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Exploring Patterns of Obsidian Conveyance in Baja California, Mexico

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The X-ray fluorescence analysis of obsidian artifacts from four study areas in Baja California, Mexico, suggests regional and local patterning in the geological sources used by indigenous hunter-gatherers during the late prehistoric and colonial periods. Obsidian artifacts were typically made from materials from the closest geological source, creating a distinct north-south pattern of obsidian distribution. In the northern region of Baja California, this pattern appears to correspond to ethnographically-documented language boundaries. However, within each study area, particular sites exhibit higher degrees of obsidian source diversity than others—a pattern that may suggest chronological or social variation in access to particular obsidian sources. Unexpectedly, projectile points do not exhibit noticeably higher levels of source diversity when compared to an aggregate of all other obsidian artifacts. Together, these patterns offer a baseline of knowledge about regional obsidian distributions and point toward potential avenues for future research on obsidian availability and conveyance in Baja California.

In western North America, recent analysis of obsidian artifacts has generated new insights into prehistoric settlement patterns and exchange networks (Eerkens et al. 2008; Mills et al. 2013), the implications of ethnolinguistic boundaries for obsidian conveyance (Whitaker et al. 2008), and changes in indigenous landscape use and resource exploitation during the colonial period (Silliman 2005). Obsidian studies are likewise poised to contribute to the archaeology of Baja California. Much scholarly debate centers on whether the coastal desert ecology of the region effectively isolated prehistoric societies, or if they exploited broad territories and maintained far-flung trade networks (Laylander 2006; Moore 2001; Porcayo 2010). Obsidian was used widely in the region's late prehistoric and early historic periods (ca. A.D. 500–1840), and the distribution of obsidian artifacts from particular sources may offer insight into local hunter-gatherer settlement patterns and exchange systems. Given that Baja California obsidian studies remain in their infancy, however, we seek first to summarize the state of knowledge regarding the archaeological and geological distribution of obsidian in the region using the behaviorally neutral concept of conveyance (Hughes 2011). Based on our dataset, we identify three possible patterns that may be used to develop and test hypotheses for the further development of Baja California archaeology.

ARCHAEOLOGICAL AND ETHNOGRAPHIC CONTEXT

The Baja California peninsula is often broken into three broad cultural regions based on the distribution of generalized linguistic groups at the time of European contact: the southern Cape Region, where indigenous Pericú and Guaycura peoples lived prior to Spanish

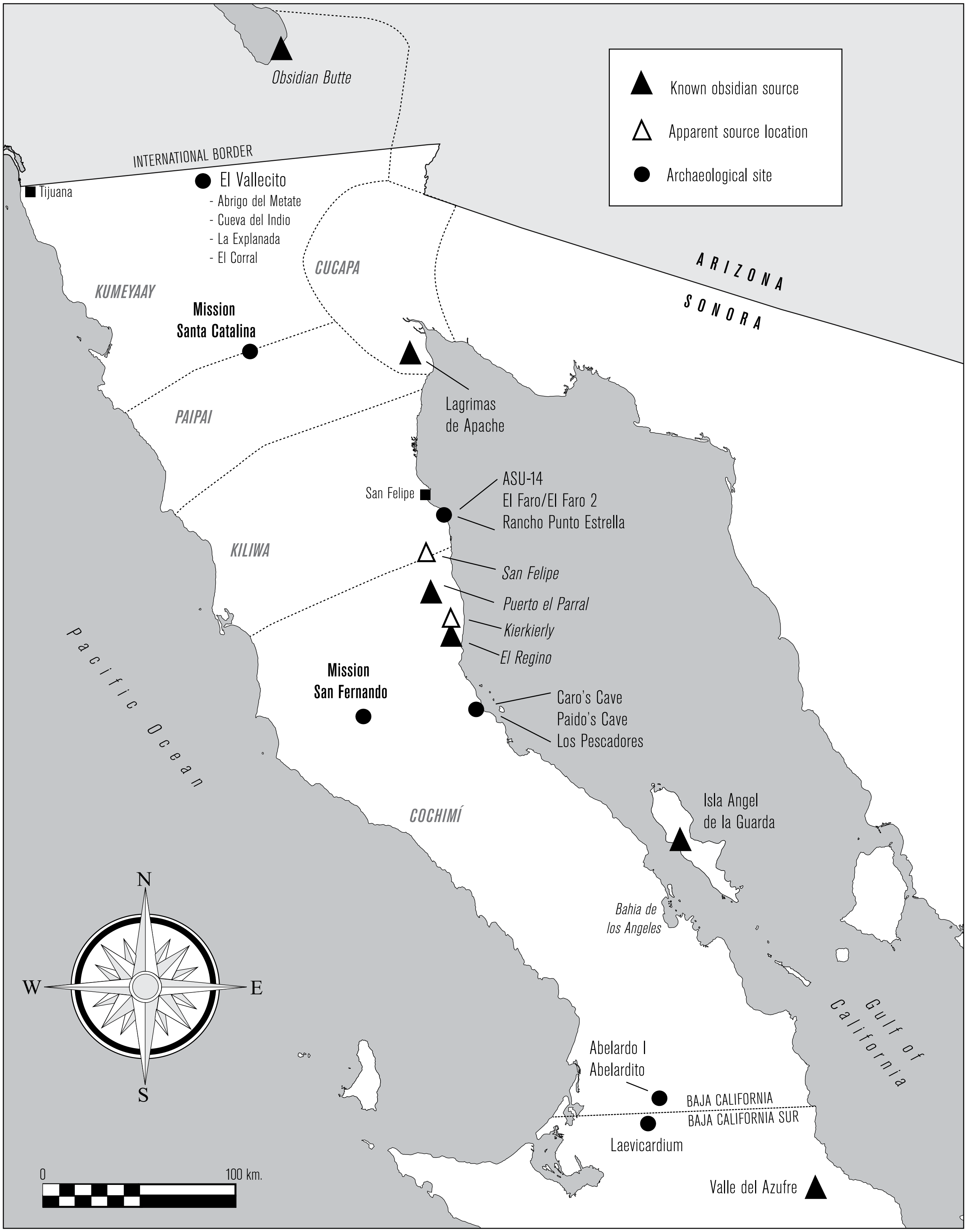

Figure 1. Baja California, with sites included in study, regional obsidian sources, and ethnolinguistic territories.

Table 1

ETHNOLINGUISTIC AFFILIATIONS, DATES, AND PROJECTILE POINT TYPES FOR SITES IN STUDY

Unit	Ethnolinguistic Affiliation	Primary Period of Occupation[a]	Obsidian Projectile Point Types Present
North-Central Region			
El Corral	Kumeyaay	Late Prehistoric	Desert Side-Notched (3), Dos Cabezas Serrated (1),
La Explanada	Kumeyaay	Late Prehistoric	Undiagnostic (1)
Cueva del Indio	Kumeyaay	Late Prehistoric	Desert Side-Notched (1), Cottonwood (1)
Abrigo del Metate	Kumeyaay	Late Prehistoric	n/a
Mission Santa Catalina	Kumeyaay/ Ko'alh, Paipai	Colonial	Desert Side-Notched (5), Undiagnostic (1)
Northeastern Region			
El Faro / El Faro 2	Kiliwa	Late Prehistoric	San Felipe (5), Undiagnostic (1)
ASU 14	Kiliwa	Late Prehistoric	Desert Side-Notched (1)
Rancho Punta Estrella	Kiliwa	Late Prehistoric	n/a
Central Region			
Caro's Cave	Northern Cochimí	Late Prehistoric (Multicomponent)	Desert Side-Notched (6), Comondú (2), Undiagnostic (2)
Paido's Cave	Northern Cochimí	Late Prehistoric (Multicomponent)	Zacatecas (1), Undiagnostic (1)
Los Pescadores	Northern Cochimí	Late Prehistoric	Comondú (1)
San Fernando Velicata	Northern Cochimí	Colonial	Comondú (2), Undiagnostic (1)
Southern Region			
Abelardito	Northern Cochimí	Late Prehistoric (Multicomponent?)	Comondú (3), Zacatecas (1), Undiagnostic (1)
Abelardo I	Northern Cochimí	Late Prehistoric	Comondú (2), Guajademi (1), Guerrero Negro (1), Amargosa (1)
Laevicardium	Northern Cochimí	Late Prehistoric (Multicomponent?)	Comondú (1), Desert Side-Notched (1), La Paz (1)

[a]Chronological placement determined by radiocarbon dates (where available) and regional archaeological patterns.

colonization; a vast region throughout the central peninsula that was home to various Cochimí groups; and the northern "Yuman" region, where several distinct ethnolinguistic groups have persisted into modern times (Mixco 2006). The Yuman groups of Baja California include the Kiliwa, Paipai, Kumeyaay, and Cucapá. Although exact cultural chronologies have not been developed for the entire peninsula, these linguistic regions generally correspond to the archaeological cultures of the late prehistoric period, circa A.D. 500–1750 (Wilken-Robertson and Laylander 2006).

This study focuses on sites throughout the state of Baja California, which covers the ancestral homelands of Cochimí groups in the south and Yuman groups in the north (Fig. 1). The indigenous peoples of this region practiced a hunting and gathering lifestyle, and were likely organized into semi-autonomous bands or clans that included between 50 and 100 individuals (Hicks 1963). Ethnographic data indicate that these clan groups were localized in that they resided in, and controlled the resources of, a discrete geographic territory (Ortega 2004; Owen 1965). Although previous researchers in Baja California have used the archaeological distribution of artifacts from particular obsidian sources to argue for much larger, cross-peninsular procurement ranges (Moore 2001), other work suggests that the relatively circumscribed territories—and broader ethnolinguistic distributions—of historically documented social groups can be extended into late prehistory (Hildebrand and Hagstrum 1995; Ortega 2004; Porcayo 2010, 2014).

The data in this study are derived from sites dating to the late prehistoric and colonial periods (A.D. 500 to 1840), based on radiocarbon dates, local archaeological patterns, and historical documentation (Table 1). In the northern peninsula, archaeological obsidian is commonly associated with ceramic artifacts, a key marker of the late prehistoric era in the broader region (Hildebrand and Hagstrum 1995:91). South of the Sierra Juárez, which represents the southern extent of indigenous precontact ceramic traditions, recent work similarly suggests that widespread obsidian use began after A.D. 500 (Des Lauriers 2010; Moore 2001; Ritter 2006a; and see overview in Sosa 2014). The focus on relatively recent periods is consistent with observations from San Diego County, California, where obsidian is most common at sites dating to the Late Prehistoric period (Dietler 2004; Laylander and Christenson 1988; McFarland 2000).

The small size of geological obsidian nodules in northern Baja California also imposed limits on lithic technology, which can serve as another, albeit approximate, temporal marker.[1] Aside from Valle del Azufre, all of the obsidian sources documented in archaeological contexts in Baja California produce small nodules, typically measuring less than 5–7 cm. in maximum dimension. Obsidian from these sources is most often associated with arrow points, small bifaces, utilized flakes, and debitage. All projectile points in this study are arrow-sized, and their morphological characteristics are largely consistent with the late prehistoric and early historic period dates for the sites presented here (Fig. 2).[2]

While placing our study within this archaeological and ethnographic background, we make two key assumptions. First, we hesitantly treat our sample as contemporaneous. We acknowledge serious shortcomings with this stance—chief among them is the possibility of mixing materials from multicomponent sites and thus flattening temporal patterns. However, a lack of radiocarbon dates and well-defined stratigraphy at many of the sites, combined with the small size of our sample, precludes fine-grained analysis of temporal trends. Therefore, with the obvious exception of artifacts from the two mission sites, we consider all the materials from the late prehistoric period together, offering some

0 1cm.	Amargosa	200–900 A.D.	0 1cm.	Guerrero Negro	1500–1800 A.D.
0 1cm.	Comondú	300–1800 A.D.	0 1cm.	Gypsum Cave	2,600 B.C.–400 A.D.
0 1cm.	Cottonwood	300–1800 A.D.	0 1cm.	La Paz	2,600 B.C.–400 A.D.
0 1cm.	Desert Side-Notched	300–1800 A.D.	0 1cm.	Lanceolate	N/A
0 1cm.	Dos Cabezas Serrated	500–1900 A.D.	0 1cm.	Roma	N/A
0 1cm.	El Zacateco	1200–1600 A.D.	N/A	San Felipe	300–1800 A.D.
0 1cm.	Guajademí	500–1500 A.D.	0 1cm.	Zacatecas	3,000–700 B.C.

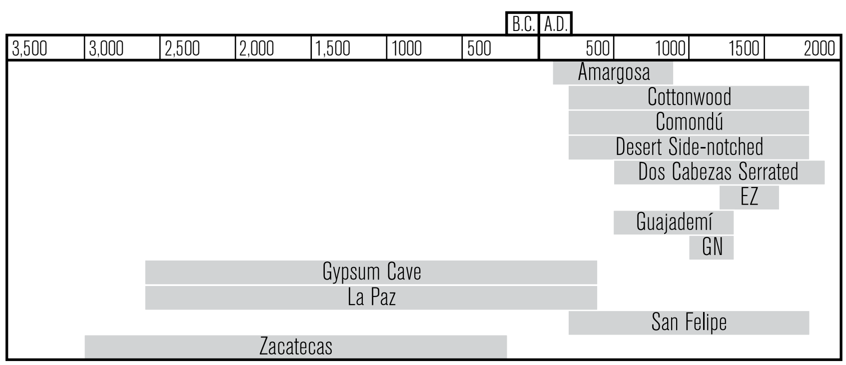

Figure 2. Morphology and chronology of Baja California projectile points (after Moranchel 2014).

thoughts on chronological variation in the discussion. Second, we assume that the general picture of Native Californian economic relationships, social organization, and language group territoriality holds for most, if not all, of the late prehistoric period and early historic period under consideration (Porcayo 2010). Drawing on the regional archaeological and ethnographic research cited above, we work from the position that small-scale, hunting and gathering groups in the northern half of the peninsula occupied autonomous territories within a broader constellation of similar groups speaking the same languages.

STUDY AREAS

Our geographic focus for this paper is the state of Baja California, ranging from the 28th parallel to the International Border. To better understand local patterns of obsidian availability and conveyance, we further identify four separate study areas that are each within the territory of one major linguistic group as mapped by recent scholars (Hinton and Watahomigie 1984; Laylander 1987, 1997; Mixco 2006) (Fig. 1).

In the north-central study area, we include data from four prehistoric sites (Abrigo del Metate, Cueva del Indio, El Corral, and La Explanada) within the Vallecito archaeological site cluster (Moranchel 2014; Porcayo and Rojas 2013). Obsidian points and debitage from these sites were stratigraphically associated, and radiocarbon dates from El Corral and La Explanada suggest occupation dates within the last 500 years of the prehistoric period. This area is directly south of the International Border, in the mountains between the modern cities of Tecate and Mexicali. This region is in the heart of the broadly distributed Kumeyaay (Tipai or Diegueño) ethnolinguistic province. We also include material from the colonial-era site of Mission Santa Catalina (1797–1840). This mission drew native people from the surrounding region, including ancestors of the modern Kumeyaay, Paipai, and Cucapá ethnolinguistic groups. Although the mission's ruins are today in the predominantly Paipai community of Santa Catarina, it is likely that the area was originally home to people speaking Ko'ahl, a dialect of Kumeyaay (Panich 2010).

The northeastern study area centers on the Gulf of California coast near the present-day city of San Felipe. Data are drawn from three clusters of prehistoric shell middens: ASU14, El Faro/El Faro 2, and Rancho Punto Estrella (Moranchel 2014; Porcayo and Rojas 2009, 2010, 2011, 2012). Obsidian artifacts from this area were primarily collected from surface deposits. However, all three sites contain ceramic artifacts, and radiocarbon dates further indicate that the primary occupation of these sites appears to have been after A.D. 500 (e.g., Porcayo 2010). This area is on the southern edge of the ethnographic territory of Kiliwa-speaking groups.

The central study area includes three prehistoric encampments along the Gulf of California coast: Caro's Cave, Los Pescadores, and Paido's Cave (Moranchel 2014; Porcayo 2012). Radiocarbon dates indicate a late prehistoric occupation of Caro's Cave, but it is likely that Los Pescadores and Paido's Cave are multicomponent sites that contain both late prehistoric and earlier deposits. For this study area, we also include data from in and around the site of Mission San Fernando Velicatá (1769–1830s), in the interior of the peninsula (Rojas et al. 2013). All four of the sites are within the Northern Cochimí linguistic province.

In the southern study area, we include three prehistoric sites: Abelardo I, Abelardito, and Laevicardium (Moranchel 2014; Porcayo et al. 2010; Porcayo, Celis, and Chavez 2011). No radiocarbon dates are available for this study area, but the materials from each site generally suggest late prehistoric occupations based on regional archaeological patterns. These sites straddle the border between Baja California and Baja California Sur, roughly halfway between the Pacific and Gulf of California coasts. The southern study area is also within the broader Northern Cochimí linguistic province. Given the distance between this area and the central study area, however, it is likely that the groups residing at these sites had some cultural and linguistic differences (see discussion in Laylander 1997).

OBSIDIAN RESEARCH IN BAJA CALIFORNIA

Only scattered attempts have been made to systematically define and characterize the geological sources of obsidian on the Baja California peninsula (Banks 1971; Bouey 1984; Douglas 1981; Hughes 1986). Scholarly understanding of these sources is hampered by intermittent studies, an incompatibility of data from different analytical techniques, and uncertainties about the geological availability and chemical variation of peninsular obsidian. Indeed, the large number of artifacts from unknown chemical groups present in archaeological assemblages complicates the use of obsidian for studying Baja California's indigenous societies. Given these issues, not to mention the growing number of Mexican, American, and Canadian researchers working on the peninsula, there is a need to ensure validity and reliability of obsidian provenance data as new geological sources are identified and characterized.

Through a combination of previous research by American and Mexican scholars, as well as our own research since 2009, scholarly understanding of the geological sources of obsidian in Baja California is slowly advancing (Panich et al. 2012; Porcayo 2014; Porcayo, Eckhardt, and Rojas 2011; Tellez et al. 2013). Thus far, artifact-quality obsidian from at least 13 distinct chemical groups has been identified in archaeological or geological deposits in the state of Baja California alone. Of these, the majority are still "unknowns" in that we do not know the precise location or extent of the primary geological deposits of the obsidian chemical group in question. Accordingly, we cannot say for certain at this point whether these unknown chemical groups each represent a single geological source, variation within particular geological sources, or even multiple sources that cannot be readily distinguished through XRF analysis (see discussion in Hughes 1998).

The artifacts in our sample match many of the obsidian sources documented in the state of Baja California, including the Obsidian Butte source in Imperial County, California, and the Valle del Azufre source in Baja California Sur (Fig. 1). Below we detail the obsidian sources located in each of our study areas, highlighting the sources present in our sample (and see Panich et al. 2012).

The north-central study area, in extreme northern Baja California, contains no known geological sources of obsidian. Glass from Obsidian Butte is found commonly at sites near the International Border, and other archaeological obsidian belongs to a large and poorly-defined chemical group first noted at the site of Mission Santa Catalina (Panich 2011). Based on artifact distributions and our reconnaissance surveys focusing on obsidian nodules in secondary geological contexts, we speculate that the Santa Catalina unknown is in the Sierra las Tinajas or the Sierra las Pintas, just outside of Kumeyaay territory. Another nearby source, Lágrimas de Apache, is immediately west of the Colorado River Delta, within the bounds of the Cucapá ethnographic territory.

The northeastern study area contains the so-called "San Felipe" obsidian source. San Felipe was one of the earliest documented geological obsidians in Baja California (Bouey 1984), but the exact location of its primary source locality remains unknown. Our reconnaissance surveys have documented geological nodules from this chemical group in arroyos leading east from the Sierra San Felipe, approximately 40 km. south-southwest of the modern city of San Felipe. Additionally, we have collected small water-worn nodules from this chemical group from beaches near Laguna Percebú and as far north as the southern extent of the Bahía de San Felipe.

The central study area is within the Puertecitos Volcanic Province and contains several known obsidian sources and unknown chemical groups (Porcayo 2012). The best documented source is called Puerto el Parral. The primary source locality includes multiple outcroppings roughly three km. south of Arroyo Matomí. Nodules of Puerto el Parral obsidian can also be found in the arroyo east of the outcroppings, as well as on the beach where the arroyo empties into the Gulf of California. Two other chemical groups—dubbed Kierkierly and El Regino—have been noted just south of the modern village of Puertecitos. The Kierkierly group has only been documented in secondary geological deposits. Nodules from the El Regino group have been found in primary geological strata near its namesake El Regino rockshelter, as well as in secondary geological deposits in the neighboring Arroyo los Heme and the more distant Arroyo el Huerfanito. Another unknown chemical group, tentatively labeled "El Juanjo," has been noted in archaeological assemblages in this study area. Based on our geological surveys, the primary source locality appears to be somewhere south of El Huerfanito.

No geological sources of obsidian are known within the southern study area. This region is roughly 110 km. northwest of Valle del Azufre, the peninsula's best documented obsidian source. Valle del Azufre yields the largest nodules of any known source on the peninsula, and native people likely exploited it much earlier and

Table 2

RESULTS OF XRF STUDY, BY SITE AND STUDY AREA

	Obsidian Butte		Santa Catarina		San Felipe		Puerto el Parral		El Regino		Valle del Azufre		Unknowns		Total		
Obsidian Sources	PP	Deb	PP	Deb	PP	Deb	PP	Deb	PP	Deb	PP	Deb	PP	Deb	PP	Deb	Total
North Central Region	**6**	**36**	**7**	**64**											**13**	**100**	**113**
El Corral	3	12	1	2											4	14	18
La Explanada	1	16													1	16	17
Cueva del Indio	2	8													2	8	10
Abrigo del Metate				33												33	33
Mission Santa Catalina			6	29											6	29	35
Northeastern Region					**5**	**26**	**2**								**7**	**26**	**33**
El Faro/El Faro 2					4	3	2								6	3	9
ASU 14					1	15									1	15	16
Rancho Punta Estrella						8										8	8
Central Region[a]					**1**		**11**	**13**	**3**	**1**			**1**	**7**	**16**	**21**	**37**
Caro's Cave							7	4	2	1			1	4	10	9	19
Paido's Cave					1			1	1					2	2	3	5
Los Pescadores							1	4						1	1	5	6
San Fernando Velicatá							3	4							3	4	7
Southern Region[b]											**12**	**31**	**1**	**4**	**13**	**35**	**48**
Abelardito											5	6			5	6	11
Abelardo I											4	17	1	4	5	21	26
Laevicardium											3	8			3	8	11

Note: PP = projectile point; Deb = debitage. [a]Unknown = El Juanjo and similar. [b]Unknowns = Unknown A and Abelardo.

more widely than other regional obsidians (Shackley et al. 1996). Two unknown chemical groups are present in archaeological assemblages in the southern study area. The "Abelardo" unknown thus far has only been identified in sites within the area, while "Unknown A" was first identified in assemblages from Bahía de los Angeles (Ritter 2006b).

As depicted in Figure 1, the current analysis omits the area around Bahía de los Angeles. Several obsidian chemical groups have been observed in geological contexts and in archaeological assemblages in that region. These include substantial geological deposits on Isla Ángel de la Guarda (Bowen 2009a, 2009b, 2012), as well as multiple other chemical groups whose geological sources are as yet unknown. Most of these unknown chemical groups were originally noted in assemblages collected by Eric Ritter and analyzed by Steven Shackley (Ritter 1994, 1995, 1997). These findings are summarized elsewhere (Panich et al. 2012:186–188).

Although we do not formally discuss obsidian availability and distribution south of the 28th Parallel, it is worth noting that in addition to Valle del Azufre, at least three other sources have been noted in Baja California Sur: Punta El Pulpito, Punta Mangles, and Toris de la Presa (Henrickson 2013:33 Ritter 2006c:101). No obsidian sources are believed to exist in the Cape Region.

METHODS

Our primary archaeological sample consists of 49 obsidian projectile points and projectile point fragments, as well as 182 other obsidian artifacts, including assayed nodules, flakes, and shatter. Only materials from sites that contained both projectile points and other obsidian artifacts were chosen for the initial analysis, but to make up for small sample sizes for some areas, contextual data from two additional sites with no projectile points are also provided (Table 2). While this small sample size imposes limits on our interpretations, it is worth noting that this paper presents the largest obsidian provenance study yet compiled for Baja California.

Materials were collected and analyzed as part of various projects conducted by the Instituto Nacional de Antropología e Historia (INAH). The projects include

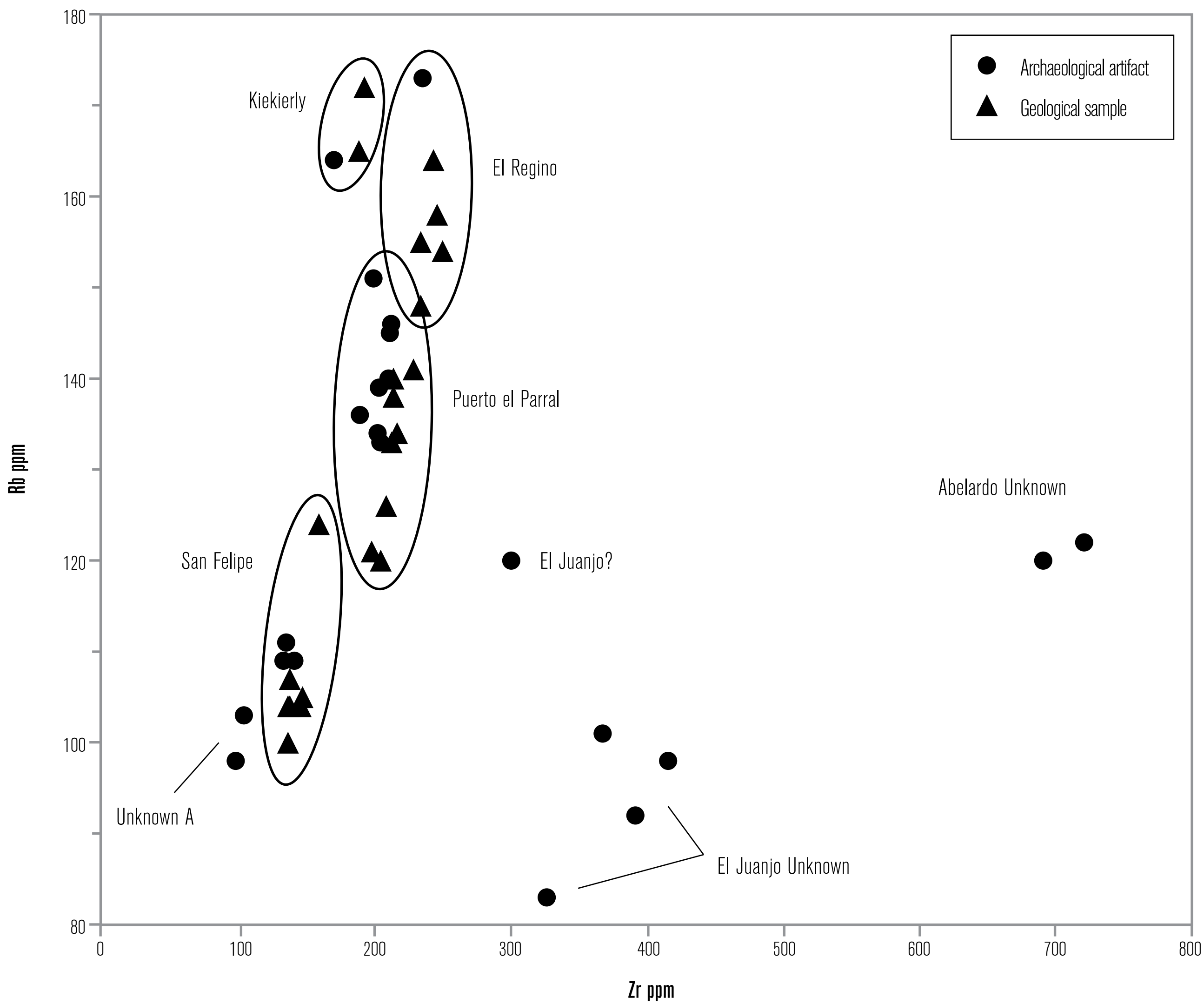

Figure 3. Biplot of Rb and Zr ppm values generated through desktop XRF for archaeological and geological samples from key Baja California chemical groups present in this study. Note that ellipses are solely for the visual presentation of source assignments; they are not statistically derived.

the following: the Proyecto Registro y Rescate de Sitios Arqueológicos de Baja California–Fase Municipio de Mexicali (Porcayo and Rojas 2009, 2010, 2011, 2012, 2013), the Salvamento Arqueológico San Felipe-Laguna Chapala (Porcayo 2012), the Salvamento Arqueológico Mina el Arco (Porcayo et al. 2010; Porcayo, Celis, and Rojas 2011), and the Proyecto Prehistoria de Baja California Fase San Fernando Velicatá (Rojas et al. 2013). Materials from Mission Santa Catalina were collected by Panich as part of the Proyecto Arqueológico de Santa Catarina (Panich 2009, 2011). The obsidian projectile points are part of a larger study conducted by Moranchel on the typology of Baja California projectile points (Moranchel 2014). Results from other obsidian studies in Baja California are included in the discussion.

The geological sources of obsidian artifacts were determined through X-ray fluorescence (XRF) spectrometry, using a combination of portable (pXRF) and desktop instruments. Those artifacts analyzed with pXRF were analyzed using a Bruker AXS Tracer III-SD handheld X-ray fluorescence spectrometer. Raw spectral data were calibrated to parts-per-million (ppm) based on an instrument- and matrix-specific, factory-generated calibration curve prepared by Bruker (Glascock and Ferguson 2012; Speakman and Shackley 2013). Desktop XRF analysis was conducted by Steven Shackley using

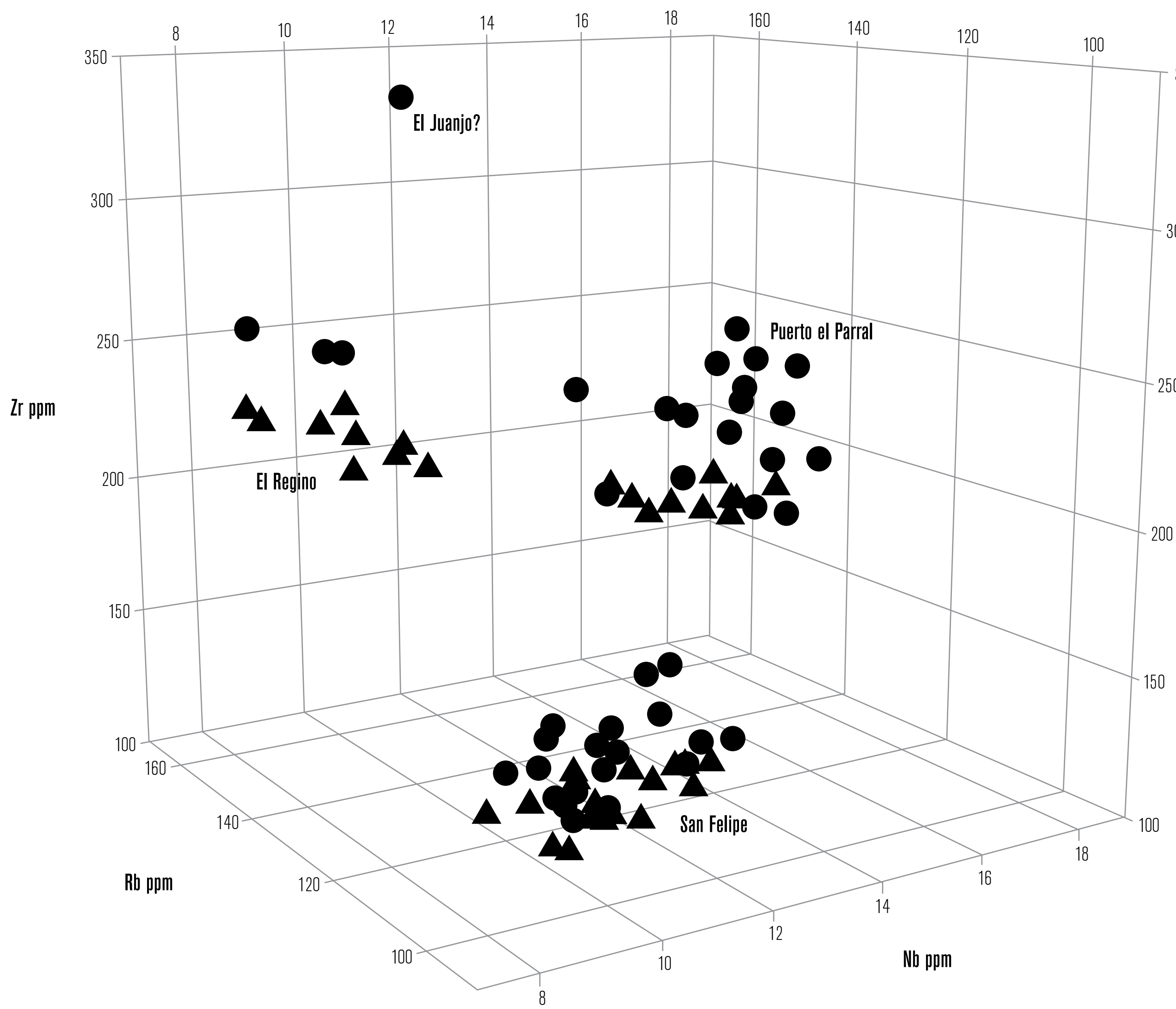

Figure 4. Three-dimensional plot of Zr, Rb, and Nb ppm values generated through pXRF for archaeological artifacts (circles) and geological samples (triangles) from key Baja California chemical groups present in this study.

a Thermo Scientific/ARL Quant'X energy-dispersive XRF spectrometer following the procedure outlined in Shackley (2005). Calibrated data were imported to the JMP statistical software package for manipulation.

For consistency, source assignments were made with intra-instrument chemical data (Figs. 3 and 4).[3] We note that in some cases the values for the archaeological artifacts analyzed, particularly using pXRF, exhibit more variation than the geological samples analyzed by the same instrument. Although it is possible that our geological samples simply do not represent the full chemical variation for particular sources, we suspect that this phenomenon is due at least in part to the small size of many of the archaeological artifacts in our sample. Tables 3 and 4 compare chemical data generated by pXRF and desktop XRF for key known and unknown obsidian chemical groups in Baja California. The results differ slightly in the parts-per-million values reported for certain elements such as Sr, Rb, and Zr. While the formal comparison of different XRF instruments is not the focus of this paper, our data illustrate the importance of ongoing debates about the comparability of data from different analytical techniques (Speakman and Shackley 2013).

RESULTS

The results offer a relatively broad look at obsidian conveyance and use in native Baja California. Three

Table 3

COMPARISON OF SELECTED ELEMENTAL CONCENTRATIONS FOR KEY BAJA CALIFORNIA OBSIDIAN SOURCES PRESENT IN THIS STUDY, BASED ON ANALYSIS OF GEOLOGICAL SAMPLES. VALUES ARE IN PARTS PER MILLION.

	San Felipe Desktop XRF (n = 7)			San Felipe pXRF (n = 16)			Puerto el Parral Desktop XRF (n = 8)			Puerto el Parral pXRF (n = 10)			El Regino Desktop XRF (n = 5)			El Regino pXRF (n = 9)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Mn	256	320	276.4	161	296	221.9	270	328	297.6	172	313	260.8	177	251	214.6	131	341	212.5
Fe	9,939	13,643	10,786.9	8,555	9,706	8,975.5	10,633	13,481	12,322.6	10,430	11,159	10,809.4	12,678	15,011	13,663.4	11,455	12,594	12,012.1
Rb	100	124	106.9	97	106	101.5	120	141	131.6	123	131	127.9	148	164	155.8	135	160	144.9
Sr	35	43	38.4	28	36	32.3	57	65	60.6	50	59	53.4	59	65	61.8	49	55	52.2
Y	30	36	32.9	29	33	31.3	33	36	34.0	31	37	34.2	35	43	38.8	37	43	39.7
Zr	137	160	143.9	123	138	131.9	198	229	212.5	192	205	199.1	234	250	242.0	212	232	223.6
Nb	4	12	8.3	8	12	10.3	12	17	14	13	16	14.4	3	11	7.4	8	10	9.2

Table 4

COMPARISON OF SELECTED ELEMENTAL CONCENTRATIONS FOR ARTIFACTS IN THIS STUDY ASSIGNED TO THE SANTA CATALINA UNKNOWN CHEMICAL GROUP. VALUES ARE IN PARTS PER MILLION.

	Santa Catalina unknown Desktop XRF (n=35)			Santa Catalina unknown pXRF (n=36)		
	Min	Max	Mean	Min	Max	Mean
Mn	212	292	256.7	131	310	215.3
Fe	8,295	12,399	9,924.7	6,688	11,482	8,587.3
Rb	132	175	150.5	112	192	141.9
Sr	31	61	41.0	27	68	40.6
Y	26	41	34.0	27	39	33.8
Zr	97	125	110.6	101	135	117.2
Nb	0	16	6.8	7	11	9.2

topics of analysis are of interest with regard to the data presented here: (1) the distribution of geological sources within the four study areas; (2) the diversity of source material within the assemblages from particular sites; and (3) the relative frequency of particular sources among the projectile points and other artifacts.

In the north-central study area, Obsidian Butte dominates the assemblages from the sites in the Vallecito site cluster. Nevertheless, the unknown chemical group first identified at Mission Santa Catalina was also an important source of toolstone for people living at some Vallecito sites, or during certain times. El Corral contained a small proportion of material from the unknown chemical group—one projectile point and two other artifacts—but obsidian artifacts from the nearby Abrigo del Metate were exclusively from the Santa Catalina unknown. For its part, Mission Santa Catalina contained only obsidian from the unknown chemical group that bears its name.

The northeastern study area was similarly dominated by one particular obsidian source, San Felipe. However, two projectile points from the Puerto el Parral source were identified at El Faro. These are the only artifacts analyzed thus far from the northeastern study area to be from any source other than San Felipe. Given the small sample sizes from ASU-14 and El Faro, the obsidian artifacts from Rancho Punta Estrella further demonstrate the prevalence of San Felipe glass in this study area.

Three of the sites in the central study area lie within the Puertecitos Volcanic Province. Not surprisingly, those sites closer to the geological source areas (Caro's Cave, Los Pescadores, and Paido's Cave) contain artifacts from a variety of sources, including El Regino and Kiekierly, as well as the unknown first documented at El Juanjo. Nevertheless, artifacts made from Puerto el Parral obsidian still comprise a majority in those three sites. Obsidian from around Mission San Fernando Velicatá, which is further from the geological source areas, is thus far limited to the Puerto el Parral source.

Valle del Azufre is the most abundant source material for the sites within the southern study area. Only the Abelardo I site contains other sources of obsidian. Besides Valle del Azufre obsidian, artifacts made from two unknown chemical groups are present at Abelardo I. These include Unknown A as well as a newly identified unknown chemical group provisionally named for the Abelardo site.

In terms of the distribution of sources within the study areas, one source tends to dominate the artifacts in any given area. The exception is the north-central study area, where Obsidian Butte and the Santa Catalina unknown appear in roughly equivalent quantities, even though most sites contain obsidian from only one or the other source. Further south, the trend of one dominant source is more pronounced, with San Felipe in the northeastern area, Puerto el Parral in the central, and Valle del Azufre in the southern study area. The only overlap of obsidian sources between study areas occurs in the northeastern and central study areas, which both share glass from the Puerto el Parral source.

Despite these general patterns, an unanticipated finding is that within each study area, particular sites exhibit higher levels of source diversity than others. As shown in Table 2, these sites include El Corral in the north-central study area, El Faro in the northeastern area, Caro's Cave in the central area, and Abelardo I in the southern area. In fact, only the central study area has more than one site that contained artifacts representing multiple obsidian sources. Given the close proximity of most sites in each study area, future research may clarify whether the distribution of archaeological obsidian at certain sites contradicts common models of obsidian exchange based on distance to particular sources.

Regional trends are less pronounced with regard to the relative frequency of individual obsidian sources among projectile points versus other obsidian artifacts. In the north-central and northeastern study areas, projectile points exhibit slightly more variation in source material than do other artifact classes. In the central and southern study areas, obsidian from non-dominant sources comprises roughly the same percentages of points and other artifacts. More robust sample sizes and more complete knowledge of regional obsidian sources will be needed to flesh out these preliminary observations.

DISCUSSION

The data presented above suggest three patterns that may be important for understanding hunter-gatherer mobility and/or exchange networks in Baja California through the analysis of obsidian artifacts. These possibilities are discussed in relationship to previous studies from Baja California, California, and the Great Basin.

Regional Source Distribution

In aggregate, the results of this study suggest that the use and circulation of materials from particular obsidian sources in Baja California were in large part geographically circumscribed. This pattern is not surprising given the broad territory included in the study, the geography of the region, and the relatively small scale of the societies in question. What is perhaps more interesting is the potential relationship between the regional distribution of obsidian sources and the ethnographically-documented boundaries of the peninsula's linguistic groups, at least in the northern peninsula.

In an earlier paper about the potential for obsidian studies to advance Baja California archaeology, Laylander (2006) examined the idea that territorial boundaries between known ethnolinguistic groups might be reflected in north-south patterns of obsidian distribution along the peninsula. He urged caution on this front, citing the wide distribution of Valle del Azufre obsidian from Ignacieño territory far into the San Borja area to the north and southern Cochimí region to the south. While his point is well taken, we note that the Valle del Azufre source is unique among peninsular obsidian sources in its abundance and nodule size.

Research in neighboring Alta California indicates that the effects of ethnolinguistic relationships on obsidian conveyance are worth investigating, especially in regions of Baja California where the available sources are more or less equal in their abundance and quality. In a study from northern California, Whitaker et al. (2008) compared archaeological obsidian assemblages with regional availability of geological obsidian, suggesting that linguistic barriers prevented certain coastal communities from obtaining obsidian raw material from the geographically closest sources. In the Sierra Nevada foothills, Whelan et al. (2012) noted that the relative distribution of Bodie Hills and Casa Diablo obsidians generally cleaves along the ethnographic boundary separating the Central and Southern Sierra Miwok. Ethnolinguistic affinities, in contrast, appear to have enabled some Native Californian groups to directly procure obsidian outside of the circumscribed territories of their "tribelet" communities. Basgall (1979) used ethnographic information to demonstrate that obsidian deposits near Clear Lake were freely available to diverse Pomo groups, some of whom regularly travelled more than 50 km. to obtain obsidian from the geological source. These studies suggest that researchers seeking to explain obsidian distributions should consider not just the effective distance between sites and sources, but also the social distance (or lack thereof) between native groups or individuals (Hughes 2011:8–9).

Our data underscore a need for further studies of how linguistic boundaries shaped the regional distribution of obsidian in Baja California. This is particularly true for northern Baja California, where scholarly understanding of late prehistoric and historic-era ethnolinguistic boundaries is relatively robust. There, the vast majority of obsidian from our study areas came from sources thought to have been in the territories of the ethnolinguistic groups represented. The north-central study area, for example, contained only glass from Obsidian Butte and the Santa Catalina unknown, sources that are within the broadly defined Kumeyaay region. This pattern is bolstered by additional regional data; other artifacts in our database indicate that Obsidian Butte is common at sites along the International Border while the Santa Catalina unknown is present in sites within Kumeyaay territory from the Pacific Coast to the Sierra Juárez (Panich et al. 2013). In neighboring San Diego County, moreover, Obsidian Butte is the most common source noted in the analysis of artifacts from late prehistoric Kumeyaay sites (see overview in Dietler 2004).[4]

The northeastern study area, home to Kiliwa-speaking groups, was dominated by San Felipe obsidian, which is available within the overarching Kiliwa territory. The distribution of other sources may also point to the importance of ethnolinguistic boundaries: no obsidian from San Felipe or Puerto el Parral (from the Northern Cochimí region) was noted in the north-central study area; and neither the north-central nor northeastern study area contained obsidian from the nearby Lágrimas de Apache source, which is within the ancestral territory of Cucapá-speaking groups.

To the south, the relationship between obsidian source distribution and language boundaries is less clear. For example, the boundary between the Kiliwa and northern Cochimí groups does not appear to have been impermeable. Two projectile points from the Puerto el Parral source were recovered from El Faro, and our database also includes two projectile points made from San Felipe obsidian that were recovered from Rancho La Bocana roughly 45 km. southeast of Mission San Fernando. Furthermore, Moore (2001:44) reported at least three artifacts from the San Felipe source in Pacific Coast sites between San Quintín and El Rosario that were otherwise dominated by Puerto el Parral glass. This pattern aligns with ethnographic observations that the Kiliwa (despite speaking a Yuman language) may have had more affinities with Cochimí groups to the south than to other Yuman-speakers such as the Paipai and Kumeyaay to the north (Mixco 2006; Wilken-Robertson and Laylander 2006).

In sum, the correlation between obsidian conveyance and linguistic boundaries is strongest for the far northern peninsula, given the relative wealth of ethnographic and archaeological data for that region. In this study, both Obsidian Butte and the Santa Catalina unknown are restricted to areas thought to have been home to Kumeyaay groups. Interestingly, artifacts manufactured from Puerto el Parral and San Felipe both occur in small quantities on opposite sides of the Kiliwa-Cochimí language boundary, perhaps representing the proposed social distance between the Kiliwa and their Yuman neighbors. But in general, the archaeological distribution of the Puerto el Parral and neighboring sources, including Kiekierly, El Regino, and El Juanjo, are heavily oriented to the south. Although more contextual data are needed, it is likely that these sources were within the homelands of Cochimí-speaking groups who interacted primarily with groups speaking the same language. More explicit testing of the relationship between archaeological obsidian distribution and ethnolinguistic boundaries may clarify these apparent patterns.

Source Diversity within Study Areas

Despite the regional patterning of obsidian source circulation, a focus on obsidian distribution at the site level reveals particular locations that exhibit more source diversity than others in the same immediate area. The exploration of this pattern is limited by the small sample sizes presented here, but it appears that raw material and/or artifacts made from distant sources of obsidian were differentially available. Two mechanisms may account for the differences in distant obsidian at sites in the same area: temporal variation or variation in particular groups' access to a wider array of obsidian raw material.

With regard to temporal variation, the evidence is equivocal. Given the prevalence of Obsidian Butte glass at many of the sites in El Vallecito, it is possible that local hunter-gatherers turned to other obsidian sources, namely the Santa Catalina unknown chemical group, when the filling of ancient Lake Cahuilla made Obsidian Butte inaccessible (McFarland 2000). Conversely, the periodic filling of Lake Maquata in the Laguna Salada Basin might have temporarily interrupted access to the area where the Santa Catalina unknown is thought to be located, forcing native people to rely on Obsidian Butte for suitable toolstone. These hypotheses, however, cannot be evaluated with the current dataset. Abrigo del Metate yielded no materials suitable for radiocarbon dating, and the three artifacts from the Santa Catalina unknown recovered from El Corral were from varying stratigraphic contexts. The small sample sizes and nature of radiocarbon assays from sites in other study areas similarly frustrate attempts to correlate obsidian source diversity with distinct temporal periods in the late prehistoric era.

The samples from historic-era Spanish mission sites, conversely, do not exhibit any source diversity. Mission Santa Catalina yielded material exclusively from the Santa Catalina unknown, and materials from the vicinity of Mission San Fernando were all from Puerto el Parral. More data from sites in the immediate areas of these missions will be needed for a conclusive interpretation, but it may be that obsidian exchange networks or procurement strategies changed during the colonial era. While indigenous people living at the missions may have had limited access to distant sources of materials such as obsidian, the evidence from mission sites in both Alta California and Baja California clearly demonstrates the persistence of indigenous lithic technologies and conveyance of distant obsidian materials (Allen 1998:81–82; Panich 2011; Panich et al. 2014).

Another, not mutually exclusive, interpretation of the variation in source diversity within each study area is that certain social groups (perhaps living at different times) enjoyed wider access to materials than their neighbors. Similar patterns have been noted in other regions where obsidian conveyance does not always follow neat distance-decay models (e.g., Ortega et al. 2014). While distance to source was likely a factor in obsidian availability, archaeological and ethnographic examples from California and the Great Basin amply demonstrate that distance itself does not signify trade or exchange (Hughes 2011; Hughes and Milliken 2007; Moratto 2011). Instead, social relationships may also have imposed constraints and offered opportunities for the acquisition of obsidian from distant sources. Or, it may be that certain groups organized their obsidian procurement strategies differently, resulting in the differential use of obsidian from a more diverse array of sources. Eerkens and Glascock (2000), for example, discuss the occasional use of minor obsidian sources in California's Eastern Sierra; certain groups in Baja California, particularly in the areas with many minor sources, may have similarly turned to locally available sources for reasons related to seasonal mobility or technological expediency.

Source Diversity among Artifact Classes

Another perspective from which to view the diversity of obsidian artifacts in this study is to examine the relative frequency of distant sources in different categories of obsidian artifacts. The data in Table 2 are organized into two broad categories, projectile points and other artifacts (including assayed nodules, flakes, and shatter). Previous research on hunter-gatherers in western North America has revealed strong patterning between similar categories. Typically, distant sources of obsidian, and other raw materials, are more often represented among projectile points and formal tools, while local sources are more frequently represented in various classes of debitage (Eerkens et al. 2007). The interpretation is that in highly mobile societies formal tools are carried far from their raw material sources and production areas while expedient tools are manufactured, used, and discarded closer to the place of raw material acquisition.

The data in our study do not strongly align with this pattern. Only two of the four study areas exhibited higher source diversity among projectile points, while the other two contained approximately equal percentages of the closest obsidian sources across the artifact categories. Moranchel's (2014) larger analysis of projectile points in Baja California indicates that most such tools were produced locally, rather than exchanged between groups, at least during the late prehistoric period. The obsidian source diversity among projectile points in our study generally supports this conclusion. The significance of these patterns, however, is limited by our incomplete understanding of the geological distribution of obsidian in Baja California (see Andrefsky 1994).

CONCLUSIONS

Our analysis of over 200 obsidian artifacts from 15 archaeological sites illuminates three preliminary patterns in obsidian use in native Baja California. First, we see some regional trends in the distribution of geological sources of obsidian across the four study areas. While artifacts generally represent the closest available source, the overall distribution may also coincide with ethnographically-documented linguistic provinces. This pattern is strongest for the northern peninsula, a region that is better understood both archaeologically and ethnographically. There, our data suggest that access to glass from Obsidian Butte and the Santa Catalina unknown chemical group may have been restricted to Kumeyaay (or closely aligned) communities. The San Felipe source occurs primarily at sites thought to have been occupied by Kiliwa groups, while the Lágrimas de Apache source, in Cucapá territory, is thus far absent in both Kumeyaay and Kiliwa sites. Further south, the relationship between obsidian availability and linguistic boundaries is less clear, but the most prevalent sources of the central and southern study area (Puerto el Parral and Valle del Azufre, respectively) are largely restricted to regions occupied by Cochimí groups. As archaeologists further examine the archaeological distribution of obsidian in Baja California, we should consider social distance alongside the effective distance between sources and archaeological sites.

Second, we examined obsidian source diversity at the site level. Despite the prevalence of particular sources in each study area, some sites exhibit more source diversity than others in the immediate vicinity. The data accumulated thus far do not suggest a clear explanation of this pattern. We speculate that in the north-central study area, native people may have turned to alternative sources of obsidian when high stands of ancient Lake Cahuilla or Lake Maquata made their usual obsidian raw material inaccessible. The diversity of sources in other study areas may also be based in chronological variation, and our preliminary data suggest that native people associated with mission sites in Baja California employed a more limited range of regional obsidians. An alternative, though not mutually exclusive, explanation is that certain groups within each study area had access to a wider array of raw materials. Further research, including enhanced site chronologies and additional lines of evidence, will be needed to evaluate these hypotheses.

Lastly, we considered the relative diversity of obsidian sources used for projectile points and other artifacts within each study area. In our sample, projectile points in Baja California do not exhibit noticeably higher obsidian source diversity than debitage and other obsidian artifacts, particularly in the two southernmost study areas. This pattern is in contrast to that observed in neighboring regions of western North America, and requires further investigation in Baja California, ideally with better intrasite chronological control.

We offer these patterns not as firm conclusions about residential mobility or raw material exchange in Baja California, but rather as potentially fruitful avenues for future research. The social explanations for the patterns noted in the distribution of obsidian artifacts from particular sources are most well-developed for the northern regions of Baja California where the contextual archaeological and ethnographic data are richest. Scholarly understanding of the greater Cochimí region of the central peninsula is less robust, and obsidian analysis consequently is not as directly applicable to our understanding of issues of mobility or social relationships in that region. Despite these limitations, we argue that a regional approach to understanding the distribution of obsidian in archaeological sites—coupled with further investigations into the geological availability of obsidian raw material—has the potential to advance the archaeology of indigenous Baja California.

NOTES

[1]In some cases, native people developed local strategies to deal with small nodule size. For example, the San Felipe-type projectile points described by Porcayo (2014) were produced through controlled bipolar reduction using a specialized toolkit.

[2]Three obsidian points in our study are characteristic of point types thought to pre-date the late prehistoric era in Baja California (Moranchel 2014). One small (max length = 3.2 cm.)

obsidian point from Laevicardium is classified as a La Paz point. This type generally dates to before 500 A.D., but may extend into the late prehistoric period (Ritter 1979:205). Two others, from Abelardito (max length = 2.2 cm.) and Paido's Cave (max length = 2.0 cm.), are provisionally classified as Zacatecas Broad Blade points, an uncommon but apparently archaic point type (Ritter 1979:198–201). The points from the southern study area are assigned to the Valle del Azufre source, while the point from Paido's Cave matches the San Felipe obsidian chemical group.

[3]Figures 3 and 4, as well as Tables 3 and 4, omit Obsidian Butte and Valle del Azufre. Both are distinct among regional obsidian sources in their chemical composition and are treated in detail elsewhere (Hughes 1986; Shackley et al. 1996). We also omit the Lagrimas de Apache source as it is not present in the archaeological sample presented here (but see Panich et al. 2012 for preliminary chemical data).

[4]We speculate that obsidian artifacts from San Diego County previously linked to the "San Felipe" source were in fact manufactured from the Santa Catalina unknown chemical group. The unknown exhibits chemical similarities with San Felipe glass, especially in comparison to Obsidian Butte (see Panich et al. 2012). Further analytical work is needed to test this hypothesis.

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