerrel Sorensen, indicates a higher frequency of prismatic blades in the collection than would be expected by the number of exhausted obsidian cores. Polyhedral cores, core-rejuvenation artifacts, and core-shaping debitage are rare in project collections; only one polyhedral core was recovered. It appears that trade for both finished blades and performed cores was going on simultaneously throughout the El Cajón region. It appears that some prismatic-blade manufacture was done in the El Cajón region, but the bulk of prismatic blades were manufactured outside the region, perhaps in the nearby Comayagua area.

Flakes and tools fashioned from Güinope obsidian have a high frequency of unremoved exterior cortex. It appears that much of the Güinope obsidian was traded into the El Cajón region as small, unworked cobbles that were reduced locally using simple percussion techniques. Flake tools also were fashioned from small cobbles derived from the La Esperanza area. This closely parallels obsidian tool manufacture at Quirigua, where the Classic Maya preferred core-blade technology on large cobbles brought in from El Chayal, but other valley residents collected small obsidian nodules from alluvial deposits and used exclusively percussion techniques to generate flake tools (Sheets 1983). Obsidian flakes and percussion tools are much more abundant in central Honduras than in many other areas of Mesoamerica, where prismatic blades are accessible more readily (Jerrel Sorensen, personal communication 1988). Of the total sample of 80 percussion tools analyzed for source provenience, 48 percent (N = 38) are from the La Esperanza source, and 38 percent (N = 30) are from Güinope. The quantity of Güinope obsidian may even be higher than that reported here. An unidentified source similar in several chemical characteristics to Güinope accounts for approximately 14 percent (N = 12) of the percussion-tool assemblage; future reconnaissance might locate this flow within the Güinope source area.

Analytical Methods

In this study, 14 Nicaraguan and four Costa Rican samples were analyzed by X-ray fluorescence (XRF) and neutron activation (NAA) at the Lawrence Berkeley Laboratory, University of California.

Procedural details, error estimates, and the composition of Standard Pottery are described in Perlman and Asaro (1969, 1971). Additional details of the method are given in Stross et al. (1983).

The most significant elements measured by XRF generally are Ba, Rb, Sr, and Zr. Also measured are Fe, Ce, Zn, Y, and Nb, and may be used in identification, especially if their abundances are unusually high. Variations in sample size and shape introduce errors in the nondestructive XRF procedure. Thin samples measured against thicker standards tend to yield values higher than the true values. The use of abundance ratios of elements having nearly the same energy (e.g., Rb, Sr, and Zr) largely cancels this error. The measurements are calibrated with El Chayal reference obsidian, with abundances of Ba, Rb, Sr, and Zr taken as 915, 149, 153, and 117 ppm respectively (Asaro et al. 1978; Stross et al. 1983).

The abundances (i.e., of Ba) or ratios (i.e., of Rb, Sr, and Zr) are calculated for the individual samples. The mean values are calculated for each group having a common provenience assignment. In addition, the standard deviations or root-mean-square deviations (RMSD) in these values are calculated and compared with statistical errors inherent in counting radioactivity; this permits evaluation of the performance of equipment and procedures.

If the RMSD of the critical elements in a group is less than 10 percent, and no sample has abundances diverging by three standard deviations or more from the mean, all the artifacts probably have the same provenience. If the RMSD for a provenience group is less than approximately 10 percent, and the group agrees to better than 10 percent with a reference group, it is assigned provisionally to the reference group. A high-precision, destructive, "short" neutron activation analysis is then made of a representative member of the group. If the abundances of an artifact agree within three standard deviations of the errors of measurements or of the RMSD of the NAA reference group, the assignment of the artifact to the reference group is confirmed. The assignments of all the artifacts in the provenience group also are considered confirmed.

Any artifact whose XRF composition does not conform to the criteria stated also is analyzed by a short NAA, and if assignment still cannot be made, often by an "extended" NAA. If the composition still does not match any of the sources known to us, it can at least be excluded positively from those sources.

In a short NAA, the elements measured are Mn, Dy, Ba, Na, and K. In an extended measurement, U, Ba, La, Ce, Sm, Eu, Yb, Co, Sc, Fe, Th, Cs, Rb, Hf, and Ta (as well as elements usually not listed) are well determined in most obsidians. The uncertainties of the calibration standard, Standard Pottery, are the major sources of systematic uncertainty after other systematic errors, believed generally to be smaller than the counting errors, have been taken into account. Standard Pottery is one of the very few standards in which the uncertainties are known for nearly all of the elements that we measure.

Generally, if an obsidian artifact belongs to a well-defined group, the abundances in the artifacts of the best-measured elements (usually 14–16 are taken) will deviate from those of the reference group by no more than 2–3 percent on the average. Appreciably greater deviations normally are taken to indicate a different source.

Analytical Results: Occurrence of Honduran and Guatemalan Sources of Obsidian in Nicaraguan and Costa Rican Archaeological Sites

Of the 14 Nicaraguan obsidian specimens subjected to elemental analysis, nine were artifacts from the site of Ninderi, and were donated for analysis by the Museo Tendiri. The other five obsidian specimens from Nicaragua were source or possible source samples. Three of the four Costa Rican samples analyzed during this study were artifacts, and one was not flaked clearly. The latter may be a prehistorically transported source sample.

The nine Nicaraguan artifacts, all from the site of Ninderi, fell into two homogeneous groups. Three of these artifacts, with the Berkeley catalog numbers NICA-9, -10, and -12, match the Ixtepeque (Guatemala) source on the basis of X-ray fluorescence analysis (Table 1). All three are prismatic blades, manufactured by the sophisticated mesoamerican core-blade system. This assignment for NICA-9 was confirmed by an "abbreviated" neutron activation analysis (Table 2). We consider a confirmation by NAA of the provenience assignment for one member of a group defined by XRF measurements as a confirmation of the entire group.

Ixtepeque is located north of Lake Guija, just inside Guatemala, a straight-line distance of 465 km. This confirms a direct connection with Mesoamerica, specifically with the Maya area. The Museo Tendiri samples did not have any chronological context, but lithic technological evidence indicates that the trade took place during the late Period V or early Period VI (periods from Lange and Stone [1984:7]), relating to the mesoamerican Terminal Classic and Postclassic. The prismatic

Table 1. Elemental Abundances and Ratios of Obsidian Artifacts from Ninderi, Nicaragua, by X-ray Fluorescence.

	Ba[a] (ppm)	Zr[a] (ppm)	Rb/Zr	Sr/Zr
Ixtepeque Provenience				
NICA-9	1,127	216	.53	.88
NICA-10	1,198	214	.54	.87
NICA-12	1,229	204	.50	.81
Mean	1,185	211	.52	.85
RMSD			.02	.04
Ixtepeque Reference[b]				
Abundance or Ratio	1,030	176	.57	.90
Error	27	6	.01	.02
Güinope Provenience				
NICA-6	1,070	120	1.43	1.61
NICA-7	1,038	128	1.39	1.64
NICA-8	1,094	154	1.46	1.72
NICA-11	1,173	138	1.38	1.60
NICA-13	1,233	141	1.39	1.65
NICA-14	1,082	138	1.42	1.69
Mean	1,115	136	1.41	1.65
RMSD			.03	.05
Güinope Reference				
Abundance or Ratio	1,070	134	1.39	1.53
Error	44		.09	.09

[a] The abundance levels of these elements depend on the shapes and thickness of the samples and are only approximate. The use of ratios (Rb/Zr and Sr/Zr) of abundances largely compensates for these variations.

[b] Stross et al. 1983.

blades collected by Lange and Sheets during the 1983 survey consistently came from later sites, and when they had intact platforms, they were large, with minimal overhang removal, and highly pecked and ground. Such platform-surface and edge preparation is characteristic of the last six centuries prior to the Spanish Conquest.

The other six artifacts from Ninderi (three percussion flakes and three prismatic blades) fell into a group of matching compositions on the basis of XRF, which match the Güinope source (Table 1). In order to obtain a better chemical description of the source, we completed our neturon activation measurements on two of the samples (NICA-6 and NICA-8) and carried out an additional abbreviated NAA on another one (NICA-11) (Table 3).

Table 2. Elemental Abundances of an Obsidian Artifact from Ninderi, Nicaragua, and Guatemala Reference, by Abbreviated NAA.

	NICA-9 (Ninderi Artifact)	Ixtepeque Reference[a]
Al (%)	7.15 ± .10[b]	7.24 ± .20[c]
Ba (ppm)	1,041 ± 36	1,030 ± 27
Dy (ppm)	2.43 ± .12	2.30 ± .11
K (%)	3.60 ± .29	3.61 ± .26
Mn (ppm)	454 ± 9	449 ± 9
Na (%)	3.13 ± .06	3.05 ± .06

[a] See Asaro et al. 1978 and Stross et al. 1983.

[b] Error is typical counting error.

[c] Error is root-mean-square deviation.

Table 3. Elemental Abundances of Obsidian Artifacts from Ninderi, Nicaragua; Rio Sapoa, Costa Rica; and Güinope, Honduras, Sources by NAA.

	NICA-6		NICA-8		NICA-11		COST-2		Reference: GÜINOPE	
	Abundance	Error	Abundance	Error	Abundance	Error	Abundance	Error	Abundance	Error
% Al	6.92	.08	7.03	.09	6.92	.12			6.87	.17
Ba	1,031	24	1,010	34	1,063	38	994	45	1,000	20
Ce	51.2	.5	50.0	.9			50.2	.7	50.8	.8
Co	.51	.05	.46	.05			.53	.07	.59	.05
Cs	8.02	.11	7.98	.12			7.91	.13	7.88	.10
Dy	2.53	.12	2.61	.12	2.56	.12	2.40	.12	2.52	.10
Eu	.526	.009	.504	.009			.513	.008	.504	.008
% Fe	.878	.013	.875	.012			.872	.012	.872	.016
Hf	3.31	.06	3.16	.06			3.26	.06	3.28	.06
% K	3.59	.24	3.54	.29	3.36	.28	3.71	.26	4.09	.25
La	28.4	.5	28.0	.5			27.2	.7	28.3	.6
Mn	520	10	514	10	518	10	510	10	519	10
% Na	2.73	.05	2.73	.05	2.69	.05	2.71	.05	2.70	.05
Rb	181	11	168	7			163	6	161	20
Sb	.43	.07	.30	.05			.43	.06	.48	.07
Sc	2.14	.02	2.12	.02			2.19	.02	2.13	.02
Sm	3.05	.03	3.04	.03			3.07	.03	2.98	.03
Ta	.873	.009	.862	.009			.899	.009	.894	.009
Th	12.00	.12	12.02	.12			12.08	.12	12.06	.13
U	3.99	.04	3.95	.04			3.96	.04	3.93	.04
Yb	1.79	.03	1.78	.04			1.81	.03	1.82	.03

Note: Elemental abundances in ppm except where otherwise indicated.

Table 4. Elemental Abundances and Ratios of Obsidian Pebbles from Nicaragua, by XRF.

	Ba[a] (ppm)	Zr[a] (ppm)	Rb/Zr	Sr/Zr
Northeast Shore Lake Nicaragua				
NICA-1	1,629	191	.30	1.31
NICA-2	1,848	256	.26	.48
Other pebbles (Luisitio)[b]				
NICA-3	1,185	219	.23	2.5
NICA-4[c]	1,212	230	.4	2.2
NICA-5	1,294	229	.26	1.9

[a] The abundance levels of these elements depend on the shapes and thickness of the samples and are only approximate. The use of ratios (Rb/Zr and Sr/Zr) of abundances largely compensates for these variations.

[b] The three pebbles from Luisitio have similar unusual compositions, with iron abundances at ~6.5–8.5%, calcium ~5–7%, titanium ~1.2%, and cerium ~30 ppm. These pebbles are probably not obsidian as their compositions are closer to that of basalt.

[c] The X-ray spectrum of NICA-4 used for the Rb, Sr, and Zr measurements had a severe lead contamination, and these results are only approximate.

The five nonartifactual samples from Nicaragua appeared to be chemically different from one another (Table 4) and from any other samples we had measured before. The two pebbles from the northeast shore of Lake Nicaragua clearly are obsidian, but in situ sources for them are unknown. Although the three pebbles from Luisitio visually look like obsidian, they have compositions different from obsidian (Table 4). Although peralkaline obsidians could have greatly enhanced abundances of iron and other elements, they also would be likely to have much higher Ce abundances than measured. The observed compositions in NICA-3, -4, and -5 are closer to basalt than obsidian. Luisitio should not be considered an obsidian source, until and unless further survey in the area encounters obsidian. We found no evidence of prehistoric use of this material, while briefly visiting the site and environs.

The two nodules found on the eastern shore of Lake Nicaragua may be from sources near there (Table 4). Because these nodules were likely to be source samples, a detailed NAA study was conducted (Table 5).

The two specimens of Nicaraguan nonartifactual obsidian (i.e., probable source) were found by a Juigalpa resident along the northeast shore of Lake Nicaragua, in the "La Mesa" or "Puerto Diaz" area, approximately 20 km northeast of Juigalpa. Chemically, these two nodules are sufficiently different from each other, and from the three collected near Luisitio, to indicate that two different sources may exist somewhere in central Nicaragua, perhaps near the north shore of Lake Nicaragua. The diversity shown in these nonartifact samples illustrates the complexity of obsidian sources in Central America, and the paucity of known sources which have been analyzed geochemically. Jaime Incer (personal communication 1983) stated that he had encountered a natural deposit of obsidian in a road cut along Highway 26, in the El Horno area about 40 km north of the north shore of Lake Managua. He stated that all nodules were small, ranging from less than 1 to 6 cm in diameter. That small size renders mesoamerican core-blade technology inapplicable. That source has yet to be analyzed geochemically. A systematic survey for obsidian sources in western Nicaragua might locate more sources.

After the Nicaraguan obsidian samples had been run, two obsidian samples from the Rio Sapoa/Bay of Salinas area of northwest Costa Rica, and two others from the Vidor site on the Bay of Culebra were analyzed. Distribution of obsidian in archaeological sites in the southern sector of Greater Nicoya is limited almost exclusively to the Nicaraguan–Costa Rican border area. For instance, out of 9,000 chipped-stone artifacts recovered by the Arenal Project, only two were of obsidian, and both were so tiny and fragmental as to not be clearly artifactual.

Table 5. Elemental Abundances of Obsidian Samples from the Northeast Shore of Lake Nicaragua and Artifacts from Costa Rica, by NAA.

	NICA-1		NICA-2		COST-1	
	Abundance	Error	Abundance	Error	Abundance	Error
% Al	6.51	.15	6.15	.07		
Ba	1,624	40	1,873	47	1,837	30
Ce	26.0	.45	39.9	.5	39.2	.07
Co	1.10	.06	.59	.08	.49	.07
Cs	1.76	.07	2.34	.12	2.32	.08
Dy	2.87	.14	7.69	.14	7.61	.15
Eu	.739	.010	1.137	.015	1.158	.016
% Fe	1.080	.012	1.175	.013	1.204	.014
Hf	4.35	.06	6.43	.08	6.36	.09
% K	2.54	.33	2.99	.31	3.61	.26
La	12.3	.5	17.1	.6	17.1	.4
Mn	640	13	611	12	591	12
% Na	3.27	.06	3.16	.06	3.10	.06
Rb	62.9	2.7	67.3	3.0	70.5	3.7
Sb	.38	.06	.79	.09	.55	.08
Sc	3.24	.03	9.13	.09	9.34	.09
Sm	2.71	.03	6.35	.06	6.43	.06
Ta	.268	.003	.280	.003	.284	.003
Th	3.13	.03	3.50	.04	3.51	.05
U	1.37	.02	1.50	.02	1.53	.03
Yb	2.58	.03	5.60	.05	5.48	.06

Note: In ppm except where otherwise indicated; errors are the 1σ uncertainties in counting X-rays.

The four Costa Rican obsidian samples were analyzed by XRF (Table 6). All were found to correlate with obsidian sources or possible sources having compositions known to us, i.e., one with Ixtepeque, one with Rio Pixcaya (Guatemala), one with Güinope, and one with the possible source near the northeast shore of Lake Nicaragua (collected by Sheets on the 1983 Nicaraguan survey). Abbreviated NAA measurements were made on all Costa Rica samples (Table 7) and the NAA analysis was completed for COST-1 (Table 5) and COST-2 (Table 3). The tentative match of COST-1 (Bay of Salinas) with the NICA-2 pebble from the northeast shore of Lake Nicaragua was confirmed. The tentative match of COST-2 (Rio Sapoa Valley) with the chemical group represented by NICA-6, -7, -8, -11, -13, and -14 was confirmed, and those artifacts are now attributed to the Güinope source. Ixtepeque (Guatemala) was confirmed as the source of COST-3 (Vidor site), and Rio Pixcaya (Guatemala) as the source of COST-4 (Vidor site).

It is significant that the elemental analyses indicated that the two flake artifacts from Ninderi came from Güinope, 250 km to the northwest. This indicates a significant level of local working of obsidian imported as a raw cobble from a considerable distance. These are primary working flakes, rather than resharpening flakes. The cortex on them also is indicative of primary percussion technology. However, the flakes are too fragmentary to allow definite identification as part of a core-blade, household percussion flake, or other manufacturing system.

The analysis of the samples from northwest Costa Rica has interesting correlations with, and one difference from, the Pacific Nicaraguan results. Both the prismatic-blade fragment (COST-3) and the tool fragment (COST-4) were matched with Guatemalan source material, but the small northwestern Costa Rican suite includes a second Guatemalan source (Rio Pixcaya) that was not represented in the Nicaraguan collection, possibly indicating that an exchange system may have bypassed Nicaragua. However, the latter collection was also small, and the difference may well be due to sampling. The source of the small primary waste flake from the Sapoa Valley (COST-2) is Güinope, which was well represented in the Nicaraguan artifacts.

The chronological contexts of the northwestern Costa Rican materials are all late Middle Poly-

Table 6. Elemental Abundances and Ratios of Obsidian Samples from Costa Rica, by XRF.

	Ba[a] (ppm)	Zr[a] (ppm)	Rb/Zr	Sr/Zr
Lake Nicaragua Provenience				
COST-1	1,703	247	.27	.48
Error			.01	.01
Reference Northeast Shore Lake Nicaragua[b]	1,848	256	.26	.48
Error			.02	.02
Güinope Provenience				
COST-2	996	123	1.27	1.52
Error			.03	.03
Reference Güinope[c]	1,070	129	1.38	1.55
Error	44		.09	.09
Ixtepeque Provenience				
COST-3	996	193	.54	.88
Error			.01	.01
Reference Ixtepeque[d]	1,030	176	.57	.90
Error	27	6	.02	.02
Rio Pixcaya Provenience				
COST-4	1,044	123	.94	1.59
Error			.02	.02
Reference Rio Pixcaya[d]	1,105	115	1.01	1.65
Error	32	3	.05	.06

[a] The abundance levels of these elements depend on the shapes and thickness of the samples and are only approximate. The use of ratios (Rb/Zr and Sr/Zr) of abundances largely compensates for these variations.
[b] See Table 4.
[c] See Table 1.
[d] See Stross et al. 1983.

chrome/Late Polychrome period (1200–1520 A.D.), and this also correlates well with the temporal placements assigned to the Nicaraguan specimens. This also correlated 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 from Norweb's testing. Only one fragment of a blade was reported

Table 7. Elemental Abundances of Obsidian Samples from Costa Rica, by Abbreviated NAA.

	Ba, ppm	Dy (ppm)	K (%)	Mn (ppm)	Na (%)
COST-3	1,001	2.36	3.54	444	2.99
Error	28	.07	.16	9	.06
Reference Ixtepeque[a]	1,030	2.30	3.61	449	3.05
Error	27	.11	.26	9	.06
COST-4	1,078	2.22	3.91	513	2.93
Error	43	.11	.26	10	.06
Reference Rio Pixcaya[b]	1,105	2.03	3.54	521	2.94
Error	32	.10	.25	10	.06

Note: See Tables 3 and 5 for COST-1 and COST-2 values.
[a] See Asaro et al. 1978 and Stross et al. 1983.
[b] See Stross et al. 1983.

Table 8. Elemental Abundances of La Esperanza Honduras Source Obsidian.

	Abundance	Error
	By NAA	
% Al	6.95	.10
Ba	825	17
Ce	50.7	.6
Co	.86	.04
Cs	4.52	.05
Dy	2.36	.07
Eu	.501	.006
% Fe	.897	.009
Hf	4.14	.05
% K	3.75	.17
La	28.9	.4
Mn	427	9
% Na	2.84	.06
Rb	163	15
Sb	.24	.14
Sc	2.54	.03
Sm	3.02	.03
Ta	.959	.01
Th	11.7	.1
U	3.53	.04
Yb	1.62	.03
	By XRF	
Zr	162	
Rb/Zr	.90	.03
Sr/Zr	.97	.02

Note: Values based on two samples, best values; ppm except where otherwise indicated.

Table 9. Concordance.

Description	LBL Sample	NAA Pill	XRF	Provenience
Payson Sheets, nodule from northeast shore Lake Nicaragua	NICA-1	2208 J	8134-4	(possible source)
Payson Sheets, nodule from northeast shore Lake Nicaragua	NICA-2	2208 K	8134-5	(possible source)
Payson Sheets, Luisitio pebbles	NICA-3,-4,-5	2121 W	8134-6, 7, 8	not obsidian
Payson Sheets, Ninderi artifact	NICA-6	2147 M	8134-9	Güinope
Payson Sheets, Ninderi artifact	NICA-7		8134-+	Güinope
Payson Sheets, Ninderi artifact	NICA-8	2161 T	8134-−	Güinope
Payson Sheets, Ninderi artifact	NICA-9	2121 Y	8134-*	Ixtepeque
Payson Sheets, Ninderi artifact	NICA-10		8134-1	Ixtepeque
Payson Sheets, Ninderi artifact	NICA-11	2121 Z	8134-(	Güinope
Payson Sheets, Ninderi artifact	NICA-12		8134-$	Ixtepeque
Payson Sheets, Ninderi artifact	NICA-13		8134-.	Güinope
Payson Sheets, Ninderi artifact	NICA-14		8134-]	Güinope
Fred Lange, #101 Bay of Salinas	COST-1	2188 J 2218 2	8139-E	like NICA-2
Fred Lange, #86 Rio Sapoa Valley	COST-2	2188 K 2207 W	8139-F	Güinope
Fred Lange, #3047 I-1-14 Vidor site	COST-3	2188 M	8139-G	Ixtepeque
Fred Lange, #3047 I-1-3 Vidor site	COST-4	2215 Z	8139-H	Rio Pixcaya
Honduras source	LESP-5,-7	2237 X, Y	8150-E, F	La Esperanza
Honduras source	GÜIN-1	2237 Z	8150-G	Güinope

from the same excavations. The low frequency of obsidian reported by Healy is comparable to the results obtained from the 1983 survey.

Although the La Esperanza source was not represented in the Nicaraguan or Costa Rican artifacts under study, it is likely that unpublished or future analyses of obsidian from those countries will encounter La Esperanza obsidian. Results of analyses made on the source samples from La Esperanza secured by Hirth are shown in Table 8.

Table 9 is a concordance of the sample descriptions with the results of our analyses.

CONCLUSIONS

Considerable research has been conducted in Mesoamerica chemically fingerprinting sources of obsidian and conducting elemental analyses to attribute obsidian artifacts found in archaeological sites to their sources. The southern periphery of Mesoamerica, however, is not as well understood, and the northern part of the Intermediate Area (central Honduras through northern Costa Rica) has been a terra incognita in lithic sourcing. Fortunately, new information on two Honduran sources of obsidian, and data on the use of those sources at sites in Honduras, Nicaragua, and Costa Rica, are now available.

The La Esperanza source had been reported previously, but there had been some misunderstandings. La Esperanza apparently is a moderately large source, by mesoamerican standards, but a systematic survey-and-testing program is needed. Nodule sizes are sufficient for core-blade technology, and evidence is clear that the mesoamerican system of macrocore shaping and prismatic-blade manufacture was a major component of lithic manufacture at this source. The more informal core-flake industry is yet to be documented at that source, and the chronology of exploitation of the source is unknown, other than for Late Classic and Postclassic exploitation, which is reasonably well demonstrated. Shaft-mining techniques and surface collection were used to obtain obsidian.

The Güinope source was smaller, less exploited, and offered smaller nodules. The more informal percussion core-flake industry predominated, but there seems to have been some core-blade exploitation, judging from the fact that some prismatic blades from the Ninderi site in Nicaragua are attributed to Güinope by these analyses. The chronology of exploitation of this source is largely unknown, with the exception of ample documentation of its use in the Postclassic period. The use may have been associated with Pipil expansion into Salvador–Nicaragua.

The La Esperanza source appears to have been more mesoamerican, with major mining operations and a predominance of core-blade technology. In contrast, Güinope appears to have been used in a fashion more common in the Intermediate Area, with no major mining operations, and a technology dominated by the more informal percussion core-flake industry.

The various leads on small sources of obsidian in Nicaragua need to be investigated. Our data indicate at least two sources remain to be pinpointed, and there may be more sources in adjoining Honduras. As more sources are analyzed and as more artifacts can be attributed to sources in this southern Mesoamerica–Northern Intermediate Area zone, the outlines of prehistoric trade, ethnic interaction, and resource exploitation should be better understood.

Although we have attributed obsidian in Nicaraguan and Costa Rican archaeological sites to sources as distant as Honduras and Guatemala, the conclusion that those sites were an integral part of the mesoamerican mercantile system would be unwarranted. Rather, in prehistoric Nicaragua and Costa Rica, the predominance of cutting edges were obtained by informal percussion removal of small flakes from locally available nodules, probably with minimal occupational specialization or centralization of economies.

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