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EXCHANGE IMPLICATIONS OF OBSIDIAN SOURCE ANALYSIS FROM THE LOWER RIO VERDE VALLEY, OAXACA, MEXICO

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This article considers the results of instrumental neutron-activation analyses of 61 obsidian artifacts recovered from excavations at four archaeological sites in the lower Río Verde valley on the Pacific coast of Oaxaca, Mexico. Determinations of source locations of these artifacts permit the examination of changes in obsidian exchange patterns spanning the late Middle Formative to the Classic period. The results show that through most of this period the importation of obsidian into the lower Verde region was dominated by sources in the Basin of Mexico and Michoacan. The data allow us to evaluate previous models of interregional relations during the Formative and Classic periods, including interaction with the highland centers of Monte Albán and Teotihuacán.

Este artículo considera los resultados de análisises instrumentales de activación neutrónica de 61 artefactos de obsidiana recuperados de excavaciones en cuatro sitios arqueológicos del valle inferior del Río Verde en la costa Pacífica de Oaxaca, México. Determinaciones de fuente de estos artefactos permiten la examinación de cambios en los patrones de intercambio de obsidiana desde el Formativo al período Clásico. Los resultados muestran que durante mucho de este período la importación de obsidiana al valle inferior del Río Verde fue dominada por yacimientos en la cuenca de México y Michoacan. Los datos nos permiten evaluar previos modelos de relaciones interregionales durante los períodos Formativo y Clásico, inclusa interacción con los centros de Monte Albán y Teotihuacán.

Recent archaeological research in the lower Río Verde valley on the Pacific coast of Oaxaca (Figure 1) has stressed the importance of interregional interaction in the social development of the region (Joyce 1991a, 1991b, 1993). A key stimulus of interaction has been the ecological complementarity of the coast relative to highland regions. The ethnohistorical record shows that at the time of the Spanish conquest a vibrant economy existed between the coast and highlands with coastal products such as shells, cacao, cotton, feathers, salt, fish, and *púrpura* dye transported to the interior in exchange for items such as cochineal, obsidian, and pulque (del Paso y Troncoso 1981; Spores 1993). Even today coastal and highland populations converge at regional markets such as Putla, Tlaxiaco, and Miahuatlán to exchange goods. However, many of the items exchanged between the coast and highlands are rarely preserved in the archaeological record and, even if nonlocal materials are preserved, it is often difficult to identify them and establish their point of origin.

Despite these methodological problems, archaeological research in the lower Río Verde valley has begun to outline Prehispanic exchange routes and patterns of interaction (Joyce 1991a, 1991b, 1993). The data have confirmed the importance of highland regions, especially the Valley of Oaxaca and the Basin

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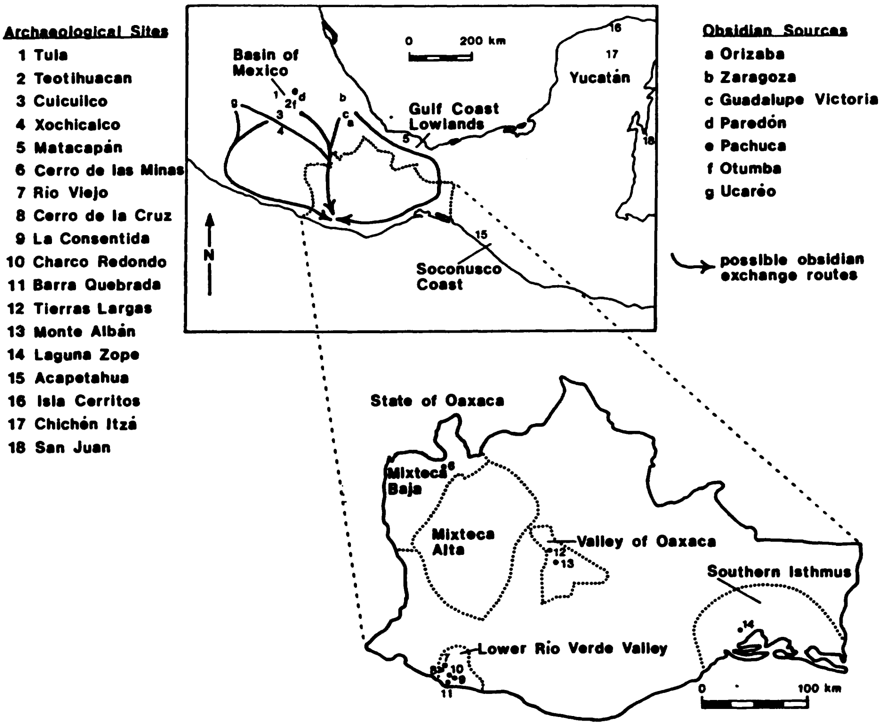

Figure 1. Mesoamerica, showing regions, sites, obsidian source locations, and possible exchange routes mentioned in the text.

of Mexico, in the external relations of coastal populations throughout the Prehispanic period. The data suggest that marine shell may have been transported to the highlands while obsidian and pottery were sent to the coast. Source studies have demonstrated that some of the pottery imported to the lower Verde came from the Valley of Oaxaca (Banker and Joyce 1991). These data, coupled with comparative studies of ceramic styles and the iconography of carved stone monuments, have been used to develop an outline of the nature and impact of external relations on lower Verde society (Joyce 1993; also see Urcid 1993; J. Zeitlin 1993). This paper continues analysis of the external relations of lower Río Verde valley populations by presenting the results of chemical source determinations for 61 obsidian artifacts from that region.

Methods

Obsidian has proven to be especially effective in studies of Prehispanic exchange because chemical characterization can identify specific source locations of 99 to 100 percent of the artifacts recovered in excavations anywhere in Mesoamerica (Cobean et al. 1991; Glascock et al. 1994; R. Zeitlin 1979). The present study uses data produced by a rapid instrumental neutron activation analysis (INAA) procedure developed by researchers at the Missouri University Research Reactor (MURR) (Elam et al. 1992; Glascock et al. 1988, 1994) to determine the source locations for 61 obsidian artifacts from the lower Verde. The sample for INAA source determinations consisted of 44 obsidian artifacts from the site of Río Viejo, 11 artifacts from Cerro de la Cruz, 5 artifacts from La Consentida, and 1 from Barra Quebrada (Figure 1). There is no doubt that the obsidian was imported into the lower Verde, because sources have not been located within the state of Oaxaca.

The artifacts for INAA source determinations were selected from a sample of several hundred obsidian artifacts excavated during 1986 and 1988 field seasons. The 1986

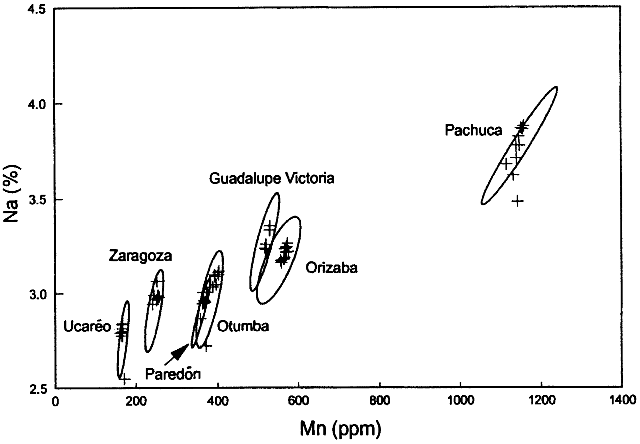

Figure 2. Scatterplot of Mn versus Na for obsidian artifacts from the lower Río Verde valley compared to the 95 percent confidence ellipses for central-Mexican sources.

project was a pilot study designed to examine early settlement in the region and to sketch the entire Prehispanic sequence of the lower Río Verde because little research had been conducted in the region prior to that time (Gillespie 1987; Grove 1988; Joyce and Winter 1989). Fieldwork involved site reconnaissance and test excavations at five sites, including Barra Quebrada and Cerro de la Cruz. The 1988 project expanded on the results of the previous work, and was focused primarily on social developments at the end of the Formative (Joyce 1991a, 1991b). Research included broad horizontal exposures of the Late Formative occupation at Cerro de la Cruz, excavation of five deep trenches at Río Viejo that sectioned deposits from the Middle Formative to the Late Classic, and test excavations at two other sites including the late Middle Formative site of La Consentida.

The majority of the obsidian artifacts selected for INAA were chosen from securely dated primary deposits and assigned to one of the seven ceramic phases established for the region based on associated pottery. Dates for the obsidian artifacts span the late Middle Formative (500–400 B.C.) to Late Classic periods (A.D. 550–900). For some periods, however, so few obsidian artifacts were available from primary contexts that the sample was augmented by inclusion of artifacts from fill or near-surface deposits that may have included redeposited or intrusive material.

The rapid INAA procedure was conducted at the Missouri University Research Reactor (MURR) using a five-second irradiation, 25-minute decay, and a 12-minute measurement. This procedure yields concentration values for six elements: barium (Ba), chlorine (Cl), dysprosium (Dy), potassium (K), manganese (Mn), and sodium (Na). Earlier work found the elements Ba, Mn, and Na to be very useful for source differentiation (Glascock et al. 1994). Source attribution is achieved by examining scatter plots of element pairs for the artifacts projected against the 95 percent confidence ellipses generated from source specimens in the MURR obsidian data base. For example, Figure 2 shows the artifacts in this study when compared with the 95 percent confidence ellipses for the major Mexican sources. Although the Paredón and Otumba sources overlap in Figure 2, they have greatly different concentrations for Ba. The average Ba concentrations in source specimens from Paredón and Otumba are 59±10 ppm and 761±15 ppm, respectively (Glascock et al. 1994). Examination of the Ba values makes the source attributes of artifacts from Paredón and Otumba clear (see Table 1).

The results of the INAA presented in Table 1 include source location of each artifact and the concentrations of the six elements examined by the rapid INAA procedure. Table 2 presents a phase-by-phase summary of the obsidian source data. The obsidian sample

Table 1. INAA Data for Lower Río Verde Valley Obsidian Samples.

		Elemental Concentrations						
Sample	Site	Ba (ppm)	Cl (ppm)	Dy (ppm)	K (%)	Mn (ppm)	Na (%)	Source
RV001	RV	0	1,552	16.57	3.26	1,158	3.88	Pachuca
RV002	RV	0	1,392	16.43	3.76	1,139	3.78	Pachuca
RV003	RV	0	1,624	16.82	4.19	1,143	3.48	Pachuca
RV004	RV	582	333	2.31	3.69	567	3.23	Orizaba
RV005	RV	720	472	3.39	3.07	392	3.10	Otumba
RV006	RV	479	663	4.99	3.93	257	2.98	Zaragoza
RV007	RV	446	670	4.95	3.82	254	2.99	Zaragoza
RV008	RV	863	435	3.63	3.35	388	3.03	Otumba
RV009	RV	0	1,525	16.92	3.29	1,155	3.86	Pachuca
RV010	RV	0	1,460	16.83	3.88	1,115	3.68	Pachuca
RV011	RV	0	1,424	15.35	3.86	1,147	3.78	Pachuca
RV012	RV	164	369	3.59	4.04	167	2.80	Ucaréo
RV013	RV	121	425	3.48	4.03	162	2.79	Ucaréo
RV014	RV	0	1,566	16.80	3.61	1,140	3.71	Pachuca
RV015	RV	940	604	1.37	3.44	521	3.23	Guadalupe Victoria
RV016	RV	0	1,401	16.05	4.04	1,132	3.62	Pachuca
RV017	RV	0	1,471	16.46	3.64	1,146	3.82	Pachuca
RV018	RV	481	556	4.91	4.26	253	2.98	Zaragoza
RV019	BQ	0	1,360	15.62	3.74	1,151	3.87	Pachuca
RV020	RV	733	309	1.78	3.49	557	3.17	Orizaba
RV021	LC	806	330	2.64	3.07	570	3.24	Orizaba
RV022	LC	761	310	1.68	3.14	566	3.19	Orizaba
RV023	LC	732	339	1.95	3.15	571	3.21	Orizaba
RV024	LC	666	350	1.74	3.67	572	3.24	Orizaba
RV025	LC	434	507	4.74	3.79	241	2.94	Zaragoza
RV026	CC	432	602	4.51	3.56	244	2.99	Zaragoza
RV027	CC	640	303	1.77	3.66	576	3.22	Orizaba
RV028	CC	668	325	2.22	3.28	571	3.22	Orizaba
RV029	CC	0	827	7.53	4.02	372	3.00	Paredón
RV030	CC	0	836	7.61	3.82	369	2.95	Paredón
RV031	CC	0	905	7.79	3.89	362	2.94	Paredón
RV032	CC	0	725	8.54	3.62	357	2.86	Paredón
RV033	CC	888	501	1.42	3.15	530	3.35	Guadalupe Victoria
RV034	CC	638	269	1.81	3.29	574	3.26	Orizaba
RV035	CC	0	918	7.93	4.18	367	2.96	Paredón
RV036	CC	783	284	2.15	3.46	559	3.16	Orizaba
RV037	RV	0	900	7.81	3.70	365	2.95	Paredón
RV038	RV	237	393	3.61	3.51	166	2.83	Ucaréo
RV039	RV	915	427	1.17	3.43	520	3.26	Guadalupe Victoria
RV040	RV	713	263	1.94	3.28	565	3.18	Orizaba
RV041	RV	0	883	7.60	3.89	366	2.96	Paredón
RV042	RV	817	317	3.27	3.97	403	3.12	Otumba
RV043	RV	827	355	3.07	3.76	402	3.10	Otumba
RV044	RV	167	354	4.04	4.50	168	2.84	Ucaréo
RV045	RV	722	317	3.50	3.61	401	3.11	Otumba
RV046	RV	758	458	3.36	3.70	393	3.09	Otumba
RV047	RV	0	1,006	7.73	4.91	363	3.00	Paredón
RV048	RV	0	990	7.89	4.68	372	3.01	Paredón
RV049	RV	1,147	439	1.58	3.78	531	3.33	Guadalupe Victoria
RV050	RV	0	895	8.13	4.82	371	2.72	Paredón
RV051	RV	0	958	8.21	4.71	375	3.01	Paredón
RV052	RV	819	390	2.73	3.51	396	3.05	Otumba
RV053	RV	863	455	1.76	3.82	518	3.24	Guadalupe Victoria
RV054	RV	835	375	2.24	3.48	529	3.33	Guadalupe Victoria
RV055	RV	426	549	4.82	4.52	252	3.06	Zaragoza
RV056	RV	451	520	5.10	4.20	250	2.96	Zaragoza
RV057	RV	173	335	3.47	4.35	167	2.81	Ucaréo

Table 1. Continued.

		Elemental Concentrations						
Sample	Site	Ba (ppm)	Cl (ppm)	Dy (ppm)	K (%)	Mn (ppm)	Na (%)	Source
RV058	RV	168	304	3.95	4.57	167	2.77	Ucaréo
RV059	RV	242	458	7.72	4.97	171	2.55	Ucaréo
RV060	RV	149	341	3.69	4.38	166	2.79	Ucaréo
RV061	RV	115	354	4.14	4.32	164	2.77	Ucaréo

Note: Site abbreviations are RV = Río Viejo; BQ = Barra Quebrada; LC = La Consentida; CC = Cerro de la Cruz. A concentration of zero means that the element was below detection in the sample.

from the lower Verde includes material from seven sources in the highlands of central Mexico. For purposes of examining possible exchange routes, the sources can be classified in three groups based on proximity (Figure 1): (1) the Zaragoza, Guadalupe Victoria, and Orizaba sources located along the Puebla-Veracruz border; (2) the Pachuca, Otumba, and Paredón sources from the Basin of Mexico; and, (3) the Ucaréo source in Michoacan, which for purposes of this study includes the nearby Zinapécuaro source; early X-ray fluorescence studies were unable to distinguish between the two, but recent MURR work suggests that most or all artifacts assigned to Zinapécuaro may actually be from Ucaréo.

Formative-Period Exchange

Current evidence suggests that before the end of the Middle Formative the lower Río Verde valley was occupied sporadically by small populations (Grove 1988; Joyce 1991a). Only a few redeposited sherds have been recovered from this period and there are few data that suggest patterns of exchange. The latter part of the Formative period (approximately 500 B.C. to A.D. 250) was, however, a time of rapid population growth and the emergence

Table 2. Phase-by-Phase Summary of the Obsidian Source Data.

Period/Phase/Date	Orizaba	Zaragoza	Guadalupe Victoria	Paredón	Pachuca	Otumba	Ucaréo
Late Middle Formative Charco Phase 500–400 B.C.	5	1	2			1	
Late Formative Minizundo Phase 400–100 B.C.	3	1	2	9		2	
Early Terminal Formative Miniyua Phase 100 B.C.–A.D. 100	1		1	2		2	2
Late Terminal Formative Chacahua Phase A.D. 100–250				no data available			
Early Classic Coyuche Phase A.D. 250–550		2			9		
Late Classic Yuta Tiyoo Phase A.D. 550–900	2	3	1		1	2	7
Postclassic Yucudzaa Phase A.D. 900–1521				no data available			
Totals	11	7	6	11	10	7	9

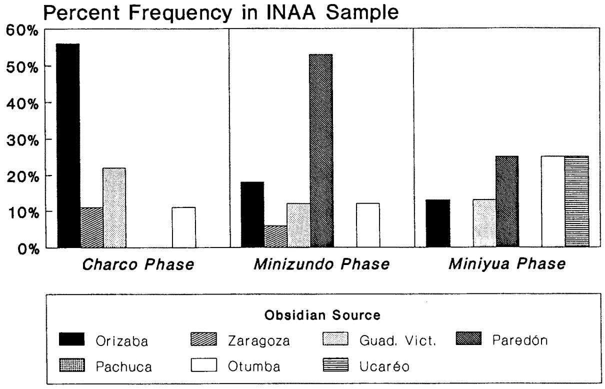

Figure 3. Histogram showing the frequency of obsidian sources in the Formative-period sample.

of complex societies in the region (Joyce 1991a). The number of sites recorded for the lower Verde increases from five during the late Middle Formative Charco phase (500–400 B.C.) to 45 by the late Terminal Formative Chacahua phase (A.D. 100–250). The overall size of sites also increased, with Charco Redondo possibly reaching 100 ha by the Late/Terminal Formative (Gillespie 1987). Evidence from excavations at several sites suggests that one or more small-scale chiefdoms probably emerged in the region by the Late Formative (Joyce 1991a:294). Obsidian was imported into the lower Verde throughout this period (Figure 3).

Formative-period obsidian was imported to the lower Verde primarily in the form of spalls, which were then reduced by simple and bipolar percussion techniques, apparently to produce usable flakes (see Clark and Lee 1984). However, the recovery of a few blade fragments and the absence of prepared cores suggest that obsidian blades were also occasionally imported.

During the late Middle Formative Charco phase the Veracruz-Puebla sources of Orizaba, Guadalupe Victoria, and Zaragoza (Figure 3) accounted for 89 percent of the total INAA obsidian sample (N = 9). Because these sources cluster within 85 km of one another, it seems likely that the obsidian reached the lower Verde through similar exchange routes (Figure 1). Obsidian could have been transported south through the interior highlands to the western Oaxaca coast, or east along the Gulf coast lowlands, then south through the Isthmus of Tehuantepec and up the Pacific coast to the lower Verde.

Data from other regions lend tentative support to the highland route. Whereas Orizaba and Guadalupe Victoria are the dominant sources of obsidian from sites in south-central Veracruz (Stark et al. 1992), they are not represented in Middle Formative samples at Laguna Zope in the southern Isthmus (R. Zeitlin 1978, 1982). Guadalupe Victoria is also the dominant source of obsidian from Middle Formative Rosario-phase contexts at the site of Tierras Largas in the Valley of Oaxaca (Pires-Ferreira 1975:Table 6). The obsidian analysis is consistent with comparative ceramic studies that suggest some stylistic crossties between the lower Verde and the Valley of Oaxaca at this time (Joyce 1991a:128).

A significant shift in the source composition of lower Verde obsidian is evident for the Late Formative Minizundo Phase (400–100 B.C.; Figure 3), when obsidian from the Veracruz-Puebla sources declines to only 35 percent of the sample (N = 17). The Basin of Mexico sources of Paredón and Otumba account for the remaining 65 percent, with over half the sample from Paredón. The high percentage of Paredón obsidian is surprising because artifacts from this source have been unusual in Late Formative to Classic-period samples examined in other regions of Oaxaca (Elam et al. 1992; Winter 1989; R. Zeitlin 1978, 1979).

Interregional relations in Late Formative Oaxaca appear to have been characterized by the reciprocal exchange of prestige goods among chiefdoms of various degrees of size and complexity (Joyce 1991a, 1993; Spencer 1982; R. Zeitlin 1979). Excavation data demonstrate that elites in the lower Verde region were importing fancy pottery from the Valley of Oaxaca and another region as yet unidentified. Obsidian flakes and spalls were probably not prestige items, but they may have reached the lower Verde through the same exchange routes. This suggestion is tentatively supported by data from the lower Verde and other regions of Oaxaca which suggest that elites had preferential access to obsidian (Joyce 1991a:277; Spencer 1982:167–174; Whalen 1981:85–87).

The high proportion of Paredón and Otumba obsidian suggests that the lower Verde region had established at least indirect exchange ties with the Basin of Mexico. Charlton (1984:35–36) has argued that the large Late Formative site of Cuicuilco in the southern Basin of Mexico may have been involved in the exploitation and export of obsidian from the Otumba and Paredón sources, which were apparently indistinguishable in early studies (Charlton et al. 1978). Hirth (1984: 137) has shown that obsidian from Otumba and Paredón was reaching sites in western Morelos in high proportions at this time. The data from the lower Verde now show that obsidian from these sources was a major component of assemblages at sites as distant as 350 km. Mechanisms for the distribution of obsidian are not well understood (Clark et al. 1989), but it is possible that Otumba and Paredón obsidian was transported through Cuicuilco to the lower Verde in exchange for coastal products such as shell and cacao. It is clear that by the Classic period the rulers of Teotihuacán (Cuicuilco's successor as the economic power in the Basin of Mexico) were importing coastal products as prestige items (Kolb 1987).

The data do not permit mapping of precise exchange routes for the movement of either Basin of Mexico or Veracruz-Puebla obsidian to the Oaxaca coast (Figure 1). A highland route is suggested for the Veracruz-Puebla obsidian because there is little correspondence between the source composition of the lower Verde obsidian samples and those from the southern Isthmus (see R. Zeitlin 1978, 1982). Two routes seem plausible for the Basin of Mexico obsidian; one would have extended east through the highland valleys to the Mixteca Baja region and the Oaxaca coast, and the other runs southwest from the Basin of Mexico down the Río Balsas drainage to the Pacific coast and east to the lower Verde.

Evidence from many regions of Oaxaca (Joyce 1991a:579–592) suggests that there was a general disruption in interregional exchange during the Terminal Formative (100 B.C.–A.D. 250). In highland Oaxaca, exchange routes may have been disrupted by increasing interpolity conflict possibly triggered by the emergence of the Monte Albán state (Joyce 1991a:579–592; Marcus 1983; Redmond 1983; Spencer 1982; Winter 1989). Evidence for warfare on the Oaxaca coast is lacking at present (Joyce 1991a, 1991b, 1993; R. Zeitlin 1990, 1993), but highland conflict may have cut coastal elites off from sources of prestige goods. For example, the data from the lower Verde suggest a decline in the importation of highland pottery and obsidian (Joyce 1991a: 515).

The INAA source determinations on eight obsidian artifacts from the early Terminal-Formative Miniyua phase (100 B.C.–A.D. 100) could be consistent with a disruption in interregional relations. During this period no single dominant source is evident in the obsidian sample; the Paredón, Otumba, and Ucaréo sources are each represented by two artifacts, while single artifacts are from Guadalupe Victoria and Orizaba (Figure 3). This pattern differs from the Middle and Late Formative periods, when obsidian from Orizaba and Paredón, respectively, makes up over half the total. Obsidian samples from the Terminal-Formative Niti phase (A.D. 100–300) in the southern Isthmus are also characterized by the absence of a dominant source (Zeitlin 1979:77). Given evidence for increased interpolity conflict in highland Oaxaca (e.g., Joyce 1991a; Marcus 1983; Spencer 1982), the obsidian data from both coastal regions may reflect the instability of Terminal-Formative exchange routes. Coastal elites may have been forced to switch from one obsidian source to another as transportation routes opened and closed with changing patterns of conflict in the highlands (Joyce 1993). The presence of obsidian from the Ucaréo source in Michoacan may also suggest the establishment of a Pacific coast exchange route that avoided the highlands. The data from the early Terminal Formative should, however, be considered with caution given the small sample size and the fact that most of the obsidian is from mound-fill deposits. In addition, few obsidian artifacts are available from the late Terminal-Formative Chacahua phase (A.D. 100–250) and none was subjected to INAA.

Classic-Period Exchange

Population size and social complexity increased in the lower Río Verde valley during the Classic period (A.D. 250–900; Grove 1988; Joyce and Winter 1989). It was at this time that sites in the region reached their greatest size and architectural elaboration. Settlement pattern data suggest the emergence of at least a three-tiered settlement hierarchy. Río Viejo became the dominant center in the region with settlement covering approximately 300 ha, massive public architecture, and numerous carved and uncarved stelae. Several other sites in the lower Verde region contained large public mounds as well as carved and/or plain stelae. Comparative ceramic data and visual identification of the distinctive green obsidian from the Pachuca source complex have suggested that by the Early Classic Coyuche phase (A.D. 250–550), elites in the lower Verde were strengthening their ties with the Basin of Mexico (Joyce 1993).

During the Classic period the form of obsidian imported into the lower Verde changed significantly. Whereas Formative-period obsidian was imported primarily as spalls, which were then reduced to usable flakes, Classic-period obsidian consisted almost entirely of prismatic blades. The absence of polyhedral cores suggests that during the Classic, finished blades were imported to the lower Verde. The change to a prismatic blade technology has been noted throughout Mesoamerica at about this time (Clark et al. 1989; Santley et al. 1986; Spence 1984). Because prismatic blades were obtained from distant sources and manufactured by specialists, it is possible that they were imported to the lower Verde and other areas of Mesoamerica as prestige goods (Clark 1986). The form of imported obsidian was consistent during the Classic, but the source distribution of the material changed significantly.

The Early Classic sample (N = 11) is dominated by Pachuca obsidian from the northern Basin of Mexico (Figure 4), with 82 percent from Pachuca and the remainder from Zaragoza. The high proportion of Pachuca obsidian reflects a dramatic shift from earlier exchange patterns; no green obsidian has been recovered from Formative deposits. The obsidian data suggest that the lower Verde was involved, at least indirectly, in exchange with the urban center of Teotihuacán in the Basin of Mexico. Teotihuacán appears to have managed the acquisition and distribution of Pachuca obsidian to some extent during the Early Classic, although the degree to which the industry was state-controlled has been debated (Charlton 1984; Clark 1986; Santley 1989a, 1989b; Santley et al. 1986; Spence 1981, 1984).

The relatively small volume of excavated deposits from the Early Classic period may have created a sampling bias, but the proportion of green obsidian artifacts at present is one of the highest for regions outside the Basin of Mexico. For example, in contemporaneous deposits at Matacapán in southern Veracruz only 6 percent of the obsidian is from Pachuca, even though Santley (1989a: 140) views the site as a Teotihuacán enclave, permanently colonized by Teotihuacán merchants. At Acapetahua on the Soconusco coast, Clark and his colleagues (1989:272) report that 20.8 percent of the obsidian is from Pachuca. Source studies from most other regions of Oaxaca have not had sufficient chronological control to permit isolation of specific Early Classic samples. The Classic-

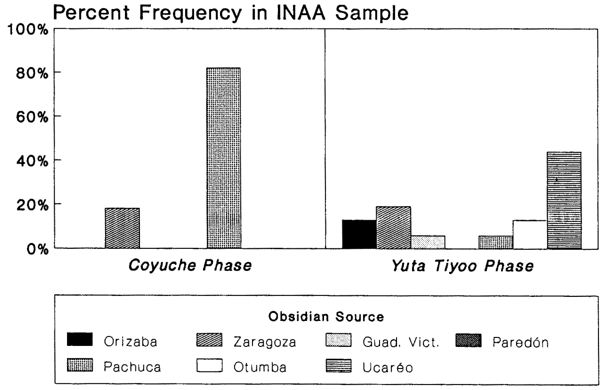

Figure 4. Histogram showing the frequency of obsidian sources in the Classic-period sample.

period data suggest, however, that Pachuca was a major source of obsidian for the Valley of Oaxaca and the Mixteca Baja, although at lower frequencies than in the lower Verde region (Elam et al. 1992:Table 1). Unlike most other regions that were consumers of Pachuca obsidian (Clark 1986:69; Santley et al. 1986: 127), the lower Verde seems to have received finished prismatic blades rather than polyhedral cores that required reduction by local specialists.

Contact with the Basin of Mexico is also suggested by Early Classic ceramic assemblages from the western coast of Oaxaca as well as the Mixteca Alta and Baja regions (Joyce 1993). Ceramics from these regions are characterized by stylistic and formal markers often linked to Teotihuacán, including imitation thin-orange pottery, cylindrical tripod vases, and bowls with annular bases and coffee-bean appliqués. The combined ceramic and obsidian data suggest that the Mixteca Alta and Baja regions were part of a corridor of communication and exchange that linked, at least indirectly, the western Oaxaca coast to the central Mexican highlands. This interaction network, however, did not extend to the eastern coast of Oaxaca. Robert Zeitlin (1978, 1979, 1982) has shown that material from Pachuca and other Basin of Mexico sources was absent from Classic-period samples in the southern Isthmus. The ceramics from the southern Isthmus also exhibited few cross-ties with pottery from the Basin of Mexico (J. Zeitlin 1978).

The INAA sample (N = 16) from the Late Classic Yuta Tiyoo phase (A.D. 550–900) indicates another significant shift in the source of obsidian imported to the lower Río Verde valley (Figure 4). Obsidian from Ucaréo, Michoacan, constitutes 43.8 percent of the Late Classic sample. Other sources represented in the sample are Zaragoza (18.8 percent), Orizaba (12.5 percent), Otumba (12.5 percent), Pachuca (6.3 percent), and Guadalupe Victoria (6.3 percent). The Late Classic sample, however, is complicated by the fact that 10 of the 16 obsidian artifacts were recovered from fill or near-surface contexts. The fact that the six artifacts from relatively unmixed strata are all from Ucaréo suggests that a sample with better chronological control from this period might yield an even higher percentage of material from that source. However, all but one of the obsidian pieces from well-dated contexts were recovered from Op. A at Río Viejo, only 20 m west of the huge platform that defines the site's civic-ceremonial center (Joyce and Winter 1989). It must therefore be considered possible that Ucaréo was a source of obsidian that was preferentially controlled by Río Viejo elites.

Data from many regions of central and southern Mexico indicate that Ucaréo was a major obsidian source during the Late Classic (Andrews et al. 1989:361; Healan 1993; Hester et al. 1973; Nelson 1985; Sorensen et al. 1989). Ucaréo was the dominant source recovered from Late Classic obsidian workshops at the central Mexican centers of Tula and Xochicalco (Healan 1993; Sorensen et al. 1989). Ucaréo obsidian was also a dominant source at several Late Classic sites in the northern Yucatan Peninsula, including

Table 3. Classic-Period Source Distribution of Obsidian from the Lower Río Verde Valley and Cerro de las Minas in the Mixteca Baja.

Source	Lower Verde	Cerro de las Minas
Pachuca	37% (10)	24% (5)
Ucaréo	26% (7)	33% (7)
Zaragoza	19% (5)	10% (2)
Otumba	7% (2)	19% (4)
Orizaba	7% (2)	0% (0)
Guadalupe Victoria	4% (1)	14% (3)

Note: Number of samples in parentheses.

Chichén Itzá and Isla Cerritos (Andrews et al. 1989; Healan 1993:Table 1). Obsidian from Ucaréo has been found as far south as the San Juan site on Ambergris Cay, Belize (Guderjan et al. 1989). Survey at Ucaréo and the surrounding region indicates intensive settlement and obsidian exploitation during the Late Classic (Healan 1993:454). Production and distribution mechanisms for Ucaréo material, however, are unclear, and hence it is difficult to assess how obsidian from that source reached the lower Verde.

Obsidian data from the site of Cerro de las Minas in the Mixteca Baja region suggest that the lower Verde-Mixteca Baja-central Mexico exchange route may have continued into the Late Classic. Classic-period obsidian from Cerro de las Minas is characterized by a high percentage (33 percent) of Ucaréo material (Elam et al. 1992). However, the samples from Cerro de las Minas are from the Ñuiñe phase, which runs through most of the Classic period (A.D. 300–800). If the Early and Late Classic–period samples from the lower Verde are combined for purposes of comparison, the source compositions from the two regions are very similar (Table 3). It is possible that a corridor of communication and exchange continued to extend from the western Oaxaca coast through the Mixteca Baja to the area of central Mexico that controlled the Michoacan obsidian sources. Obsidian from the Basin of Mexico sources of Otumba and Pachuca as well as the Puebla-Veracruz sources of Zaragoza, Orizaba, and Guadalupe Victoria could also have reached the lower Verde via the Mixteca Baja, although other highland routes or the Gulf coast cannot be excluded.

Conclusions

This study has begun to outline exchange networks through which Prehispanic populations in the lower Río Verde valley obtained obsidian. It should be stressed, however, that the small number of artifacts subjected to INAA for each period cannot be considered as representative of the entire assemblage of obsidian at the sites examined here. The conclusions reached by this study should therefore be considered as tentative models of obsidian exchange to be modified by future research.

The INAA source determinations of obsidian from the lower Río Verde valley generally support the patterns of exchange hypothesized previously (Joyce 1993). The obsidian data suggest that the widespread network of Late Formative exchange may have extended from the lower Verde to as far as the Basin of Mexico and possibly the site of Cuicuilco. The hypothesized disruption of exchange patterns resulting from conflict in the Oaxacan highlands during the Terminal Formative is tentatively supported by the absence of a dominant source of obsidian in the lower Verde at that time. However, the disruption of interregional exchange in Oaxaca during the Terminal Formative may have forced coastal populations to look to other regions to obtain prestige items. This may have encouraged the strengthening of ties with the Basin of Mexico during the Early Classic, as suggested by the obsidian and comparative ceramic data (Joyce 1993).

Obsidian imported to the lower Verde from the Late Formative to the Late Classic was dominated by sources in the Basin of Mexico and Michoacan, while the Puebla-Veracruz sources were generally less important. The dominant source in the lower Verde shifted from Paredón during the Late Formative to Pachuca by the Early Classic, and Ucaréo during the Late Classic. These data contrast markedly with evidence from the southern Isthmus, only 300 km to the east, that shows a focus on material from the Puebla-Veracruz sources during the same time span, probably transported through a Gulf-coast exchange route (R. Zeitlin 1978, 1979, 1982). Only during the late Middle Formative was there a high proportion of obsidian in the lower Verde from the Puebla-Veracruz sources. Even then, however, there is little correspondence between sources of obsidian represented in the lower Verde and in the southern Isthmus.

The obsidian data support comparative ceramic evidence suggesting that throughout the Formative and Classic periods there was little interaction between the east and west coasts of Oaxaca (Joyce 1993). The relative lack of interaction between the lower Verde and the southern Isthmus probably resulted, at least in part, from interpolity competition among the ethnically diverse populations of the Oaxaca coast. Variation in coastal exchange patterns probably also resulted from differential access to exchange routes owing to geographical proximity and differing networks of social relations. Whereas the evidence suggests little interaction along the coast, the INAA results show that lower Verde populations maintained important exchange ties with highland regions from the late Middle Formative to at least the Late Classic.

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