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ABSTRACT

Despite their ubiquity, surface occurrences of obsidian artifacts at archaeological sites throughout western North America have traditionally been viewed as unworthy of serious attention because of the difficulty in dating them. In the past 40 years, the time sensitivity of certain Great Basin projectile point types has been established, which brings the importance of surface collections more center stage. With the coming of age and refinement of geochemical methods, obsidian artifacts from these surface sites can now be analyzed using nondestructive instrumental methods and matched to their geological eruptive origin on the basis of congruence in trace and rare earth element chemistry. Many of these surface assemblages in the Great Basin contain considerable numbers of obsidian projectile points that, when matched to their chemical source of origin, open up entirely new ways to investigate change and continuity in past land use and social relations.

The present study was conducted in the lower Humboldt Valley of western Nevada, where large numbers of obsidian projectile points have been collected by professional archaeologists over the past century and housed in academic institutions and museums. In this study, more than 900 obsidian projectile points and bifaces were analyzed from 24 sites and localities within the lower Humboldt Valley using energy-dispersive X-ray fluorescence (EDXRF) to bring data to bear on the question of whether changes in obsidian source use occurred there over the past 5000 years (as determined by time-sensitive projectile points). Significant changes were identified in the direction and distance-to-source of arrow points vs. dart points, and in the source and direction of Humboldt series points and of Humboldt Basal-notched bifaces, which implicate directional shifts through time in social relations among peoples using—and during some periods living at sites in—the lower Humboldt Valley. These results provide independent data to evaluate current views about land use, artifact conveyance, social relations, and technological change in the western Great Basin and beyond.

INTRODUCTION

> If we dismiss most of the archaeological record as distorted, mixed, or disturbed, and seek only those provenience units which appear to represent little capsules of human behavior, we will continue to have an impoverished, unrealistic view of the past. We must seek rather to understand the archaeological record in the state in which it is available to us. If we hold out for the very few sites where we may "recognize" undistorted "analytical units," then we will have very few remains from the past with which to work. The challenge is how to use the "distorted" stuff… (Binford, 1981: 205).

Several years ago, I initiated a study of potential change in obsidian source use in the lower Humboldt Valley, located south of Lovelock, in central-western Nevada (see fig. 1)—a continuation of research conducted over the past several decades investigating time-space patterning in obsidian source use in California and the Great Basin. The lower Humboldt Valley is an ideal area for continuing and extending this research. Beginning with the earliest archaeological excavation in the western Great Basin more than a century ago (Loud and Harrington, 1929), studies conducted in the valley and environs resulted in the recovery of thousands of obsidian artifacts, many of them time diagnostic, and their safe storage in museums, which made them available for nondestructive analysis. Excavations have been conducted at a few sites subsequent to the Lovelock Cave work, but the vast majority of chipped stone artifacts from the lower Humboldt Valley have been recovered from shallow or surface contexts and subjected to long-term burial/exposure histories. The surface sites were often dismissed as containing little information relevant to the chronology-building interests of early Great Basin archaeologists, but as chronological matters have come under better control it's clear that these sites comprise an important database for addressing the information potential underscored by Binford in the opening quote (see also Kelly, 1997: 36). The important pioneering studies by Weide (1968), Thomas (1971, 1973), Bettinger (1975, 1977), and

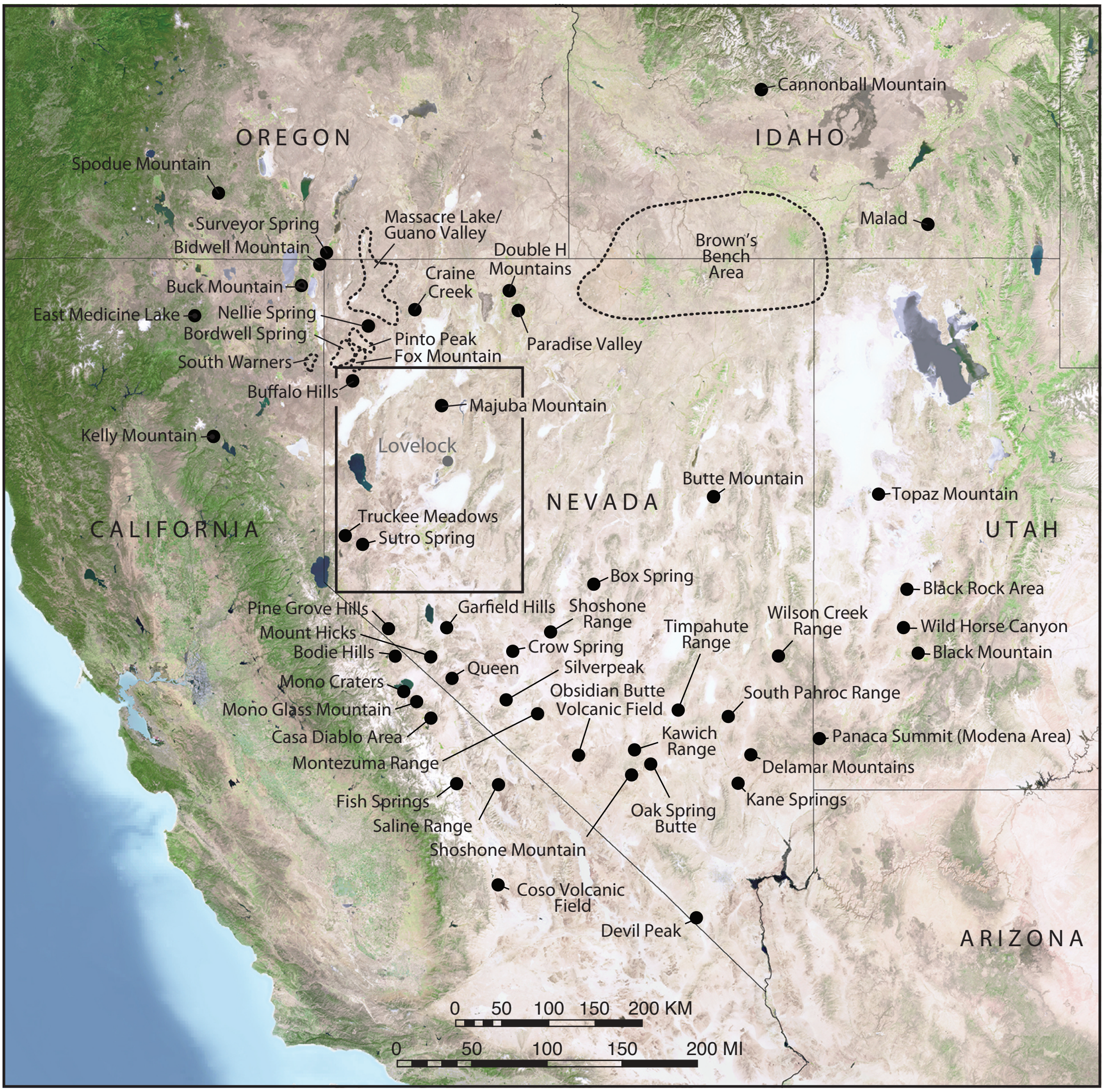

FIG. 1. The Great Basin, showing the locations of significant obsidian sources, including those used to make projectile points recovered from lower Humboldt Valley archaeological sites. Rectangle encloses area shown in greater detail in figure 2.

Beck (1984) illustrated some of the research potential of large surface assemblages to provide insights into past human land use in different parts of the Great Basin. What can be learned from surface assemblages in the lower Humboldt Valley and how might these lessons be extended more generally in other parts of the western Great Basin? This study is devoted to exploring some aspects of this question.

In addition to large artifact sample size, the lower Humboldt Valley is located proximate to numerous sources of high-quality obsidian (see figs. 1, 2). The volcanic glasses from these geological sources have been analyzed for trace element composition and therefore satisfy the baseline requirements for geochemical composition comparison with obsidian artifacts; because of their abundance in the study area, their time-

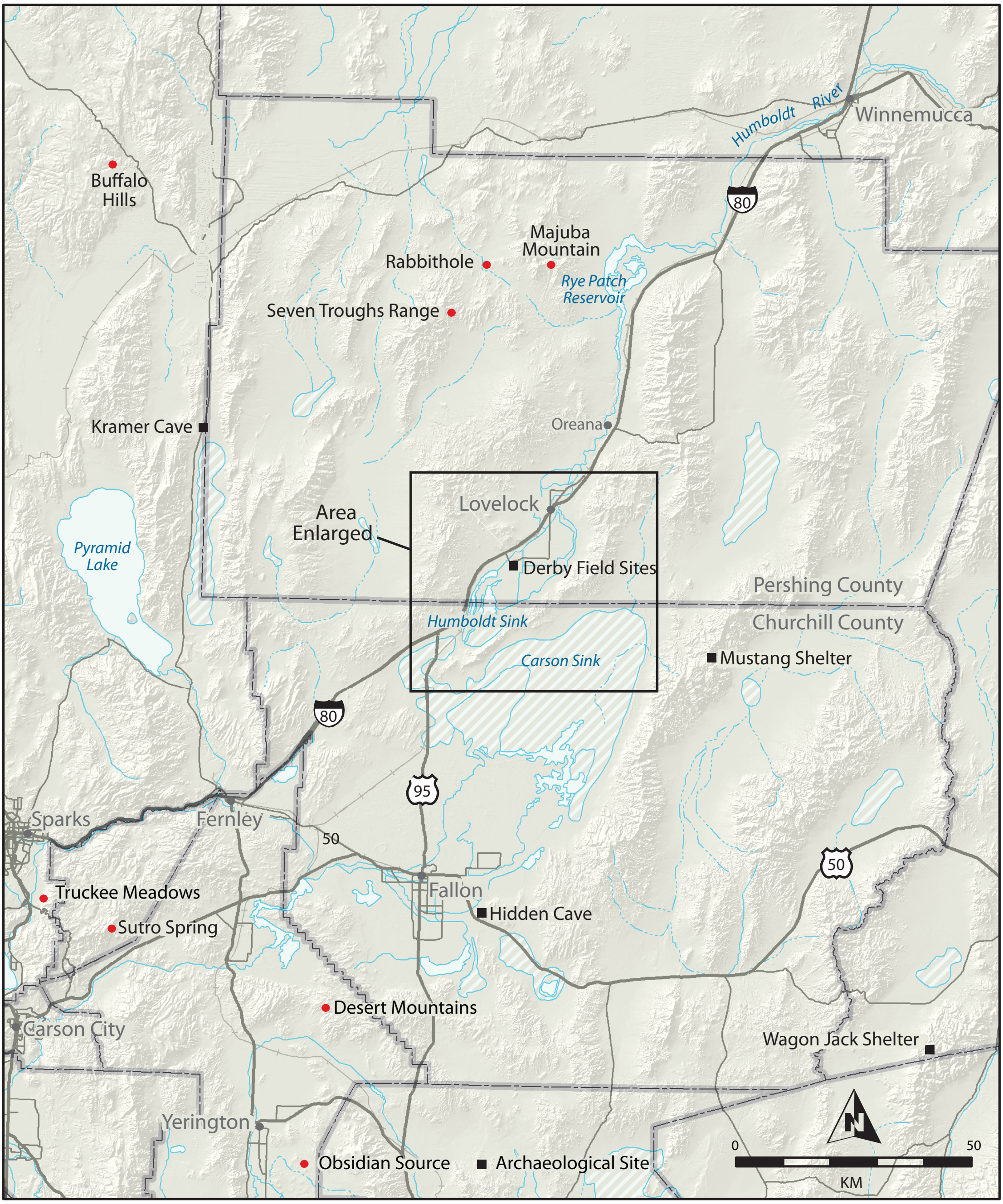

FIG. 2. The lower Humboldt Valley study area, showing the location of nearby archaeological sites and obsidian sources referred to in the text. Rectangle encloses area shown in greater detail in figure 3.

sensitive attributes, and nonperishable nature, projectile point types are the most useful index fossil to employ for dating (see below). At some sites in close proximity to the study area (primarily Hidden Cave) well-controlled stratigraphic data are available to bracket the ages attributed to some projectile point types, whereas ages for other types were arrived at through application of cross-dating.

As this study's title indicates, the research reported here pertains strictly to investigating potential spatial and temporal variability in obsidian projectile point conveyance—obsidian debitage and other artifact forms may have been created, procured, moved, and used differently through time, and that is a matter for separate future study.

Several questions are addressed in this study: (1) were there any significant changes in obsidian source use through time in the lower Humboldt Valley? (2) if so, is there a significant relationship between point type or artifact class and distance/geographic direction to obsidian source? (3) were arrow points made more frequently from distant or local sources ? (4) were obsidian dart points made more frequently from distant or from local sources? (5) was reworking and recycling a significant factor in interpreting the results? (6) does linear distance to source predict relative frequencies of the obsidian sources used to make projectile points during particular phases or through all temporal periods? (7) are the number of obsidian sources represented during dart times more (or less) diverse than those used during the time arrow points were in use? and (8) is there an association between climatic change and change in projectile point type?

Answers to these questions are directly relevant to evaluating the underlying analytical proposition driving this study: that contrasts and continuities in obsidian conveyance patterns inform on overall settlement/subsistence mobility and social interaction that relate to and are reflective of changes in past human land use and adaptations in the western Great Basin.

BACKGROUND

Caves were the first places subjected to archaeological excavations in the Great Basin in part because of the unusual preservation of organic materials they contain. Early archaeological work (e.g., Loud and Harrington, 1929; Harrington, 1933; Cressman, 1942) focused on caves as repositories for perishable artifacts that found no counterpart in "distorted," shallow, open-air sites. At the time of the earliest serious scientific studies, very little was known about the age of the archaeological deposits nor about what sequence of artifact forms they might document, so the rich deposits in these cave sites served as convenient starting points for chronology building in the Great Basin. In many cases, despite the rich inventory of perishable artifact types, sequence building was compromised by the bewildering array of trash and storage pits dug into the deposits by prehistoric occupants through the millennia, significantly mixing and altering the original stratigraphic record. So, even though the perishable artifacts themselves (baskets, sandals, decoys, etc.) could be directly dated by ^{14}C, because they were not often found in direct association with other types of nonperishables (e.g., chipped stone projectile points) the dates derived for cave and rockshelter utilization had compromised utility when extended to open air sites.

This situation changed as more sites with clearer and better-dated stratigraphy were excavated and reported. Following the early work of L.L. Loud at Lovelock Cave in 1912 and Mark Harrington's excavations there in 1924, between 1950 and 1970 Robert F. Heizer and his students and associates at the University of California, Berkeley, conducted numerous surveys and excavations of archaeological sites within and proximate to the Humboldt Sink in Churchill and Pershing counties, Nevada (see fig. 3). The publications resulting from these efforts (e.g., Heizer, 1951; Heizer and Krieger, 1956; Baumhoff, 1958; Elsasser, 1958; Roust, 1966; Cowan and Clewlow, 1968; Heizer and Napton, 1970) and those specifically devoted to chipped stone projectile point

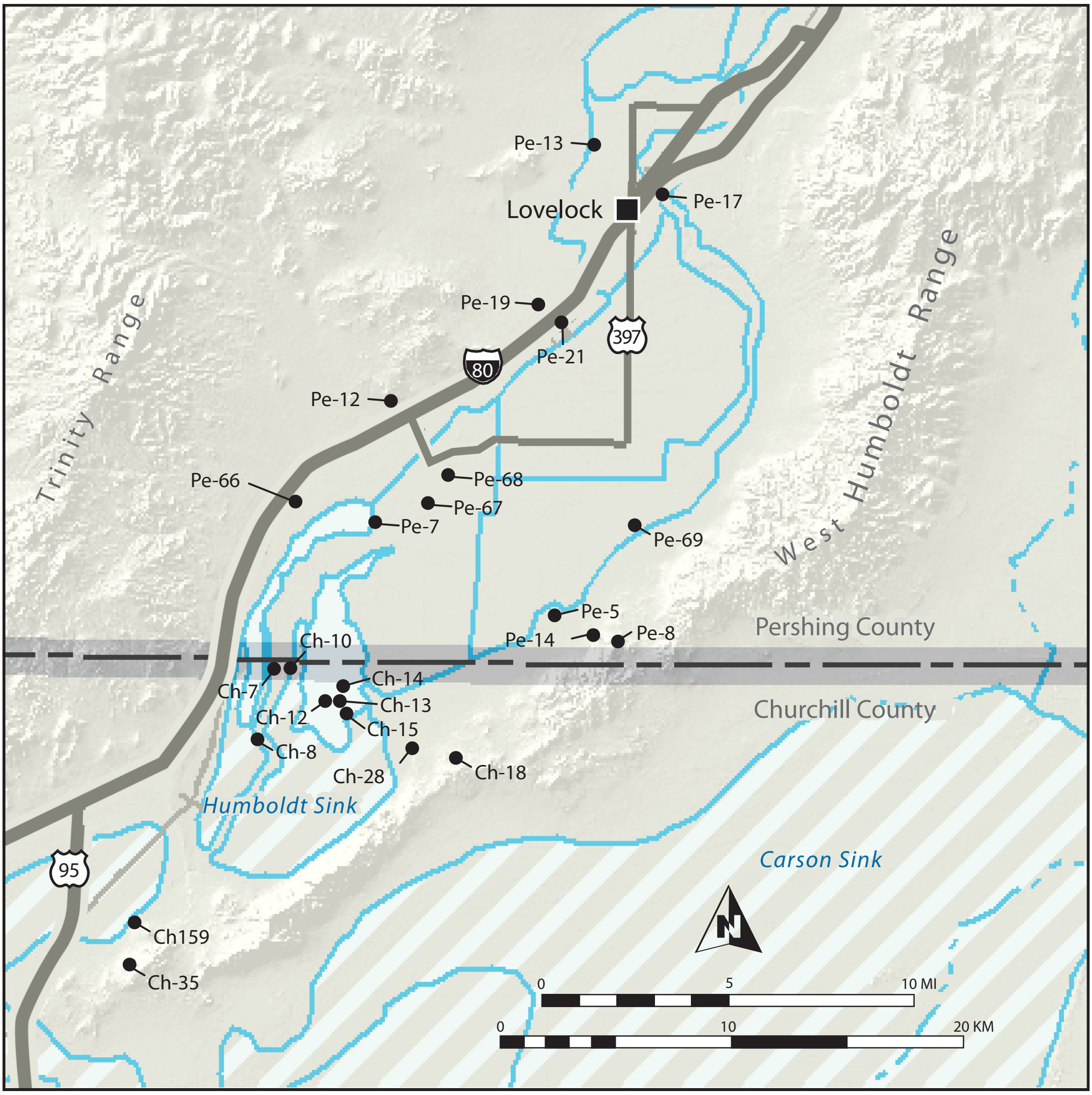

FIG. 3. Detail of the lower Humboldt Valley, showing the general locations of archaeological sites and collection areas within the lower Humboldt Valley study area outlined in figure 2.

typology (O'Connell, 1967; Clewlow, 1967, 1968a; Heizer and Clewlow, 1968; Clewlow and Napton, 1970) form the underpinning for all subsequent work. The early work on point typology provided a chronological foundation for cross-dating, and the later refinements to the "Berkeley System" by Thomas (1970, 1981) introduced a metric basis for objectifying the projectile point classification process which, up until this time, had been largely intuitive (for recent reviews, see Hughes, 2013a; Thomas, 2013).

But improvements in dating alone would not have been a sufficient underpinning for conducting the present study. That critical "added ingredient" came from research in geology, geochemistry, and physics over the last several decades, when instrumental methods were developed that allowed nondestructive compositional analysis of archaeological artifacts. Energy dispersive X-ray fluorescence (EDXRF)—the instrumental method employed here—began to come of age in the early 1980s with the advent of high-speed microcomputers capable of collecting and deconvolution of complex X-ray spectra in a fraction of the time previously attainable. The speed, precision, and accuracy of compositional analyses achievable with this technique have improved significantly over what was achievable in the early 1980s, and these advances have been applied to obsidian "sourcing "research throughout the world. The trace element composition "signatures" determined for archaeologically significant geological obsidian sources in the Great Basin and adjacent areas form the reference sets against which compositional data on artifacts were compared. These geological reference sets are cited below as appropriate.

More generally, the lower Humboldt Valley figured prominently as an important exception to the basinwide applicability of the Desert Culture concept (Jennings and Norbeck, 1955; Jennings, 1957; Aikens, 1978), as Heizer (1967) and others (e.g., Meighan, 1959) pointed to the relatively well-watered areas of the Humboldt Valley as offering resources sufficient to justify the presence of a prehistoric "lacustrine subsistence regime" (Napton, 1969; Heizer and Napton, 1970) in the area. There has been a great deal of discussion and debate over the utility of either-or subsistence classifications (see papers in Janetski and Madsen, 1990) but, compared with the early archaeological attention devoted to sites in and proximate to the Humboldt Sink, with the important exception of Livingston's (1986, 1988) work, no detailed scientific studies have appeared on materials other than basketry (e.g., Adovasio, 1986; Tuohy and Hattori, 1996; Berger et al., 1998; Fowler and Hattori, 2011) for nearly 50 years.

THE STUDY AREA

The lower Humboldt Valley is bounded geographically on the east by the West Humboldt Range (1876 m [6155 ft] elevation), on the west by the Trinity Range (2071 m [6795 ft] elev.), at the north around the town of Lovelock, and at the south by Humboldt Bar which, before it was cut through in 1915, formed a natural dam for Humboldt Lake in times of high water. This massive Great Basin lake, a part of Pleistocene Lake Lahontan prior to ca. 13,000 years ago, began to shrink, ultimately resulting in its isolation perhaps during the early-middle Holocene (Davis, 1982). Subsequently, the lake was fed by the Humboldt River. Natural lake levels fluctuated significantly thereafter. In 1845 Kern (1876: 478) wrote that "Humboldt Lake is about 8 miles long by 2 in width; it is marshy, overgrown with bulrushes, at the upper end," in 1846 the lake "consisted of some pools of standing water…covered with a yellowish slime, and emitting a most disagreeable fetor. The water was too alkaline for either man or beast to drink" (Bryant [1848] quoted by Antevs, 1938: 41), but as of the summer of 1882 Humboldt Lake "covered an area of about 20 square miles, was 12 feet deep in the central part, did not overflow, and although somewhat alkaline was inhabited by both fish and molluscs, and was sufficiently pure for human use" (Russell, 1885: 66–67). Local Native Americans were no doubt intimately familiar with the waxing and waning of available water in the lake: "Humboldt Lakebed sites 10 through 15 were known by the Indians as *Papasepuwait*, "Water Dries Off"" (quote from undated U.C. Berkeley archaeological site survey record form; see also Loud, 1929: 131).

Many of the detailed historical accounts of the filling and drying up of Humboldt Lake are significant at the seasonal and yearly scales (see Kelly, 2001: table 2-2) but it's the cumulative effect and expression of weather oscillations over longer periods of time (the climate) that are of more concern to us. Short term—seasonal, or a summer or two's worth of no (or lots of) water inflow into the lake—fluctuations could have had little or only a fleeting effect on the overall settlement/subsistence activities of peoples living proximate to its shores. But longer-term episodes—affecting the availability and viability of water-dependent lake and marsh plants, birds, and animal resources exploited by humans—are another matter entirely (e.g., Peterson et al., 2021) that certainly would have encouraged seasonal mobility to environmentally more productive areas or outright abandonment of the area until things changed. As Kelly (2001) emphasized for the adjacent Carson Sink, having too much water can be as bad as having too little when it comes to maintaining the all-important biological balance of resources on which humans, birds, and animals depend. A critical question is then: how long—and how severe—would climatic changes need to have been to encourage adaptive shifts detectable in the archaeological record?

In addition to changes in regional temperature and evaporation rate, the variations in Humboldt Lake levels throughout the Holocene were largely influenced by variations in water inflow from the Humboldt River. Consequently, one cannot apprehend the nature of the variable resource bases available to peoples of the Humboldt Sink and the lower Humboldt Valley in particular, absent consideration of the climatic contexts affecting the Humboldt River. These multidimensional influences on prehistoric human life have been acknowledged for decades (e.g., Antevs, 1948; Aschmann, 1958; Baumhoff and Heizer, 1965; Davis, 1982; Elston, 1982; Aikens, 1983), but recent climatic data (Nichols, 1989; Viau et al., 2002; Cook et al., 2010; Louderback et al., 2010; Lytle et al., 2012; Mensing et al., 2013; Millar et al., 2018; Thomas, 2020a) have provided much more precise detail on certain temporal intervals.

Table 1 presents a rough correlation between current interpretations of climate change in the Lahontan area, how they may have been expressed archaeologically in the lower Humboldt Valley, and how these data correlate with projectile point chronology. I will return to consider these variables and their intersections after presenting the substantive details of artifact-to-source (chemical type) attributions for time-sensitive points.

ARCHAEOLOGICAL SITE DESIGNATIONS

Prior to discussing the archaeological site collections, the systems used to identify archaeological sites in this study area require clarification.

Before the California Archaeological Survey was established at Berkeley in 1948 there was no uniform site designation system in place. Subsequently, sites in Nevada were reported with a prefix of 26, followed by a two-letter county designation, then a sequential number. Lovelock Cave was designated 26-Ch-18: *26* represented Nevada in then-alphabetical order within the United States, *Ch* was the two-letter abbreviation for Churchill County, and *18* was the sequential number given to the site within that county. The sites recorded by Loud were incorporated into this system, and those relevant to this study appear in appendix 1.

The Nevada State Museum (NSM) maintained its own site designation system which was slightly different from, and sometimes at odds with, the one used at Berkeley. NSM sites reported in the early 1960s used the same two letter-hyphen system as Berkeley, but from 1969 onward the NSM discontinued using hyphens to separate state, county, and site number and renumbered certain of the Berkeley sites. For example, Lovelock Cave, designated 26-Ch-18 in the Berkeley system, is 26Ch5 at the NSM.

After the UCAS was abolished at Berkeley in 1961 and the Archaeological Research Facility [UCARF] came in to existence, the 26 prefix was discontinued and by 1967 the U.S. postal code prefix NV was adopted. Lovelock Cave is referred to as 26-Ch-18 in the late 1950's (Grosscup, 1958), then as NV-Ch-18 nearly two decades later (Heizer and Napton, 1970).[1]

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[1] Because the majority of sites in this study are known in the published literature by their Berkeley site designations, it seemed advisable to continue referring to the sites by those numbers here, while providing a cross reference for others (in appendix 1). Sites with no Berkeley equivalent are referred to herein by their NSM designations. Unless needed for clarification, state prefixes (26- and or NV-) for these sites are not repeated in the text. By contrast, California archaeological sites recorded at Berkeley (Heizer, 1948) were designated with a three-letter county prefix (e.g., Mod- for Modoc County),

TABLE 1

Correlation of Temporal Periods, Local Phases, Projectile Point Types, Inferred Climatic Conditions, and Human Response in the Lower Humboldt Valley Over the Past 5000 Years

Time Period	Local Phase	BP	cal. AD/BC[1]	Point Type	Climate and Inferred Effects in the Lower Humboldt Valley	
Terminal Prehistoric	Dune Spring	250	AD 1660	Desert Series		
		500	AD 1436		Wetter conditions, reduction in residential mobility	
Late Archaic	Late Lovelock	750	AD 1280	Rosegate Series	Medieval Climatic Anomaly; continuing drought, residential occupation	
		1000	AD 1034			
		1250	AD 740			Early wet interval, but overall continuing aridity Increase in residential occupation
Middle Archaic		1500	AD 600	Elko Series		
	Transitional Lovelock	1750	AD 315			
		2000	AD 30/10 BC		Extreme aridity, decrease in local population, increased mobility	
		2250	250 BC			
		2500	600 BC			
		2750	837 BC		Continued wetter conditions, sparse archaeological ^{14}C record	
	Early Lovelock	3000	1276 BC			
		3250	1500 BC			
		3500	1760 BC	Overlap		Cooler and wetter conditions, high residential mobility, caching activities prominent, absence of residential sites
		3750	2140 BC	Gatecliff Series	Wetter conditions, and evidence for residential occupation	
Early Archaic		4000	2500 BC			
		4250	2880 BC			
		4500	3150 BC			
		4650	3430 BC			
		5000	3700 BC			

[1] ^{14}C dates calibrated via OxCal 4.4, InterCal 20. Local phase boundaries compromised from Bennyhoff (1958), Grosscup (1960), Elston (1986), Bennyhoff and Hughes (1987), and Fowler and Fowler (2008). Point type temporal ranges after Thomas (1981, 1988). Climatic condition and inferred effects summarized from Thomas (2022a).

L.L. Loud's Collection and Subsequent Work: The majority of projectile points analyzed here were collected by L.L. Loud from lower Humboldt Valley sites over a century ago. Commenting on one locality, Loud (1929: 132) wrote that "Site 13 was noted for the manufacture of chipped implements of obsidian and brightly colored flints.... There were many bushels of refuse chips exposed and the writer collected about a thousand worked specimens." Considering the size of Loud's surface collection at Ch-13, it is puzzling that Heizer and Clewlow (1968) made no mention of the site in their description of projectile points from nearby site Ch-15. Given the relative paucity of surface artifacts noted and collected at Site 15 (Loud, 1929: 131)—described by Heizer and Clewlow (1968: 59) as "an enormous and extensive surface site"—

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then given a sequential number. This distinction for California sites is employed in the text and in footnotes 20, 36, and 37. Beginning in 1903 the museum used 1- catalog prefixes for archaeological material from California and Nevada, and by 1958 a 2- prefix began being applied to archaeological material from Nevada (e.g., Baumhoff, 1958). Artifacts with L- prefixes denote specimens from the Jeremiah B. Lillard Collection housed at the PAHMA. Table 2 provides a site-specific breakdown of the sample analyzed and appendix 1 presents a concordance of site designations employed.

it appears that the latter authors actually considered Ch-13 and Ch-15, as well as Ch-14, to be one large site (Heizer, n.d.: 3; also, Heizer and Clewlow, 1968: [map 1]; Livingston, 1988: 52). Catalog entries at the Phoebe Apperson Hearst Museum of Anthropology (hereafter, PAHMA) document that many of the illustrated projectile points identified by Heizer and Clewlow (1968) as having come from Ch-15 actually were found at Ch-13 and Ch-14 and this same conflation appears in specimens illustrated by Hester and Heizer (1973).[2] In the present study every attempt has been made to present accurate catalog/site provenience for each artifact, but at the scale of this study, the site location differences between Ch-13, Ch-14, and Ch-15 are of little interpretive significance. Loud's sketch map (Loud and Harrington, 1929: pl. 1), shows these sites located about a mile apart. Specimens erroneously attributed to Lovelock Cave (Ch-18) have been corrected on the basis of inspection of museum catalog entries.[3]

PARTITIONING THE OBSIDIAN SOURCE UNIVERSE

Prior to investigating the research questions posed above, the geographic locations of relevant obsidian sources require consideration. As was done in previous analyses at Hidden Cave (Hughes, 1985) and the Carson Sink (Hughes, 2001), obsidian sources identified in lower Humboldt Valley sites were grouped relative to their direction and distance from the study area. Table 2 lists the approximate linear distance from these sources to sites in the lower Humboldt Valley. Five distance-bounded groups were isolated that comport as much as possible with the geography of the obsidian-bearing landscape of the study area: volcanic glasses erupted <100 km from the lower Humboldt Valley (considered "local" in this study), those ca. 100–160 km distant, those ca. 161–240 km distant, and sources located between 241–299 km, and >300 km away.[4] The distance par-

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[2] These include Ch-13 projectile points illustrated by Heizer and Clewlow (1968) in fig. 2g, i, k, m, p, q; fig. 3g; fig. 4e, k; fig. 5h, m, n, p; fig. 6a d, j, l, n, q; fig. 7h, n, r; fig. 9b; fig. 10g, j, o, r; fig. 11d, f; fig. 12a, j. The specimens illustrated in Heizer and Clewlow 1968: fig. 5f and fig. 6i are from Ch-14. With respect to the specimens illustrated in Hester and Heizer (1973), fig. 3e and fig. 4e, f (all three from Ch-13) and fig. 3d, are from Ch-14. The point illustrated in fig. 1a; cat. no. 1-65041), said to have been made from obsidian, is listed in the PAHMA catalog as quartzite and having been recovered from the Humboldt lakebed. The artifact actually illustrated in fig. 1a is specimen 1-39071. In fig. 2, specimen "e" is actually 1-17542 from Ch-13, point "f" is actually cat. no. 1-65534, specimen "h" is 1-65556, and specimen 'i" is 1-65532. Figure 3 correction is noted in endnote 2. In fig. 4, specimen "c" (1-65382) was classified as an Gatecliff Contracting Stem using the Monitor Valley Key (Thomas, 1981). All these corrections have been incorporated in the tables herein.

[3] In March, 1982, Donald Tuohy informed me that many of the obsidian artifacts from Loud's 1912 excavations at Lovelock Cave were housed in the Nevada Historical Society (NHS), and that these had been transferred from Berkeley after Loud's 1912 excavations. Consequently, they would not have been reported by Loud and Harrington (1929), by Grosscup (1960), nor in the subsequent publications on projectile points from this site (Clewlow, 1968a; Clewlow and Napton, 1970). Tuohy graciously sent these obsidian artifacts—apparently from Lovelock Cave—to me for source analysis. However, a check of the obsidian projectile points catalog numbers against the original Berkeley catalog ledgers showed that 28 of the artifacts sent to the NHS, and forwarded to me by Tuohy, were from Ch-13—not Lovelock Cave (Ch-18)—and another five points were from Ch-14.

This finding is difficult to reconcile this finding with the explicit statement that: "the University of California sent L.L. Loud to the cave to conduct archaeological excavations. Between April 1 and August 1, 1912, he obtained, unassisted, 10,000 specimens from the cave. This collection was divided between the University of California and the Nevada Historical Society" (Kroeber and Lowie, 1929: vii).

No evidence (e.g., marginal notations) exists in the PAHMA catalog to indicate that any obsidian artifacts from Lovelock Cave were sent to the NHS, although such notes do exist for many of the Ch-13 projectile points later sent from Berkeley to the NSM. The serial and sequential numbering of the projectile points in question documents that they were cataloged into the Berkeley system before they were sent to the NHS so, lacking transmittal documentation, one can only assume that that when Kroeber and Lowie referred to the "collection" they intended the term to apply to all of the archaeological material collected by Loud (including his extensive surface collections at lowland sites)—not just the material from Lovelock Cave. Because there were too few chipped stone points recovered from Lovelock Cave to share with the NHS, it appears that those from nearby site (Ch-13) were substituted because points occurred there in abundance. Regardless of how the error, or ambiguous statement, occurred, Kroeber and Lowie's account should be corrected in light of conflicting primary data.

[4] This partitioning is admittedly arbitrary, and could have been done using smaller geographic distance "bins." However, doing so would have, in many cases, reduced source-specific point frequencies to sizes insufficient for statistical evaluation.

TABLE 2

Approximate Linear Distance from Lower Humboldt Valley (LHV) Sites to Obsidian Sources (Chemical Types) Identified in the Archaeological Assemblages

Chronological bins (<100, 100–160, 161–240, 241–299, >300 km) indicated with alternating background of white and gray.

Source Name	Distance km (mi)	Direction from LHV
Majuba Mountain	71 (44)	North
Seven Troughs Range	71 (44)	North
Rabbithole	77 (48)	North
Desert Mountains	94 (58)	South
Sutro Spring	101 (63)	South
Truckee Meadows	118 (74)	South
Buffalo Hills	127 (79)	North
Fox Mountain	142 (88)	Northwest
Pinto Peak	152 (95)	Northwest
Garfield Hills	156 (97)	South
Pine Grove Hills	161 (100)	South (Mono Basin area)
Bordwell Spring	169 (105)	Northwest
Nellie Spring	171 (106)	Northwest
South Warners	177 (110)	Northwest
Craine Creek	183 (114)	Northwest
Mount Hicks	185 (115)	South (Mono Basin area)
Bodie Hills	189 (118)	South (Mono Basin area)
ML/GV	198 (123)	Northwest
Double H Mountains	201 (125)	Northeast
Paradise Valley	208 (129)	Northeast
Crow Spring	215 (134)	South
Mono Craters	228 (142)	South (Mono Basin area)
Queen	228 (142)	South (Mono Basin area)
Mono Glass Mountain	232 (144)	South (Mono Basin area)
Buck Mountain	239 (149)	Northwest
Bidwell Mountain	247 (153)	Northwest
Lookout Mountain	248 (154)	South (Mono Basin area)
Sugar Hill	251 (156)	Northwest
Rainbow Mine	252 (156)	Northwest
Surveyor Spring	253 (157)	Northwest
Shoshone Mountain	272 (169)	South
East Medicine Lake	299 (186)	Northwest
North Domes Cluster	327 (203)	South
Oak Spring Butte	374 (232)	South
Brown's Bench	391 (243)	Northeast

TABLE 2 *continued*

Source Name	**Distance km (mi)**	**Direction from LHV**
Spodue Moutain	398 (247)	Northwest
Shoshone Range	442 (275)	South
West Sugarloaf (Coso)	442 (275)	South
Panaca Summit	487 (302)	East
Cannonball Mountain	496 (308)	Northeast
Wild Horse Canyon	527 (327)	East
Malad	592 (368)	Northeast

titioning was relatively straightforward, but in one instance a slight modification was made. Table 2 shows that, if rigid distance boundaries had been adhered to, artifacts assigned to Buck Mountain and to Bidwell Mountain would have been analyzed in separate distance "bins." This would violate the geological interconnectedness of obsidians erupted in the Warner Mountains (Russell, 1928)—separated geographically by only a few km—so Buck Mountain was shifted to the >240 km category along with other Warner Mountains obsidians. A case could be made for shifting Pine Grove Hills into a closer bin (100–160 km) but only one artifact is involved. A geological argument also could be made for lumping a number of northwestern Nevada obsidians together (Fox Mountain, Pinto Peak, Bordwell Spring, Nellie Spring, and Massacre Lake/Guano Valley), but this would have expanded by nearly 60 km the distance from the closest (Fox Mountain) to the most distant (Massacre Lake/Guano Valley) and compromised investigation of the effects of distance in the lower Humboldt Valley. Consequently, these chemical varieties of obsidian were retained in their original distance-based categories.

Because the sites in this study are located over a linear distance of ca. 40 km, distance-to-source values were computed from an arbitrary midpoint in the lower Humboldt Valley at the Pershing/Churchill County line. This compromise results in Pershing County sites being somewhat closer to northern sources and, conversely, puts Churchill County sites a bit closer to sources to the south. In fact, Ch-35 at the southwest end of the study area, is about 42 km distant from Pe-13, the most northeasterly site in this study. The locations of the obsidian sources (chemical types) discussed below appear in figures 1 and 2.

Sources Located North of the Lower Humboldt Valley

Geological eruptive sources for obsidians of the Rabbithole, Seven Troughs Range, and Majuba Mountain chemical type (Hughes, 1985, 2001) occur geographically closest to sites in the lower Humboldt Valley.[5] Of these three, Majuba Mountain erupted the largest nodules and cobbles, whereas obsidian known from Rabbithole and Seven Troughs typically occurs as smaller nodules and was probably exploited mostly via bipolar reduction for making arrow points and expedient tools, although larger darts also were occasionally made from them. In addition to outcrops at Majuba Mountain, artifact-quality nodules and small cobbles from this source have been redeposited into Poker Brown (and other) washes, and this material—along with Rabbithole obsidian—recently has been identified in Humboldt River gravels as far south as Oreana. Thus, Majuba Mountain is considered a local

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[5] The obsidian reported by Macdonald et al. (1992: 172) from Cow Creek (their sample RLS-21) is an example of the Seven Troughs Range chemical type (Hughes, 2001: table 8-25), and their Rocky Canyon (RLS-29) locality represents obsidian of the Majuba Mountain chemical type (Hughes, 1985: table 73). Sample RLS-31from the Trinity Range—mentioned by Cowan (1972: 7) as a small source of inferior obsidian located only a few km west of Lovelock—is a "new" chemical type, but its trace-element fingerprint does not correspond with that of any of the obsidian projectile points analyzed in the present study.

TABLE 3

The Number of Obsidian Artifacts Analyzed from Each Lower Humboldt Valley Archaeological Site/Locality

Totals include 23 artifacts from S.M. Wheeler's collection SPC no. 1-11. Minimal information on the NSM site record form suggests that these points may have come from Ch-8 on the Humboldt Lake Bed.

Site	Points (N)	Percent of Total
Ch-12	2	0.22
Ch-13	314	34.73
Ch-13, 14, 15	2	0.22
Ch-14	12	1.33
Ch-15	352	38.94
Ch-18	57	6.31
Ch-28	7	0.77
Ch-35	7	0.77
Ch-7	4	0.44
Ch-8	23	2.54
Ch159	3	0.33
HLB	8	0.88
Pe-12	1	0.11
Pe-13	4	0.44
Pe-14	1	0.11
Pe-17	2	0.22
Pe-19	3	0.33
Pe-21	1	0.11
Pe-5	41	4.54
Pe-66	17	1.88
Pe-67	15	1.66
Pe-68	2	0.22
Pe-69	2	0.22
Pe-7	23	2.54
Pe-8	1	0.11
Total	904	100.00

source, along with Rabbithole and Seven Troughs Range. Buffalo Hills, a geochemically complex "source" (Hughes, 2019) containing fist-size nodules, occurs geographically midway between the nearby sources and those more distant in northwestern Nevada.[6]

Considerably farther northwest, obsidians of the Massacre Lake/Guano Valley, Pinto Peak, Fox Mountain, and Bordwell Spring chemical types occur (Hughes, 1986), as does volcanic glass at Craine Creek, at Buck Mountain, Sugar Hill, and Bidwell Mountain in the Warner Mountains the

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[6] For many years, the geographical source for this chemically distinctive obsidian was unknown, reported in several publications simply as "Unknown B" (e.g., Hughes, 2001, Hughes and Milliken, 2007). Over the last decade, the eruptive source for this obsidian has been identified: it is in the Buffalo Hills of northwestern Nevada (see fig. 2).

Medicine Lake Highland (East Medicine Lake), and south-central Oregon (Spodue Mountain; Hughes, 1986).

Obsidians of the Paradise Valley, Double H Mountains, and Brown's Bench varieties erupted to the northeast (Hughes, 1990a, 2001), along with obsidian from Malad, Idaho (Hughes, 1984; Nelson, 1984). All of these sources contain large nodules and small cobbles suitable for artifact manufacture.

Sources Located South of the Lower Humboldt Valley

The closest artifact-quality obsidian sources located in this direction are Truckee Meadows (C.B. Concrete), Sutro Spring, and Garfield Hills (Hughes, 1985),[7] followed by the more distant Crow Spring (Hughes, 1983), Shoshone Mountain, Oak Spring Butte, and North Domes Cluster (the latter located within the Obsidian Butte Volcanic Field; Hughes, 2010), Shoshone Range (Hughes, 2020a) and West Sugarloaf (Hughes, 1988). Although Shoshone Range obsidian has, to date, only been observed as small nodules (similar in size to those at Rabbithole and the Seven Troughs Range) and was used comparatively rarely (Hughes, 2020a), the other obsidians in this geographic group are of sufficient size for manufacture of dart and arrow points.

Another group of obsidians erupted in the vicinity of Mono Lake and southward. These include—from closest to most distant—Pine Grove Hills, Mt. Hicks, Bodie Hills, Queen (Jack, 1976), Mono Craters and Mono Glass Mountain (Jack, 1976; Hughes, 1989), and Lookout Mountain in the Casa Diablo area (Hughes, 1994a). Neutron activation and major element data for some of these sources appear in Ericson (1981: tables 1-2, 3-1). These obsidians occur between 100–160 km south of the study area, and (with the exception of Pine Grove Hills, which yields nodules ca. 5 cm in diameter) all produced volcanic glass that cooled into large, high-quality cobbles and nodules.

Sources Located East of the Lower Humboldt Valley

Several obsidian sources occur to the east of the study area (see fig. 1), but only Wild Horse Canyon and Panaca Summit (Nelson, 1984; Hughes, 2005), both containing high-quality nodules and small cobbles, were identified in the lower Humboldt Valley collections.

LEAST-COST PATH ISSUES

Table 2 lists the absolute line (straight-line) distance from major obsidian sources to an arbitrary midpoint in the lower Humboldt Valley, absent a formal least-cost path analysis. Least-cost-path analysis can be weighted to consider numerous variables (e.g., slope, elevation, other geographic features) that may or may not be relevant to this study depending on the social mechanism(s) of projectile point conveyance (i.e., effective and social distance considerations; Kelly, 1992, 2011; Hughes, 2011, 2018a). Assume, for example, that all Elko series points were moved directly from the source to sites in the lower Humboldt Valley during the floruit of the series. In this case, least-cost-path analysis could provide important insights into real-world travel costs during that period of time. But if those same Elko points arrived via a variety of mechanisms (direct access, proximate relatives and neighbors, in-marrying spouses) at different times within the temporal period—which seems likely—the importance of absolute distance, as well as least-cost-path distances, may be misleading and inflated. Assuming that all obsidian was acquired via direct access, least-cost-path analysis comes to the fore, but,

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[7] Two additional obsidian-bearing localities are closer to the lower Humboldt Valley—in the Dead Camel Mountains and the Desert Mountains southwest of Fallon—although at the time of this writing the eruptive location for only one of these (in the Desert Mountains) has been confirmed by in-field reconnaissance (see fig. 2). Small obsidian pebbles/nodules representing two different chemical types were identified at archaeological site Ch3134 (Hughes, 2014), at sites in the Carson Desert (Hughes, 2016a), and one of those types occurred at Ch2616 within the Fallon Naval Air Station (Hughes, 2016b).

unfortunately, we have no empirical basis to justify this assumption. Because we have insufficient control over these affective variables, I have not emphasized least-cost factors here.

There are a number of ways to get from place to place, but long-standing understanding and familiarity with the vicissitudes of social and effective environments no doubt selected in favor the most efficient routes. These were "codified" from decades and generations of experience, through learning that the shortest route isn't always the best or how things can depend on time of year, social relations with neighbors, and kin obligations. In this sense, trade routes and/or trails (often following game trails), are effective proxies of least-cost paths because, based on the accumulation of generations of experiences, they proved to be the overall best way to get from place to place over the millennia. As we know from archaeological analysis, however, all of these routes may not have been in use/existence at the same time and they may have carried different materials for different reasons during different periods of time (Hughes, 1994b).

We know that numerous trails connected the lower Humboldt Valley with other areas. Fowler and Liljeblad (1986: fig. 19), Liljeblad and Fowler, 1986: 415–416), d'Azevedo (1986: 470–471), and Fowler (1989: 9) note historic connections between the lower Humboldt Valley and adjacent areas emphasizing, as did Riddell (1960a), the influence that wide-ranging subsistence practices had on social organization and external relations. Hughes and Bennyhoff (1986) drew on archaeological and ethnographic data (e.g., Sample, 1950; Davis, 1961; Heizer, 1978) to propose how some of the trails and trade routes connected California with the western Great Basin during different prehistoric time periods. Their reconstructions, based on shell artifact distributions (Hughes and Bennyhoff, 1986: fig. 1), connect the lower Humboldt Valley with the Mono Lake area, central California, and areas north although, based on then current knowledge, these same routes were not all reflected in obsidian distributions (Hughes and Bennyhoff, 1986: fig. 2).

PREVIOUS RESEARCH ON OBSIDIAN IN THE LOWER HUMBOLDT VALLEY

This is not the first instrument-based analysis of obsidian artifacts from the lower Humboldt Valley. During the early 1970s, while working on his pioneering study of the geological sources for obsidian artifacts found in California, Robert Jack analyzed a large number of artifacts from the Humboldt Sink provided to him by Robert Heizer. Based on the success of obsidian-sourcing research conducted on California (Jack, 1976) and Mesoamerican artifacts (e.g., Jack and Heizer, 1968), Heizer was keen to extend similar studies to the Great Basin. Jack's notes (in possession of the author) document that he analyzed over 400 obsidian artifacts—predominantly typologically distinctive projectile points—from various sites and localities (mostly Ch-13 and Ch-15) within the Humboldt Sink. This was a major undertaking that never resulted in publication probably because: (1) Jack retired from the staff of the Geology Department at Berkeley in 1973; (2) someone else with Jack's expertise was not available to take on xrf data interpretation; (3) it would have been extremely difficult to distinguish among and between superficially similar obsidian sources using the rapid-scan technique Jack employed on artifacts at that time (see Hughes, 1998: 106–107 for discussion), and (4) compared with California, the inventory of artifact-quality geological obsidian sources in Nevada was, at that time, nascent at best. Nonetheless, comparison of catalog numbers listed in Jack's notes shows that all the typologically distinctive artifacts he analyzed are included in the present study.

Derby Airfield Sites

Obsidian studies undertaken at sites proximate to the Derby Airfield south of Lovelock (see fig. 2) formed the basis for the conclusion that:

> there apparently was a major shift in obsidian conveyance into the project area from an older pattern directed at Mt. Majuba [sic] located to the east along

> the Humboldt River corridor, to a very late prehistoric reliance on obsidian from the Inyo-Mono region, most importantly Mt. Hicks glass. This pattern may relate to expansion of Numic (Paiute) peoples from their homeland in the southwestern Great Basin at this time (McGuire and Hildebrandt, 2013: 87).

The obsidian conveyance shifts advanced for Derby Airfield sites were made predominantly on the basis of source-specific obsidian hydration analysis of debitage/flakes (McGuire and Hildebrandt, 2013: appendix A). Seventy-two of 80 samples subjected to obsidian hydration from these seven sites were described as flakes and only eight classifiable obsidian points were recovered (McGuire and Hildebrandt, 2013: table 11). The interpretations of the present study and those from the Derby Airfield thus appeal to different data sets. Conclusions based on obsidian hydration data from flakes and those based on source-specific analysis of time-sensitive obsidian points may not accord because the artifacts themselves reflect different uses, and because their formerly distinct source-specific procurement, distribution, conveyance, and use-life histories may have been quite different.

As we will see, these Derby Airfield conclusions contrast with those reached here. Lower Humboldt Valley data presented here do not support an increase in southern (Mono Basin area [Mt. Hicks]) obsidian during the time of the putative Numic expansion within the last 1000 years or so; in fact, the evidence indicates just the opposite.

Rye Patch Reservoir Sites

In the early 1980s, obsidian source analysis was conducted on artifacts recovered from various archaeological sites examined in connection with construction of Rye Patch Reservoir, located about 60 km up the Humboldt River from Lovelock (see fig. 2). No technical report of the laboratory analyses appears in the publication, but Rusco and Davis (1987: A-1) provided a narrative summary of the results of 269 xrf analyses. They wrote that most of the obsidian (ca. 60%) came from the nearby Majuba Mountain source, with "the next largest number (14.9%)…from a source in the Pine Grove Hills, south of Walker Lake." Some years ago, I published an analysis and evaluation of the efficacy of procedures and protocol of the laboratory conducting the Rye Patch analyses, pointing to methodological and statistical shortcomings of this research that could compromise the accuracy of artifact-to-source attributions (Hughes, 1984; also, Hughes, 1986: 55–85). In short, my evaluation of the procedures applied to the Rye Patch study leaves me with no confidence in the results. Although it seems logical that the nearest high-quality obsidian source might be the most frequently represented at the Rye Patch sites (but see below), logic isn't the issue: it's the reliability and validity of the instrumentation and attribution procedures underpinning the results. Lacking explicit presentation of those procedures—which allow independent verification/refutation of the substantive (artifact-to-source) attributions—one is unfortunately forced to take the analyst's word for it. It is hoped this important Rye Patch collection will someday be subjected to reanalysis. More recently, Skinner (2003) conducted a provenance analysis of obsidian from the Old Humboldt Site (26-PE-670), but the results were not reported by artifact type/class.

THE LOWER HUMBOLDT VALLEY SAMPLE

More than 900 obsidian projectile points, bifaces, and fragments from 24 archaeological sites and localities in the lower Humboldt Valley were analyzed in the present study (see table 3), but slight disagreements were encountered between the longitude/latitude data and map plots for certain sites. Map plot comparisons for Loud's sites (Loud and Harrington 1929: pl. 1) with PAHMA object card data suggests that sites 7 and 8 are mislocated: Site 7 is located north of site 8 on Loud's map, but longitude/latitude data from the PAHMA indicate the reverse. A similar problem exists for relational plots for Ch-13, Ch-14, and Ch-15. But if Heizer and Clewlow (1968) correctly identified these latter three localities as parts of one large site, slight map imprecision is more a minor technical issue than a substantive obstacle to the present study. Location ambiguity also applies to artifacts attributed to the HLB (Humboldt Lake Bed); only eight of the specimens in table 3 can be attributed with certainty to this locality. The others (bearing 1-11- catalog prefixes) appear to be from Ch-8, but minimal information on the survey form—and no actual map plot—contribute to uncertainty. An additional issue is that Loud's map (Loud and Harrington, 1929: pl. 1) shows Humboldt County immediately north of Churchill County. This might be construed as a mistake, but it wasn't: Loud's base map was drafted before Pershing County came into existence (in 1919).

In addition to Loud's work, Harrington and his field assistants made casual surface collections at unspecified locations on the north end of Humboldt Lake bed during the time he was conducting excavations at Lovelock Cave (see Harrington, 1927). The artifacts were subsequently deposited in the Southwest Museum, where Harrington was Curator of Archaeology from 1928–1964, and apparently loaned to Heizer for analysis; it is these artifacts that are listed by Heizer and Clewlow (1968: table 2) as "Harrington."[8] Table 3 presents the overall distribution artifacts analyzed.

Of this total, 737 were recognized time-marker forms (table 4), and another 32 were attributable at least to the arrow/dart level of temporal resolution. Table 3 shows that the vast majority of points (75%; 680 of 904 artifacts) came from just three sites: Ch-13, Ch-14, and Ch-15. Ch-13 and Ch-14 were never excavated, but Ch-15 was subject to several small test excavations that produced very few typable obsidian points (Livingston, 1988; Heizer, n.d.). A small number of points came from excavated sites for which reports exist—Ch-18 (Loud and Harrington, 1929, Grosscup, 1960, Clewlow and Napton, 1970), Ch-35 (Heizer and Krieger, 1956), Ch159 (Stanley et al., 1970; Pe-8 (Baumhoff, 1958), Pe-14 (Heizer, 1951), Pe-67 (Cowan and Clewlow, 1968)—but the other specimens were recovered from surface contexts. The artifacts analyzed here were obtained via research study loans granted by the Phoebe Apperson Hearst Museum of Anthropology (PAHMA), University of California, Berkeley, the Nevada State Museum, Carson City (NSM), and the Smithsonian Institution, Museum of the American Indian (SI-MAI). Collections were personally examined by the author, with assistance from several museum individuals (see Acknowledgments). At the time of in-museum inspections at the PAHMA and NSM, decisions were made about which specimens would be suitable for analysis. Because the basal elements of Great Basin points (in addition to general size) are the most diagnostic for making typological ascriptions, only those specimens with intact basal elements were selected for analysis. To constrain, as much as possible, the temporal element of the study, no tips or point midsections (regardless of size) were analyzed, nor were morphologically nondiagnostic bifaces. Metric attributes were generated for most specimens; see supplementary file S1 (https://doi.org/10.5531/sp.anth.0105), which presents metric attributes for 624 of the 904 artifacts included in this analysis.[9] Projectile points were classified into types following the metric criteria proposed by

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[8] A list of the artifacts in question (under Southwest Museum [now incorporated within the Autry Museum of the American West] accession number 569) was provided to me by Autry Museum staff, but I was unable to examine nor analyze them because of a research moratorium imposed by the Museum during a collections reorganization. The whereabouts of the much larger Newhall collection from Ch-15 examined by Heizer and Clewlow is unknown. The obsidian points from the Derby Collection in the Humboldt Sink (housed at the NSM) were unavailable for study when the current project was initiated.

[9] The reader should consult Cowan and Clewlow (1968) for Pe-67, Clewlow (1968a) and Clewlow and Napton (1970) for Ch-18, and Thomas (2022b) for Ch-13, Ch-15, and Pe-67 for metric data not included in supplement 1. The projectile point measurements in Thomas (2022b) are not reproduced here, but I did incorporate the typological assignments made from their metric analyses.

TABLE 4

Site-Specific Distribution of Time-Sensitive Obsidian Projectile Points from Archaeological Sites and Localities in the Lower Humboldt Valley

Point type abbreviations: CT = Cottonwood Triangular, DSN = Desert Side-notched, RS = Rosegate, ECN = Elko Corner-notched, EE = Elko Eared, ES = Elko series, GCS = Gatecliff Contracting Stem, GSS = Gatecliff Split Stem, GS= GatecliffSeries, NSN = Northern Side-notched.

Time Period	**AD 1300–Historic**		**AD 750–1300**	**AD 750–1500 BC**			**1500–3750 BC**			**2000–4500 BC**	
Point Series	**Desert**		**Rosegate**	**Elko**			**Gatecliff**				
Point Type	**CT**	**DSN**	**RS**	**ECN**	**EE**	**ES**	**GCS**	**GSS**	**GS**	**NSN**	
Archaeological Site											**Totals**
Ch-7	–	–	2	1	–	–	–	–	–	–	3
Ch-8	2	2	8	2	1	1	2	–	–	1	19
Ch-12	–	–	–	–	1	–	–	–	–	–	1
Ch-13	6	7	147	23	31	1	30	23	5	9	282
Ch-13, -14, -15	–	–	–	1	–	–	–	–	–	–	1
Ch-14	–	–	4	1	2	–	1	2	–	–	10
Ch-15	29	93	65	20	24	–	26	13	16	9	295
Ch-18	3	1	18	2	7	–	2	3	–	–	36
Ch-28	–	–	5	–	–	–	–	1		–	6
Ch-35	–	–	3	–	1	–	–	–	–	–	4
HLB	–	1	–	–	1	–	–	–		–	2
Pe-5	–	–	3	2	8	–	3	2		1	19
Pe-7	5	5	3	3	–	–	–	–	1	–	17
Pe-12	–	1	–	–	–	–	–	–	–	–	1
Pe-13	1	1	1	–	1	–	–	–	–	–	4
Pe-17	–	2	–	–	–	–	–	–	–	–	2
Pe-19	–	–	–	–	–	3	–	–	–	–	3
Pe-21	–	–	–	–	1	–	–	–	–	–	1
Pe-66	2	1	9	2	–	–	–	–	–	–	14
Pe-67	4	5	5	1	–	–	–	–		–	15
Pe-69	–	1	–	–	1	–	–	–		–	2
Totals	52	120	273	58	79	5	64	44	22	20	737

Thomas (1981), Thomas and Bierwirth (1983), and Pendleton (2020a, 2020b). Points collected by Loud from Ch-13, Ch-14, and Ch-15 were originally cataloged in lots—specimens within each lot were, at that time, assigned the same museum catalog number regardless of how many typologically distinct points occurred within each. To allow identification of individual artifacts within each lot I have appended, where appropriate, a lowercase letter (and, in some cases, a number).

This study focused explicitly on obsidian, but projectile points found at lower Humboldt Valley sites also were made from other toolstone materials (Loud, 1929: 132). I did not examine, nor quantify, data on non-obsidian occurrences at individual sites, but the large surface collection examined by Heizer and Clewlow (1968) from Ch-15 provides a rough approximation of material breakdown in the study area. Heizer and Clewlow's (1968: table 1) data indicate that 65.7% (N = 626) of all the classifiable points they examined were made from obsidian, that 27.8% (N = 266) were made from "silicates" (probably chert and chalcedony), with 6.4% (N = 61) manufactured from basalt and "other igneous" material.

Methodological Issues

In a previous volume in this series I discussed the protocol used to assign artifacts to a distinctive chemical variety of obsidian, often referred to as a "source" (Hughes, 2020a; see also Hughes, 1998). That discussion dealt principally with the use of primary data in making artifact-to-source (chemical type) attributions. In source analysis, primary data have to do with trace-element composition of obsidian artifacts and secondary data refer to the obsidian source identifications made on the basis of the primary data. In the artifact-classification enterprise, primary data are the actual metric variables (length, width, etc.) generated for each artifact, while secondary data are the typological categories that derive from (are dependent on) primary data (e.g., Desert Side-notched, Rosegate, etc.; see Kitchin, 2014). Although perhaps obvious, I emphasize that it is the derived classifications (i.e., the point types themselves) that are compared and manipulated in this study—not the primary data (presented in supplementary files S2–20: https://doi.org/10.5531/sp.anth.0105)—although correspondences and contrasts in primary data are the basis on which each individual artifact is attributed to chemical type. The importance of primary data in projectile point classification has been emphasized by Thomas (1970, 1981, 2013), and I have underscored the critical role of quantitatively precise and accurate primary geochemical data for making instrument-based identifications of artifacts in obsidian provenance analysis (Hughes, 1984, 1986; Hughes and Milliken, 2007; Hughes and Thomas, 2020).

Artifact Classification Issues

Obsidian projectile points were classified according to Monitor Valley Key metric criteria proposed by Thomas (1981) and Thomas and Bierwirth (1983). Overall, metrics worked well for classifying dart types (i.e., Gatecliff series, Elko series), but they were somewhat less satisfactory in separating some Rosegate arrow points from Gatecliff Series darts (see below). The metric criteria for identifying Rosegate points excluded a number of lower Humboldt Valley specimens with much narrower neck width and proximal shoulder angle. Thickness and neck-width measurements put these specimens squarely within the range of arrow points (Hildebrandt and King, 2012; see supplementary files S15–S17), though some of them are more "stemmed" than corner notched (see fig. 21). Similar problems in using the Monitor Valley key have been encountered elsewhere in the west (e.g., Hildebrandt and King, 2002), and Thomas (1981; personal commun., 2018) has cautioned about the pitfalls of applying the Monitor Valley key to areas outside the area where it was developed.

Figure 6A presents the d/a (dart/arrow) index values determined for 461 obsidian projectile points (279 arrow points and 182 dart points) from the lower Humboldt Valley presented in supplementary files S3–S17. The mean d/a value for arrows points is 10.31 ± 1.40 mm, while d/a values determined for darts is 15.49 ± 4.13 mm. It is clear from these data, as Hildebrandt and King (2012) demonstrated from a larger sample, that arrow points can be distinguished from dart points most of the time on the basis of dart-arrow index values—they considered d/a values >11.8 to be dart points, while values <11.8 specified arrow points (also McGuire et al., 2018: 40). Note that *most of the time* is the operative phrase here. Just as with the artifacts in Hildebrandt and

FIG. 4. View of Humboldt Lake on April 7, 2007, looking southeast from the Trinity Range, with the West Humboldt Range in the background. Photo courtesy of Jack Hursh, Nevada Bureau of Mines and Geology.

King's sample (2012),[10] projectile points from the present study also do not all fall neatly on one side or the other of the d/a line; overall, the values for lower Humboldt Valley arrow points are not statistically different from darts ($t = 1.19 < t_{0.05} = 1.96$).

Sorting the obsidian projectile points recovered from the adjacent Carson Desert and Stillwater Mountains (Kelly 2001: table 4-3) on the basis of maximum thickness/neck width (see fig. 6B) reveals a similar distinction between arrow and dart points to that observed by Hildebrandt and King (2002), suggesting that some of the artifacts from the Carson Sink classified as dart points would be considered arrow points using the Hildebrandt/King criteria.[11] Just as in the lower Humboldt Valley, d/a values for Carson Sink arrows are not statistically different from darts.[12] Fewer problems were encountered with identification of Desert series points, but in some cases side notching appears to have been executed on small flakes, resulting in shallow, asymmetrical side notches at variance with Monitor Valley metrics and the "classic" illustrated varieties (e.g., Baumhoff and Byrne, 1959: pl. 1). Some of the lower Humboldt Valley side-notched points actually have convex bases (see fig. 21: D, G, I)—not concave as is typical of archetypal Desert Side-notched forms—and some Desert Side-notched points have notches higher up (i.e., more toward the tip) than on the side of the blade proximate to the base (see fig. 8: H, L). Because no new chronological information from the lower Humboldt Valley was available to support any finer temporal resolution, these typologically problematic artifacts

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[10] Data presented by Hildebrandt and King (2012, table 2) show that d/a index values for Rosegate points (the Rose Spring Series) are not statistically different from those of the Elko series ($t = -1.87 < t_{0.05} = 1.96$).

[11] Even in stratified deposits at Hidden Cave, two specimens classified as Rosegate arrow points (2/32557 and 1-B-890) have W+T values that fall within the range of Gatecliff series dart points, and five other Gatecliff series points have W+T values <12—within the range for arrows (data from Pendleton, 1985: table 53).

[12] D/a index for arrow points = 10.12 ± 1.84 mm (N = 58); dart points = 15.43 ± 3.86 (N = 36); $t = -1.24 < t_{0.05} = 1.96$.

FIG. 5. Panoramic view southeast from the Trinity Range taken from Ragged Top Mountain, about 20 kilometers southwest of Lovelock, on April 21, 2019. The Humboldt Sink is in middle of the photo, with the West Humboldt Range, the Carson Sink, and the Stillwater Range beyond. Lovelock Cave (Ch-18) is marked with a red dot. Photo courtesy of Jack Hursh, Nevada Bureau of Mines and Geology.

were examined—as an analytical category—only at the "arrow point" level.

At finer scale, differentiating between Rosegate (specifically, the Rose Spring contracting-stem variant identified by Lanning, 1963: 252) and Gatecliff Contracting stem points can be problematic (cf. Thomas 1981: 23).[13] D/a measurements for specimens from both series, reported from the Carson Sink (fig. 6B) and Hidden Cave (fig. 6C), show that the neck width + thickness measurements for the large sample of obsidian Gatecliff series points from Hidden Cave overlaps with values from elsewhere in the Carson Sink.[14] The range of d/a values for the small number of Rosegate arrow points from Hidden Cave (Pendleton, 1985: table 53) overlaps with the range for darts and arrows from the Carson Sink (fig. 6B), just as it does in the larger sample from the lower Humboldt Valley (fig. 6A).[15]

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[13] The metric criteria for distinguishing between Rose Spring and Gatecliff points affect many of the artifact type-identifications made prior to widespread use of the Monitor Valley key in the western Great Basin. To cite only two examples: metric data in supplementary data file S4 would reclassify two Rose Spring Corner-notched points from Ch-18 illustrated by Clewlow (1968a: fig. 2e, v) as Gatecliff Contracting Stem points, and one point (1-65382) from Ch-15, classified by Heizer and Clewlow (1968, fig. 6p) and Hester and Heizer (1973: fig. 4c) as a Rose Spring Contracting Stem, keys out as a Gatecliff Contracting Stem.

[14] Hidden Cave d/a index for arrow points = 11.42 ± 1.29 mm (N = 5); Carson Sink d/a values for arrow points= 10.14 ± 1.84 mm (N = 58). Hidden Cave d/a for dart points = 17.43 ± 3.17 (N = 108); Carson Sink dart values = 15.43 ± 3.86 (N = 36). Hidden Cave arrows vs. Carson Sink darts, $t = -0.985 < t_{0.05} = 1.96$). But Hidden Cave darts are statistically distinguishable from Carson Sink arrows, $t = 1.99 > t_{0.05} = 1.96$.

[15] Recognition of this problem may have contributed to the eventual elimination of Rose Spring Contracting Stem and Side-notched variants from the Monitor Valley key (Thomas, 1981). The earliest version of the key (Thomas, 1970: 37, fig.

Perhaps equally significant to the present study, given the current disagreement on Rosegate/Elko identifications in the western Great Basin (Smith et al., 2013; Hockett et al., 2014), data in supplementary files S4–S6 show that measurements for 152 Rosegate points from the lower Humboldt Valley have a mean thickness of 3.51 ± 0.68 mm, while thickness measured on 83 Elko series points (combined Elko Corner-notched and Elko Eared) yielded a mean thickness value of 5.04 ± 1.06 mm. These values are not significantly different ($t = 1.22 < t_{0.05} = 1.96$).

SAMPLE BIAS

Artifact Collecting

There can be little question that the assemblages recovered from these sites have been seriously affected for decades by nonacademic artifact collectors. Commenting on the material recovered in 1950 from Pe-5, Elsasser (1958: 39) wrote that: "Unquestionably, collectors have visited the site at times when many of the artifacts were not covered by sand. During such collection, the cruder artifacts…probably were overlooked, while the coveted points were taken freely." Nearly 40 years earlier Loud (in Loud and Harrington, 1929: 130) remarked that "The Pugh Brothers ha[d] obtained a cigar box full of [obsidian] specimens" from the site, while Heizer and Krieger (1956: 5) noted that "numerous collections, many of them comprising several thousand pieces, are in the hands of local townspeople." Because larger points (i.e., dart points) are easier to see, one would expect that they would have been collected more frequently than smaller, harder-to-spot arrow points (cf. Heizer and Clewlow, 1968: 67). But the shifting Humboldt lakebed sands—periodically covering, then exposing different parts of these low-lying archaeological sites—would certainly have been another factor affecting the surface visibility of all artifacts. The fact that several very large, complete obsidian points were recovered from the Humboldt lakebed by S.M. Wheeler in 1939, as well as during the 1950s and 1960s by crews from Berkeley, attests to the importance of environmental vicissitudes. Kelly (2001: 158ff.,173, 175, n. 4) discussed similar problems in the Carson Desert, and Smith (2015) approached the problem from a complementary perspective.

In addition, we know from artifact collectors that any complete point encountered will be retained. Even though red-colored obsidian might be considered very special and rare, there's no evidence to suggest that this feature alone would influence a decision whether to bypass or collect that or the next complete point found—regardless of color. This suggests that—in addition of the burial/exposure and size-graded variables acknowledged previously— each complete point encountered would have an equal chance to be collected (and/or reworked) regardless of the geochemistry of the artifact. Consequently, the points collected can be assumed to be a geochemically unbiased approximation of the density/distribution of obsidian points on the original landscapes. The problem here is that we know that for thousands of years indigenous native peoples also reworked and repurposed points, even though the nature and extent of those activities were comparatively minimal if only because there were fewer people around to do it. While acknowledging the time-transgressive element of what was available on the landscape, we can probably eliminate obsidian source selection bias even though the overall collector's effects remain.

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4) presented metric criteria for distinguishing among Rose Spring Contracting Stem, Corner-notched, and Side- notched variants, and they appeared also in a later iteration (Hatoff and Thomas, 1976: 286, fig. 11). But in more recent references, metric distinctions identified in the earliest key are not presented and form variants appear to have been merged into the Rosegate Series temporal type (e.g., Thomas, 1981: fig. 11; Thomas and Bierwirth, 1983: 179-180). Gatecliff series points from the lower Humboldt Valley are not significantly thicker (mean= 4.68 ± 1.12 mm) than Rosegate points (mean= 3.50 ± 0.68; $t = 0.901 < t_{0.05} = 1.96$), nor do they have significantly different neck widths (Gatecliff= 8.92 ± 2.84 mm; Rosegate= 6.84 ± 1.22 mm; $t = 0.673 < t_{0.05} = 1.96$).

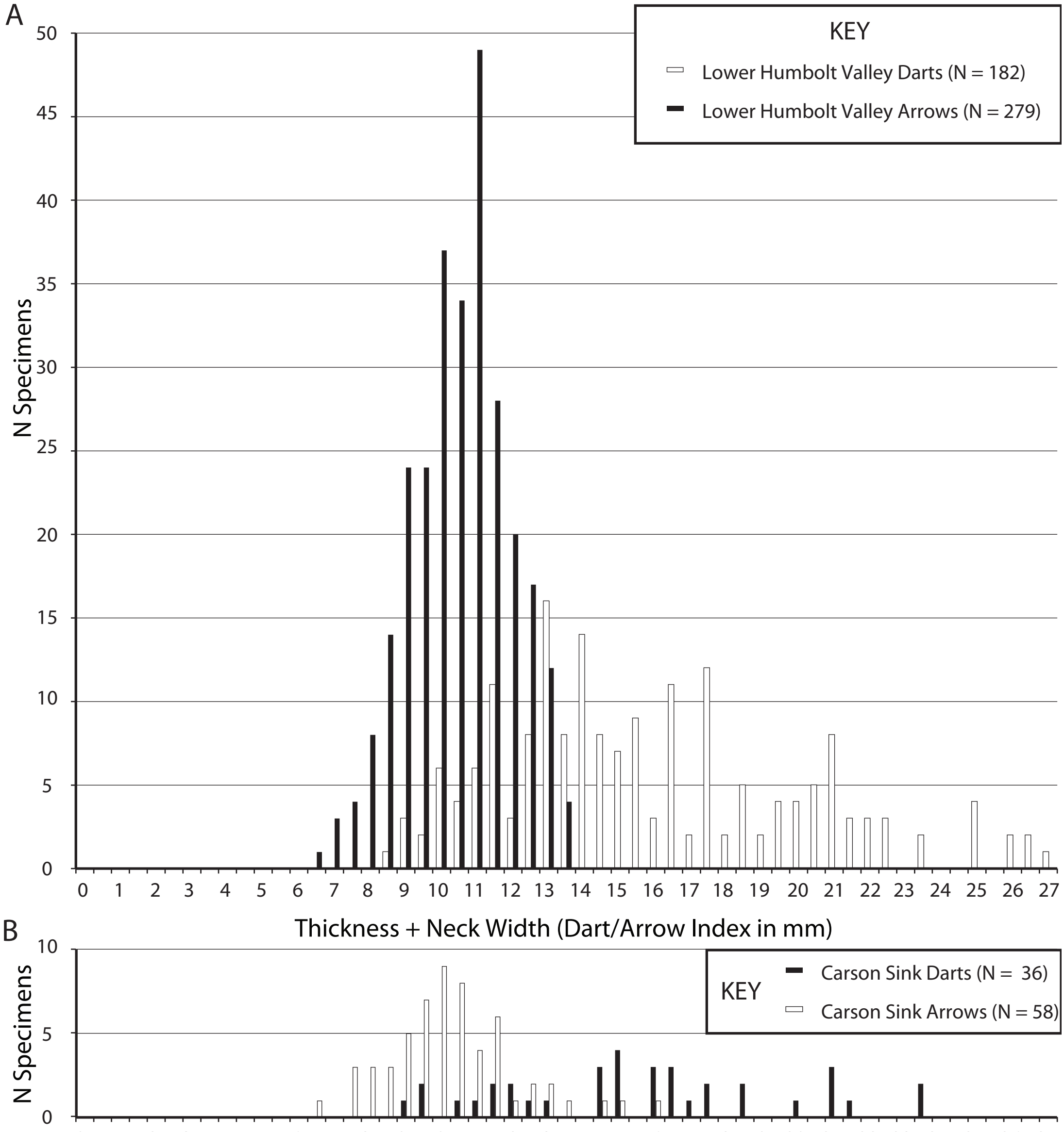
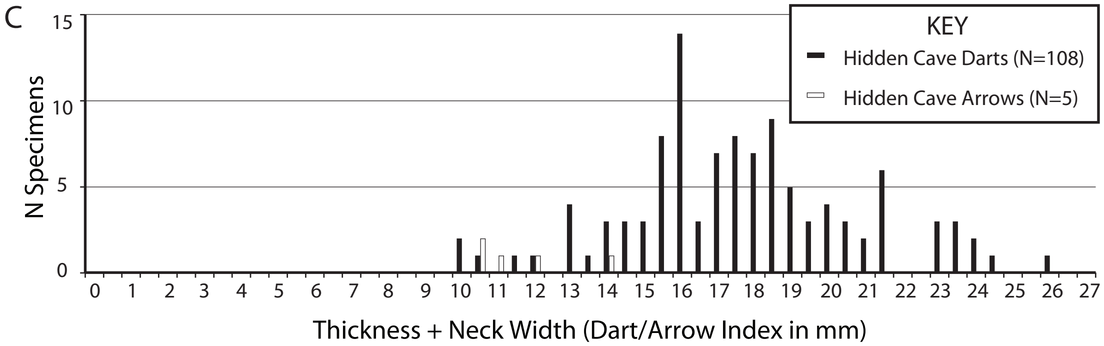


FIG. 6. Histogram of neck width + maximum thickness (dart/arrow index) values for obsidian projectile points. **A.** Values for artifacts from the Lower Humboldt Valley (data from supplement 1). Mesurements for four Elko Corner-notched spears (1-18863, 1-65433, 1-65630, and 1-65645) not included. **B.** Values for artifacts from the Carson Sink. Data from Kelly, 2001: table 4-3. **C.** (*opposite page*) Values for artifacts from Hidden Cave. Data from Pendleton, 1985: table 53.



Effects of Artifact Reworking and Refabrication

When encountered in good condition, larger points (darts) could have been resharpened/reworked into serviceable smaller forms (arrow points). In fact, based on this truism, there's been significant debate over the utility of projectile points as time markers in the Great Basin (e.g., Flenniken and Wilke, 1989; Bettinger et al., 1991). If artifact rejuvenation/reworking was a significant factor in the lower Humboldt Valley study we would expect that, if more darts were made from southern than from northern obsidian sources, greater numbers of southern-source obsidian points should be found in later (i.e., arrow category) assemblages. Conversely, if more darts were made from northern than from southern sources, greater numbers of northern-source obsidians should be found in later (i.e., arrow category) assemblages. We will return to evaluate how the lower Humboldt Valley data square with these expectations.

Methodology

Another unavoidable mitigating factor in this study is methodological. Change in obsidian source use through time in the study area is being investigated here using named projectile point types—and their attendant age ranges—as currency. The problem is, of course, that if one is investigating change by using categories that are essentialist—hence categorically bounded—any changes identified are, by definition, between and among categories (i.e., between Desert Side-notched and Rosegate points, between Rosegate and Elko, etc.) and these categories themselves could subsume and obscure finer changes (like the possible shift from dart to arrow function, cf. Heizer and Baumhoff 1961: 128) that may have occurred within a period. This is the old problem of trying to identify dynamics using static categories (cf. Dunnell, 1995; Beck, 1998, 1999; Ramenofsky, 1998; see Thomas, 2013, for discussion; and Bowker and Star, 2000, for examples outside archaeology) and it needs to be acknowledged when evaluating the conclusions advanced here. As noted elsewhere (Hughes and Thomas, 2020) an interpretive focus on numerical differences in abundance between categories may be misleading because of the vastly different temporal spans over which certain projectile point types were in use. I will return to this issue below.

ANALYSIS CATEGORIES

Typologically early projectile points have been reported elsewhere in western Nevada (e.g., Tuohy 1984; Rusco and Davis, 1987), but the vast majority of archaeological sites known from the lower Humboldt Valley vicinity, with the exception of Leonard Rockshelter (Heizer, 1951; Smith et al., 2022), date within the last 5000 years.[16]

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[16] We know relatively little about the long-term depositional history of Humboldt Lake, but it is the terminal basin and receptor for aeolian and fluvial sediments from surrounding basins and ranges, including the Black Rock Desert. Deflation of earlier sediments undoubtedly occurred through the Holocene. Consequently, there's little question that older (i.e., pre-

Over this time span, projectile points have served admirably as time markers for what has been termed the "short" chronology (see Thomas, 1981, for discussion of the "short" and "long" projectile point chronologies in the Great Basin). The Monitor Valley key for projectile point classification has been extended west to Hidden Cave (Pendleton, 1985), the Carson Sink (Drews, 1988; Elston, 1988; Kelly, 2001) and to collections from the lower Humboldt Valley (Thomas, in press b), so I continued its application here. Supplementary data file S1 provides a complete listing of all points measured and classified here using the Monitor Valley key (see fn. 9), and they can be recombined and/or resorted to serve other research interests. The named types employed and their approximate temporal ranges in the western Great Basin appear in table 1; they are described briefly and discussed below. The site-specific distribution of all time-marker types appears in table 4, and the site distribution of nonmarkers appears in table 5. Recent direct dates for certain projectile point types (from Smith et al., 2013) will be mentioned as they bear on revisions or reevaluation of the temporal range of individual types.

Temporally Sensitive Forms

Desert Series (N = 172): In all 172 Desert series projectile points (Desert Side-notched, N = 120; Cottonwood Triangular, N = 52) were identified using the metric criteria proposed by Thomas (1981). First defined by Baumhoff and Byrne (1959) the Desert Side-notched type is comparatively small, with pronounced and usually well-executed side notches low on the blade element. They have been found in ethnographic collections as tips on arrows (Thomas, 1978). Cottonwood points were defined by Lanning (1963) in triangular and leaf-shaped variants; both forms are considered time markers for the Yankee Blade phase (cal AD 1300–AD 1850) at nearby Hidden Cave (Thomas, 1985) and in the Carson Desert (Tuohy, 1987a; Drews, 1988; Elston, 1988; Kelly, 2001). Figures 7 and 8 present illustrations of Desert Series points analyzed from the lower Humboldt Valley.

Rosegate Series (N = 273): Lanning (1963: 252) originally defined Rose Spring series points in side-notched, corner-notched, and contracting-stem variants, but provided no metric criteria to identify them. Thomas (1970: fig. 4), with subsequent modifications by Hatoff and Thomas (1976), generated metric criteria to separate these variants, and additional modifications were introduced by Thomas (1981) and Thomas and Bierwirth (1983) for classifying points from the Monitor Valley area. Based on temporal cooccurrence, Thomas (1981) combined Rose Spring and Eastgate points (the latter defined by Heizer and Baumhoff, 1961) into a single temporal type—which he named Rosegate. Bettinger (personal commun.) maintains, however, that Eastgate points occur earlier than Rose Spring points in the White Mountains.

Altogether 273 Rosegate series projectile points were analyzed from 19 sites in the lower Humboldt Valley (see table 4; fig. 9). Rosegate series points are considered time markers for the Underdown phase (cal AD 750–AD 1300) at Hidden Cave (Thomas, 1985), but, as noted above, there are metric differences among some of the small, corner-notched points in lower Humboldt Valley sites that conflict with the Monitor Valley key criteria for Rosegate (as specified by Thomas, 1981). This is not news: for example, weight measurements suggest that projectile points found together in an animal skin pouch at Wa-197 are Elko series (dart) points (Thomas, 1981: 31), whereas maximum thickness/neck width measurements support the classification of these specimens as Rose Spring/Eastgate (arrow) points (Hockett et al., 2014) as proposed earlier by Hester (1974) and Heizer and Hester (1978: 162). ^{14}C associations and obsidian hydration data from sites along the Sierra-Cascade front (Hildebrandt and King, 2002) suggest that Rosegate point may be several centuries older in the western Great Basin than previously believed.

5000 BP) archaeological sites exist in the lower Humboldt Valley, buried under meters of alluvial overburden.

TABLE 5

Site-Specific Distribution of Obsidian Bifaces and Other Form Classes from Archaeological Sites and Localities in the Lower Humboldt Valley Point Type/Form Class

	Humboldt	Humboldt	Carson	Small	Small	Small	Misc. dart	Great Basin	Concave	Totals
Archaeological Site	**Basal-notched**	**Series**		**Corner-notched**	**Side-notched**	**Stemmed**		**Stemmed**	**Base**	
Ch-7	1	–	–	–	–	–	–	–	–	1
Ch-8	–	4	–	–	–	–	–	–	–	3
Ch-12	–	1	–	–	–	–	–	–		1
Ch-13	18	8	–	–	3	–	–	–	3	32
Ch-14	1	1	–	–	–	–	–	–	–	2
Ch-13, -14, -15	–	1	–	–	–	–	–	–	–	1
Ch-15	19	27	3	–	5	1	–	2	–	57
Ch-18	1	18	–	1	–	–	–	–	1	21
Ch-28	–	1	–	–	–	–	–	–	–	1
Ch-35	–	1	–	–	–	–	–	–	–	1
Ch159	–	–	–	–	–	–	3	–	–	3
HLB	1	5	–	–	–	–	–	–	–	6
Pe-5	–	8	10	2	–	–	1	–	1	22
Pe-7	1	3	–	1	1	–	–	–	–	6
Pe-8	–		–	–	–	–	–	–	1	1
Pe-14	–	1	–	–	–	–	–	–	–	1
Pe-66	2		–	–	–	1	–	–	–	3
Pe-68	–	2	–	–	–	–	–	–	–	2
Totals	44	81	13	4	9	2	4	2	6	165

Given these ambiguities and to avoid, as much as possible, typological confusion, points were classified as Rosegate only when they matched the Monitor Valley criteria; otherwise they were described as small corner notched, small side notched, or small stemmed. Thus, Rose Spring, Eastgate (i.e., Rosegate), and small, corner-notched points (including Carson points, see below) were grouped for later analysis into a common "arrow points" temporal pool.

Elko Series (N = 142): In total, 142 Elko series projectile points were analyzed from 19 sites in the lower Humboldt Valley (Elko Eared, N = 79; Elko Corner-notched, N = 58; Elko Series, N = 5). First described by Heizer and Baumhoff (1961: 128) in corner-notched and eared variants, these relatively large points were identified as time markers by O'Connell (1967) and are thought to have served as darts to tip atlatls. Elko series points (Corner-notched and Eared variants) are considered time markers for the Reveille phase (1500 cal BC–cal AD 750) at nearby Hidden Cave (Thomas, 1985), and ^{14}C assays from two nearby burials containing Elko points—at Pyramid Lake (Tuohy and Stein, 1969) and near Litchfield in the Honey Lake Valley (Riddell,1974: see supplement S22, https://doi.org/10.5531/sp.anth.0105)—date near the midpoint of this range. More recently,

TABLE 6

Longitudinal Data for U.S. Geological Survey Reference Standard

		Trace and Minor Elements						
		Rb	**Sr**	**Y**	**Zr**	**Nb**	**Ba**	**$Fe_2O_3^T$**
RGM-1 (measured)[1]	Mean	150.4	110.6	26.9	220.3	10.2	813.5	1.86
	s.d.	2.64	2.03	2.19	2.28	1.70	14.91	0.13
	CV (%)	1.75	1.84	8.17	1.04	16.7	1.83	0.68
RGM-1 (recommended)[2]		149	108	25	219	9	807	1.86

[1] Values in parts per million (ppm) except total iron [in weight %]; a, mean, sample standard deviation, and coefficient of variation (in %) for each element determined from 150 separate analyses.

[2] From Govindaraju (1994).

however, an Elko Eared point from Elephant Mountain Cave, about 125 km north of the lower Humboldt Valley, has been ^{14}C dated to 6879 ± 58 BP—much older than previously believed (Smith et al., 2013). Hockett et al. (2014) contend instead that the point in question is a large side-notched specimen, but the artifact illustration—particularly the radiograph (Smith et al., 2014: fig. 1 bottom row, right)—and associated metrics (Smith et al., 2014: 568) are consistent with the Monitor Valley key ranges for Elko points. What this unexpectedly early date portends for the viability of the "short chronology" in the western Great Basin remains to be seen. Hockett and Goebel (2019) have addressed dating, and identification, of Elko points in the eastern Great Basin. Figures 10–13 provide illustrations of specimens found in the lower Humboldt Valley.

Gatecliff Series (N = 130): A total of 130 Gatecliff series projectile points were analyzed from 20 sites in the lower Humboldt Valley (Gatecliff Split Stem, N = 44; Gatecliff Contracting Stem, N = 64; Gatecliff series, N = 22). Gatecliff series points (Split Stem and Contracting Stem variants), were defined by Thomas (1981) from stratigraphic context at Gatecliff Shelter, these are comparatively large dart points that come in split-stem and contracting-stem variants, some of which previously were referred to as the Pinto series (Hester and Heizer, 1973). They are considered time markers for the Devils Gate phase (3750–1500 cal BC) at Hidden Cave (Thomas, 1985) and the Carson Sink (Kelly, 2001), consistent with ^{14}C dates associated with this series at Kramer Cave (Tuohy, 1980; Hattori, 1982) near Winnemucca Lake. But carbonized wood from a housefloor at Las-194 (828 cal BC) suggests the points may have persisted somewhat later in northeastern California (O'Connell and Ericson, 1974: table 1). ^{14}C dates from nearby 26WA2460 (Young and Hildebrandt, 2017) on house structures containing Gatecliff series and Elko series points suggest a short period of temporal overlap when both forms were in use. Figures 14 and 15 illustrate some examples from the lower Humboldt Valley.

Northern Side-notched (N = 20): These large side-notched dart points, originally defined by Gruhn 1961), are quite common in pre-5000 year old assemblages to the north of the Humboldt Sink, where they are time markers for the period from ca. 6500–4500 BP in Surprise Valley (O'Connell, 1975; O'Connell and Inoway, 1994). Delacorte and Basgall (2012) show that the distribution of the type did not extend as far south as the lower Humboldt Valley. This may have been the case, as Delacorte and Basgall suggest, as a reflection of a social boundary between groups, but it also may be because the majority of sites in the study area simply date later than the floruit of the type. Nine different obsidian sources are represented in the lower Humboldt Valley sample, and very few obsidian Northern Side-notched points occur at these sites (see fig.

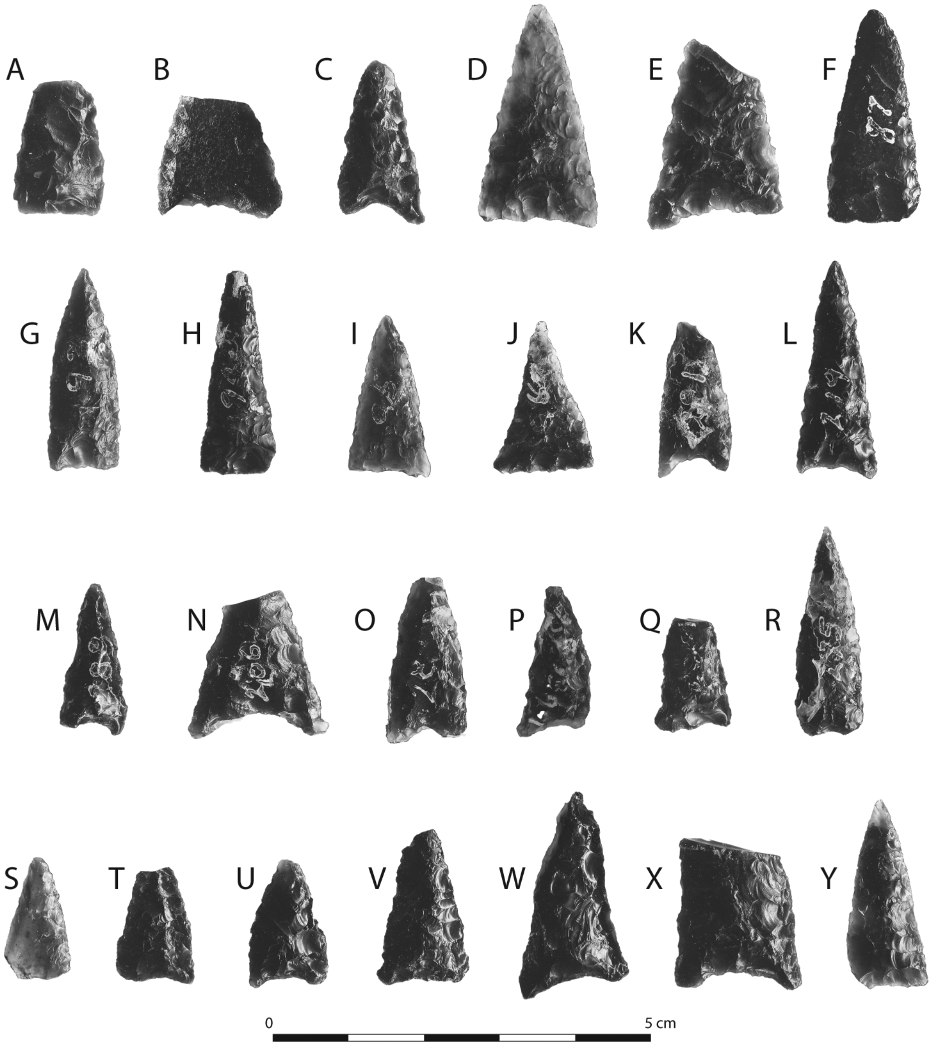

FIG. 7. Obsidian Cottonwood Triangular projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A.** 1-11-72 (Ch-8); **B.** 1-11-73 (Ch-8); **C.** 1-18865e (Ch-13); **D.** 1-18868c2 (Ch-13); **E.** NSM 385 (Ch-13); **F.** 1-65088 (Ch-15); **G.** 1-65094 (Ch-15); **H.** 1-65095 (Ch-15); **I.** 1-65096 (Ch-15); **J.** 1-65097 (Ch-15); **K.** 1-65280 (Ch-15); **L.** 1-65278 (Ch-15); **M.** 1-65283 (Ch-15); **N.** 1-65285 (Ch-15); **O.** 1-65287 (Ch-15); **P.** 1-65289 (Ch-15); **Q.** 1-65706.13 (Ch-15); **R.** 1-65224 (Ch-15); **S.** 1-66274 (Ch-15); **T.** 14-1-2 (Pe-7); **U.** 14-1-9 (Pe-7); **V.** 14-1-140 (Pe-7); **W.** 14-1-146 (Pe-7); **X.** 14-1-147 (Pe-7); **Y.** 1-46043 (Pe-66).

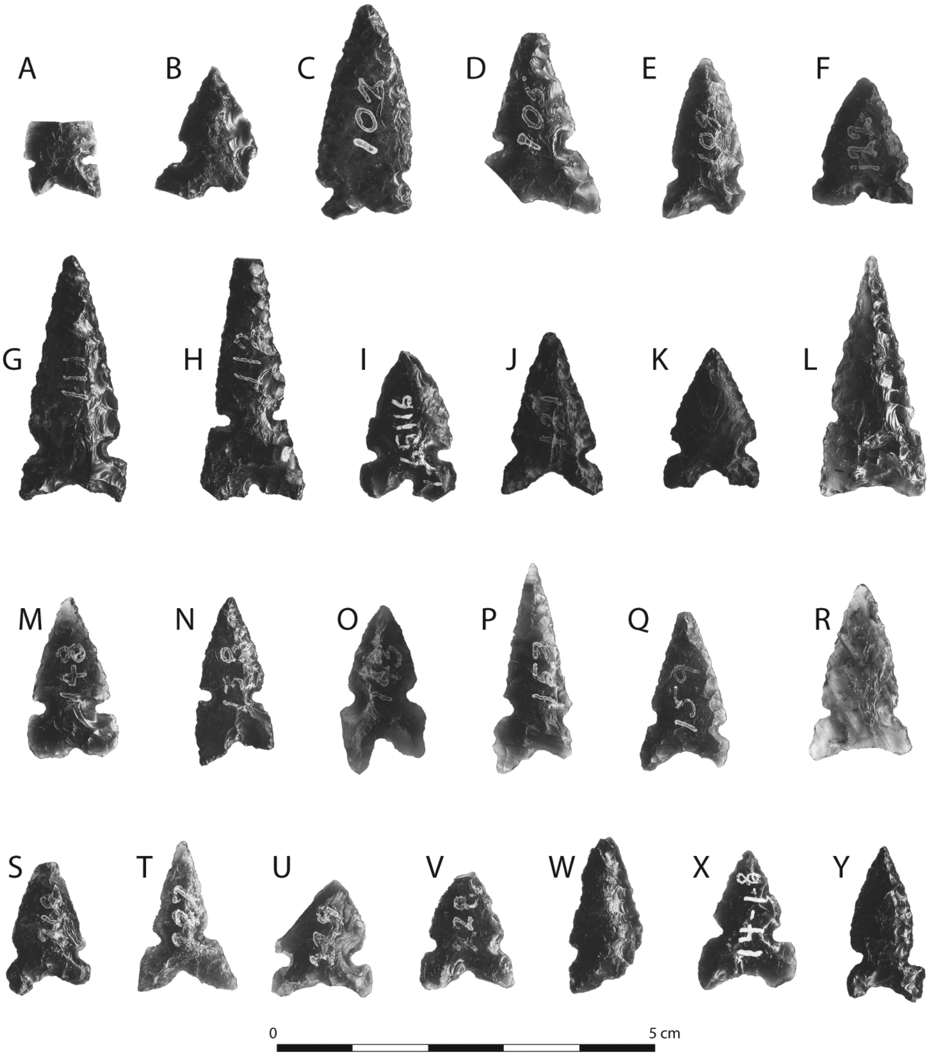

FIG. 8. Obsidian Desert Side-notched projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A.** 1-18969a (Ch-3); **B.** 1-18969b (Ch-13); **C.** 1-65103 (Ch-15); **D.** 1-65106 (Ch-15); **E.** 1-65110 (Ch-15); **F.** 1-65123 (Ch-15); **G.** 1-65112 (Ch-15); **H.** 1-65113 (Ch-15); **I.** 1-65116 (Ch-15); **J.** 1-65122 (Ch-15); **K.** 1-65124 (Ch-15); **L.** 1-65129 (Ch-15); **M.** 1-65148 (Ch-15); **N.** 1-65139 (Ch-15); **O.** 1-65143 (Ch-15); **P.** 1-65153 (Ch-15); **Q.** 1-65159 (Ch-15); **R.** 1-65206 (Ch-15); **S.** 1-65218 (Ch-15); **T.** 1-65226 (Ch-15); **U.** 1-65228 (Ch-15); **V.** 1-65227 (Ch-15); **W.** 14-1-136 (Pe-7); **X.** 14-1-8 (Pe-7); **Y.** 1-46035 (Pe-66).

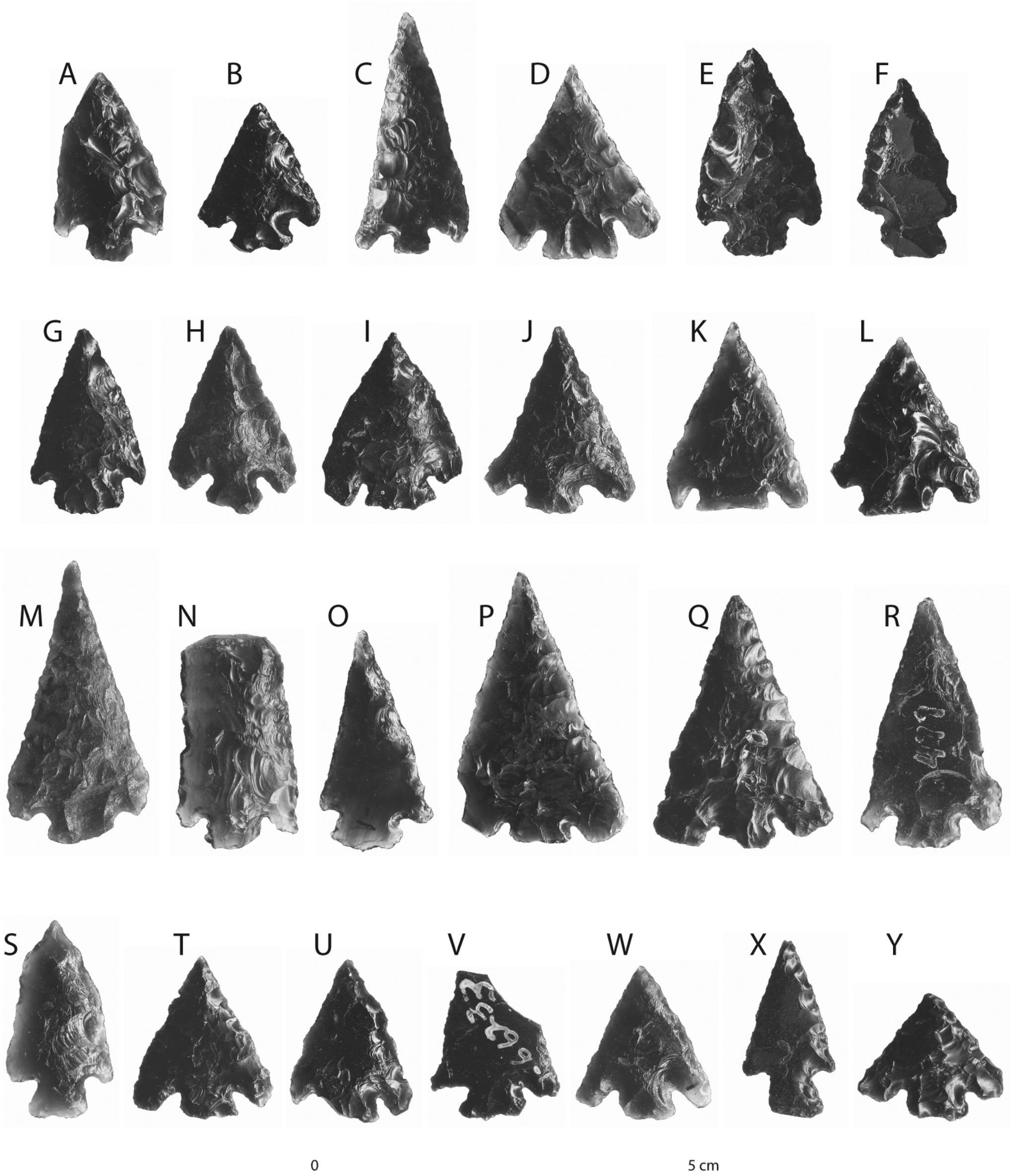

FIG. 9. Obsidian Rosegate series projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-11-66 (Ch-8); **B**. 1-17566 (Ch-13); **C**. 1-17571 (Ch-13); **D**. 1-17573 (Ch-13); **E**. 1-17577 (Ch-13); **F**. 1-18671(Ch-13); **G**. 1-18672 (Ch-13); **H**. 1-18678 (Ch-13); **I**. 1-18690 (Ch-13); **J**. 1-18696 (Ch-13); **K**. 1-18698 (Ch-13); **L**. 1-18701 (Ch-13); **M**. 1-65590 (Ch-15). **N**. 1-18705 (Ch-13); **O**. 1-18724 (Ch-13); **P**. 1-65469 (Ch-15); **Q**. 1-65470 (Ch-15); **R**. 1-65477 (Ch-15); **S**. 1-18732 (Ch-13); **T**. 1-18703 (Ch-13); **U**. 1-46037 (Pe-66); **V**. 1-66233 (Ch-15); **W**. 14-1-126 (Pe-7); **X**. 14-1-4 (Pe-7); **Y**. 1-19158 (Ch-28).

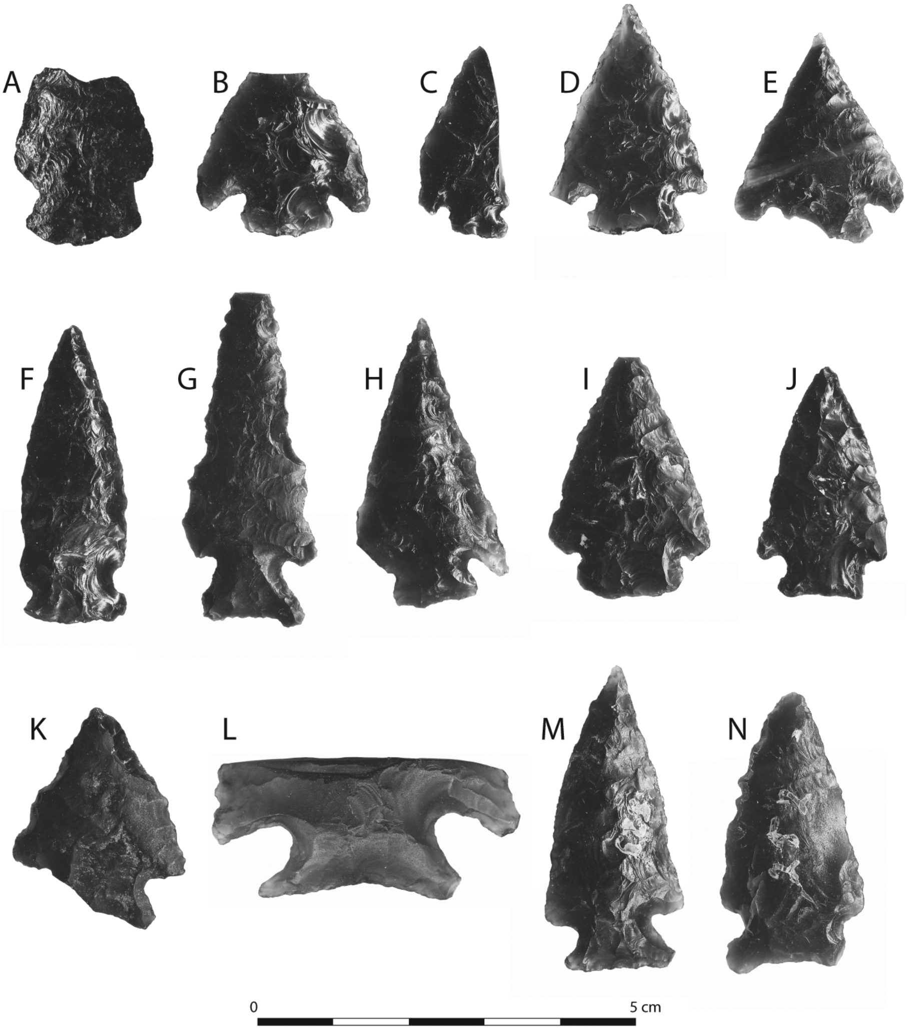

FIG. 10. Obsidian Elko Corner-notched projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-18609b (Ch-7); **B**. 1-11-77 (Ch-8); **C**. 1-11-62 (Ch-8); **D**. 1-18786 (Ch-13); **E**. 1-18799 (Ch-13); **F**. 1-18864j (Ch-13); **G**. 1-17467 (Ch-14); **H**. 1-18853 (Ch-13); **I**. 1-18865a (Ch-13); **J**. 1-18864f (Ch-13); **K**. 1-18872 (Ch-13); **L**. 1-65645 (Ch-15); **M**. 1-65525 (Ch-15); **N**. 1-65250 (Ch-15).

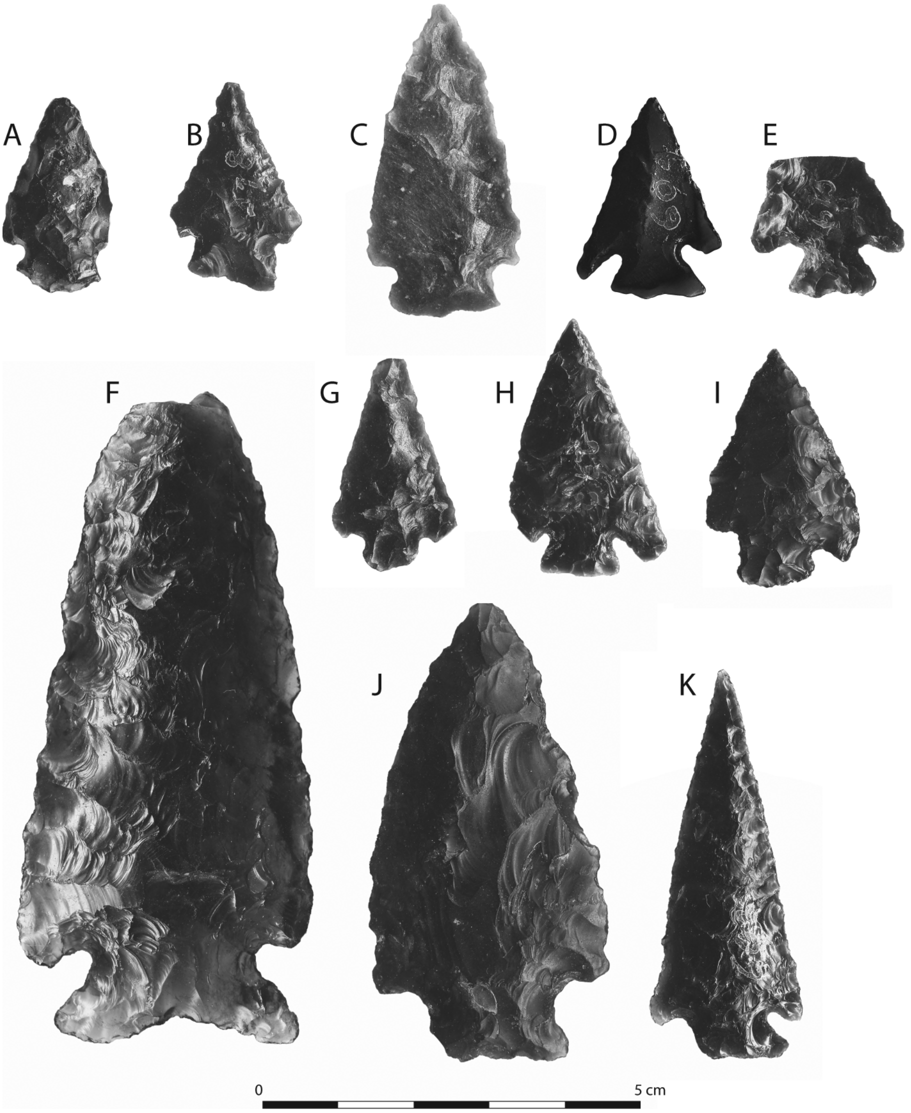

FIG. 11. Additional obsidian Elko Corner-notched projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-65311 (Ch-15); **B**. 1-65426 (Ch-15); **C**. 14-1-unknown (Pe-7); **D**. 1-65607 (Ch-15); **E**. 1-65616 (Ch-15); **F**. 1-65630 (Ch-15); **G**. 14-1-12 (Pe-7); **H**. 2-25286 (Ch-15); **I**. 1-46042 (Pe-66); **J**. 1-18863 (Ch-13); **K**. 1-65605 (Ch-15).

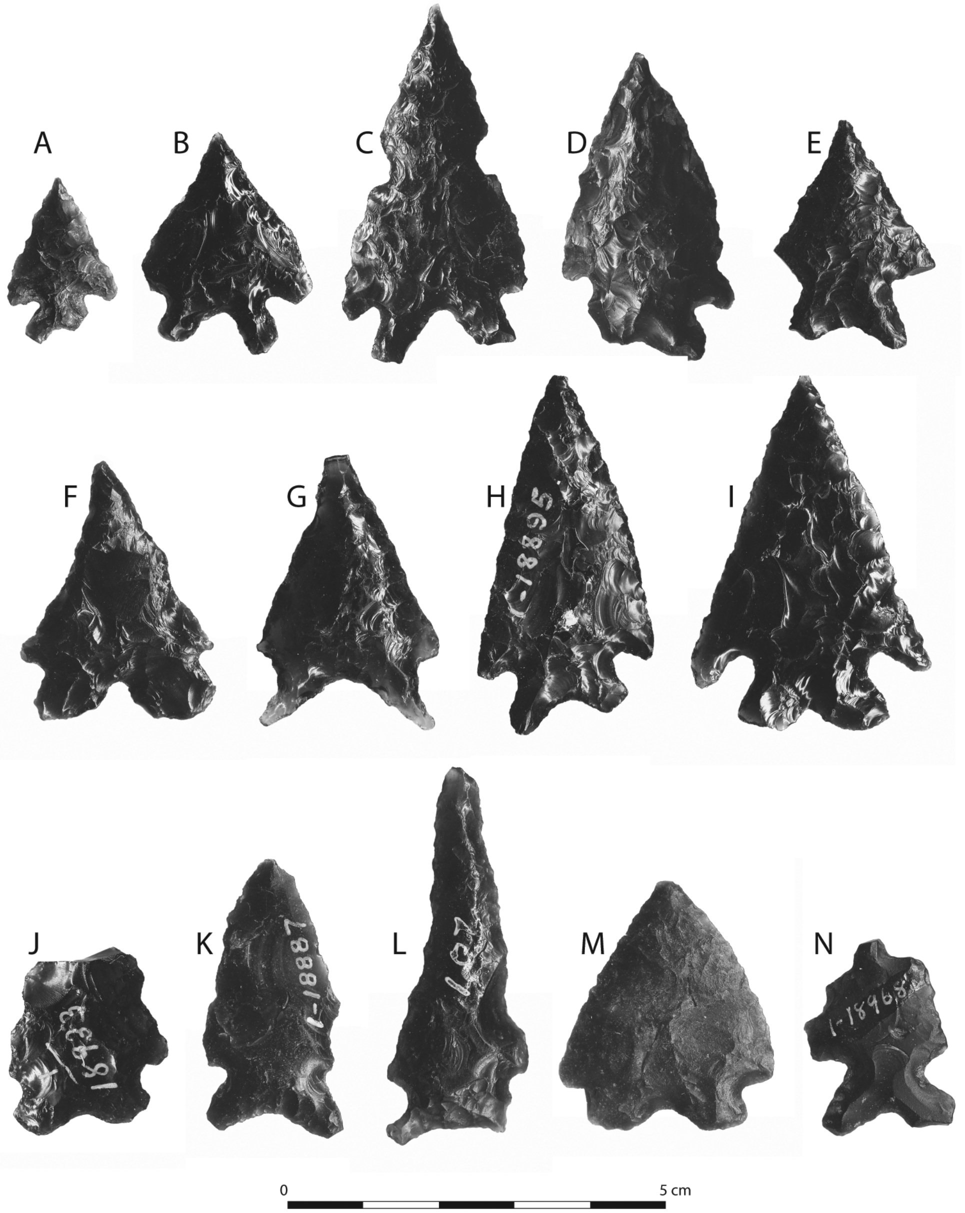

FIG. 12. Obsidian Elko Eared projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-11-69 (Ch-8); **B**. 1-18615 (Ch-10/12); **C**. 1-17539 (Ch-13); **D**. 1-18885 (Ch-13); **E**. 1-18873 (Ch-13); **F**. 1-18878 (Ch-13); **G**. 1-18888 (Ch-13); **H**. 1-18895 (Ch-13); **I**. 1-18899 (Ch-13); **J**. 1-18933f (Ch-13); **K**. 1-18887 (Ch-13); **L**. 1-65108 (Ch-15); **M**. NSM 196 (Ch-13); **N**. 1-18968 (Ch-13).

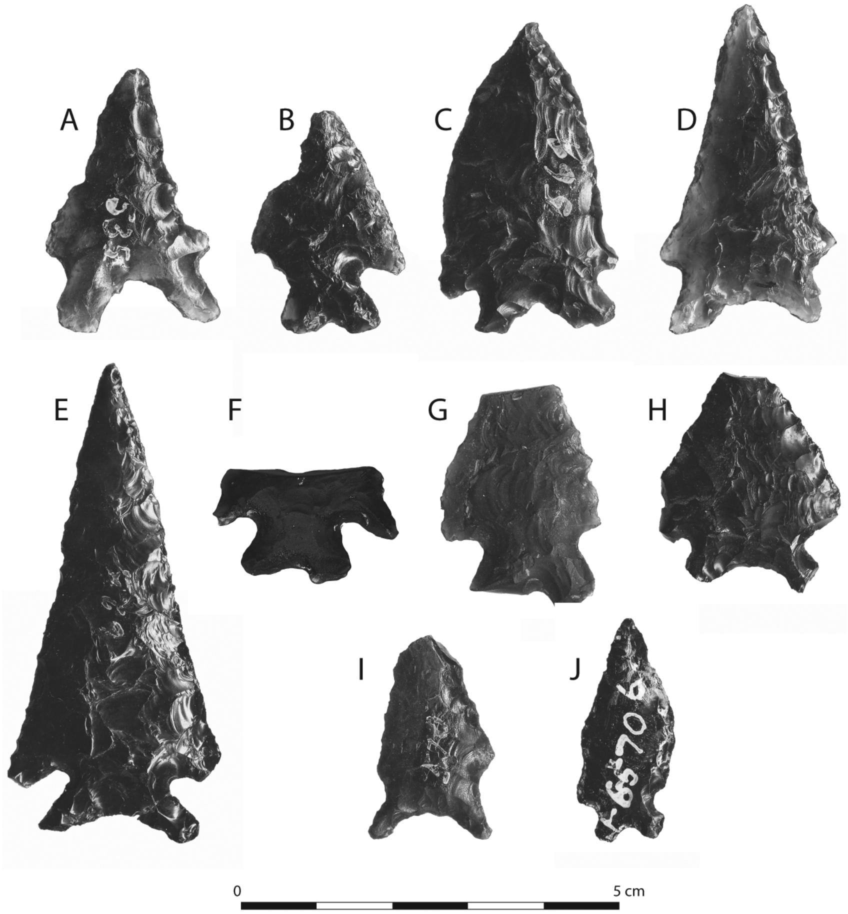

FIG. 13. Additional obsidian Elko Eared projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-65537 (Ch-15); **B**. 1-18864k (Ch-13); **C**. 1-65566 (Ch-15); **D**. 1-65570 (Ch-15); **E**. 1-65631 (Ch-15); **F**. 2-27793 (Pe-5); **G**. 2-28017 (Pe-5); **H**. 1-65272 (Ch-15); **I**. 1-18873 (Ch-13); **J**. 1-65706.17 (Ch-15).

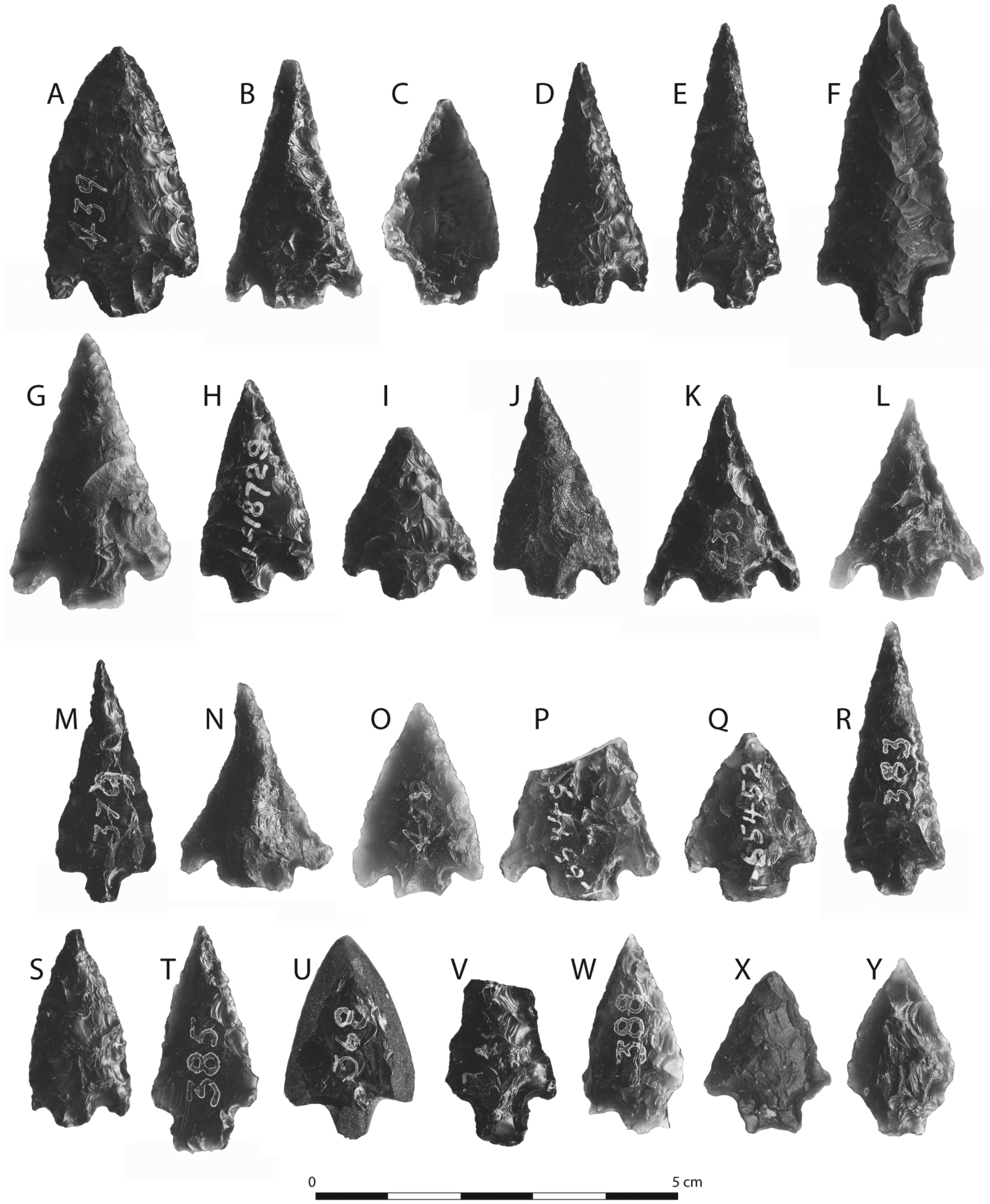

FIG. 14. Obsidian Gatecliff Contracting Stem projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-65437 (Ch-15); **B**. 1-11-64 (Ch-8); **C**. 1-17585 (Ch-13); **D**. 1-18816 (Ch-13); **E**. 1-18845 (Ch-13); **F**. 1-18859 (Ch-13); **G**. 1-18856 (Ch-13); **H**. 1-18729 (Ch-13); **I**. 1-18864g (Ch-13); **J**. 1-18751 (Ch-13); **K**. 1-65431 (Ch-15); **L**. 1-11-61 (Ch-8); **M**. 1-65377 (Ch-15); **N**. 1-65441 (Ch-15); **O**. 1-65448 (Ch-15); **P**. 1-65449 (Ch-15); **Q**. 1-65452 (Ch-15); **R**. 1-65381 (Ch-15); **S**. NSM 383 (Ch-13**?**); **T**. 1-65383 (Ch-15); **U**. 1-65366 (Ch-15); **V**. 1-66236 (Ch-15); **W**. 1-65386 (Ch-15); **X**. 2-27914 (Pe-5); **Y**. 1-17794 (Ch-13).

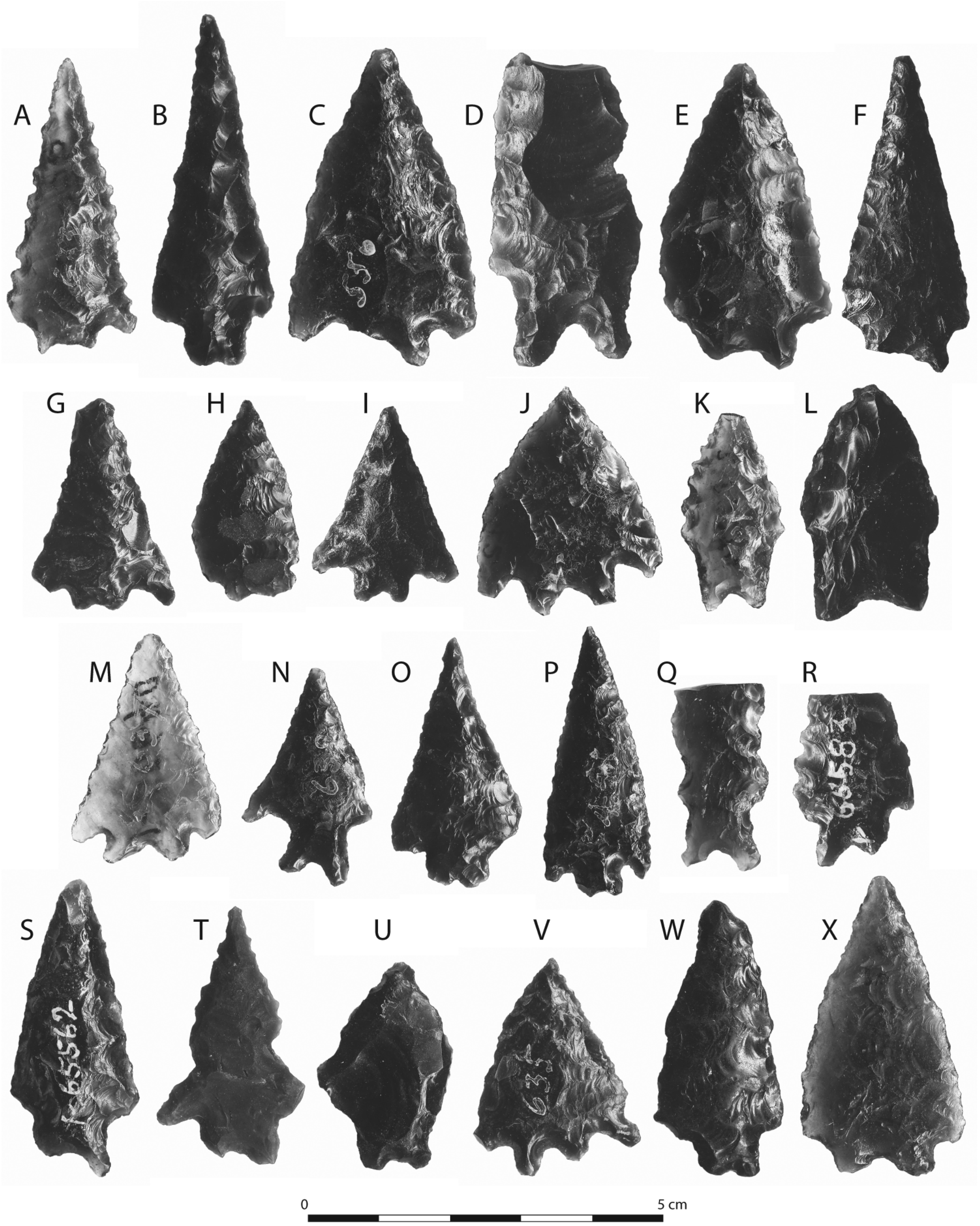

FIG. 15. Obsidian Gatecliff Split Stem projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-65636 (Ch-15); **B**. 1-17801 (Ch-28); **C**. 1-65558 (Ch-15); **D**. 1-18933c (Ch-13); **E**. 1-65559 (Ch-15); **F**. 1-18894 (Ch-13); **G**. 1-18828 (Ch-13); **H**. 1-18741 (Ch-13); **I**. 1-18795 (Ch-13); **J**. 1-17542 (Ch-13); **K**. 2-25274 (Ch-14**?**); **L**. 1-18915 (Ch-13); **M**. 1-65640 (Ch-15); **N**. 1-65642 (Ch-15); **O**. 1-18827 (Ch-13); **P**. 1-65439 (Ch-15); **Q**. 1-18970g (Ch-13); **R**. 1-65583 (Ch-15); **S**. 1-65562 (Ch-15); **T**. 2-27901 (Pe-5); **U**. 1-66239 (Ch-15); **V**. 1-65638 (Ch-15); **W**. 1-18865h (Ch-13); **X**. 1-65555 (Ch-15).

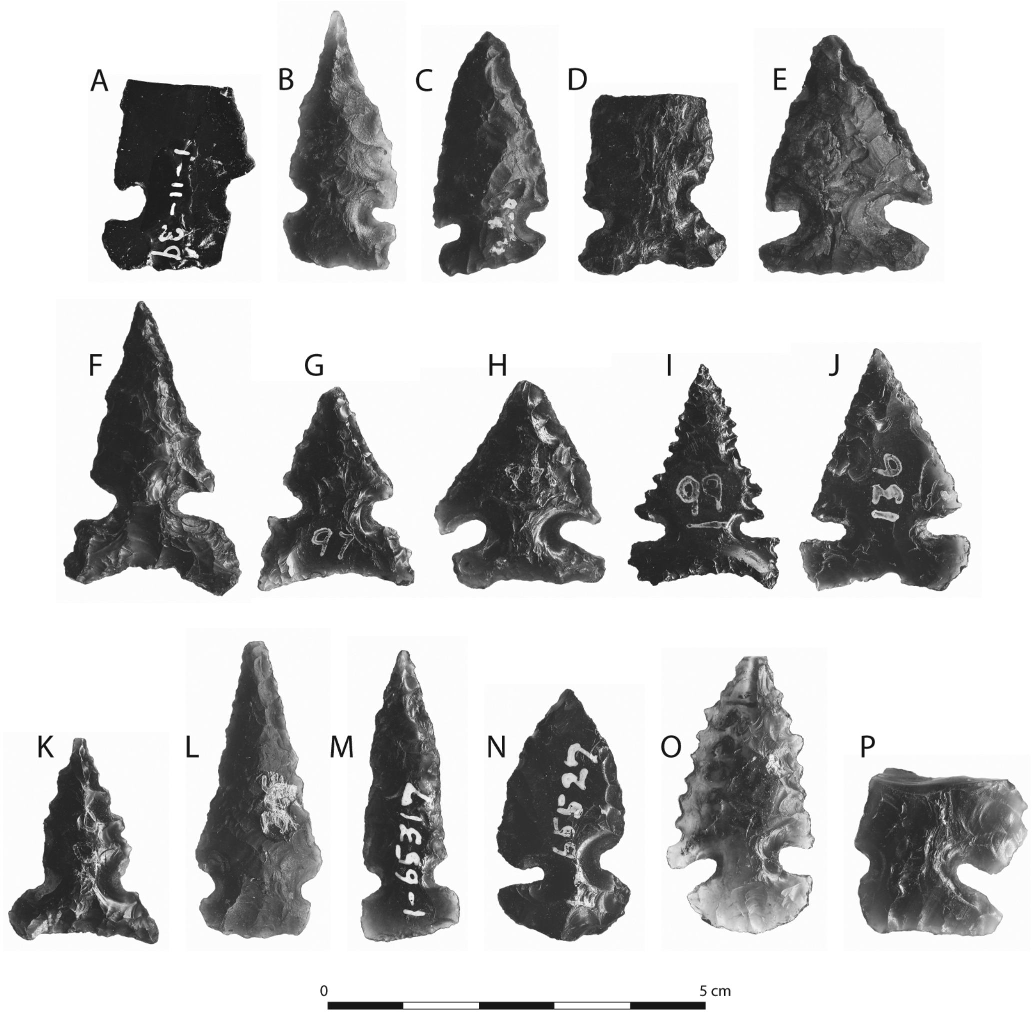

FIG. 16. Obsidian Northern Side-notched projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-11-39 (Ch-8); **B**. 1-17570 (Ch-13); **C**. 1-18865f (Ch-13); **D**. 1-18900f (Ch-13); **E**. 1-18936 (Ch-13); **F**. 1-18937 (Ch-13); **G**. 1-65098 (Ch-15); **H**. 1-65099 (Ch-15); **I**. 1-65100 (Ch-15); **J**. 1-65137 (Ch-15); **K**. 1-65101 (Ch-15); **L**. 1-65314 (Ch-15); **M**. 1-65317 (Ch-15); **N**. 1-65527 (Ch-15); **O**. 1-65521 (Ch-15); **P**. NSM 384 (Ch-13).

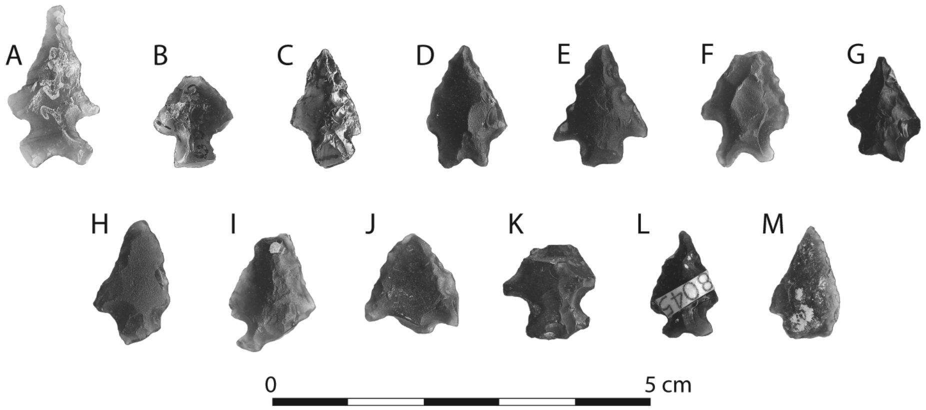

FIG. 17. Obsidian Carson projectile points from sites in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A.** 1-65244 (Ch-15); **B.** 1-65706.14 (Ch-15); **C.** 1-66252 (Ch-15); **D.** 2-27921 (Pe-5); **E.** 2-27923 (Pe-5); **F.** 2-27927 (Pe-5); **G.** 2-27968 (Pe-5); **H.** 2-27983 (Pe-5); **I.** 2-27997 (Pe-5); **J.** 2-27999 (Pe-5); **K.** 2-28032 (Pe-5); **L.** 2-28045 (Pe-5); **M**. 2-28048 (Pe-5).

16); they were absent from sites at Rye Patch Reservoir (Rusco and Davis, 1987), from sites near Derby Airfield south of Lovelock (McGuire and Hildebrandt, 2013), and quite rare in the Carson Sink (Kelly, 2001).

Less Temporally Sensitive Forms

The following group of projectile points and bifaces are either temporally insensitive and/or believed to have been used over very long periods of time, so that their utility as time markers may be less "exact" than the better-known temporal markers discussed above. Nonetheless, some forms—like Carson points, small corner-notched, side-notched, and stemmed forms—can still serve as gross time markers because their size supports the view that they were used as tips on arrows. Humboldt Basal-notched bifaces are a special case, which I discuss at greater length below.

Carson Points (N = 13): These points were first defined by Kelly (2001: 96–97, fig. 4-15) from sites in the Carson Sink, although over 40 years earlier Elsasser (1958: 41) recognized small obsidian points at Pe-5 in the lower Humboldt Valley that "show the most refined pressure flaking techniques, even points less than 15 mm. long being well-chipped." No metric criteria other than length have been proposed to identify these small corner-notched points, so the lower Humboldt Valley artifacts potentially attributable to the type were compared on this basis (see fig. 17). Kelly's data (2001: table 4-3) show that the 44 measurable Carson Sink examples average 12.98 mm in total length, with a sample standard deviation of 2.08 mm, and a coefficient of variation of 16.3%. So, using a two-sigma cutoff for length, lower Humboldt Valley specimens were classified as Carson points if they were less than ca. 17 mm in total length.[17] Despite their distinctive appearance, there is currently no agreement as to their precise temporal range, though, based on size, use as arrow points seems likely. In the Carson Sink, the vast majority of specimens were recovered at very few sites (Kelly, 2001: 97). This same relationship seems to hold in the lower Humboldt Valley; 10 of 13 points were recovered from Pe-5, and the other three came from Ch-15—they were not identified at any other site in the valley.

Humboldt Basal-Notched Bifaces (N = 44): First named by Heizer and Clewlow (1968) Humboldt Basal-notched bifaces have proved difficult to date despite their distinctive mor-

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[17] Using this strict cut-off, only two of the specimens classified as Carson points by Kelly (2001: table 4-3; nos. 5946, 5986) fall outside this range.

phology.[18] Over 40 years ago, Bettinger (1978) proposed that the type marked the period between ca. 1300–650 BP, but this age range was questioned by Thomas (1981), who found little independent stratigraphic or ^{14}C related evidence for that time range—at least in the central Great Basin. Other studies are relevant to evaluate Bettinger's (1978) original age estimate. Lanning (1963: 260; pl. 8h) recovered a burial (#2) containing a Humboldt Basal-notched point in association with an *Olivella* Saucer bead. *Olivella* Saucers are diagnostic of Bennyhoff and Hughes's (1987: 149) Middle Period, dated from ca. 200 BC–AD 100, although new AMS dating for saucers in central California indicate that they may have persisted somewhat later in time (Groza et al., 2011). Obsidian hydration rim values on Humboldt Basal-notched specimens from the Rose Spring site (Yohe, 1998: table 10) are of similar age to those recovered from the nearby Coso Volcanic Field (Gilreath and Hildebrandt, 1997: table 16, fig. 19), where they overlap with the end of the Elko series around 1200 BP. Excavations at Iny-30 recorded Humboldt Basal-notched points in association with ^{14}C dated structures spanning the period between 1800–1400 BP (Basgall and McGuire, 1988: 357); Delacorte and Basgall (2012: 10-3) add that Humboldt Basal-notched variants "cross-cut the dart-arrow divide, persisting from the late Newberry era into the early part of the Haiwee period" in the Inyo-Mono region (see also Basgall and Giambastiani, 1995: 52; Polson, 2009: table 5.1). Garfinkel and Yohe (2004) proposed that this type had two different temporal spans in the southwestern Great Basin—one between ca. 6000–2500 BP, the other from 2500–1200 BP—although none of the specimens they illustrate (Garfinkel and Yohe, 2004: fig. 3) display the classic diagonal flaking characteristic (e.g., Bettinger, 1978: 1; Hester and Heizer, 1973: fig. 1f; Pendleton, 1985: fig. 61b, g, i, l; cf. Green, 1975: pl. 2a–f) that Hattori (1982: 121) described as a feature indicating "temporal and cultural relationships between Humboldt and Pinto [now Gatecliff series] points" and that Elston (1982: 191–193) identified as a formal characteristic distinguishing pre-Archaic from Early Archaic points in the western Great Basin. Farther north in the High Rock country, Layton (1970: 252; Layton and Thomas, 1979) considered the forms (which he termed Humboldt #2) diagnostic of the Silent Snake phase dated ca. 4000–1500 BC which squares with data from South Fork Shelter where a Humboldt Basal-notched point with "finely executed, parallel or diagonal ripple flaking" (Heizer et al/: 1968: 8, table 1) was recovered from below a level dated to 3320 ± 200 BP (2146 – 1112 cal. BC).[19]

However, all these new or revised age estimates for Humboldt Basal-notched bifaces come from the northern and southwestern Great Basin and Owens Valley—not from areas in immediate proximity to the lower Humboldt Valley.[20] Thus,

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[18] This morphological distinctiveness actually applies only to the "classic" variants (i.e., those illustrated by Heizer and Clewlow, 1968: fig. 3 c-h; Hester and Heizer, 1973: fig. 1e-h; Heizer and Hester, 1978: fig. 6.2 bottom row; Bettinger, 1978: fig. 1; Thomas, 1981: fig. 5a-c), with gently rounded, somewhat lobed (as opposed to pointed) basal elements. Pendleton (2020a, 2020b) recently has underscored the difficulty in making clear metric separation of Humboldt Basal-notched from similar concave-base forms (i.e., those termed Humboldt Concave Base A, Humboldt Concave Base B). In this study, I have followed her generalization (Pendleton, 2020b: 490-491) that Humboldt Basal-notched bifaces are triangular to straight-sided in plan view with mean basal width/maximum width ratios greater than those for the Humboldt series (also Pendleton, 1985: 196). In practice, however, clear distinctions are sometimes difficult to make (cf. Pendleton, 2020b: fig. 14.16A, U, A′, E′ [classified as Humboldt series], and Pendleton, 2020b: fig. 14.17, all classified as Humboldt Basal-notched) so I have been conservative in making type-specific attributions.

[19] All ^{14}C dates presented in years BP (before present) were converted to calendar years using the OxCal 4.4, IntCal 20 curve.

[20] Comparative evidence bearing on potential age and source-use for Humboldt Basal-notched bifaces also comes from central California archaeological sites. First illustrated by Lillard and Purves (1936: 15), over eighty years ago Heizer and Fenenga (1939: 386) and Lillard et al. (1939: 77) emphasized diagonal ribbon flaking as a diagnostic trait of the Middle Horizon in central California (also Beardsley, 1948: 11; 1954: 74; Davis and Treganza, 1959: 40). Additional specimens from Ala-13, Sac-66, Sac-107, SJo-59, and SJo-91—some with classic diagonal ribbon flaking—have been identified in Early/Middle Transition period contexts (e.g., Lillard, Heizer, and Fenenga, 1939: pl. 24, no. 1; Bickel 1981: pl. 9g, table 3-68; Moratto, 1984: fig. 5.16). J.A. Bennyhoff's phase charts (in Elsasser, 1978: fig. 4) assign the Sac-66 specimen (L-19540) to the Morse phase, dated to ca. cal 250 BC–cal AD 125 (Bennyhoff,

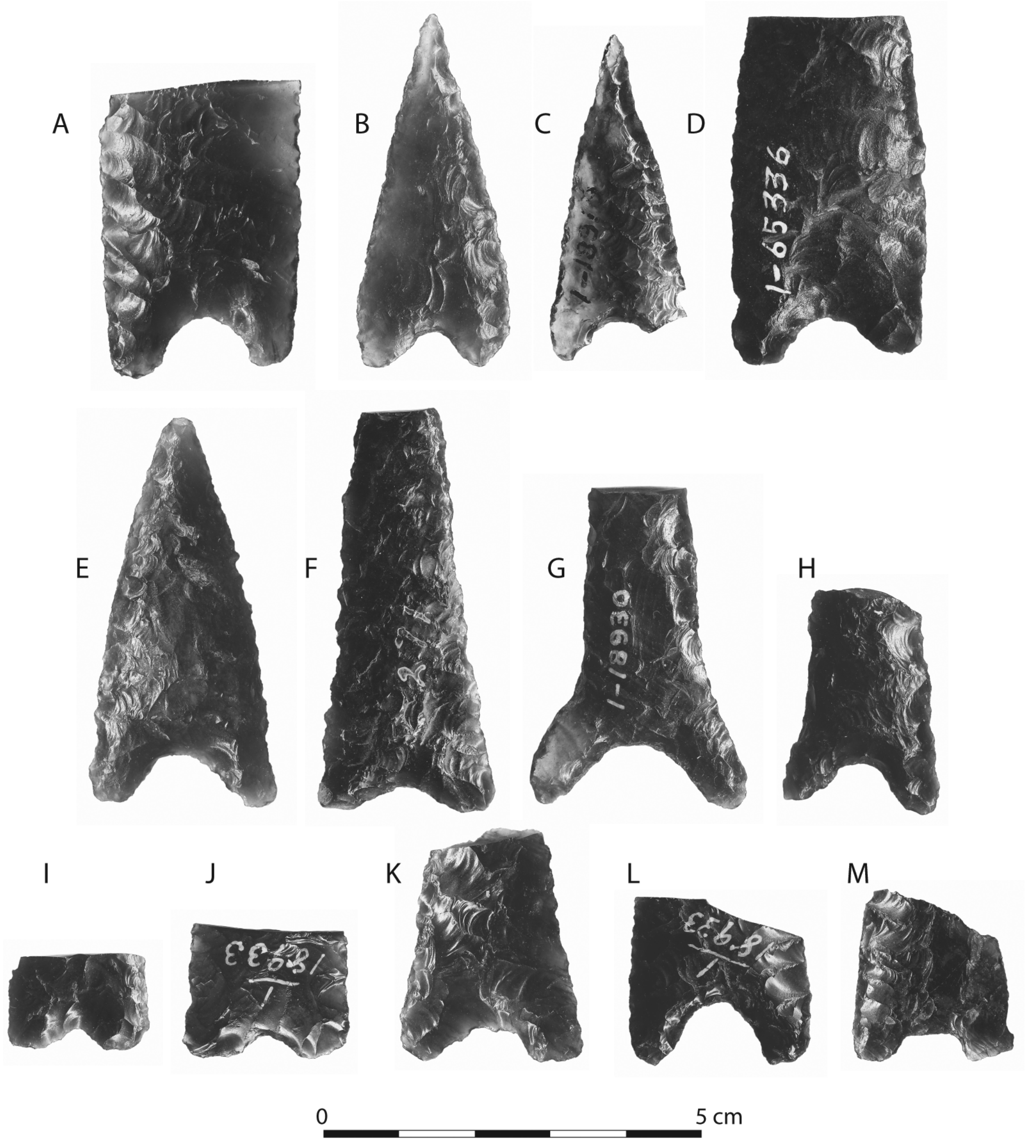

FIG. 18. Obsidian Humboldt Basal-notched bifaces from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-18606 (Ch-7); **B**. 1-17552 (Ch-13); **C**. 1-18919 (Ch-13); **D**. 1-65336 (Ch-15); **E**. 1-18926 (Ch-13); **F**. 1-65270 (Ch-15); **G**. 1-18930 (Ch-13); **H**. 1-18932b (Ch-13); **I**. 1-18932c (Ch-13); **J**. 1-18933b (Ch-13); **K**. 1-18933d (Ch-13); **L**. 1-18933e (Ch-13); **M**. 1-18933h (Ch-13).

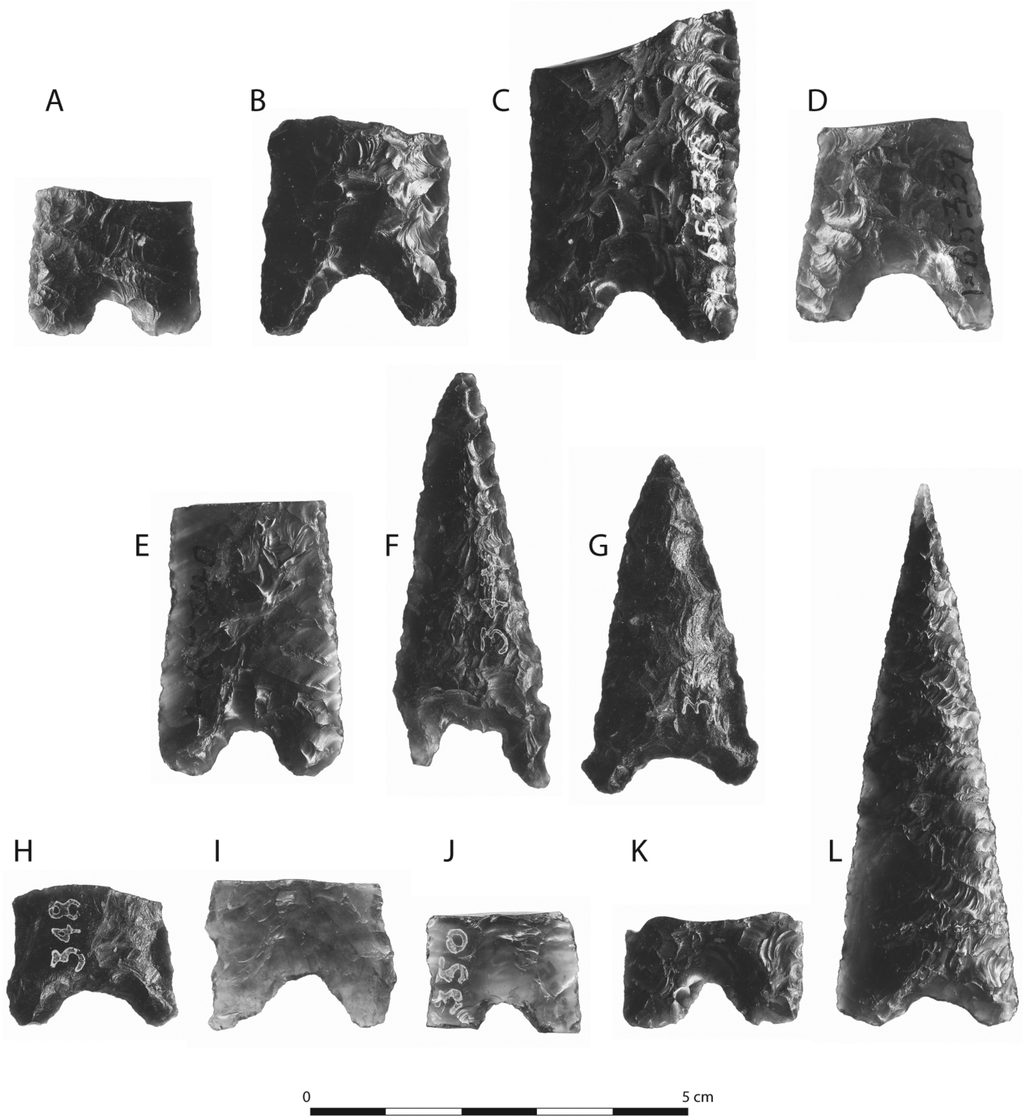

FIG. 19. Additional obsidian Humboldt Basal-notched bifaces from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-18933i (Ch-13); **B**. 1-18934 (Ch-13); **C**. 1-65337 (Ch-15); **D**. 1-65339 (Ch-15); **E**. 1-65340 (Ch-15); **F**. 1-65342 (Ch-15); **G**. 1-65343 (Ch-15); **H**. 1-65347 (Ch-15); **I**. 1-65348 (Ch-15); **J**. 1-65349 (Ch-15); **K**. 1-65350 (Ch-15); **L**. 1-45483 (Ch-15).

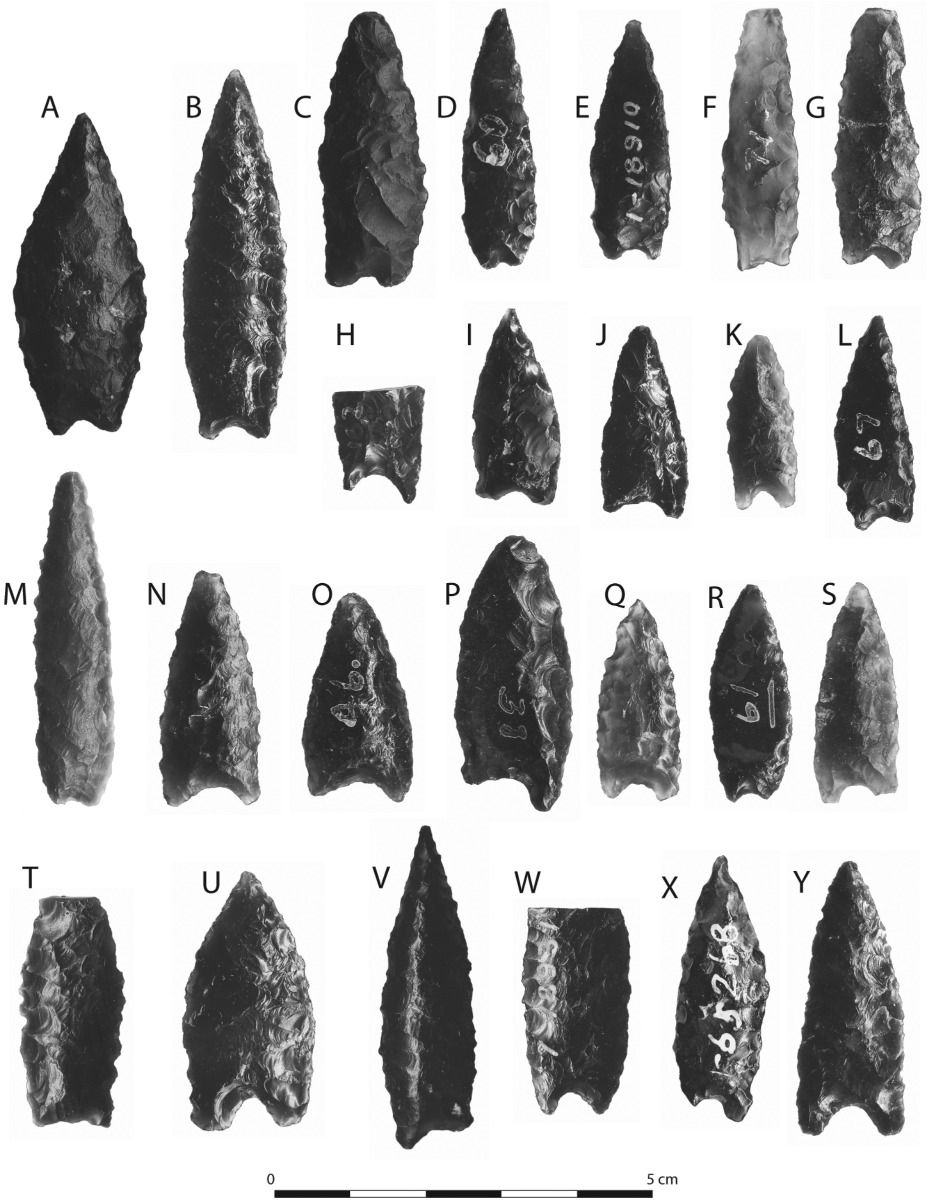

FIG. 20. Obsidian Humboldt series projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-46046b (Pe-66); **B**. 1-39077 (HLB); **C**. 1-39070 (HLB); **D**. 1-65060 (Ch-15); **E**. 1-18910 (Ch-15??); **F**. 1-65071 (Ch-15); **G**. 1-39069 (HLB); **H**. 2-25226 (Ch-15); **I**. 1-18902 (Ch-13); **J**. 13/477-009 (Ch-18); **K**. 1-65050 (Ch-15); **L**. 1-65067 (Ch-15); **M**. 2-25575 (Ch-21); **N**. 1-39068 (HLB); **O**. 1-65045 (Ch-15); **P**. 1-65037 (Ch-15); **Q**. 1-39067 (HLB); **R**. 1-65061 (Ch-15); **S**. 1-11-48 (Ch-8); **T**. 1-18949 (Ch-13); **U**. 1-65038 (Ch-15); **V**. 1-18917 (Ch-13); **W**. 1-18931 (Ch-13); **X**. 1-65268 (Ch-15); **Y**. 1-11-69 (Ch-8).

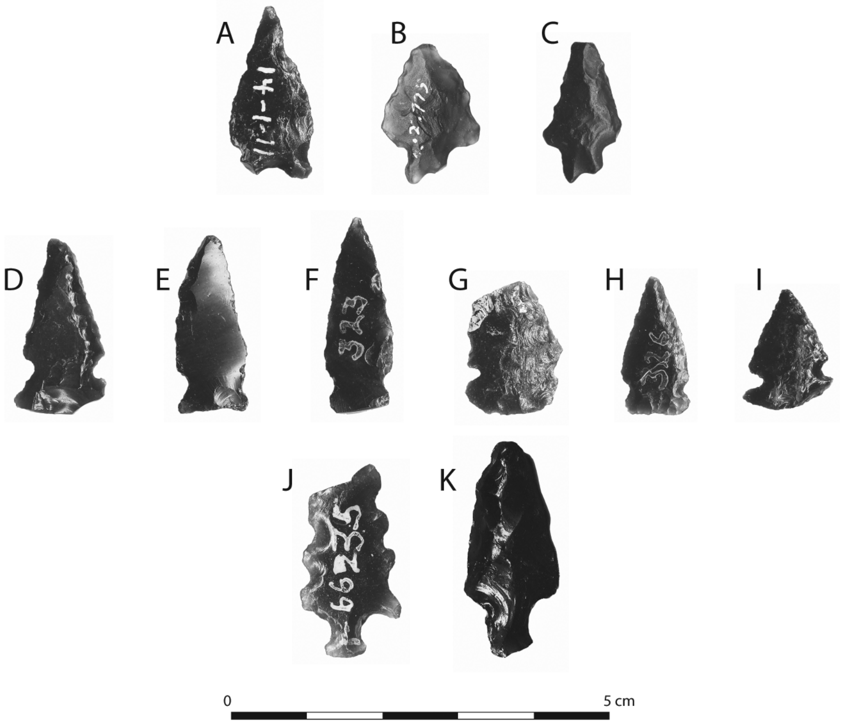

FIG. 21. Small corner-notched (A-C), side-notched (D-I), and stemmed (J-K) obsidian projectile points from sites and localities in the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 14-1-11 (Pe-7); **B**. 2-27775a (Pe-5); **C**. 2-27775b (Pe-5); **D**. 1-18665 (Ch-13); **E**. 1-65136 (Ch-15); **F**. 1-65322 (Ch-15); **G**. 14-1-130 (Pe-7); **H**. 1-65325 (Ch-15); **I**. 1-18865d (Ch-13); **J**. 1-66235 (Ch-15); **K**. 1-46041 (Pe-66).

the same caveats Thomas (1981) made about unwarranted extension of the Monitor Valley criteria to adjacent areas without empirical evidence apply here in the case of Humboldt Basal-notched bifaces. To date, the only local stratigraphic occurrence of the type was at Hidden Cave, where 13 of 19 specimens were recovered from stratum II (Pendleton, 1985: table 53; Thomas, 1985: table 13), dated to ca. 1900–50 cal BC. Humboldt Basal-notched bifaces are extremely rare or absent elsewhere in the Carson Sink and the Stillwater Mountains (Tuohy et al., 1987; Elston, 1988; Kelly, 2001, 2007).[21] None was found at any of the Falcon Hill sites (Hattori, 1982). Figures 18 and 19 illustrate some of the

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1994a: fig. 6.4), and his notes ascribe the Sac-107 artifact (L-12504) to the same phase. The Early period in central California is currently dated ca. 2400–850 cal BC (Rosenthal et al., 2007:154). Diagonal ribbon flaking is present on contracting stem points from the terminal Early period site SJo-112 (Olsen and Wilson, 1964: fig. 7a, b, and e), but isn't a characteristic of Late period assemblages in central California sites (cf. Bennyhoff in Elsasser, 1978: figs. 5, 6; Bennyhoff, 1994a: fig. 6.2). EDXRF analysis data in supplementary data file S21 show that four artifacts from three central California sites (fig. 54) were made from obsidian source material located south of the Mono Basin area—two each from Lookout Mountain (Casa Diablo area) and Mt. Hicks. An exhaustive search for other specimens was beyond the scope of the present study, but it's worth reporting that additional artifact fragments with diagonal ribbon flaking were recovered from Sac-66 (e.g., L-18257 with Burial 41; L-18273 with Cremation 3; L-19547 with burial N10; L-18316, L-18425, L-18430). Although most of them lack intact basal elements, they all display distinctive diagonal ribbon flaking and each was manufactured from an obsidian source in the Mono Basin area.

[21] Tuohy and Dansie (1997:32) attributed a possible pre-Mazama age to a Humboldt Basal-notched point recovered from Spirit Cave based on comparison with an artifact fragment from nearby Hidden Cave. However, I see no formal resemblance between the Hidden Cave artifact in question (20.3/973; Pendleton, 1985: fig. 67e) and artifact 1-20-17 from Spirit Cave (Tuohy and Dansie, 1997: fig. 2, left; Hughes, 2013b: fig. 1c).

Humboldt Basal-notched points recovered from the lower Humboldt Valley.

Humboldt Series (N = 81) and Other Concave Base Points (N = 6): In all 81 Humboldt series points and three concave base artifacts were identified in the lower Humboldt Valley assemblages (see fig. 20). Heizer and Clewlow (1968) named Humboldt Concave Base points from a large surface collection from Ch-15, from which they segregated two general variants: a larger version, termed Humboldt Concave Base A, and a smaller form, Humboldt Concave Base B. No metric criteria were advanced to distinguish between them, and Thomas's (1981) analysis suggested that they are generally poor time markers. Nonetheless, a cache of Humboldt Concave Base points was dated to 4030 ± 85 BP (2788–2342 cal BC) at Shinners Site C at Falcon Hill (Hattori, 1982: 132), and Delacorte (1997: 78–80) considers them an Early Archaic time marker. The few larger concave base points recognized in the lower Humboldt Valley are morphologically similar to forms Clewlow (1968b) named Black Rock Concave base, but dating of this form is imprecise (Rondeau et al., 2017).

Small Corner-notched (N = 4), Side-notched (N = 9), and Stemmed Points (N = 2): As noted above, there are metric differences among some of the small side-notched, corner-notched, and stemmed points in lower Humboldt Valley sites that conflict with the Monitor Valley key criteria. Consequently, these forms were segregated from named types to facilitate examination of possible differences in obsidian source composition. A complete listing of all of these points, and illustrations of some of them appear in fig. 21). Metric data appear in supplementary files S15–S17.

Large Stemmed (N = 2): Two large stemmed obsidian points from the lower Humboldt Valley were analyzed via EDXRF (fig. 22). These two specimens are similar to examples of Lake Mohave and Silver Lake points within the Great Basin Stemmed series (sensu Tuohy and Layton, 1977) illustrated by Beck and Jones (2009: figs. 6.12, 6.13, 6.16).

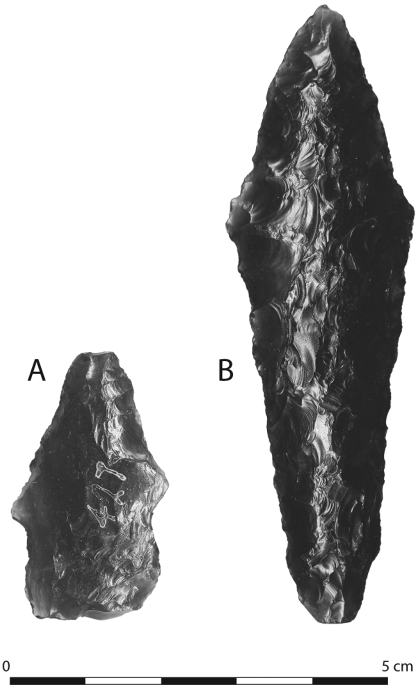


FIG. 22. Large stemmed obsidian projectile points from the lower Humboldt Valley: catalog numbers followed by site designation within parentheses. **A**. 1-65425 (Ch-15); **B**. 1-39076 (HLB).

LABORATORY INSTRUMENTATION AND ANALYSIS

Nondestructive instrumental analysis of these lower Humboldt Valley artifacts was performed by the author on a QuanX-EC™ (Thermo Electron Corporation) energy dispersive X-ray fluorescence (EDXRF) spectrometer equipped with a silver (Ag) X-ray tube, a 50 kV X-ray generator, digital pulse processor with automated energy calibration, and a Peltier cooled solid-state detector with 145 eV resolution (FWHM) at 5.9 keV. The X-ray tube was operated at differing voltage and current settings, using different primary beam filters, to optimize excitation of the elements selected for analysis. All specimens were measured for rubidium (Rb Kα), strontium (Sr Kα), yttrium (Y Kα), zirconium (Zr Kα), niobium (Nb Kα) composition and to determine ratios of the elements iron and manganese (Fe Kα/Mn Kα).

Barium (Ba Kα), manganese (Mn Kα), and iron (as $Fe_2O_3^T$) composition also was determined for certain artifacts, with X-ray tube current scaled to the physical size of each specimen.

X-ray spectra were acquired and elemental intensities extracted for each peak region of interest, then matrix-correction algorithms were applied to specific regions of the X-ray energy spectrum to compensate for interelement absorption and enhancement effects. After making these corrections, intensities were converted to elemental concentration estimates (i.e., parts per million [ppm] and weight in percent) by employing a least-squares calibration line established for each element based on up to 30 international rock standards certified by the U.S. Geological Survey (USGS), the U.S. National Institute of Standards and Technology, the Geological Survey of Japan, the French Centre de Recherches Petrographiques et Geochimiques, and the South African Bureau of Standards. Additional information on calibration, artifact-to-source (i.e., chemical type, sensu Hughes, 1998) attribution protocol, and element-specific measurement resolution appears in Hughes (1988, 1994a, 2015).

The USGS's RGM-1 (obsidian rock) standard was analyzed with each group of artifacts to monitor any possible machine drift or calibration issue. Rather than repeat the individual results below each of the supplementary tables, table 6 presents the summary statistics for a sample of 150 analyses conducted on the RGM-1 standard throughout the course of this project. These data show that precision (repeatability) and accuracy (the congruence with given USGS values) is extremely high—better (lower) than the combined X-ray counting uncertainty and linear regression fitting error estimate for any individual measurement on an artifact at 120–360 seconds livetime. The sole exception is Nb, which was expected when any element occurs in low abundance and approaches detection limits at a specified X-ray counting time. Overall, these results give high confidence in the precision and accuracy of the measurements reported here for obsidian artifacts (reported in supplementary tables S2–21).

As noted in a previous study (Hughes, 2020a) some artifacts could not be confidently assigned to chemical type solely on the basis of Rb vs. Zr ppm data. "Source" (sensu Hughes, 1998) assignments for specimens with overlapping Rb/Zr profiles were partitioned further in stepwise fashion using Ba vs. Fe/Mn and $Fe_2O_3^T$/Nb vs. Zr/Y data to effect clear separation between and among chemical types. Other ratios were used occasionally if none of these provided satisfactory resolution. In all cases, primary data (presented in the supplements) supporting the artifact-to-source attributions have been plotted below to document the chemical type attributions.

EDXRF LABORATORY ANALYSIS RESULTS

Trace and rare earth composition data for each artifact—determined by EDXRF analysis—appears in type-specific supplements 2–21, with metric data for each in supplement 1. Composition error estimates for each artifact measured by EDXRF appear in the type-specific data supplement, and the numbers of artifact plots on some figures have been reduced for visual clarity. Hence, the number of actual plots on any particular figure may not correspond exactly to the tabulations in the supplements because of convergence of data points at publication scale.The number of source-specific occurrences of each time-marker type appears in table 7, and source-specific occurrences of nontime markers are listed in table 8.

Desert Series (N = 172; table 4): A total of 172 obsidian points classified as members of the Desert series (Cottonwood Triangular, N = 52; Desert Side-notched, N = 120) were analyzed from lower Humboldt Valley collection. Supplementary data tables 2 and 3 and figure 23 present EDXRF data on these artifacts.

Cottonwood Triangular (N = 52): Ten different chemical types are represented in this sample of Cottonwood Triangular points from the lower

TABLE 7

Source-Specific Distribution of Time-Marker Points from Lower Humboldt Valley Archaeological Sites and Localities

Distances from the lower Humboldt Valley listed in table 2. ML/GV= Massacre Lake/Guano Valley. Point type abbreviations follow those listed in table 4. Chronological bins (<100, 100–160, 161–240, 241–299, >300 km) indicated with alternating background of white and gray.

	Desert Series		**Rose-gate**	**Elko Series**			**Gatecliff Series**			**Northern Side Notched**	
Obsidian Source	**CT**	**DSN**	**RS**	**ECN**	**EE**	**ES**	**GCS**	**GSS**	**GS**	**NSN**	**Total**
Majuba Mountain	33	48	116	26	35	4	26	16	11	10	325
Seven Troughs	–	1	8	1	–	–	–	–	1	1	12
Rabbithole	–	1	2	–	–	–	–	–	–	–	3
Desert Mountains	–	–	–	1	–	–	–	–	–	–	1
Sutro Spring	–	2	4	2	2	–	3	3	–	–	16
Buffalo Hills	3	9	68	10	7	–	11	4	5	2	119
Fox Mountain	–	2	6	–	3	–	1	–	–	–	12
Pinto Peak	2	3	6	3	3	–	1	2	–	2	22
Garfield Hills	–	3	2	–	1	–	–	1	–	–	7
Truckee Meadows	–	–	–	–	1	–	–	–	–	–	1
Nellie Spring	–	–	1	–	–	–	–	–	–	–	1
Pine Grove Hills	–	–	–	1	–	–	–	–	–	–	1
Bordwell Spring	2	7	18	3	3	–	2	3	–	–	38
South Warners	–	2	4	–	1	–	2	–	–	–	9
Mt. Hicks	1	10	8	5	8	1	4	5	1	1	44
Bodie Hills	4	8	10	2	9	–	10	4	2	1	50
ML/GV	–	3	1	1	1	–	1	–	1	–	8
Double H Mountains	–	6	3	–	–	–	1	–	–	–	10
Paradise Valley	1	1	9	–	–	–	–	1	–	1	13
Queen	–	4	–	–	3	–	–	1	1	–	9
Buck Mountain	–	–	–	–	–	–	–	2	–	1	3
Bidwell Mountain	–	–	–	–	–	–	–	1	–	–	1
Lookout Mountain	1	–	1	–	1	–	–	–	–	–	3
Shoshone Mountain	–	1	–	–	–	–	–	–	–	–	1
East Medicine Lake	–	–	1	–	–	–	–	–	–	–	1
Oak Spring Butte	–	–	–	–	–	–	1	–	–	–	1
Brown's Bench	–	–	–	1	–	–	–	–	–	1	2
Spodue Mountain	–	1	–	–	–	–	–	–	–	–	1
Shoshone Range	–	1	–	–	–	–	1	–	–	–	2
West Sugarloaf (Coso)	–	1	–	–	–	–	–	–	–	–	1
Panaca Summit	2	1	–	–	–	–	–	–	–	–	3

TABLE 7 *continued*

	Desert Series		**Rose-gate**	**Elko Series**			**Gatecliff Series**			**Northern Side Notched**	
Obsidian Source	**CT**	**DSN**	**RS**	**ECN**	**EE**	**ES**	**GCS**	**GSS**	**GS**	**NSN**	**Total**
Cannonball Mountain*	–	–	1	–	–	–	–	–	–	–	1
Malad	1	–	–	1	1	–	–	–	–	–	3
North Domes Cluster	–	–	–	–	–	–	–	1	–	–	1
Surveyor Spring	–	1	–	–	–	–	–	–	–	–	1
Unknown	2	4	4	1	–	–	–	–	–	–	11
Total	52	120	273	58	79	5	64	44	22	20	737

Humboldt Valley. Figure 23A shows that Majuba Mountain and Panaca Summit are somewhat similar in Rb/Zr composition, but Ba data distinguish between them (see fig. 23B). Two artifacts (1-11-73 from the Humboldt Lakebed, and 1-65095 from Ch-15) were made from geographically unknown varieties of obsidian.

Desert Side-notched (N = 120): A total of 120 Desert Side-notched points—made from 22 different sources of obsidian—were analyzed in this study (fig. 24). Figure 24A shows that Sutro Spring and the Shoshone Range (Hughes, 2020b: table 7.4) have similar Rb/Zr compositions, but Ba concentration values separate them, supporting the attribution of one point (1-65119.2 from Ch-15) to Shoshone Range obsidian and the other to Sutro Spring. Four artifacts (1-18969e and 1-18969f from Ch-13, 1-65158 and 2-39638 from Ch-15) have trace-element composition profiles unlike any of the standards in my current regional reference collection.

Rosegate Series (N = 273; table 4): In all 273 Rosegate series points—representing 19 different chemical types—were identified in this lower Humboldt Valley collection. Supplementary data table S4 and figure 25 present EDXRF data on these artifacts.

Elko Series (N = 142; table 4): A total of 142 Elko series points (including Corner-notched, N = 58; Eared, N = 79, and variants identifiable only to the series level, N = 5) were analyzed from this lower Humboldt Valley collection. Trace element composition data documenting these artifact-to-source (chemical type) attributions appear in supplementary data tables 5–7.

Elko Corner-notched (N = 58): Thirteen different chemical types are represented in the Elko Corner-notched points analyzed here (EDXRF data in suppl. 5, fig. 26).

Elko Eared (N = 79): The 79 Elko Eared obsidian points in this lower Humboldt Valley sample were made from 15 different obsidian sources. EDXRF data appear in supplementary data table S6, fig. 27.

Elko Series (N = 5): Five obsidian points in this sample could be attributed only to the Elko series level. Supplementary table S7 and figure 28. show that four of these points were made from Majuba Mountain obsidian, and the other was manufactured from Mt. Hicks volcanic glass. A Mt. Hicks determination for the Ch-8 artifact was made on the basis of Fe/Mn ratio data.

Gatecliff Series (N = 130; table 4): A total of 130 obsidian Gatecliff series points (Split Stem, N = 44; Contracting Stem, N = 64, and variants identifiable only to the series level, N = 22) were identified in this lower Humboldt Valley collection. Trace element composition data documenting artifact-to-source (chemical type) attributions appear in supplementary data tables S8–10.

Gatecliff Split Stem (N = 44): Thirteen different chemical varieties of obsidian are represented in this sample of 44 Gatecliff Split Stem points (EDXRF data in supplementary data table S8, fig. 29).

TABLE 8

Source-Specific Distribution of Non-Time-Marker Points from Lower Humboldt Valley Archaeological Sites and Localities

Distances from obsidian sources to sites in the lower Humboldt Valley listed in table 2. Chronological bins (<100, 100–160, 161–240, 241–299, >300 km) indicated with alternating background of white and gray.

Obsidian Source	**Humboldt Basal-notched**	**Humboldt Series**	**Carson***	**Small Corner-notched**	**Small Side-notched**	**Small Stemmed**	**Dart***	**Great Basin Stemmed**	**Concave Base**	**Total**
Majuba Mountain	–	39	6	1	5	–	1	–	1	53
Seven Troughs	–	1	1	–	–	–	–	–	–	2
Rabbithole	–	–	1	–	1	–	–	–	–	2
Sutro Spring	–	3	–	–	–	–	1	–	–	4
Buffalo Hills	–	12	1	–	–	2	1	–	1	17
Fox Mountain	–	1	–	1	–	–	–	1	–	3
Pinto Peak	–	2	–	–	–	–	–	–	–	2
Garfield Hills	–	1	–	–	–	–	–	–	–	1
Crow Spring	–	–	–	1	–	–	–	–	–	1
Bordwell Spring	1	3	–	–	–	–	–	–	–	5
South Warners	–	1	–	–	–	–	–	–	–	1
Mt. Hicks	13	8	–	–	1	–	–	1	1	24
Bodie Hills	27	3	1	–	–	–	1	–	2	34
ML/GV	–	3	–	–	–	–	–	–	–	3
Double H Mountains	–	2	1	–	–	–	–	–	–	3
Paradise Valley	–	–	1	–	–	–	–	–	–	1
Queen	3	–	–	–	–	–	–	–	–	3
Sugar Hill	–	–	1	–	–	–	–	–	–	1
Shoshone Mountain	–	–	–	–	1	–	–	–	–	1
Panaca Summit	–	1	–	–	–	–	–	–	–	1
Wild Horse Canyon	–	–	–	–	1	–	–	–	–	1
Malad	–	–	–	1	–	–	–	–	–	1
Unknown	–	1	–	–	–	–	–	–	–	1
Total	44	81	13	4	9	2	4	2	6	165

TABLE 9

Distribution of Time-Sensitive Obsidian Projectile Points by Distance and Direction from the Lower Humboldt Valley

Totals exclude two Cottonwood Triangular points from unknown sources and two specimens from eastern sources; five Desert Side-notched and four Rosegate series points from unknown and/or eastern sources; and one Elko Corner-notched point from an unknown source. N= north; S= south.

Time Period	**AD 1300–Historic**				**AD 750–1300**		**AD 750–1500 BC**						**1500–3750 BC**						**2500–4500 BC**		
Series	**Desert**				**Rosegate**		**Elko**						**Gatecliff**								
Point Type	**Cotton-wood Trian-gular**		**Side-notched**				**Corner-notched**		**Eared**		**Series**		**Con-tracting Stem**		**Split Stem**		**Series**		**NSN**		
Distance from LHV (km)	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**N**	**S**	**Totals**
0–100	33	–	50	–	126	–	27	1	34	0	4	–	26	–	16	–	12	–	11	–	340
101–160	5	–	14	5	80	6	13	2	14	4	–	–	13	3	6	4	5	–	4	–	178
161–240	3	5	19	22	36	18	4	8	5	20	–	1	6	14	6	10	1	4	2	2	186
241–299	–	1	1	1	–	1	–	–	–	1	–	–	–	0	1	–	–	–	–	–	6
>300	1	–	1	2	2	–	2	–	1	–	–	–	–	2	–	1	–	–	1	–	13
Totals	42	6	85	30	244	25	46	11	54	25	4	1	45	19	29	15	18	4	18	2	723

Gatecliff Contracting Stem (N = 64): Thirteen chemical distinct varieties of obsidian are represented in this sample of Gatecliff Contracting Stem points (EDXRF data in supplementary data table S9, fig. 30).

Gatecliff Series (N = 22): Twenty-two obsidian points in this sample could be attributed only to the Gatecliff series level EDXRF data (supplementary data table S10, fig. 31).

Northern Side-notched (N = 20; table 4): Supplementary data table 11 and figure 32 present EDXRF data on the 20 obsidian NSN points recognized in this lower Humboldt Valley collection. Figure 32A shows that chemical overlap exists in Rb/Zr composition between South Warners and Mt. Hicks, between Buck Mountain and Malad, and between Bodie Hills and the Seven Troughs Range obsidians. However, plots of other elements (fig. 32B) clearly separate these geological obsidians, and allow unambiguous "source" (chemical type) assignment for the artifacts in question. Likewise, chemical similarities exist among several northwestern/northeastern Nevada obsidians, but again plots of different elements (fig. 32C) discriminate among them. Two artifacts from Ch-15 (1-65521 and 1-65527) are morphologically similar to Fish Slough Side-notched points (Basgall et al., 1995) but there is no direct evidence from the lower Humboldt Valley to support an age range commensurate with that proposed for the Owens Valley area.

Humboldt Basal-notched (N = 44; table 5): Forty-four obsidian artifacts from eight archaeological sites and localities in the lower Humboldt Valley were analyzed by EDXRF. Supplementary data table 12 presents EDXRF data on these artifacts and relevant data are

TABLE 10

Shannon, Simpson, and Berger-Parker Diversity Indexes Determined for Time-Sensitive Obsidian Projectile Point and Biface Distributions in the Lower Humboldt Valley

For ranks, largest number is least diverse; smallest number the most diverse.

Point type/series	**Shannon Index**		**Simpson Index**		**Berger-Parker Index**		**Three Index Average**	**Shannon (H′) Evenness**	**Simpson (1/d) Evenness**
	H′ Value	H′ Rank	1/D Value	1/D Rank	1/d Value	1/d Rank			
Desert series (n = 166)	2.091	1	3.91	4	2.05	6	3.67	6.645	0.085
Rosegate series (n = 269)	1.858	4	3.88	5	2.32	2	3.67	5.472	0.122
Elko series (n= 141)	1.975	3	4.10	3	2.17	3	3.00	5.817	0.114
Gatecliff series (n = 130)	2.057	2	4.75	1	2.45	1	1.33	6.162	0.123
Northern Side-notched (n = 20)	1.706	6	4.04	2	2.00	5	4.33	3.748	0.222
Humboldt series (n = 80)	1.816	5	3.72	6	2.05	4	5.00	4.792	0.146
Humboldt Basal-notched (n = 44)	0.929	7	2.19	7	1.63	7	7.00	1.288	0.408

plotted in figure 33. The Ch-15 artifact was assigned to Bordwell Spring on the Basis of Fe/Mn ratio data.

Humboldt Series (N = 81; table 5): In all 81 Humboldt series points, made from 14 different chemical varieties of obsidian, were analyzed via EDXRF from these lower Humboldt Valley sites. Supplementary data table S13 presents EDXRF data on these artifacts; figure 34A–E plot source classification data.

Carson (N = 13; table 5): EDRXF analysis was conducted on 13 of these small obsidian points from two lower Humboldt Valley sites. EDXRF data appear in supplementary data table S14; plots appear in figure 35. The Pe-5 artifact was assigned to Double H Mountains on the basis of $Fe_2O_3^T$/Nb vs. Zr/Y data.

Small Side-notched (N = 9; table 5): Nine small side-notched obsidian points from three lower Humboldt Valley sites were analyzed via EDXRF. Supplementary data table S15 presents composition data on these artifacts; figure 36 plots relevant source-assignment data.

Small Corner-notched (N = 4; table 5): Four small corner-notched obsidian points from two lower Humboldt Valley sites were analyzed via EDXRF. Supplementary data table S16 presents EDXRF data on these artifacts, chemical type attribution plots appear in figure 37. Note that Crow Spring and Mt. Hicks have similar Ba vs. Fe/Mn profiles (fig. 37B), but Crow Spring contains >30 ppm more Rb and Zr/Y composition ratios >7. Pe-5 artifact 2-27775a has a Zr/Y ratio of 4.35 and a Fe/Mn ratio of 15.5 confirming its assignment to Crow Spring (cf. Hughes, 2020b: fig. 7.4C).

Small Stemmed (N = 2; table 5): Two small-stemmed obsidian points from two lower Humboldt Valley sites were analyzed via EDXRF. Supplementary data table S17 and figure 38 present EDXRF data on these artifacts. Rb/Zr data (fig. 38A) indicate that both of these small points was manufactured from obsidian of the Buffalo

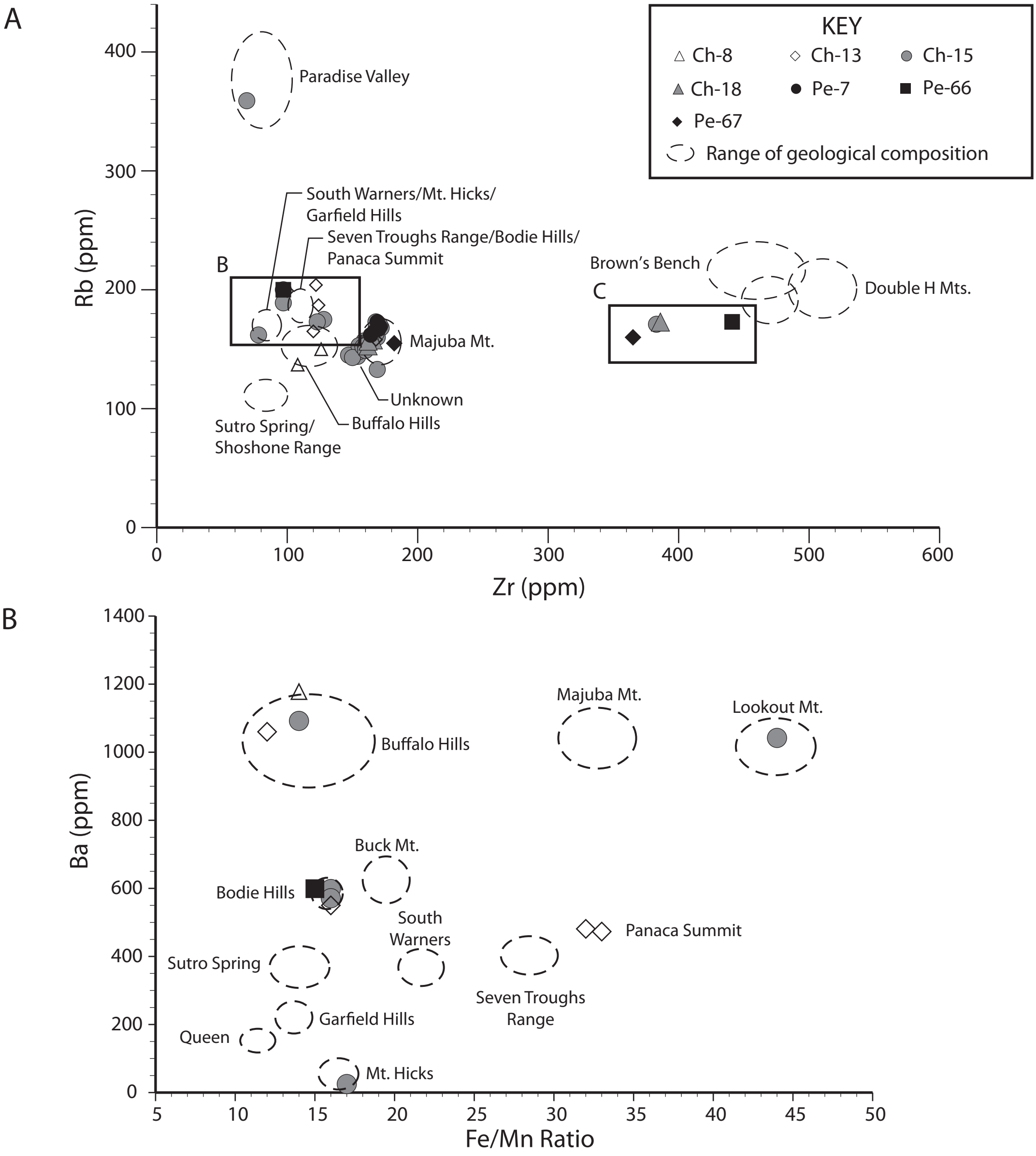
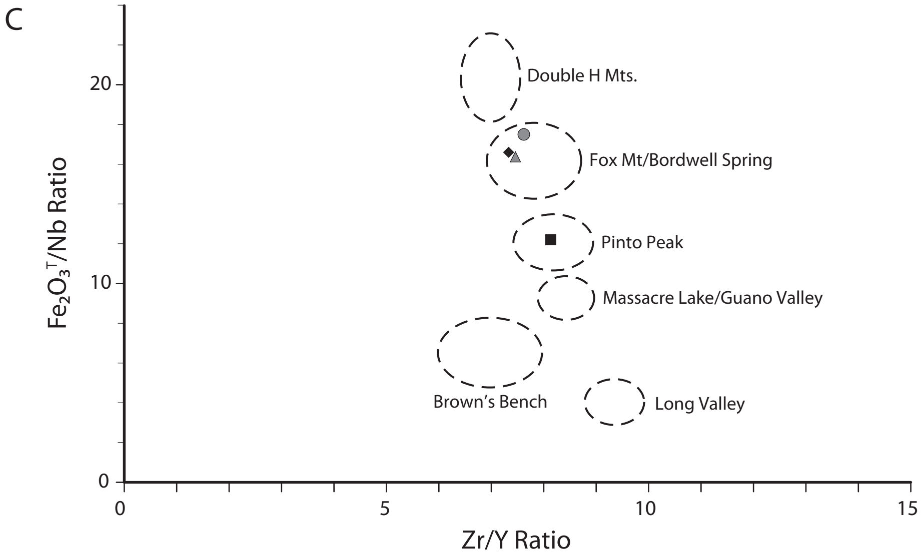


FIG. 23. Trace element composition of obsidian Cottonwood Triangular projectile points from the lower Humboldt Valley (*above and opposite page;* plotted from data in supplement 2). **A.** Rb vs. Zr composition for obsidian projectile points from seven archaeological sites and localities. **B.** Ba vs. Fe/Mn composition for obsidian projectile points undifferentiated by Rb/Zr data. **C.** $Fe_2O_3^T$/Nb vs. Zr/Y composition for obsidian projectile points undifferentiated by Rb vs. Zr and Ba vs. Fe/Mn composition. Error estimates for each artifact measurement appear in supplement 2. The numbers of artifact plots do not always correspond exactly to the tabulations in the supplements because of convergence of data points at this scale.



Hills chemical type; Ba vs. Fe/Mn data (fig. 38B) corroborate the assignments.

Concave Base (N = 6; table 6): EDXRF analysis was performed on six concave base obsidian points from four lower Humboldt Valley. Supplementary data table S18 and figure 39 present EDXRF data on these artifacts. Rb/Zr data (fig. 39A) indicate that two points were manufactured from obsidian of the Bodie Hills chemical type, with single specimens made from Majuba Mountain, Buffalo Hills, and Mt. Hicks volcanic glass; Ba vs. Fe/Mn data (fig. 39B) corroborate the assignments. $Fe_2O_3^T$/Nb vs. Zr/Y data (fig. 39C) were employed to assign one artifact to obsidian of the Bordwell Spring chemical type (see also Hughes, 1986: fig. 9).

Large Stemmed (N = 2; table 6): Two large-stemmed obsidian points— similar to examples of the Lake Mohave and Silver Lake types within the Great Basin Stemmed series—from two lower Humboldt Valley sites were analyzed via EDXRF. Supplementary data table S19 and figure 40 present EDXRF data on these artifacts. Rb/Zr data (fig. 40A) indicate that one of these points was manufactured from obsidian from Mt. Hicks, and the other—corroborated by Ba vs. Fe/Mn data (fig. 40B)—matches obsidian of the Sugar Hill chemical type (Hughes, 1986: table 7).

Miscellaneous Darts (N = 4; table 6): Four obsidian points—lacking diagnostic morphology to attribute to type—from two lower Humboldt Valley sites were analyzed via EDXRF. Supplementary data table S20 and figure 41 present EDXRF data on these artifacts. Rb/Zr data (fig. 41A) indicate that each of these points was manufactured from a different chemical variety of obsidian: Sutro Spring, Bodie Hills, Buffalo Hills, and Majuba Mountain. All four chemical type attributions were corroborated by Ba vs. Fe/Mn data (fig. 41B).

THE ABSENT AND SINGLETONS

Before moving to comparative analysis, a few remarks are appropriate about the obsidian sources not represented in the lower Humboldt Valley sample. First, the absence of Mono Craters and Mono Glass Mountain volcanic glass is noteworthy. High-quality Mono Craters glass may be absent because it was erupted and available for artifact manufacture only a few hundred years ago (Sieh and Bursik, 1986; 2007; Bursik et al., 2014; see also 2002 paper by Hull: supplement S23, https://doi.org/10.5531/sp.anth.0105), but late eruption doesn't account for the absence of Mono Glass Mountain material—aphyric, toolstone-caliber obsidian has been avail-

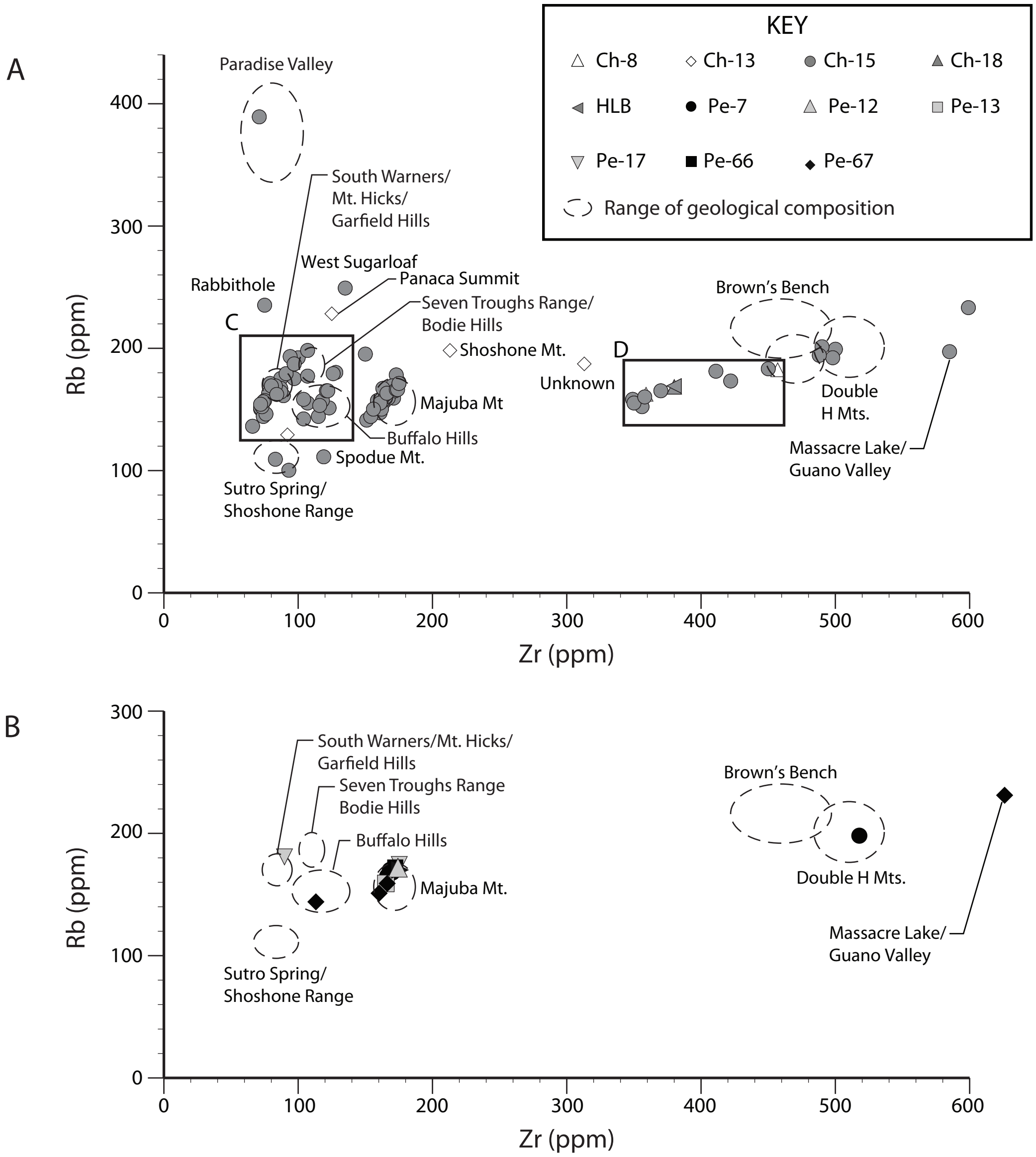
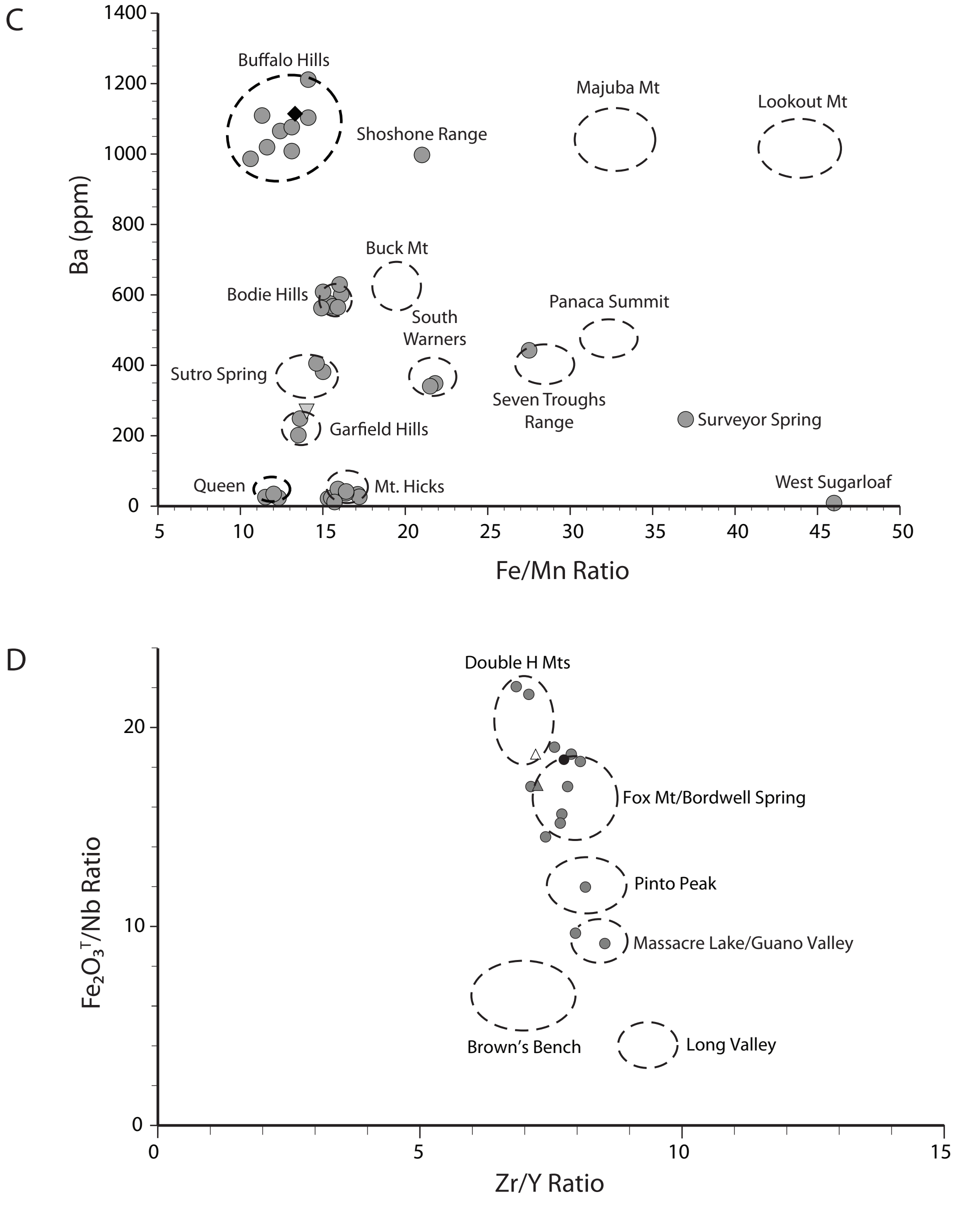


FIG. 24. Trace element composition of obsidian Desert Side-notched projectile points from the lower Humboldt Valley (*above and opposite page;* plotted from data in supplement 3). **A.** Rb vs. Zr composition for projectile points from five archaeological sites and localities. **B.** Rb vs. Zr composition for obsidian Desert Side-notched projectile points from six Pershing County archaeological sites. **C.** (*opposite page*) Ba vs. Fe/Mn composition for projectile points from two archaeological sites undifferentiated by Rb/Zr composition. **D.** $Fe_2O_3^T$/Nb vs. Zr/Y composition for projectile points undifferentiated by Rb vs. Zr and Ba vs. Fe/Mn composition


C
Buffalo Hills
Majuba Mt
Lookout Mt
Shoshone Range
Buck Mt
Bodie Hills
South Warners
Panaca Summit
Sutro Spring
Seven Troughs Range
Garfield Hills
Surveyor Spring
Queen
Mt. Hicks
West Sugarloaf
Ba (ppm)
1400
1200
1000
800
600
400
200
0
5
10
15
20
25
30
35
40
45
50
Fe/Mn Ratio
D
Double H Mts
Fox Mt/Bordwell Spring
Pinto Peak
Massacre Lake/Guano Valley
Brown's Bench
Long Valley
$Fe_2O_3^T$/Nb Ratio
20
10
0
0
5
10
15
Zr/Y Ratio

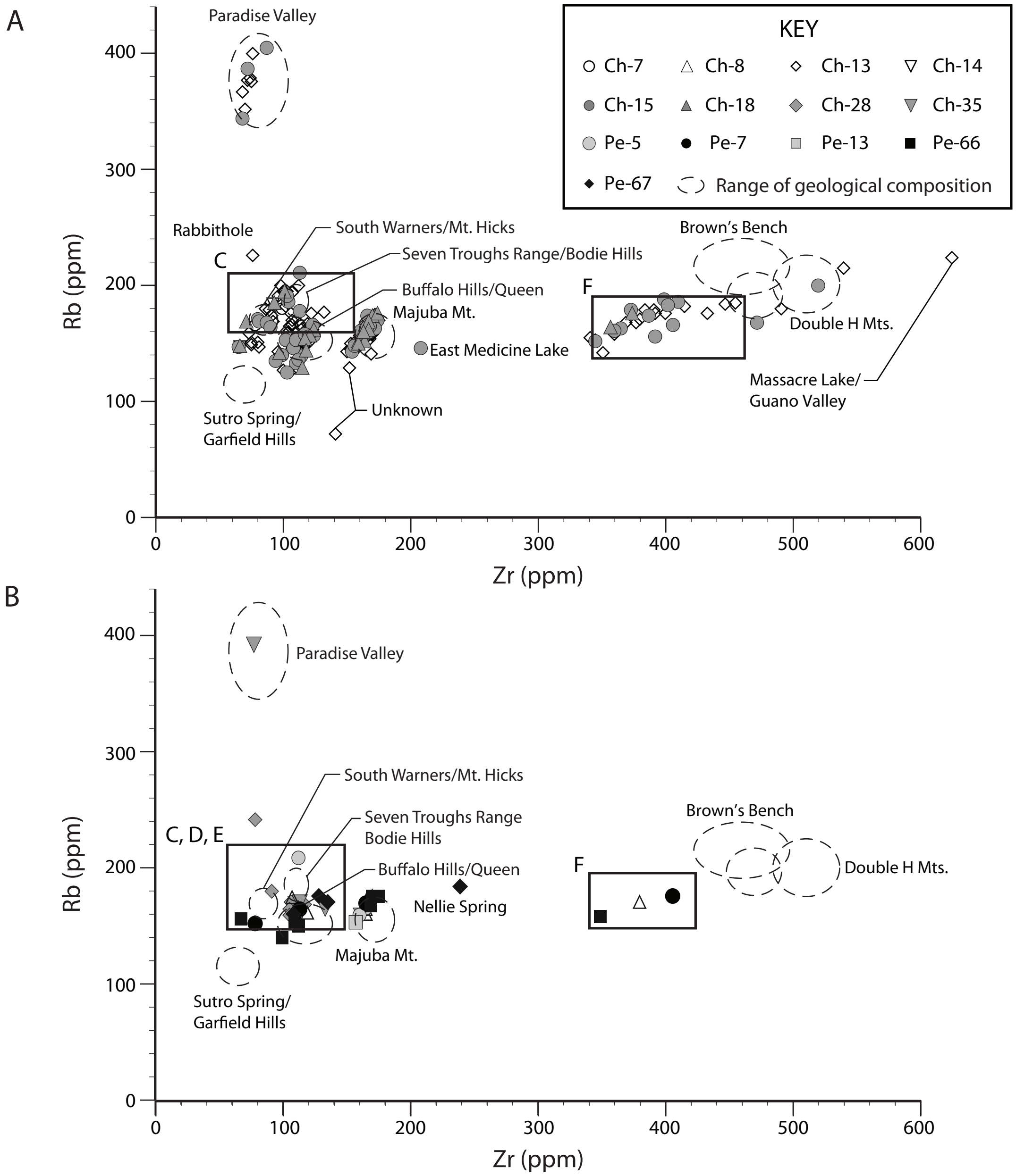
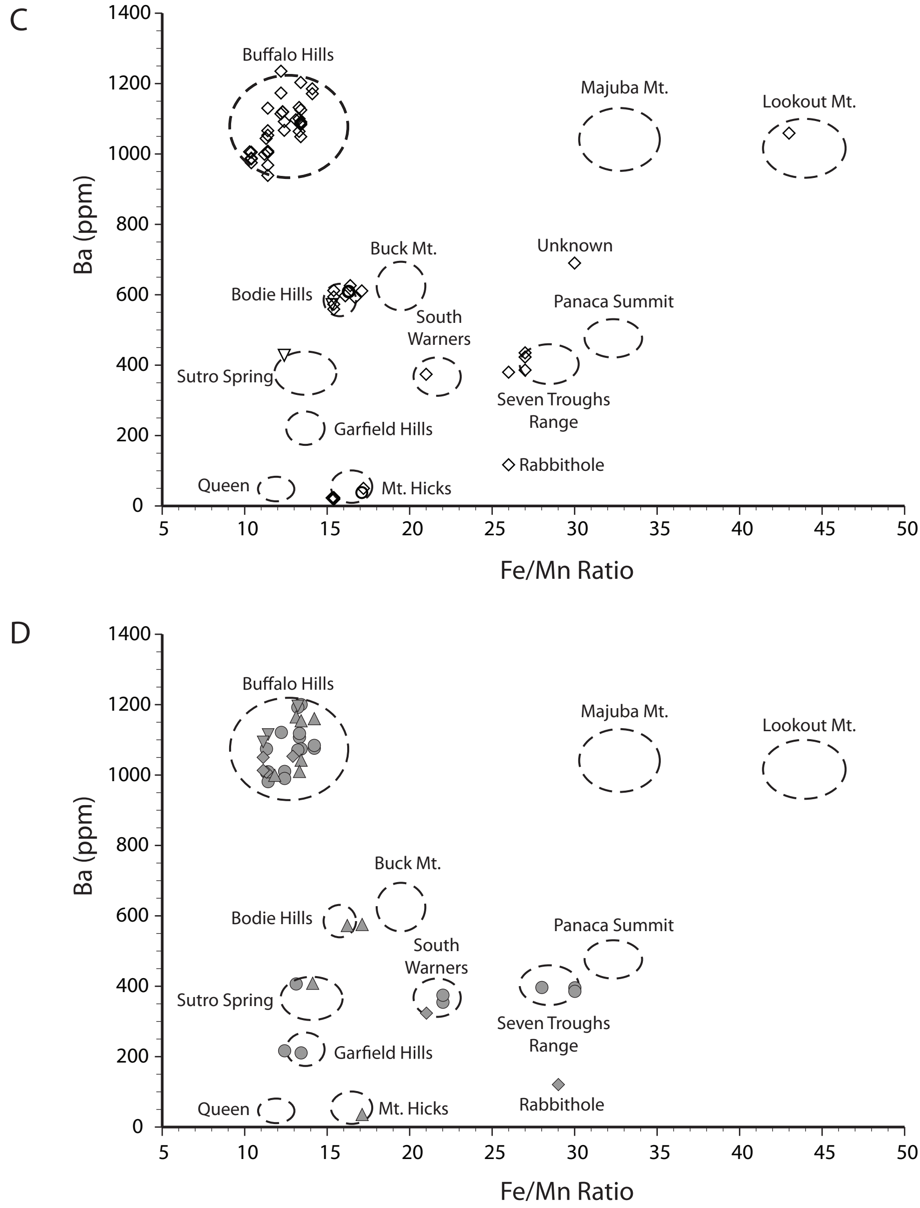
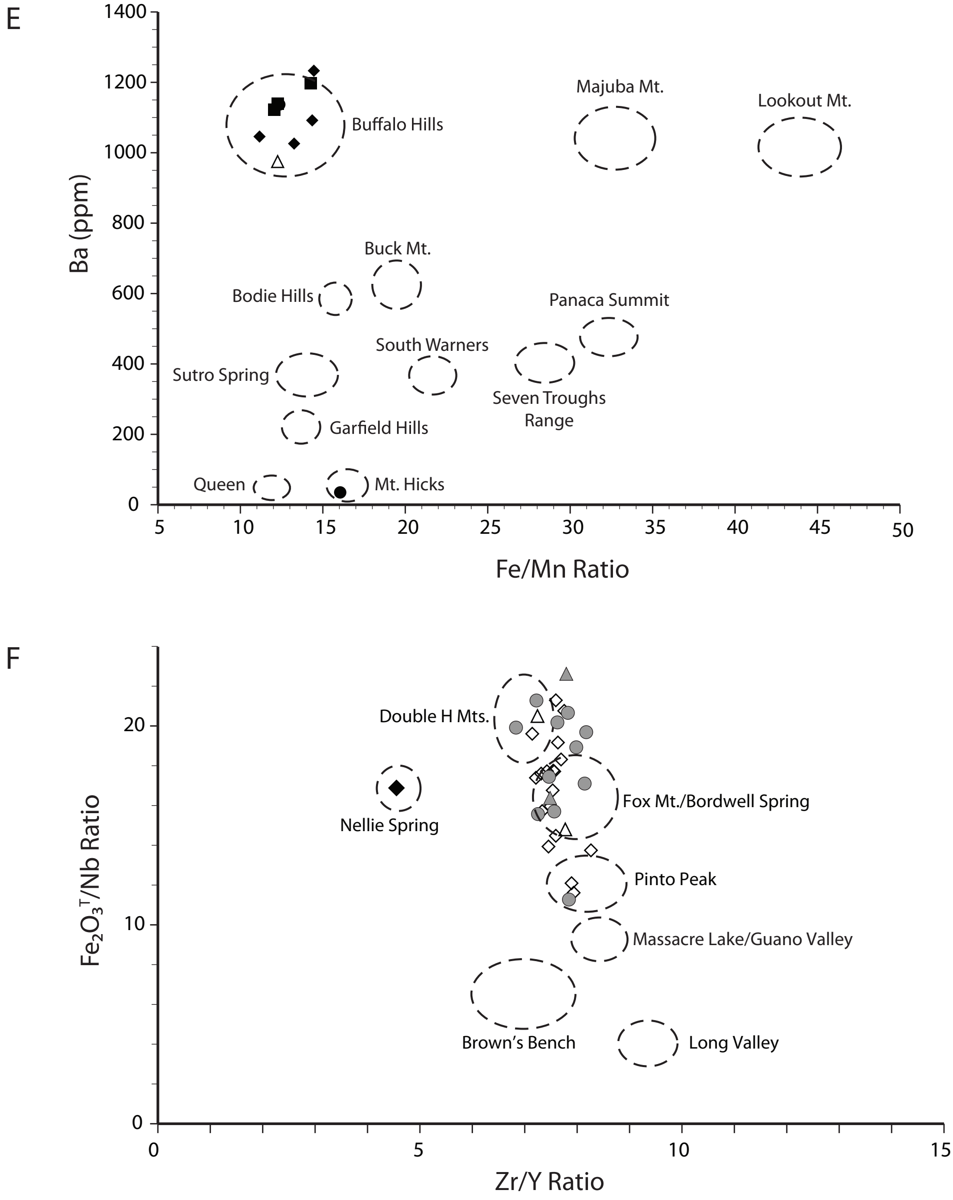


FIG. 25. Trace element composition of obsidian Rosegate series projectile points from the lower Humboldt Valley (*above;* plotted from data in supplement 4). **A.** Rb vs. Zr composition for projectile points from five Churchill County sites. **B**. Rb vs. Zr composition for projectile points from seven archaeological sites and localities in the lower Humboldt Valley *Note*: composition values for artifact 1-46039 from Pe-66 (made from Oak Spring Butte obsidian) plot off the chart at this scale. **C.** (*opposite page*) Ba vs. Fe/Mn composition for



projectile points undifferentiated by Rb/Zr composition (data from supplement 4). **D**. Ba vs. Fe/Mn composition for projectile points undifferentiated by Rb/Zr composition. Artifact 1-65528 (made from East Medicine Lake obsidian) plots off the chart at this scale. **E.** (*following page*) Ba vs. Fe/Mn composition for projectile points from four archaeological sites and localities undifferentiated by Rb/Zr composition. **F.** $Fe_2O_3^T$/Nb vs. Zr/Y composition for projectile points undifferentiated by Rb vs. Zr and Ba vs. Fe/Mn composition.


E
Ba (ppm)
1400
1200
1000
800
600
400
200
0
5
10
15
20
25
30
35
40
45
50
Fe/Mn Ratio
Buffalo Hills
Majuba Mt.
Lookout Mt.
Buck Mt.
Bodie Hills
Panaca Summit
South Warners
Sutro Spring
Seven Troughs Range
Garfield Hills
Queen
Mt. Hicks
F
$Fe_2O_3^T$/Nb Ratio
20
10
0
5
15
Zr/Y Ratio
Double H Mts.
Nellie Spring
Fox Mt./Bordwell Spring
Pinto Peak
Massacre Lake/Guano Valley
Brown's Bench
Long Valley

able there for the last 2 my (Gilbert et al., 1968; Noble et al., 1972; Metz and Mahood, 1985). With the exception of a few artifacts from the Casa Diablo area (i.e., Lookout Mountain, N = 3), obsidian from this major source just south of Mono Lake is conspicuously absent. Likewise, Craine Creek, located almost exactly the same distance northwest as Mt. Hicks is to the south, was identified in Black Rock Desert sites (McGuire et al., 2018) and significantly represented in Ruby Pipeline sites (King, 2016), but absent from sites in the lower Humboldt Valley.

In addition, even though 38 distinct chemical varieties of obsidian were identified in this lower Humboldt Valley study, 15 of them were represented by single artifacts. These are predominantly sources located at considerable distance (>ca. 240 km) from the lower Humboldt Valley (e.g., Cannonball Mountain, Oak Spring Butte, Wild Horse Canyon, Spodue Mountain, and West Sugarloaf [in the Coso Volcanic Field]; see fig. 1).

THE RELATIVE FREQUENCY OF DIFFERENT OBSIDIANS IN THE LOWER HUMBOLDT VALLEY SAMPLE

With source and type-specific data in hand, we can take a look at the source-specific relative frequency (Thomas, 1988: 404ff.) variability among these artifacts. For example, consider the probability of finding an obsidian Elko Eared point made from Mt. Hicks obsidian anywhere in the lower Humboldt Valley. Table 8 shows that there were 79 obsidian Elko Eared points identified in this sample and that eight of them were made from Mt. Hicks obsidian. The probability of this event can be expressed using the formula:

$$\text{probability} = p\ (A) = s\ /\ (s + f)$$

where *s* represents a success (the actual occurrence of a Mt. Hicks Elko Eared point in the sample) and *f* = the number of Elko Eared artifacts made from some other obsidian source. In this case, this probability is computed to be p = 0.092:

$$p = 8\ /\ (79 + 8) = 0.092$$

And if we examine aggregate source-specific attributions for Gatecliff points at the series level (combining contracting-stem, split, and series variants) the probability of finding a Gatecliff series point made from Bodie Hills obsidian in the lower Humboldt Valley is:

$$p = 16\ /\ (16+146) = 0.110$$

Using the same tabled data set, the probability of one of these Gatecliff points being made from nearby Majuba Mountain obsidian is: p = 0.290.

Other comparisons and predictions can be made using the data in tables 8 and 9, but it's important to appreciate that broader interpolation of these data could be misleading because of the variable distances and directions of obsidian sources to the lower Humboldt Valley.[22] Majuba Mountain obsidian—obtainable <75 km from the valley—is much more likely to be represented in the projectile point inventory because it is so much closer to lower Humboldt Valley sites than alternative high-quality glasses. Consequently, we need to control for the effects of distance and direction before arriving at any overall conclusion about patterning and change in obsidian source use and conveyance through time.

STATISTICAL ANALYSIS CONSIDERATIONS AND DISTANCE

The distance based distributions used in this project posed some statistical challenges. A glance at table 9 reveals that—local sources aside—the vast majority of time-sensitive points occurred in just two distance categories: those 101–160 and those 161–240 km north and south from the lower Humboldt Valley. So, to simplify the computations that follow, data for the artifacts occurring in the two most distant categories (241–299 and >300 km) were pooled into a >240 category since these two distance "bins" contained only 18 artifacts—2% of the total of time sensitive artifacts from sources north and south

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[22] Other valleys and sites they contain are situated at varying distances and directions from artifact-quality glasses, so the distance-to-source parameters will be different in each case.

of the lower Humboldt Valley. However, even this pooling occasionally yielded small cell sizes in which more than 20% of E_i values were less than 5—violating the guidelines for proper application of the chi-square (χ^2) test (Thomas, 1976a: 298)—and even more pooling (into a >161 category) was sometimes necessary. Furthermore, the samples compared here also are much larger than those suggested for application of Fisher's Exact test. This necessitated a practical compromise: when cell sizes were very small, statistical comparisons were made using 2×2 χ^2 contingency tables and when cell sizes were large enough, row by column χ^2 analysis was undertaken (using Yates's Correction for Continuity if appropriate). Because of the "power efficiency" of the Kolmogorov-Smirnov (hereafter, K-S) test relative to χ^2 when confronted with variable sample sizes (Siegel, 1956: 136), complementary K–S two-sample tests were done using the distance-based categories (101–160, 161–240, and >240) when sample sizes were adequate.

COMPARATIVE ANALYSIS RESULTS

The relatively close geographic proximity among these sites allows the site-specific EDXRF results to be combined, and the type-specific source distributions compared on the basis of distance and direction. Before diving more deeply into the results, note that 81% of all time-sensitive points attributable to obsidian source (N = 586 of 723)[23] were made from obsidian sources located north of the lower Humboldt Valley and that 47% of this sample (N = 340 of 723) came from volcanic glass erupted from the closest northern sources (<100 km distant). This is the gross baseline from which more detailed investigations can proceed.

More in-depth exploration can begin by creating an "abundance index"—the ratio of the number of obsidian sources used (by projectile point series) in relation to the total number of points observed in each series. The larger the "abundance index" value, the less diverse the series. For example, if we found that the sample of 166 Desert series points was made only from two obsidian sources, the abundance index value of 83 would reflect very low source-use diversity, and decreasing abundance index values would signal increasing source-use diversity. In fact, obsidian Desert Series points in the lower Humboldt Valley sample yield an index value of 6.92 (derived by computing 166/24). By iteration the value for Rosegate points is 14.16, the value for Elko series is 7.42, and the value for Gatecliff series is 6.5. The index value for Rosegate points is more than twice that for other series, but in what ways could that matter? In this case it could matter because greater abundance is suggestive of more intensive utilization, a wider foraging radius and/or social contacts, providing some independent evidence to evaluate current hypotheses about the social and economic effects of bow-and-arrow use in the Great Basin (Grayson, 2011: 324–325; Bettinger, 2013; Grund, 2017). Evaluating the issue requires a closer and more sober consideration of diversity.

CONSIDERING DIVERSITY

As sample size increases, so does the probability of sample diversity. In this case, absolute number of obsidian projectile points constrains the number of obsidian sources that can be represented. It isn't possible to have 15 obsidian sources represented in a sample of 10 projectile points, but it is quite possible to have the reverse—10 sources represented in a sample of 15 artifacts. *Diverse* is a relative term, but it carries quantitative implications. A sample of five Desert Side-notched projectile points representing only one obsidian source would be considered much less diverse than the same number Desert Side-notched points each made from a different source of obsidian. Qualitatively, we describe the former as an example of lack of diversity, whereas the latter would be considered

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[23] The legend accompanying table 9 specifies artifacts excluded from this total.

TABLE 11

Distance Based Distribution of Time-Sensitive Point Types in the Lower Humboldt Valley

Desert Series total excludes six points from unknown obsidian sources; Rosegate series total exclude four points from unknown sources; and Elko Series total excludes one specimen from an unknown source.

Distance (km)	Desert Series	Rosegate Series	Elko Series	Gatecliff Series	Northern Side-notched	Total
<100	83	126	66	54	11	340
101–160	24	86	33	31	4	178
161–240	49	54	38	41	4	186
>240	6	3	4	4	1	18
Total	162	269	141	130	20	722

highly diverse. But these qualitative generalizations overlook critical affective factors. The lower Humboldt Valley study confronts us with classes of artifacts (projectile point types) of differing sample size and with variable obsidian source attributions. We can't evaluate diversity absent sample-size considerations, nor can we address potential meaning of difference in the absolute numbers of particular sources within each projectile point class—the issue of abundance. This is true because although a sample of 20 Desert Side-notched points might be made from 20 sources, 10 of which might be from the same source, with a single occurrences of the other 10.

Table 7 shows that Desert series (Cottonwood and Desert Side-notched types) were made from 24 sources of obsidian, that Rosegate and Elko points each were made from 19 sources, and Gatecliff series points were manufactured from 20 geochemical varieties of obsidian. At first blush these data might appear to support the impression that all point types are about equally diverse in terms of the numbers of sources represented, but differences in sample size are not taken into account. There are 166 Desert series points, 269 Rosegates, 141 Elkos, and 130 Gatecliffs in the current sample for which an obsidian source (chemical type) determination could be made. Taking differences of sample size into consideration, are Desert series points more or less diverse than Rosegates? Are Rosegates more or less diverse than Elko series?

A Closer Look at Lower Humboldt Valley Obsidian Point Diversity

In this modest diversity exploration, classes are operationally defined as discrete projectile point types; richness refers to the numbers of obsidian sources represented within each class (point type); and evenness as a measure of the variability of obsidian-source use within each type-specific (class) category. As noted above *diversity* is a term with qualitative and quantitative meaning, and is often used interchangeably with the term *richness* in biological (e.g., Magurran, 1988, 2004) and in archaeological literature (e.g., Jones et al., 1983; Beck and Jones, 1989; Jones et al., 1989; Rhode, 1988; Shott, 1989; Grayson and Cole, 1998; Eren et al. 2016; Thomas, 2020b).

Two indices (the Shannon and the Simpson index) are commonly employed to evaluate diversity in data like those presented in tables 8 and 9. As Magurran (1988, 2004) emphasizes, these indexes are sensitive to different things: Simpson's is weighted toward the most abundant species (in this case, point types) and less sensitive to richness (i.e., how many points [N] occur within each point class), while the Shannon index emphasizes the richness, as opposed to evenness, of certain species (i.e., point types) and introduces "high bias in small samples" (Magurran 2004: 150). The advantage of the Shannon index is that it is nonparametric and therefore comparisons between

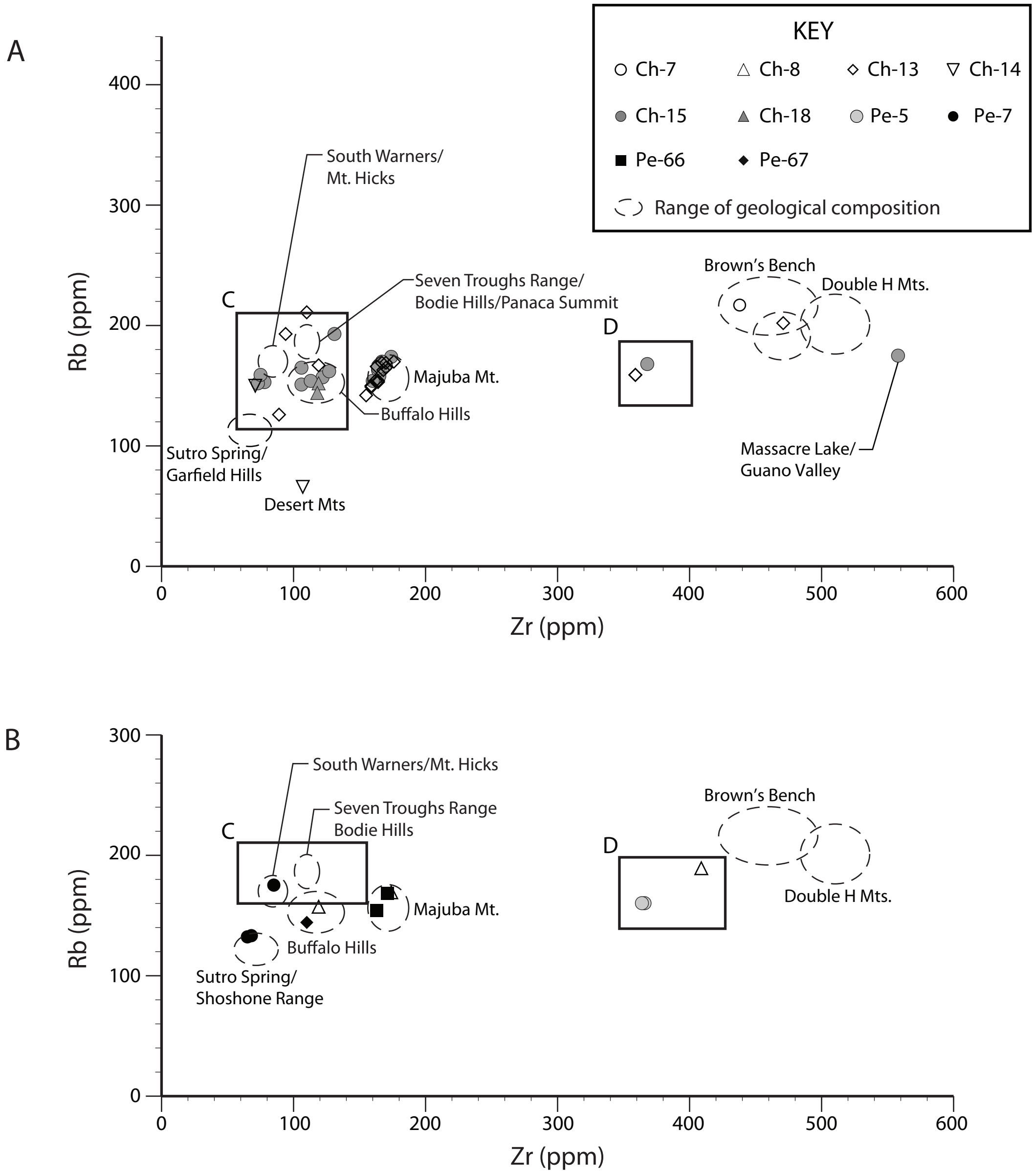
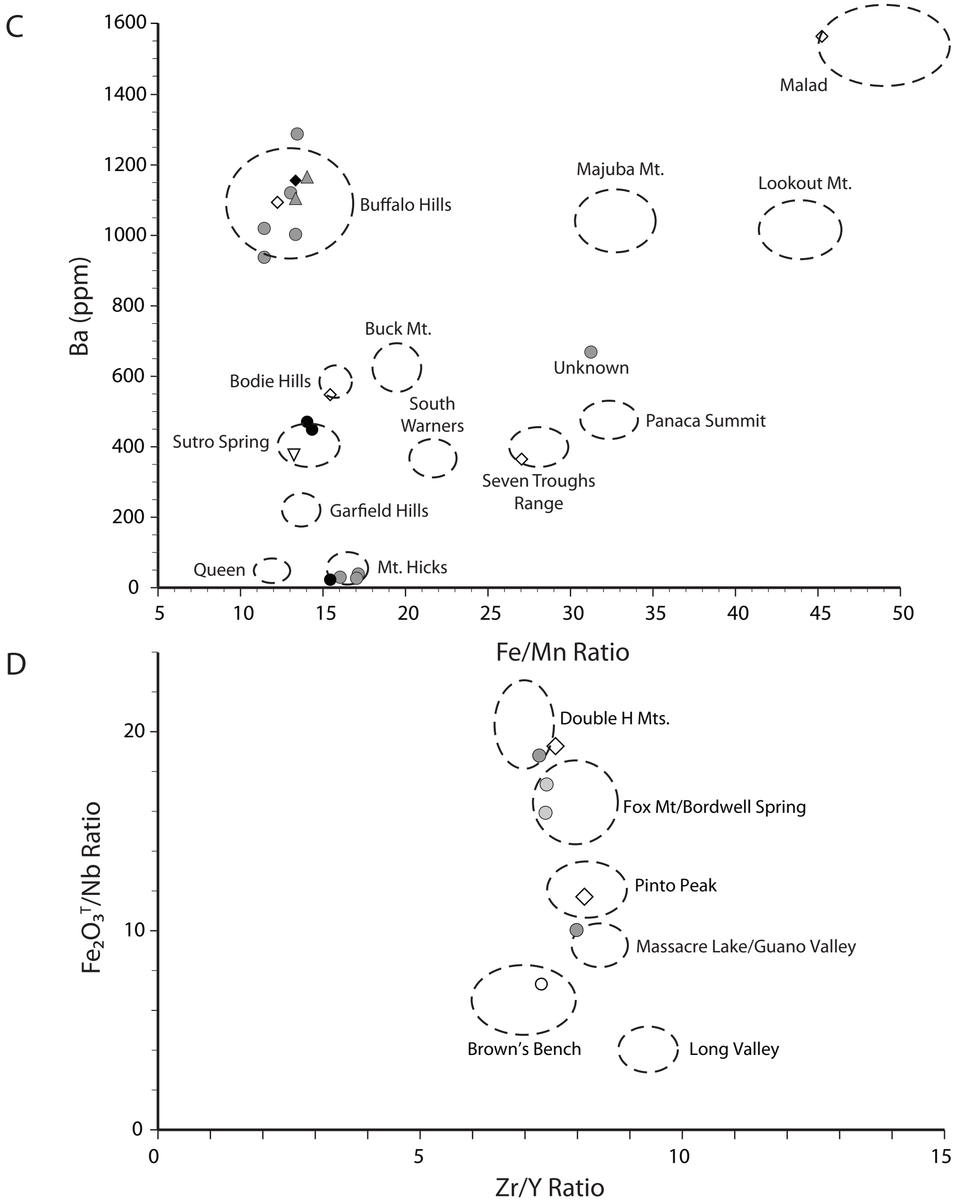


FIG. 26. Trace element composition of obsidian Elko Corner-notched projectile points from the lower Humboldt Valley (*above and opposite page;* plotted from data in supplement 5). **A.** Rb vs. Zr composition for projectile points from five Churchill County archaeological sites. **B.** Rb vs. Zr composition for projectile points from five archaeological sites and localities. **C.** Ba vs. Fe/Mn composition for projectile points undifferentiated by Rb/Zr composition. **D.** $Fe_2O_3^T$/Nb vs. Zr/Y composition for projectile points undifferentiated by Rb vs. Zr and Ba vs. Fe/Mn composition.


C
1600
1400
1200
1000
800
600
400
200
0
Ba (ppm)
5
10
15
20
25
30
35
40
45
50
Fe/Mn Ratio
Malad
Majuba Mt.
Lookout Mt.
Buffalo Hills
Buck Mt.
Bodie Hills
Unknown
South Warners
Panaca Summit
Sutro Spring
Seven Troughs Range
Garfield Hills
Queen
Mt. Hicks
D
20
10
0
Fe$_2$O$_3^T$/Nb Ratio
0
5
10
15
Zr/Y Ratio
Double H Mts.
Fox Mt/Bordwell Spring
Pinto Peak
Massacre Lake/Guano Valley
Brown's Bench
Long Valley

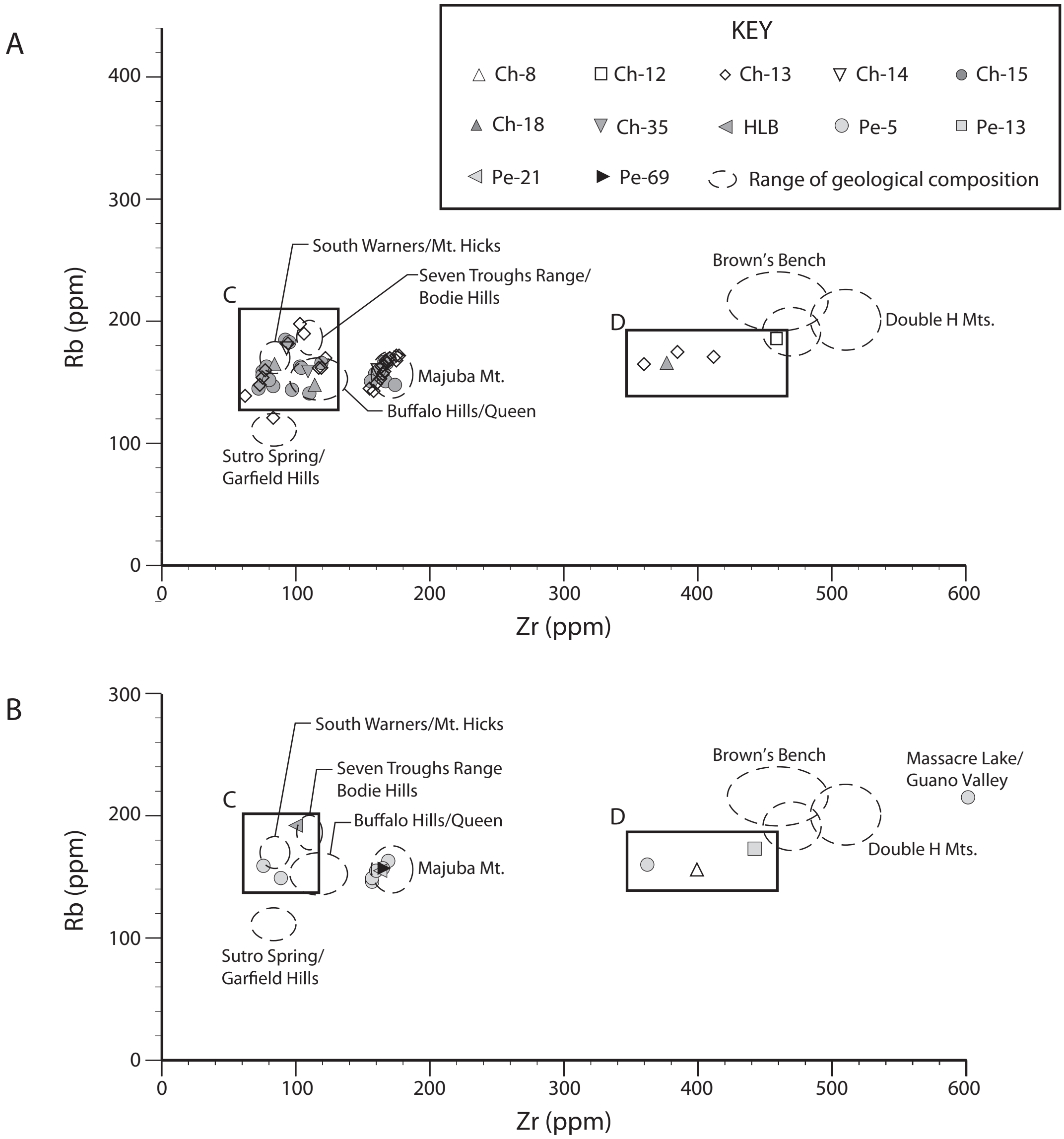
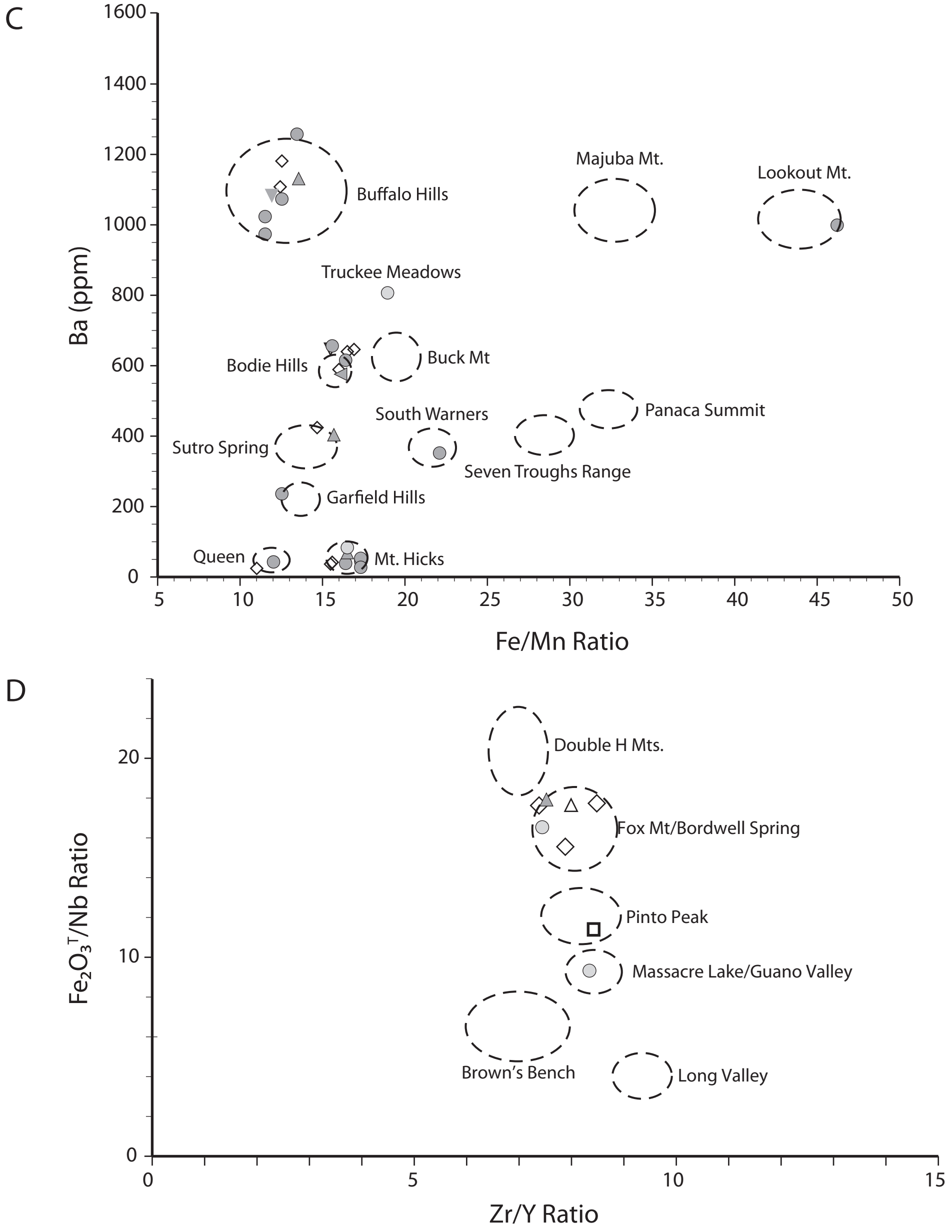


FIG. 27. Trace element composition of obsidian Elko Eared projectile points from the lower Humboldt Valley (*above and opposite page;* plotted from data in supplement 6). **A.** Rb vs. Zr composition for obsidian Elko Eared projectile points from six Churchill County archaeological sites in the lower Humboldt Valley. **B.** Rb vs. Zr composition for projectile points from five archaeological sites and localities. **C.** (*opposite page*) Ba vs. Fe/Mn composition for projectile points from seven archaeological sites and localities undifferentiated by Rb/Zr composition. **D.** $Fe_2O_3^T$/Nb vs. Zr/Y composition for projectile points undifferentiated by Rb vs. Zr and Ba vs. Fe/Mn composition.


C
Ba (ppm)
1600
1400
1200
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800
600
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200
0
Buffalo Hills
Majuba Mt.
Lookout Mt.
Truckee Meadows
Bodie Hills
Buck Mt
South Warners
Panaca Summit
Sutro Spring
Seven Troughs Range
Garfield Hills
Queen
Mt. Hicks
5
10
15
20
25
30
35
40
45
50
Fe/Mn Ratio
D
$Fe_2O_3^T$/Nb Ratio
20
10
0
Double H Mts.
Fox Mt/Bordwell Spring
Pinto Peak
Massacre Lake/Guano Valley
Brown's Bench
Long Valley
0
5
10
15
Zr/Y Ratio

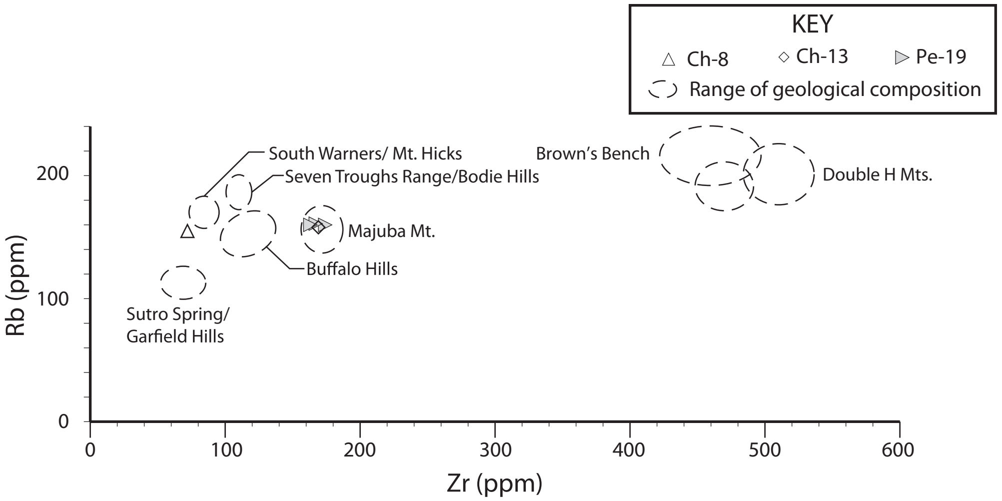

FIG. 28. Rb vs. Zr composition for obsidian Elko series projectile points from the lower Humboldt Valley (plotted from data in supplement 7).

index values for units (projectile point types) can be done using a t-test. By contrast, the nonparametric Simpson index lacks such tests but it "provides a good estimate of diversity at relatively small samples sizes and will rank assemblages consistently (Magurran, 2004: 101), and is "recommended for its ability to consistently rank assemblages when sample size varies" (Magurran 2004: 161; see also Lande et al., 2000). Berger-Parker index values also were computed because they give a simple measure of the uniformity of species abundance (dominance), though biased by sample size and richness.

The data in table 7 were used to compute a Shannon diversity index (H′), Simpson's index (D), and Berger-Parker index values for the 723 time-marker points attributable to source on the basis of point type. Even though the forms don't enjoy widely recognize time-marker status, computations also appear in table 10 for Humboldt Series (N = 81) and Humboldt Basal-notched points (N = 44) because they are morphologically distinct.

SHANNON DIVERSITY INDEX: Results of the Shannon diversity index (H') computations are briefly summarized. The H' values for the Desert Series (2.091) are slightly greater than for Rosegate points (1.858) but a t-test shows the types are not significantly different (Hutcheson's t-test = 1.653 <t = 1.96, p = 0.099, df = 317). Rosegate H' values are slightly lower (1.858) than those for Elko Series points (1.975), but the difference between types is not statistically significant (Hutcheson's t-test = 0.887 <t = 1.96, p = 0.376, df = 281). The H' values for Gatecliff Series points (2.057) are slightly greater than for the Elko Series (1.975), but they are not significantly different (Hutcheson's t-test = 0.515 <t = 1.96, p = 0.607, df = 270). H' values for Gatecliff Series are higher (2.057) than Northern Side-notched points (1.706), but again they are not significantly different (Hutcheson's t-test = 1.268 <t = 1.96, p = 0.215, df = 28).

DARTS VS. ARROWS: For this comparison, the arrow point category consists of the sum of Desert Series and Rosegate Series abundance (H' = 2.025), while the dart category subsumes Elko, Gatecliff, and Northern Side-notched (H' =2.072). Table 10 shows that sample sizes between categories are very different, but the H' values determined do not support any statistically significant differences between arrows and darts (Hutcheson's t-test = 0.435 <t = 1.96, p = 0.664, df = 637).

Eliminating the small sample of Northern Side-notched points, table 10 shows that the obsidian sources for Humboldt Basal-notched points are the most homogeneous, while those representing Desert series points are more heterogeneous (i.e., more diverse).

Simpson Diversity Index: We can now consider these same data computed using the Simpson index. As Magurran (1988: 153) suggests, the Simpson D index values were converted to reciprocals (i.e., 1/D) to make them easier to compare. The higher the 1/D value, the greater the diversity. The reciprocal values in table 10 show quite clearly that the least diverse category is Humboldt Basal-notched points. The most diverse category here is Gatecliff series, followed by Elko series, Northern Side-notched, Desert series, Rosegate series, and Humboldt series. The Northern Side-notched result may be an artifact of small sample size; it is over six times smaller than the least frequent class (Gatecliff series, N= 130) in this comparative study.

The Simpson (1/D) computations (table 10) also rank the obsidian sources for Humboldt Basal-notched points as the most homogeneous (least diverse), and the Gatecliff series points as more heterogeneous (most diverse).

Regardless of what measure one prefers, figure 42 shows the Simpson and Shannon indexes produced highly consistent evenness rankings of point types ($r^2 = 0.928$).

Berger-Parker Index: The Berger-Parker index values largely mirror those of the Simpson index; Gatecliff series points are the most diverse, followed by Rosegate, Elko, Humboldt, and Desert series and Northern Side-notched points. As with the other two indexes computed, values for Humboldt Basal-notched points place them as the least diverse (table 10). The Berger-Parker and Simpson indexes (fig. 43) also are highly concordant.

General Summary: Regardless of which diversity index one favors, they all agree on one thing: Humboldt Basal-notched bifaces are by far the least diverse category. Interestingly, the Simpson index—the one most sensitive to differences in sample size—ranks the major dart-point categories (Gatecliff, Elko, and Northern Side-notched) as more diverse than arrow points (Desert and Rosegate series). Gatecliff series points rank first or second in all three of the diversity indexes, followed closely by points of the Elko series, which rank third in all three indexes. The least overall ranking agreement occurs among the point categories containing the largest (Desert and Rosegate series) and smallest (Northern Side-notched) sample sizes.

By averaging the rankings for all three indexes in table 10, the following order emerges (from least diverse to most diverse): Humboldt Basal-notched, Humboldt series, Northern Side-notched, Desert series and Rosegate series, Elko series, and Gatecliff series. These findings carry implications for evaluation of the influence of reworking/refabrication factors in the lower Humboldt Valley case.

In gauging these results, it's important to keep in mind that these indexes emphasize (or are biased toward) different aspects of diversity—the Shannon index is biased more toward sample richness, whereas the Simpson index emphasizes evenness (or dominance). It's also crucial to emphasize that these are measures of overall source-use diversity by time: they do not inform on possible differences in the geographic direction(s) or distances from which obsidian may have been obtained at different periods in the past.

What about Sample Size Issues? To the extent that sample size is driving these distributions, we'd expect that the more projectile points one analyzes, the more obsidian source will be identified.[24] The linear regression fit for the distribution in figure 44 is $r^2 = 0.545$, but when Humboldt Basal-notched points are eliminated (for reasons discussed at greater length below), the linear fit rises to $r^2 = 0.791$ (fig. 45) and the logarithmic $r^2 = 0.843$. It thus appears that there is a significant relationship between the observed number of

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[24] This is true in a statistical sense, but in practice the actual number of obsidian sources likely to be represented in the study is finite (i.e., limited).

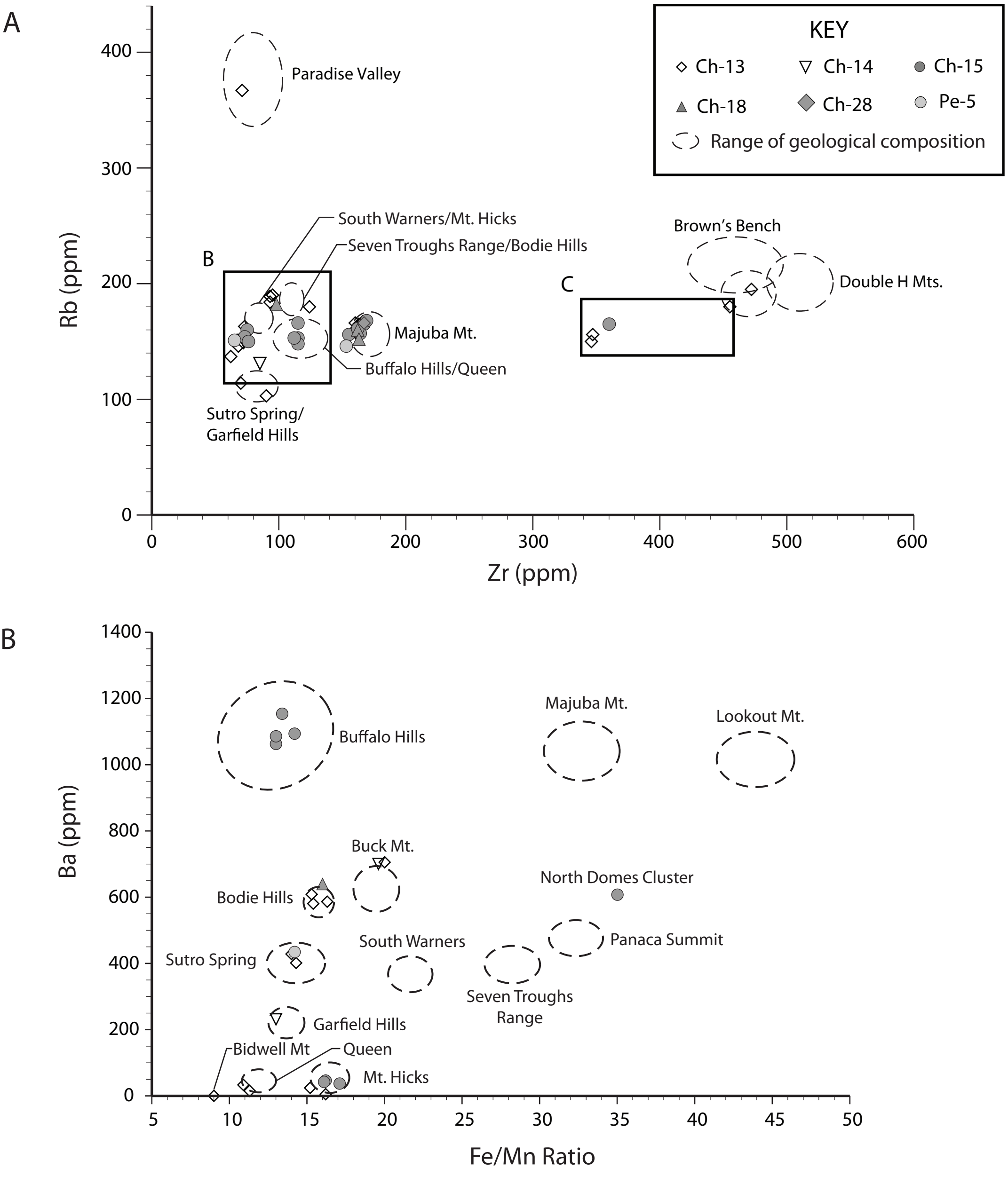
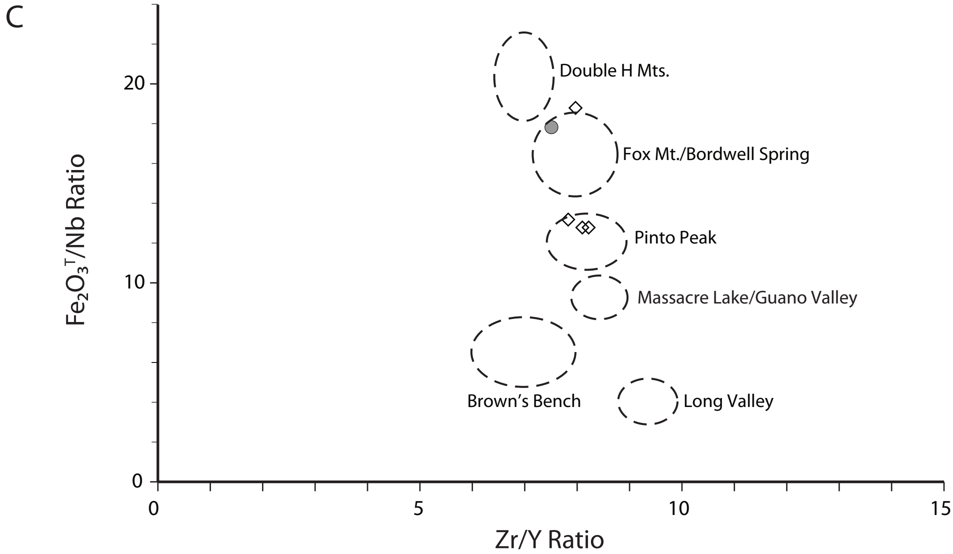


FIG. 29. Trace element composition of obsidian Gatecliff Split-stem projectile points from the lower Humboldt Valley (*above and opposite page;* plotted from data in supplement 8). **A.** Rb vs. Zr composition for projectile points from seven archaeological sites and localities. **B.** Ba vs. Fe/Mn composition for projectile points undifferentiated by Rb/Zr composition. **C.** (*opposite page*) $Fe_2O_3^T$/Nb vs. Zr/Y composition for projectile points undifferentiated by Rb vs. Zr and Ba vs. Fe/Mn composition.



obsidian projectile points and the number of obsidian sources used in their manufacture.

The comparison done above gives a sense of the overall relationship between number of obsidian sources and the number of obsidian points observed in each class, but are there additional factors that should be considered?

What about Geographic Direction? Consider only the number of artifacts and distance. Figure 46 plots the number of obsidian artifacts in each class against geographic distance from the lower Humboldt Valley, based on data in table 9. An overall fall-off by distance is apparent and, with the exception of Rosegate points, the shapes of the curves for all time-sensitive points are remarkably similar to the Carson Sink (Raven, 1994: fig. 19.1). The divergence observed in Northern Side-notched points is very likely due to small sample size. These data may highlight the difference in source "catchment" radius in Rosegate times, which we explored to a certain extent by considering diversity. Note, however, that this figure illustrates the overall effect of distance—not direction—from the lower Humboldt Valley.

But because occurrences by distance are averaged, figure 46 gives a very different impression than afforded by the more nuanced presentations in figures 49 and 50. Even though the overall distance relations are the same, the rather dramatic differences between the north/south distribution of certain point types detailed above are largely lost here. Nonetheless, figure 46 offers an object lesson.

Leaving aside the small sample of Northern Side-notched points, a straightforward reading of this figure would be that many more Rosegate points were made from obsidian sources 101–160 km from the lower Humboldt Valley than were points of the Elko series. However, this belies a more significant fact: plotting by distance and direction reveals details obscured by figure 46. In fact, as figures 47 and 48 show, there is a major difference in the distance/direction distribution within the Rosegate series just as there is within the Elko series. A more thorough exploration of these details appears in later sections.

Figure 47 plots the relationship between the number of obsidian sources used and the number of points in each class, based on their locations north of the lower Humboldt Valley. As this figure shows, there is a very strong linear relationship here ($r^2 = 0.980$) indicating that, indeed, the number of obsidian sources used and the number of points observed are very highly correlated. Even if we eliminate Northern Side-notched points

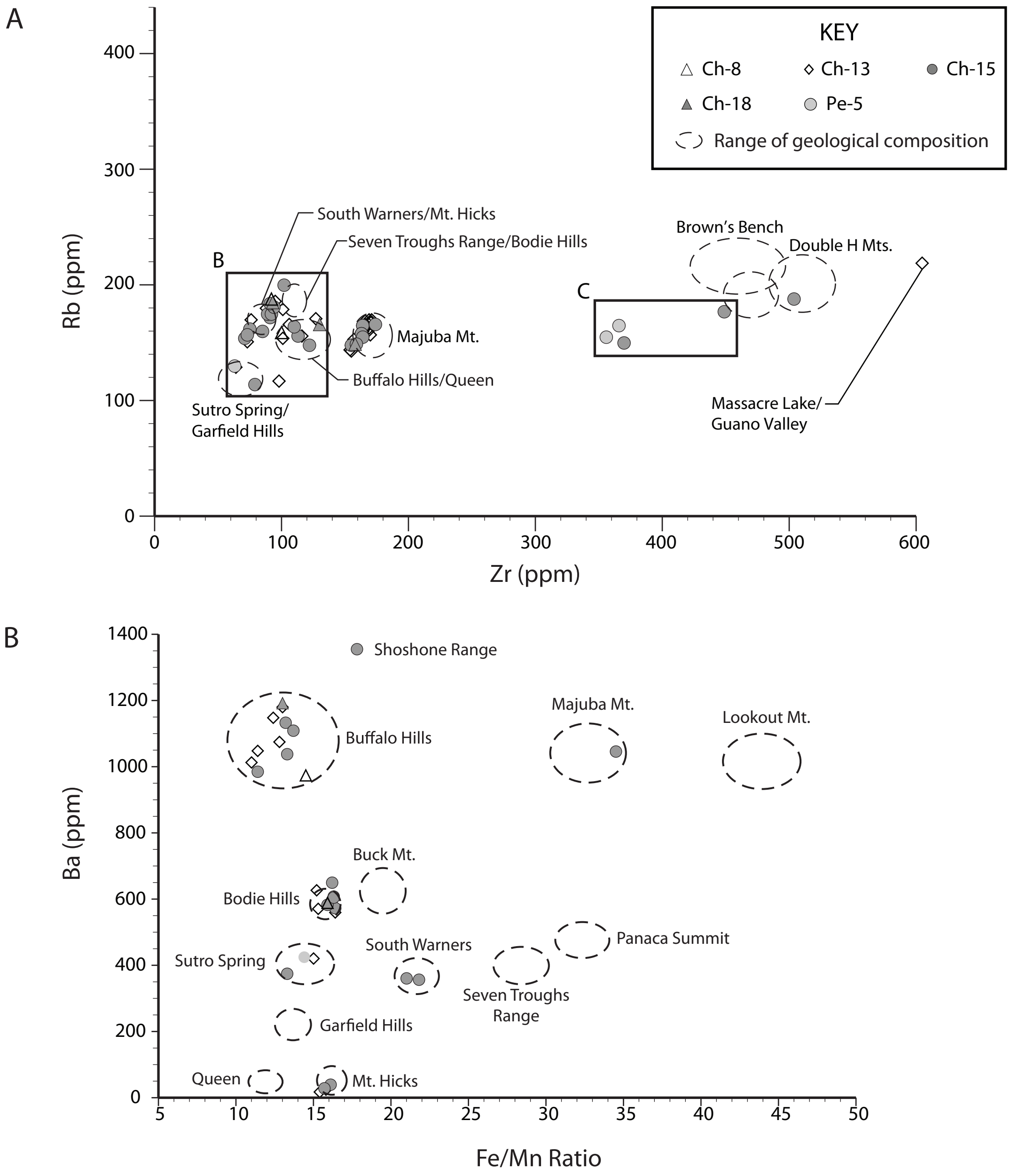
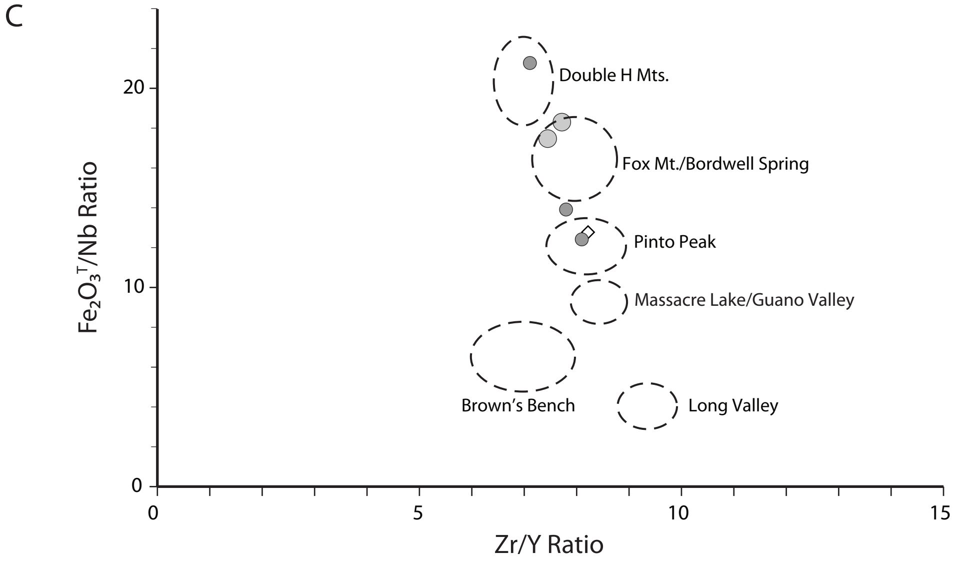


FIG. 30. Trace element composition of obsidian Gatecliff Contracting-stem projectile points from the lower Humboldt Valley (*above and opposite page;* plotted from data in supplement 9). **A.** Rb vs. Zr composition for projectile points from five archaeological sites and localities. Composition values for artifact NSM 383 from Ch-13 (made from Oak Spring Butte obsidian) plot off the chart at this scale. **B.** Ba vs. Fe/Mn composition for projectile points undifferentiated by Rb/Zr composition. **C.** (*opposite page*) $Fe_2O_3^T$/Nb vs. Zr/Y composition for projectile points undifferentiated by Rb vs. Zr and Ba vs. Fe/Mn composition.



(because of low sample size) the correlation coefficient is still very high ($r^2 = 0.984$).

Figure 48—plotting the number of obsidian sources used and the number of points in each class based on their location south of the lower Humboldt Valley number—gives a different result from the north. Employing the same artifact classes as in the northern example, there is a very low correlation ($r^2 = 0.537$), due primarily to the fact that very few Northern Side-notched points were manufactured from any southern source and, conversely, that a large number of Humboldt Basal-notched bifaces were made from obsidian source material located to the south. As done above, eliminating Northern Side-notched points results in a dramatic elevation of overall correlation coefficient (to $r^2 = 0.981$), but results in significant changes to the Humboldt series and Humboldt Basal-notched categories.

COMPARING THE DISTRIBUTIONS OF TIME MARKERS

As noted above, the lower Humboldt Valley study confronts us with classes of artifacts (projectile point types) of differing sample size and with variable obsidian-source attributions. We investigated some elements of those intersections in the section above on diversity, but recognized that they lacked directional and distance considerations critical to evaluating temporal and spatial significance. To do that, we have to consider in detail the distance and directional occurrences of these time-sensitive artifacts. This section first documents the local vs. nonlocal frequencies of time-sensitive obsidian points, then investigates in greater detail the incidence of time-marker points by direction and distance from the lower Humboldt Valley. At each juncture, the substantive results are summarized.

THE LOCAL LEVEL

The source-specific data appear in table 7, from which we can examine the gross effect of direction to source through time. Excluding artifacts from unknown sources (N = 12), and those from the east (N = 5), shows that that 68.8% (33 of 48) of the Cottonwood points in this sample, 44% (51 of 116) of Desert Side-notched points; 46.8% (126 of 269) of Rosegate Series; 49.1% (28 of 57) of Elko Corner-notched; 43% (34 of 79) of Elko Eared; 36.4% (16 of 44) of Gatecliff Split

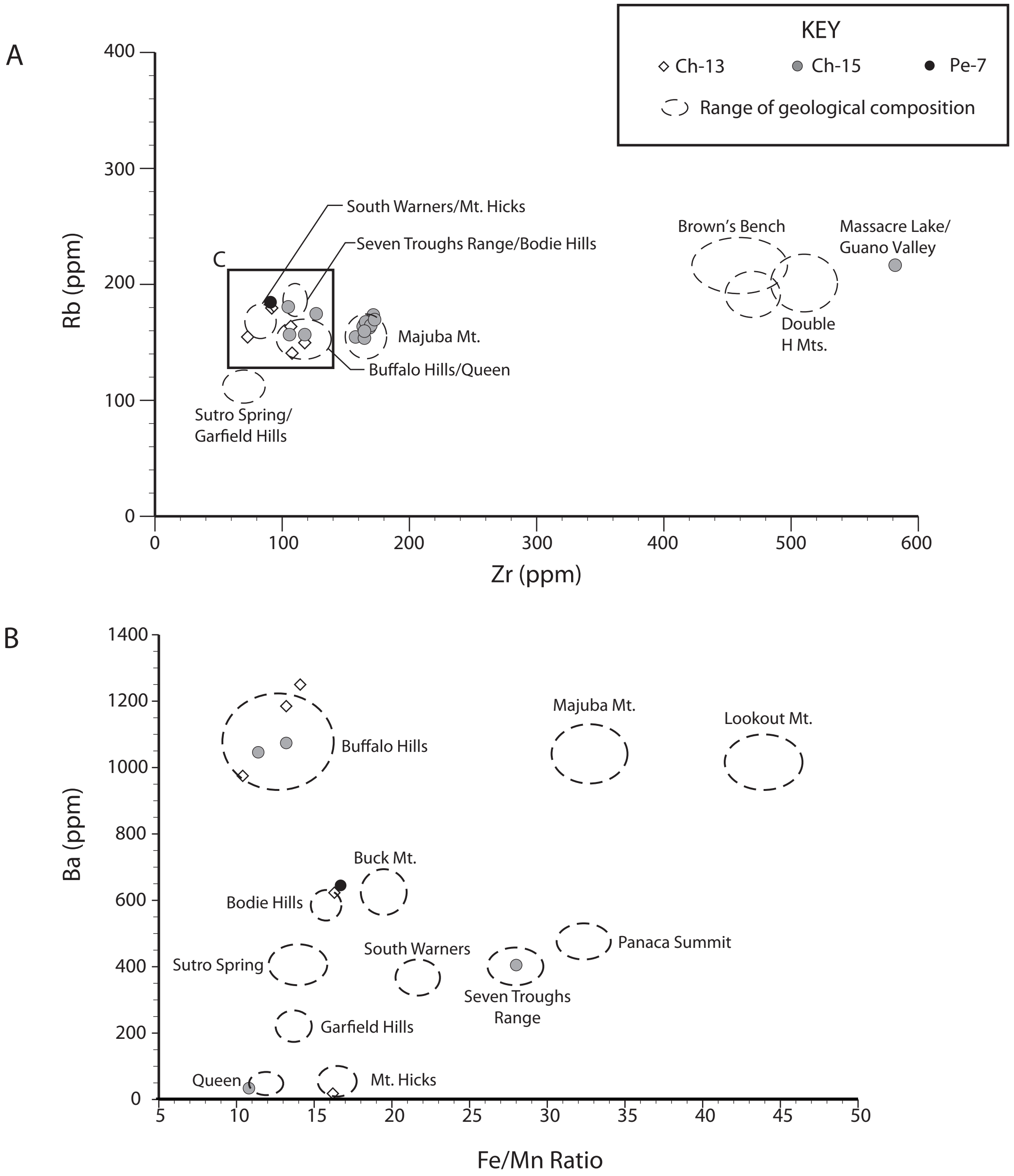


FIG. 31. Trace element composition of obsidian Gatecliff series projectile points from the lower Humboldt Valley (plotted from data in supplement 10). **A.** Rb vs. Zr composition for projectile points from three archaeological sites. **B.** Ba vs. Fe/Mn composition for projectile points undifferentiated by Rb/Zr composition (data from supplement 10).

Stem, and 40.6% (26 of 64) of Gatecliff Contracting Stem points were manufactured from "local" sources—that is, places where obsidian could have been obtained within 70–75 km (or perhaps even closer) to lower Humboldt Valley sites.[25]

The Nonlocal Level

Data pooled to the series level show that 84 of 164 (52.4%) of Desert series points were made from local obsidian, but, as noted above, the type-specific frequencies are different. Are they significantly different? A chi-square test on the frequencies in table 9 indicates that the local/nonlocal frequencies between Cottonwood Triangular and Desert Side-notched points are significantly different ($\chi^2 = 8.347$, df = 1, p = 0.004, $\varphi = 0.226$) with 36% of the chi-square variability due to the underrepresentation of Cottonwood points from nonlocal sources (N = 15 observed vs. 23 expected). A chi-square test on the frequencies in this table shows no significant difference exists between Elko Eared and Elko Corner-notched artifacts ($\chi^2 = 0.494$, df = 1, p = 0.482), and Gatecliff Split Stem and Contracting Stem variants also show no significant difference in local/nonlocal source representation ($\chi^2 = 2.04$, df = 2, p = 0.361).

The chi-square tests show that all but the Desert Series are essentially similar in terms of local vs. nonlocal source use frequencies, so we can pool the frequencies by point series to investigate possible differences. Referring to the raw data pooled from table 9, a 2×2 contingency test shows that the local/nonlocal use frequencies between Desert Side-notched and Rosegate series points could have arisen by chance ($\chi^2 = 0.270$, df = 1, p = 0.604), as could have the observed frequencies between Rosegate series and Elko series points ($\chi^2 = 0.004$, df = 1, p = 0.995) and between Elko series and Gatecliff series points ($\chi^2 = 0.761$, df = 1, p = 0.383). Although the Northern Side-notched point were recovered in comparatively small numbers (N= 20), the local vs. nonlocal frequency distributions observed between them and Elko Series points could have arisen by chance ($\chi^2 = 0.471$, df = 1, p = 0.493), as could the distribution of Northern Side-notched and Gatecliff series points ($\chi^2 = 1.279$, df = 1, p = 0.258).

Summary: With the exception of Cottonwood Triangular points within the Desert Series, there is no statistical support for differences between local and nonlocal obsidian use within and among the time-marker point types in the lower Humboldt Valley.

Comparisons by Direction

Understanding the overall relationship of local vs. nonlocal obsidian use is important, but we now need to examine possible differences between the uses of all sources located north and south of the lower Humboldt Valley. Are there any patterns that emerge from these data?

We can investigate this using the partitioned discrete geographic categories in table 9. In some cases, the frequencies of points from sources beyond 240 km were very small, so they were combined for analysis into a >240 km category.

The North: We begin in the north, comparing the distributions of Cottonwood and Desert Side-notched points. These distributions could have been drawn from the same statistical population (K-S $D = 0.198 < D_{0.05} = 0.257$, $N_1 = 42$; $N_2 = 85$), so they were pooled for comparison with Rosegate points. The combined Desert series (Cottonwood + DSN) profile was not significantly different from that of Rosegate points (K-S $D = 0.137 < D_{0.05} = 0.149$, $N_1 = 127$; $N_2 = 244$), so these were pooled. The pooled (Desert series + Rosegate series) profile was also statistically indistinguishable from Elko Corner-notched (K-S $D = 0.039 < D_{0.05} = 0.213$, $N_1 = 371$; $N_2 = 46$), so these frequencies were combined with those for Desert series and Rosegate series. The

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[25] Regardless of distances involved, we should be mindful of the fact that people frequently picked up, reused, and repurposed earlier projectile points when they were encountered in good condition. There is considerable evidence for this practice in far western North America (e.g., Barrett, 1910: 246, 253; Kelly, 1932: 141; Stewart, 1941: 432; Riddell, 1960a: 50; Fowler, 1992: 106).

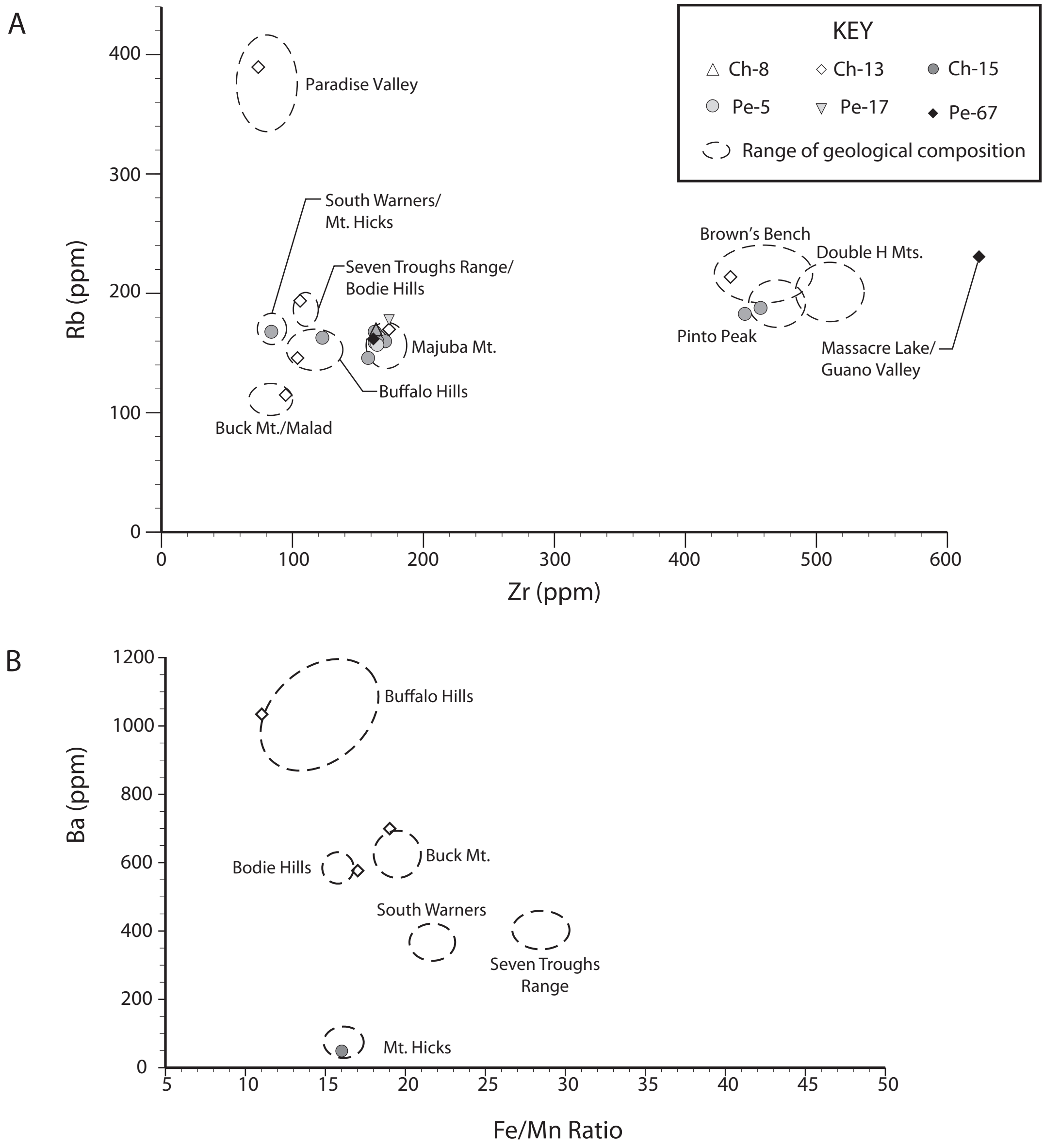
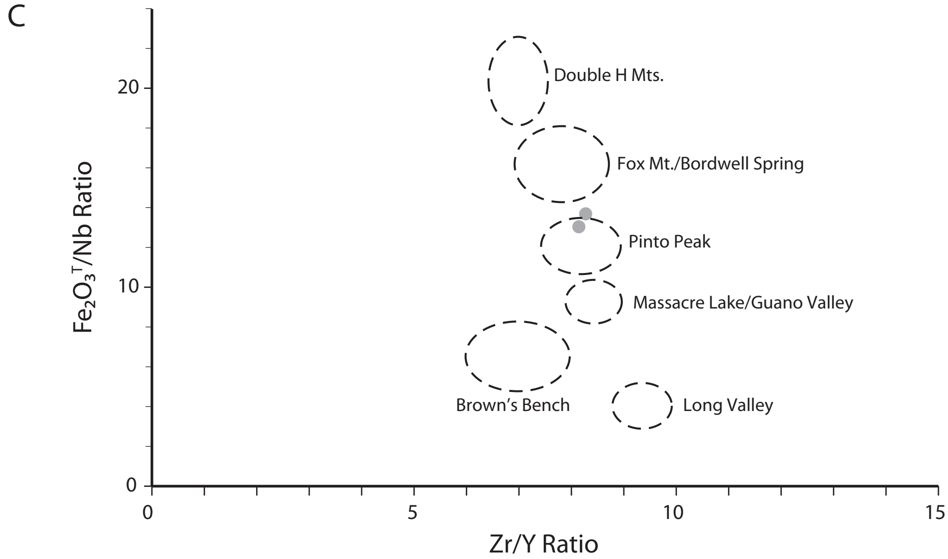


FIG. 32. Trace element composition of obsidian Northern Side-notched projectile points from the lower Humboldt Valley (*above and opposite page;* plotted from data in supplement 11). **A.** Rb vs. Zr composition for projectile points from five archaeological sites and localities. **B.** Ba vs. Fe/Mn composition for projectile points undifferentiated by Rb/Zr composition. **C.** (*opposite page*) $Fe_2O_3^T$/Nb vs. Zr/Y composition for projectile points undifferentiated by Rb vs. Zr and Ba vs. Fe/Mn composition.



subsequent comparison with Elko Eared points (K-S D = 0.064 <$D_{0.05}$ = 0.197, N_1 = 417; N_2 = 54) and the pooled addition of Elko series specimens (K-S D = 0.427 <$D_{0.05}$ = 0.682, N_1 = 471; N_2 =4) did not change the relationship, so all frequencies were once again pooled (Desert series, Rosegate series, and Elko series) for comparison with Gatecliff points. The pooled comparison with Gatecliff Contracting Stem (K-S D = 0.025 <$D_{0.05}$ = 0.212, N_1 = 475; N_2 =45), the then pooled comparisons including Gatecliff Split Stem (K-S D = 0.086 <$D_{0.05}$ = 0.260, N_1 = 520; N_2 =29) and Gatecliff series (K-S D = 0.105 <$D_{0.05}$ = 0.326, N_1 = 549; N_2 =18) were all pooled for comparison with Northern Side-notched (K-S D = 0.040 <$D_{0.05}$ = 0.326, N_1 = 567; N_2 =18).

The congruence among all these profiles suggests that there is no significant difference by time period or distance between or among any obsidian projectile points manufactured from sources to the north of the lower Humboldt Valley (see fig. 49).

THE SOUTH: As we did for obsidian points from the north, comparison begins here with the distributions of Cottonwood and Desert Side-notched points. These distributions could have been drawn from the same statistical population (K-S D = 0.167 <$D_{0.05}$ = 0.608, N_1 = 6; N_2 = 30), so they were pooled for comparison with Rosegate points. The combined Desert series (Cottonwood + DSN) profile was not significantly different from that of Rosegate points (K-S D = 0.101 <$D_{0.05}$ = 0.354, N_1 = 36; N_2 = 25), so these were pooled. The pooled (Desert series + Rosegate series) profile was also statistically indistinguishable from Elko Corner-notched (K-S D = 0.092 <$D_{0.05}$ = 0.446, N_1 = 61; N_2 = 11), so these frequencies were combined with those for Desert series and Rosegate series. The subsequent comparison with Elko Eared points (K-S D = 0.034 <$D_{0.05}$ = 0.316, N_1 = 72; N_2 = 25) and the pooled addition of Elko series specimens (K-S D = 0.186 <$D_{0.05}$ = 1.37, N_1 = 97; N_2 = 1) did not change the relationship, so all frequencies were once again pooled (Desert series + Rosegate series + and Elko series) for comparison with Gatecliff points. The pooled comparison continued with Gatecliff Contracting Stem (K-S D = 0.044 <$D_{0.05}$ = 0.341, N_1 = 98; N_2 = 19), followed by the comparisons including Gatecliff Split Stem (K-S D = 0.087 <$D_{0.05}$ = 0.373, N_1 = 117; N_2 = 15) and Gatecliff series (K-S D = 0.189 <$D_{0.05}$ = 0.690, N_1 = 132; N_2 = 4). These were all pooled for comparison with Northern Side-notched (K-S D = 0.183 <$D_{0.05}$ = 0.969, N_1 = 136; N_2 = 2), all suggestive of a random distribution.

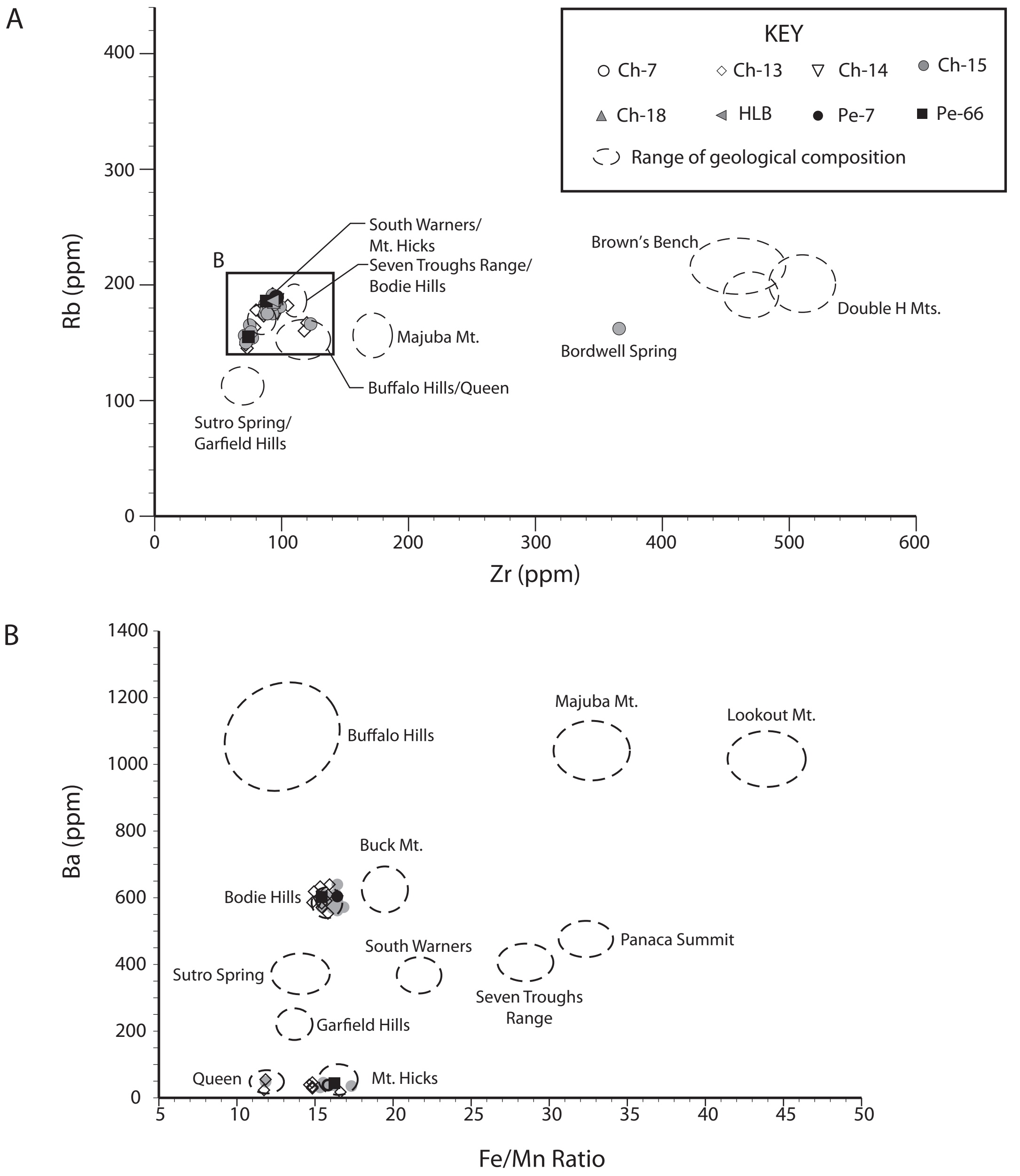


FIG. 33. Trace element composition of obsidian Humboldt Basal-notched bifaces from the lower Humboldt Valley (plotted from data in supplement 12). **A.** Rb vs. Zr composition for bifaces from eight archaeological sites and localities in the lower Humboldt Valley. **B.** Ba vs. Fe/Mn composition for bifaces undifferentiated by Rb/Zr composition.

As was the case with obsidian points conveyed from the north, the similarity among all these profiles suggests that there is no significant difference by time period or distance between and among obsidian projectile points manufactured from sources to the south of the lower Humboldt Valley (fig. 50).

Looking at the results solely on the basis of their distance and direction informs us about the homogeneity of points within each category (north vs. south), but what about the relationship between the two areas?

Figure 51 allows us a direct comparison. Because there were no statistically significant differences detected within the northern sources distribution nor within their southern counterparts, all points—regardless of type—were pooled into north/south bins. Apart from visual differences apparent in this figure, a K-S test shows that these distributions are significantly different (K-S D = 0.661 $>D_{0.01}$ = 0.155) and that they were drawn from statistical populations with different distance profiles. Whereas local (<100 km) sources dominate the northern group, sources >161 km to the south comprise a greater relative frequency than was observed for the same distance in the north.

Comparisons by Distance

To investigate whether differences exist within distance categories, the nonlocal obsidian point frequencies in table 9 were stratified by artifact series, direction, and distance from the lower Humboldt Valley sites. Direction and distance-to-source data appear in table 2.

A total of 20 obsidian Northern Side-notched points were identified in the lower Humboldt Valley, making statistical comparison of their sourcing results less secure than for other better-represented point types. Eleven of these large dart points were made from the most proximate "local" sources and nine others from sources at varying distances to the north. Only three Northern Side-notched points were made from southern obsidian sources, two from Bodie Hills and one from Mt. Hicks.

As noted previously, projectile points from nonlocal sources can be considered largely in two distance-bounded groups; volcanic glasses erupted closer to the lower Humboldt Valley (ca. 100–160 km), and those farther away (ca. 161–240 km). More distant sources (located between 241–299 and >300 km away) also were represented in the artifact inventory. Of these very distant glasses, four match the chemical signature of Malad, Idaho, obsidian, which erupted nearly 600 km to the northeast in southern Idaho (see fig. 1). Eighteen artifacts from sources located >240 km from the lower Humboldt Valley (nine each from southern and northern sources) were included in statistical analysis when they satisfied the requirements discussed above. Despite small numbers, it is noteworthy but perhaps not surprising that Desert Series points are the most frequently represented (39%; N = 7 of 18 specimens) in the very distant obsidian sources (>240 km) category in lower Humboldt Valley sites. Five artifacts were made from obsidian sources erupted to the east in Utah/eastern Nevada. Of this total, three were Desert series points and a Humboldt series point made from Panaca Summit (Modena area) obsidian, along with a small side-notched point made from Wild Horse Canyon volcanic glass.

The proximity of lower Humboldt Valley sites to artifact-quality obsidian of the Majuba Mountain chemical type vitiates a meaningful comparison of local north vs. south obsidian largely because, as figure 2 shows, the only obsidian source south of Majuba Mountain in the "local" distance category yields mainly small marekanite glass. The Truckee Meadows and Sutro Spring sources located south of the lower Humboldt Valley yield larger nodules, but their most intensive exploitation seems to have been in the Truckee area, the Carson River Valley, and near Reno. Consequently, the sections that follow examine point type distributions within and between distance categories by direction, then by arrow vs. dart categories.

The 101–160 km Distance Category: Data in table 9 allow us to address the questions:

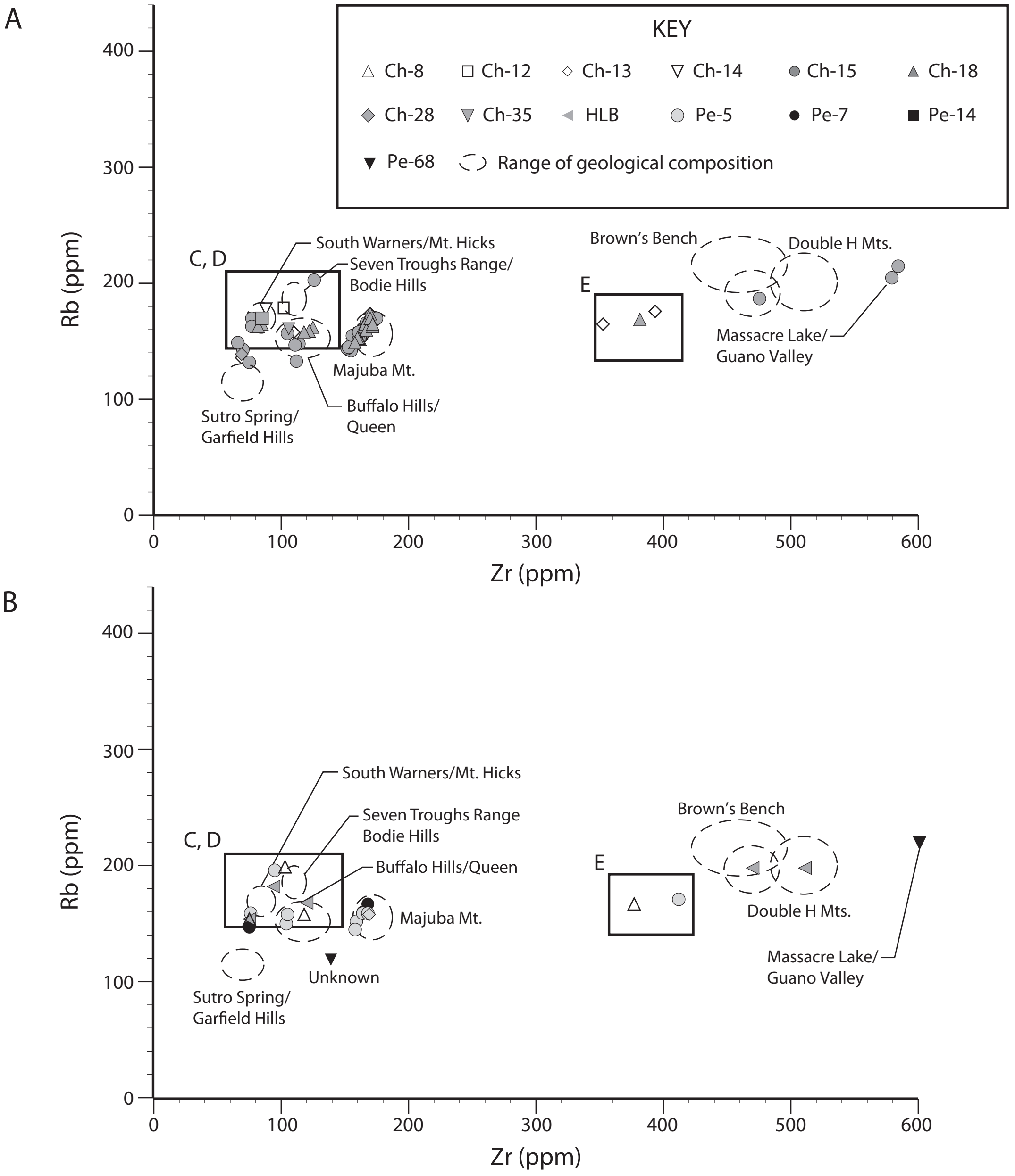
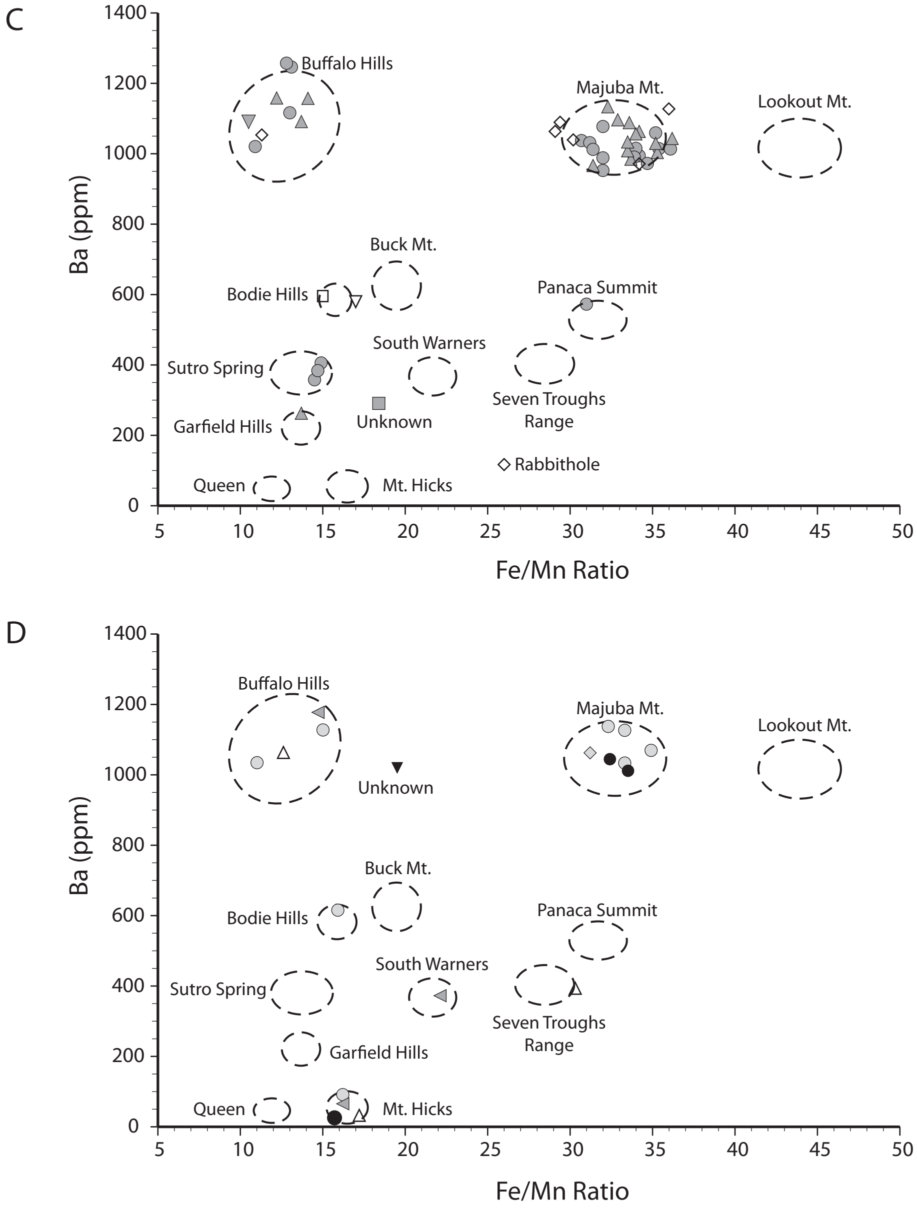
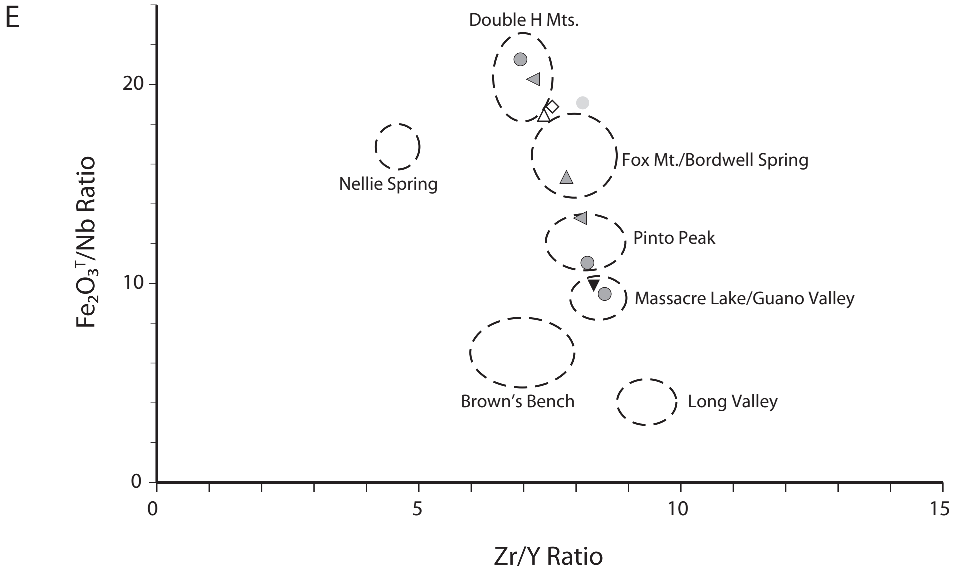


FIG. 34. Trace element composition of obsidian Humboldt series bifaces from the lower Humboldt Valley (*above and opposite page;* plotted from data in supplement 13). **A.** Rb vs. Zr composition for bifaces from eight archaeological sites and localities in the lower Humboldt Valley. **B.** Rb vs. Zr composition for bifaces from five archaeological sites and localities in the lower Humboldt Valley. **C.** Ba vs. Fe/Mn composition for bifaces undifferentiated by Rb/Zr composition. **D.** Ba vs. Fe/Mn composition for bifaces from five archaeological sites and localities undifferentiated by Rb/Zr composition. **E.** (*page 82*) $Fe_2O_3^T$/Nb vs. Zr/Y composition for obsidian Humboldt series bifaces undifferentiated by Rb vs. Zr and Ba vs. Fe/Mn composition.


C
Ba (ppm)
1400
1200
1000
800
600
400
200
0
Fe/Mn Ratio
5
10
15
20
25
30
35
40
45
50
Buffalo Hills
Majuba Mt.
Lookout Mt.
Buck Mt.
Bodie Hills
Panaca Summit
South Warners
Sutro Spring
Seven Troughs Range
Garfield Hills
Unknown
Rabbithole
Queen
Mt. Hicks
D
Ba (ppm)
1400
1200
1000
800
600
400
200
0
Fe/Mn Ratio
5
10
15
20
25
30
35
40
45
50
Buffalo Hills
Majuba Mt.
Lookout Mt.
Unknown
Buck Mt.
Bodie Hills
Panaca Summit
South Warners
Sutro Spring
Seven Troughs Range
Garfield Hills
Queen
Mt. Hicks



- Is there a directional difference between Desert Series points in the 101–160 km distance category? Yes; 19 of 24 (79%) came from northern sources.
- Is there a directional difference between Rosegate Series points in the 101–160 km distance category? Yes; 93% (80 of 86) derive from northern sources.
- Is there a directional difference between Elko Series points in the 101–160 km distance category? Yes; 82% (27 of 33) came from northern sources.
- Is there a directional difference between Gatecliff Series points in the 101–160 km distance category? Yes; 74% (24 of 31) came from northern sources.
- Is there a directional difference between Northern Side-notched points in the 101–160 km distance category? Yes; all four identified came from northern sources.

Summary: the vast majority of points 100–161 km distant from the lower Humboldt Valley, regardless of time period, were manufactured from obsidian source material located to the north of the valley.

The 161–240 km distance category. Again referring to the data in table 9, we can ask:

- Is there a directional difference between Desert Series points in the 161–240 km distance category? Yes; 55% (27 of 49) came from southern sources.
- Is there a directional difference between Rosegate Series points in the 161–240 km distance category? Yes; 67% (36 of 54) derive from northern sources.
- Is there a directional difference between Elko Series points in the 161–240 km distance category? Yes; 76% (29 of 38) came from southern sources.
- Is there a directional difference between Gatecliff Series points in the 161–240 km distance category? Yes; 68% (28 of 41) came from southern sources.
- Is there a directional difference between Northern Side-notched points in the 161–240 km distance category? No; two artifacts each came from northern and from southern sources.

Summary: the vast majority of Desert Series and Rosegate series points 161–240 km distant from the lower Humboldt Valley were made

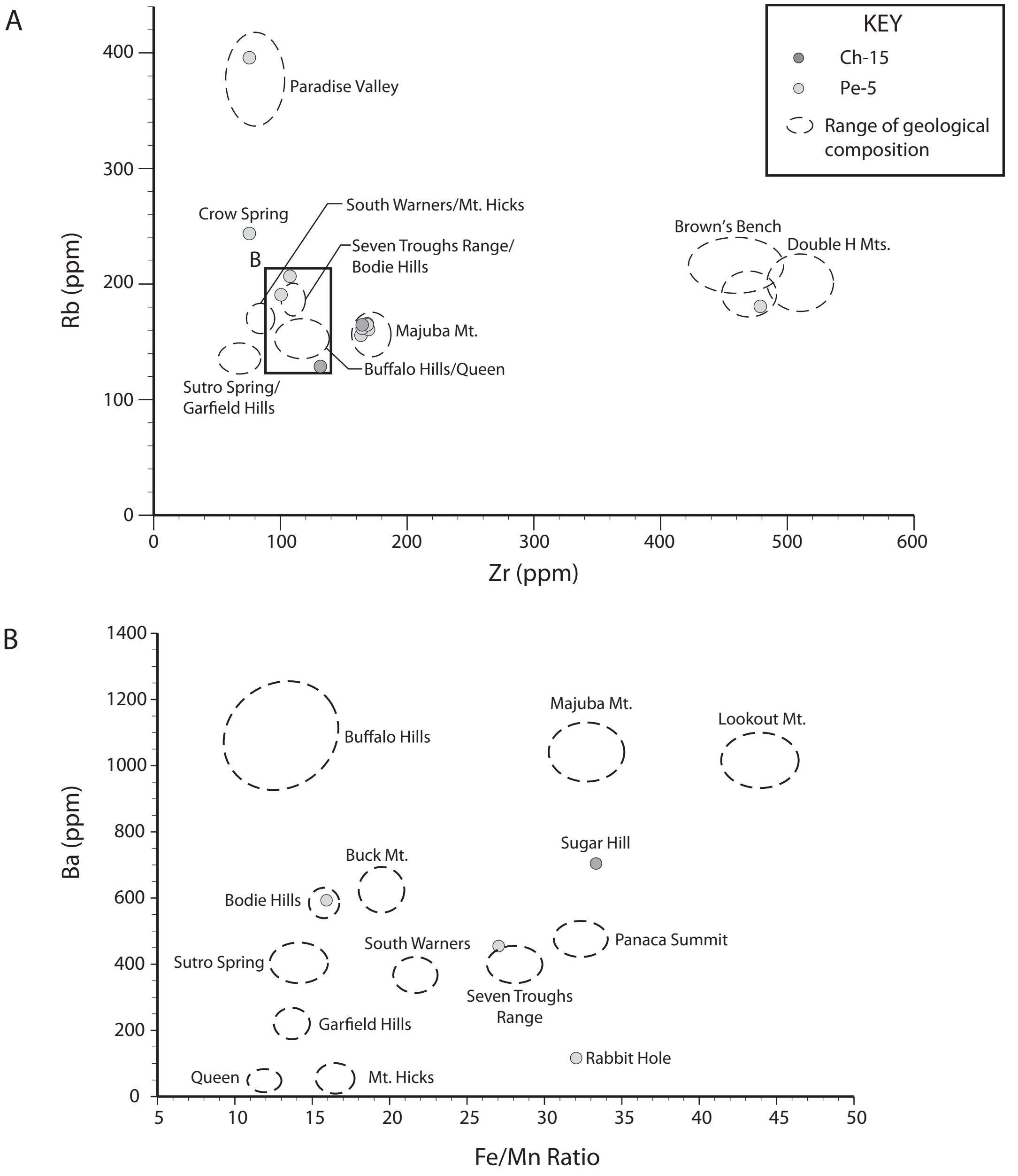


FIG. 35. Trace element composition of obsidian Carson series projectile points from the lower Humboldt Valley (plotted from data in supplement 14). **A.** Rb vs. Zr composition for projectile points. **B.** Ba vs. Fe/Mn composition for projectile points undifferentiated by Rb/Zr composition.

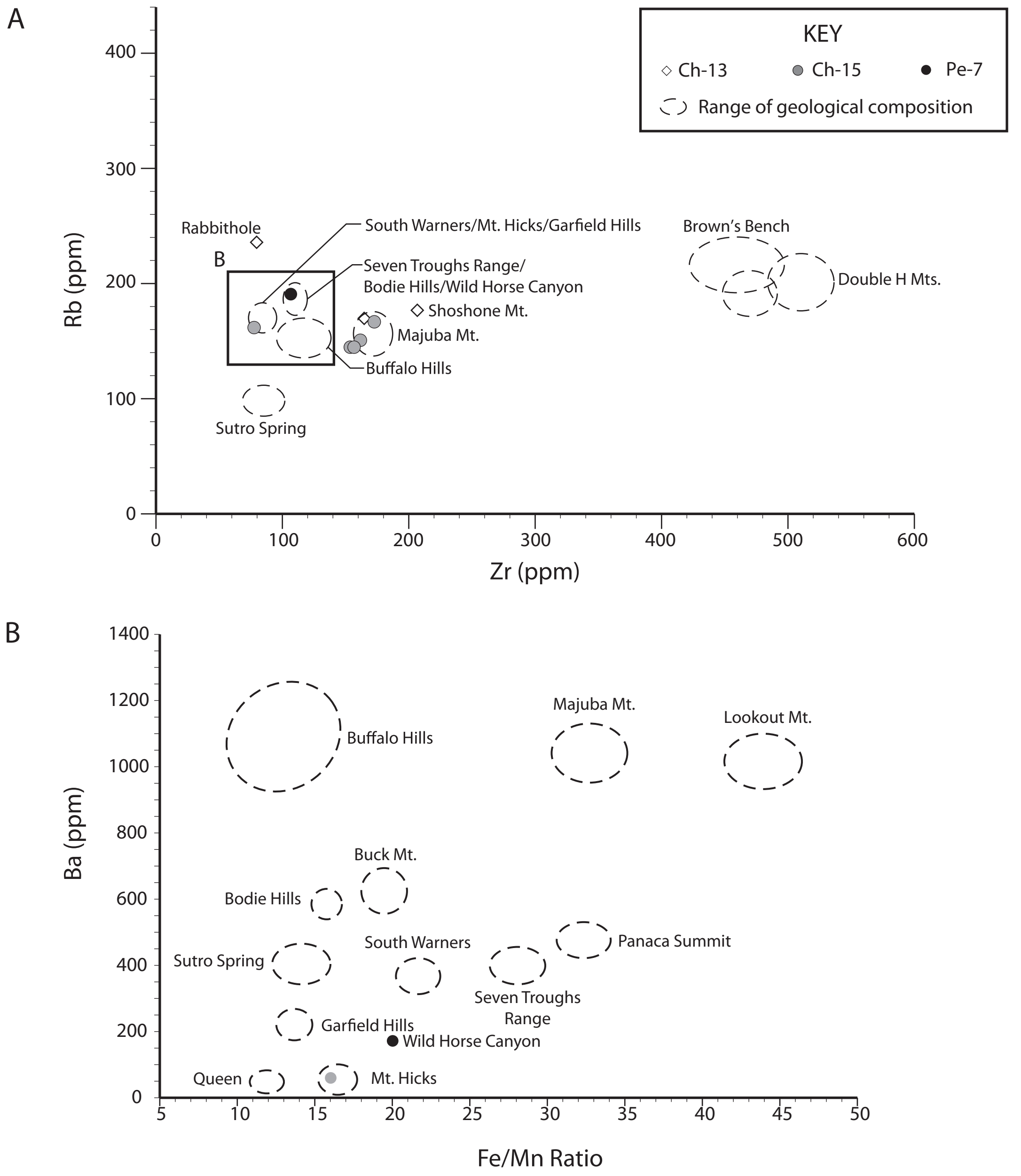


FIG. 36. Trace element composition of small side-notched obsidian points from the lower Humboldt Valley (plotted from data in supplement 15). **A.** Rb vs. Zr composition for small side-notched obsidian points. **B.** Ba vs. Fe/Mn composition for points undifferentiated by Rb/Zr composition.

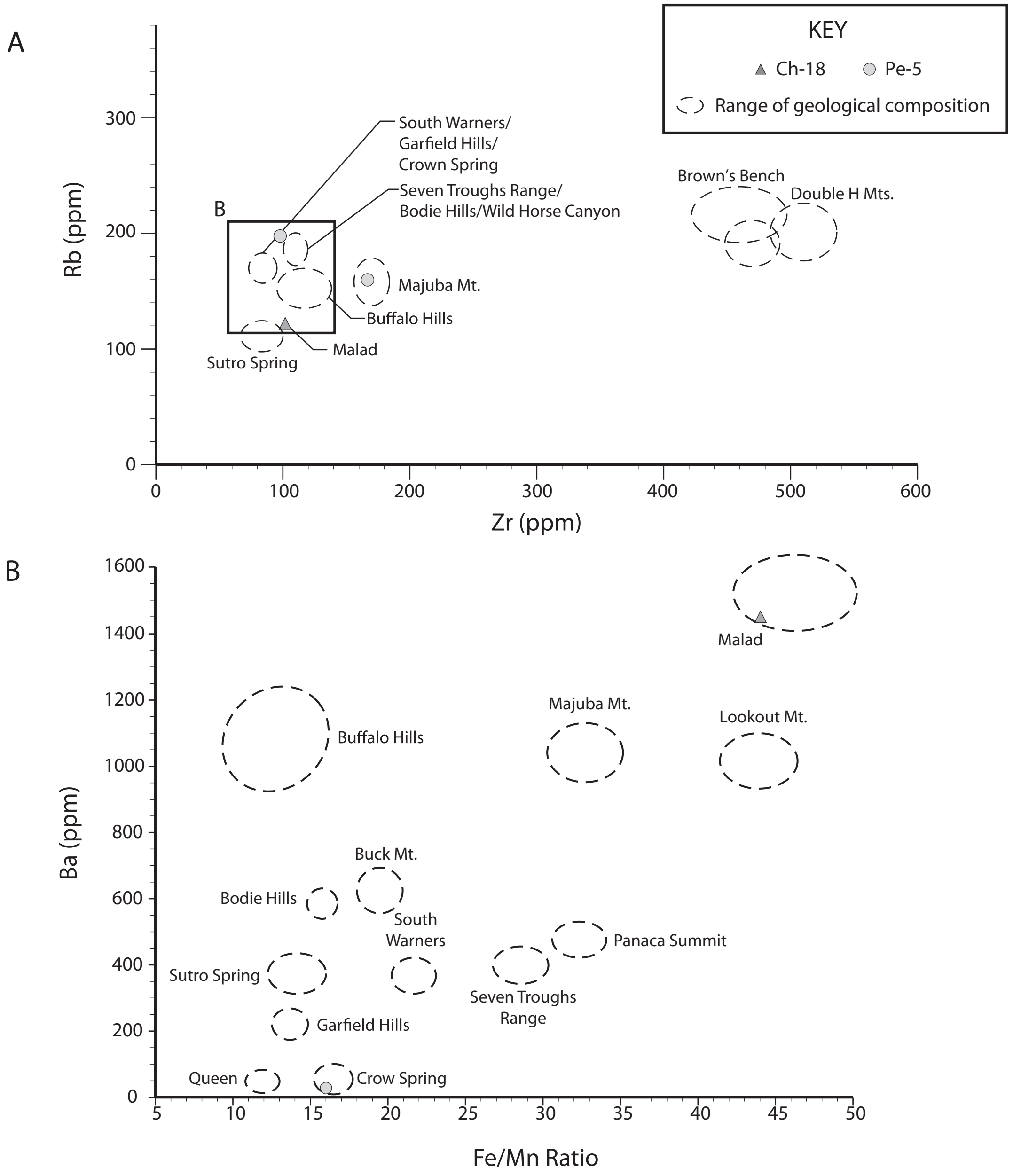


FIG. 37. Trace element composition of small corner-notched obsidian points from the lower Humboldt Valley (plotted from data in supplement 16). **A.** Rb vs. Zr composition for small corner-notched points. **B.** Ba vs. Fe/Mn composition for small corner-notched obsidian points.

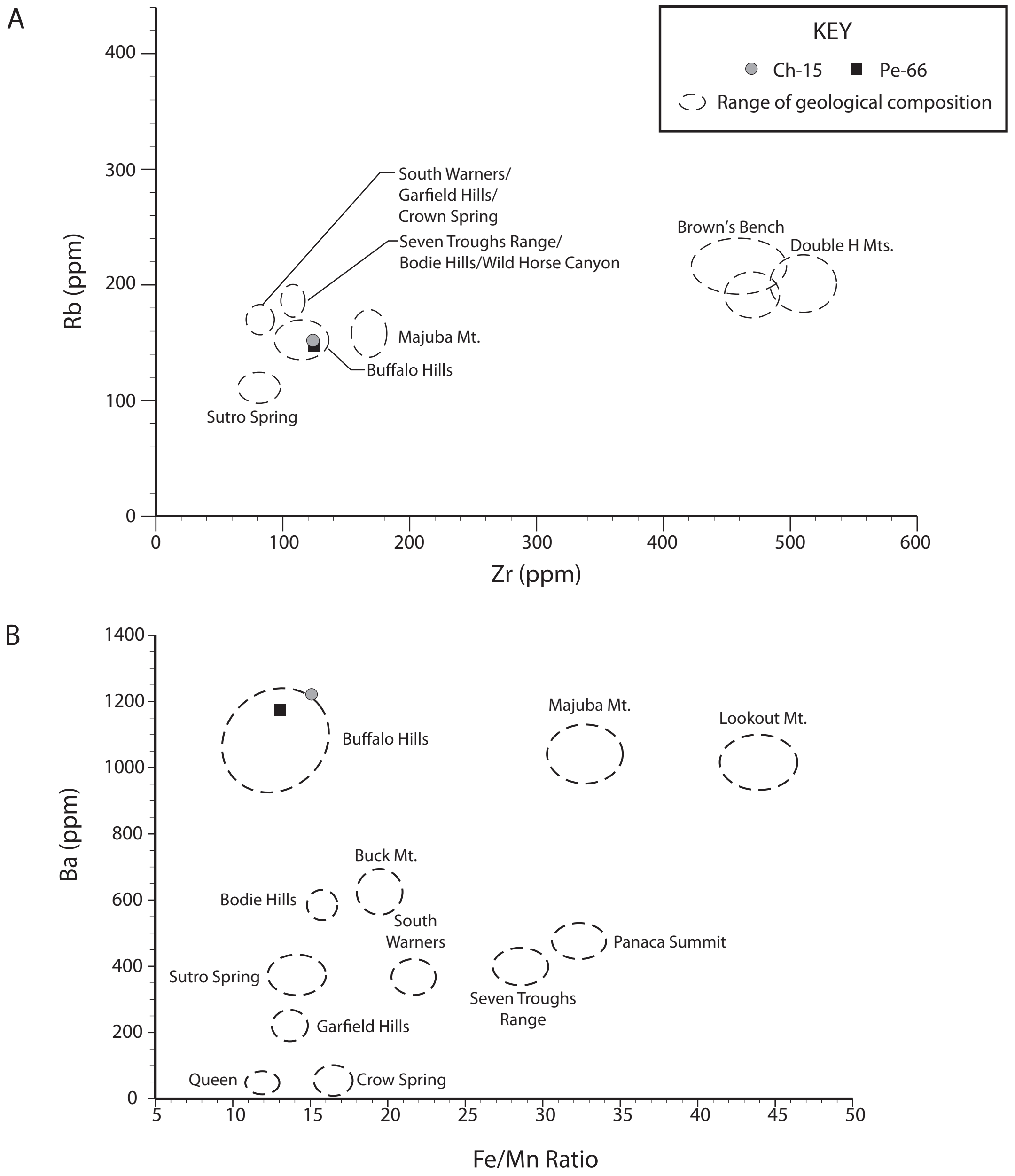


FIG. 38. Trace element composition of small stemmed obsidian points from the lower Humboldt Valley (plotted from data in supplement 17). **A.** Rb vs. Zr composition for small stemmed points from two archaeological sites and localities in the lower Humboldt Valley. **B.** Ba vs. Fe/Mn composition for small stemmed obsidian points.

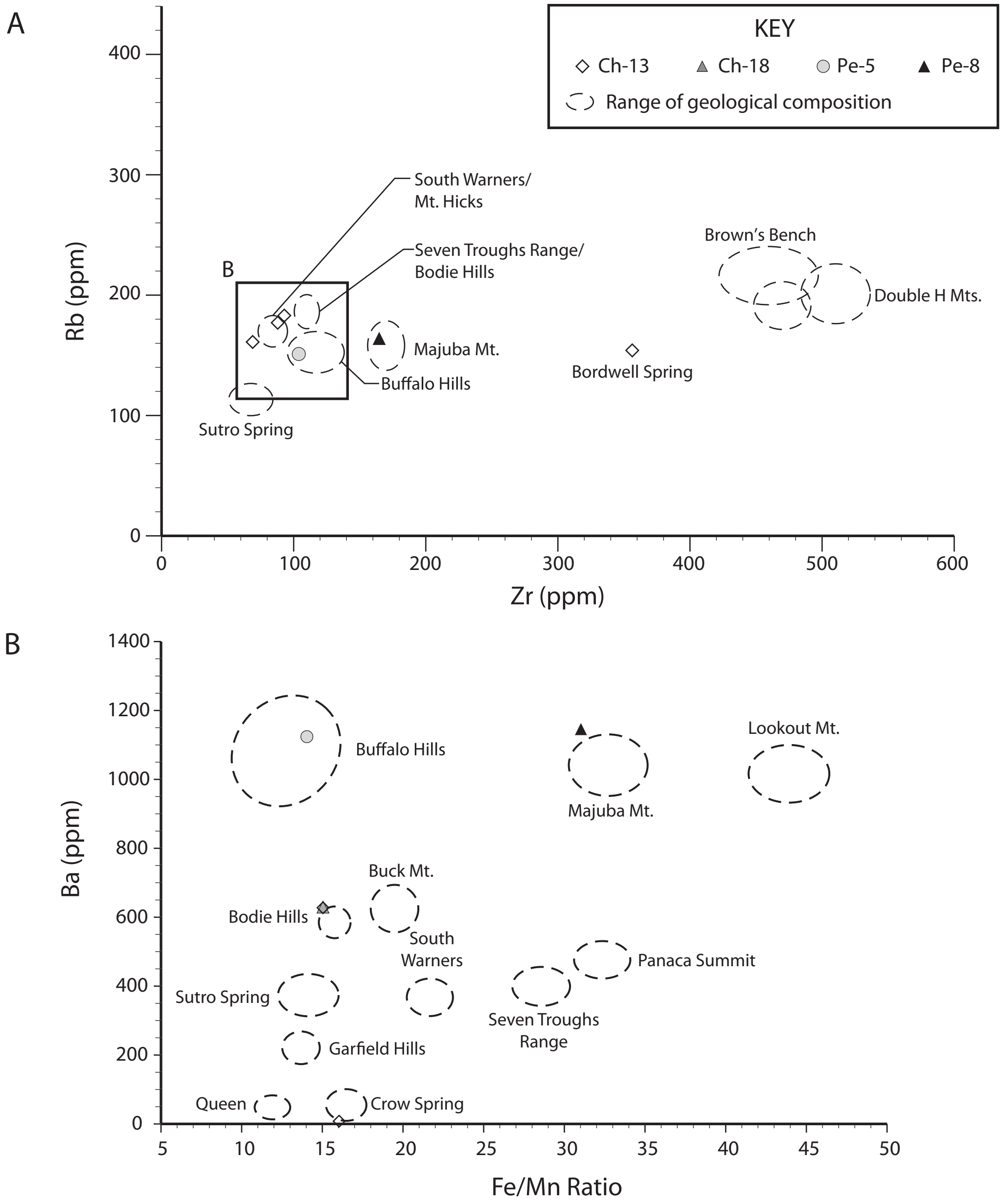


FIG. 39. Trace element composition of Concave base obsidian points from the lower Humboldt Valley (plotted from data in supplement 18). **A.** Rb vs. Zr composition for Concave base obsidian points. **B.** Ba vs. Fe/Mn composition for obsidian points.

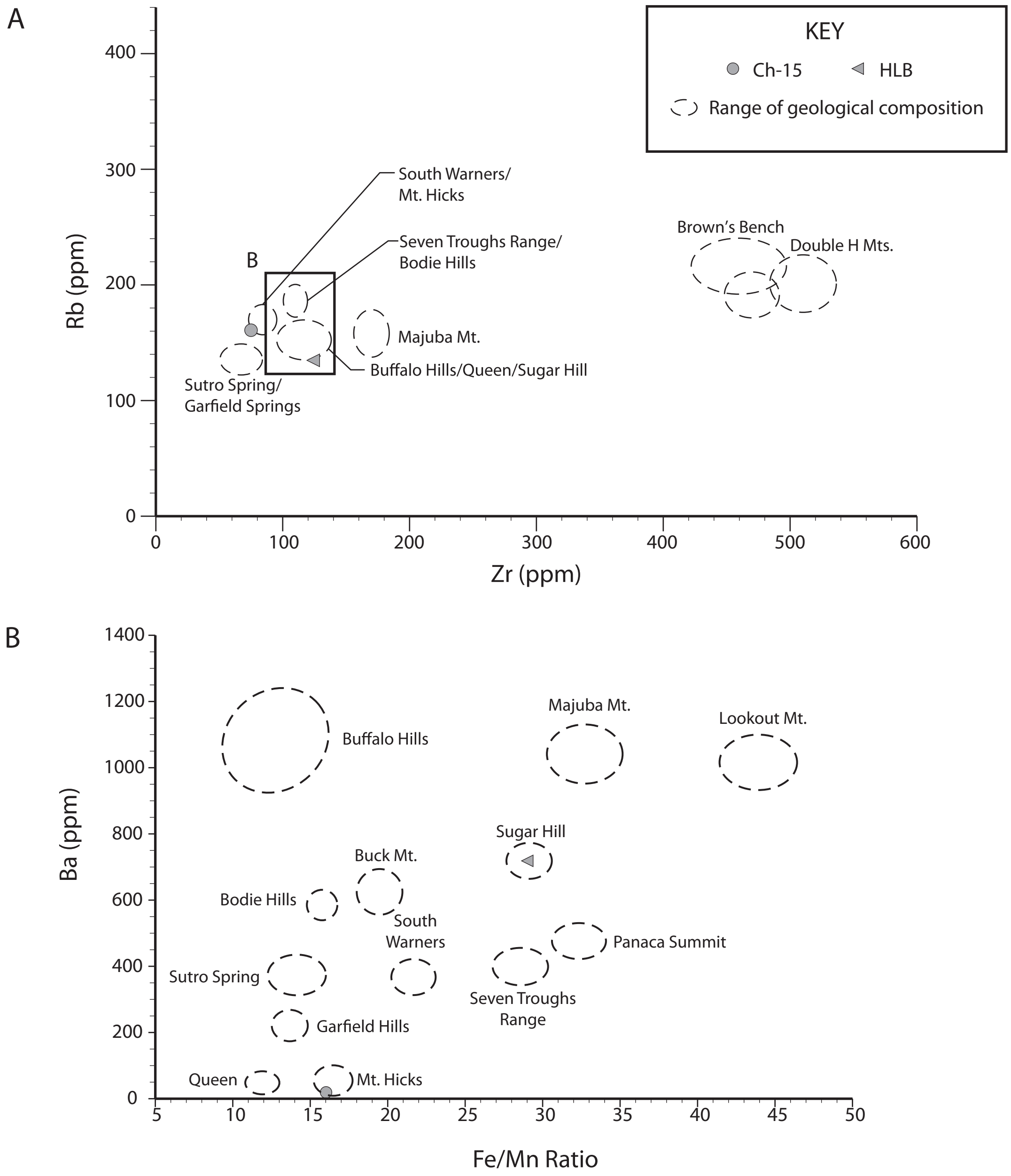


FIG. 40. Trace element composition of Great Basin Stemmed obsidian points from the lower Humboldt Valley (plotted from data in supplement 19). **A.** Rb vs. Zr composition for Great Basin Stemmed obsidian points from Ch-15. **B.** Ba vs. Fe/Mn composition for an obsidian point from Ch-15.

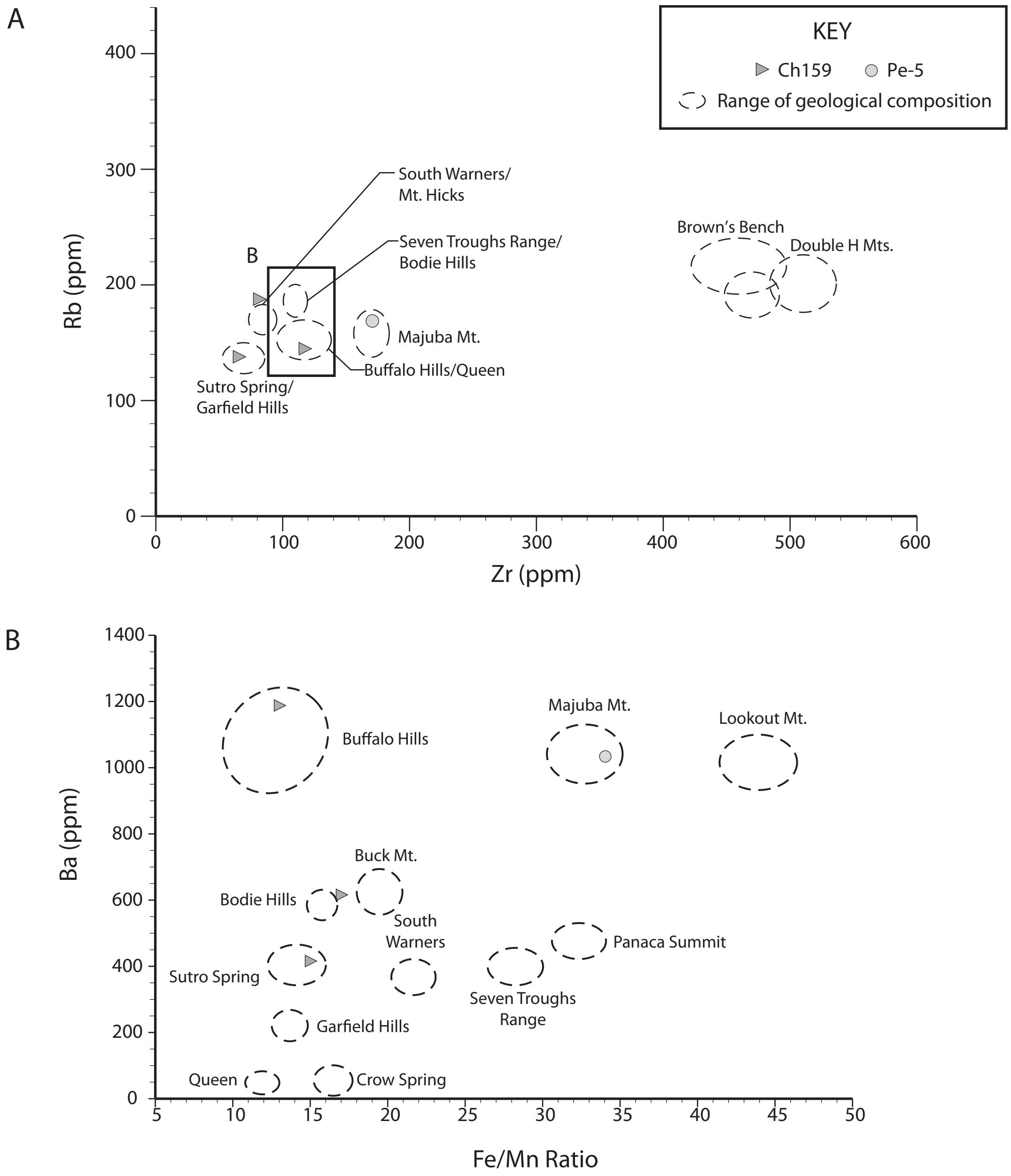


FIG. 41. Trace element composition of miscellaneous obsidian dart points from the lower Humboldt Valley (plotted from data in supplement 20). **A.** Rb vs. Zr composition for obsidian dart points. **B.** Ba vs. Fe/Mn composition for miscellaneous obsidian dart points.

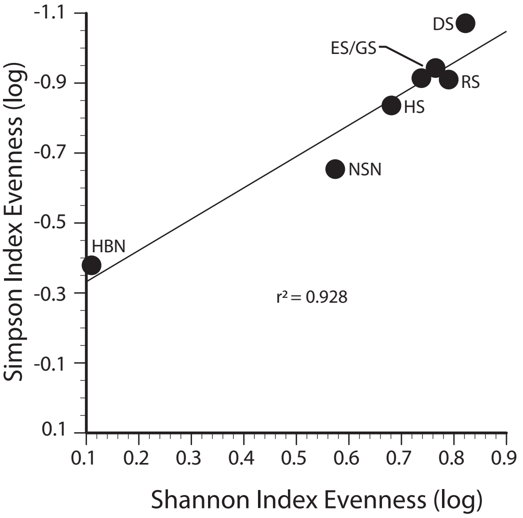


FIG. 42. Bivariate diagram of the relationship between Simpson and Shannon evenness measures for obsidian projectile points from the lower Humboldt Valley. Point type abbreviations follow those listed in table 4.

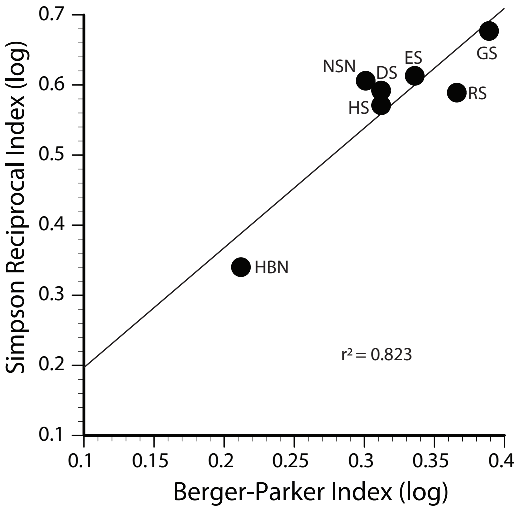


FIG. 43. Bivariate diagram of the relationship between Simpson and Berger-Parker index measures for obsidian projectile points from the lower Humboldt Valley. Point type abbreviations follow those listed in table 4.

from obsidian sources located to the north of the valley, while the preponderance of Elko and Gatecliff points came from obsidian sources located to the south.

INSIDE THE DISTANCE CATEGORIES

These differences can now be compared on the basis of geographic direction.

The 101–160 km Distance Category:

- Is there a difference in geographic direction (north vs. south) within the Desert Series? A Fisher's Exact test of the data in table 9 shows that there is no statistical difference between Cottonwood Triangular and Desert Side-notched points in this distance category ($p = 0.544$).
- Is there a directional difference (north vs. south) between Desert Series and Rosegate Series points in the 100–160 km distance category? A Fisher's Exact test of the data in table 9 shows that there is no statistical difference between them at the 0.05 alpha level ($p = 0.598$).
- Is there a directional difference (north vs. south) between Rosegate Series and Elko Series points in the 100–160 km distance category? A chi-square analysis of the frequencies in table 9 suggests that these distributions are not statistically significant ($\chi^2 = 3.302$, $p = 0.06$).
- Is there a directional difference (north vs. south) between Elko Series and Gatecliff Series points in the 100–160 km distance category? No. These distributions could represent the same statistical population ($\chi^2 = 0.191$, $p = 0.662$).
- Is there a directional difference (north vs. south) between Gatecliff Series and Northern Side-notched points in the 100–160 km distance category? Few Northern Side notched points occurred within this distance category but the results show that Gatecliff Series and Northern Side-notched points could have been drawn

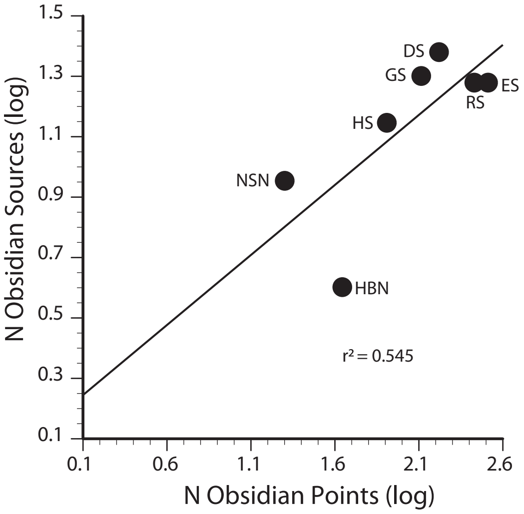


FIG. 44. Bivariate diagram of the relationship between the numbers of obsidian sources and the number of time-sensitive obsidian points from the lower Humboldt Valley. Data from tables 7 and 8. Point type abbreviations follow those listed in table 4.

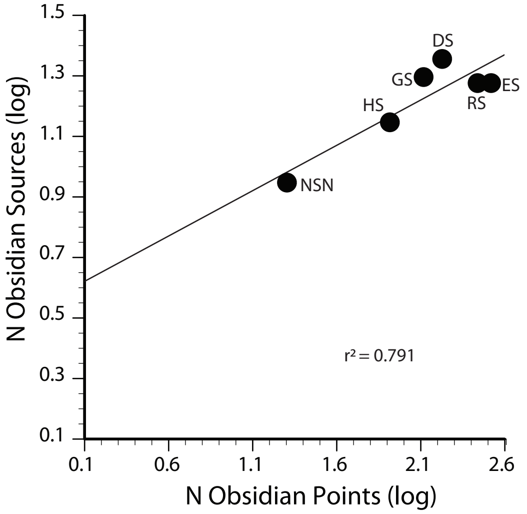


FIG. 45. Bivariate diagram of the relationship between the numbers of obsidian sources and the number of time-sensitive obsidian points from the lower Humboldt Valley excluding Humboldt Basal-notched bifaces. Data from tables 7 and 8. Point type abbreviations follow those listed in table 4.

from the same underlying population (Fisher's Exact p = 0.562).

- Are there overall differences (north vs. south) among time-sensitive points in the 100–160 km category? Comparing the occurrences for all time-sensitive points in table 9 (except very small Northern Side-notched point frequencies) shows no statistically significant difference (χ^2 = 6.909, p = 0.749; K-S D = 0.283 <$D_{0.05}$ = 0.299).

Summary: there were no significant differences by north-south direction in the 100–161 km category between Desert series and Rosegate series, between Rosegate and Elko series, or between Elko and Gatecliff points.

THE 161–240 KM DISTANCE CATEGORY

- Is there a directional difference (north vs. south) between Desert Series and Rosegate Series points in the 161–240 km distance category? The data from table 9 suggests that these distributions represent different statistical populations (χ^2 = 4.948, df = 1, p = 0.026; φ = 0.219). Most of the chi-square variability (29.5%) is due to the overrepresentation of Desert series points from southern sources (N = 27 observed vs. 21 expected), and another 26.9% to the underrepresentation of Rosegate series points from southern sources (N = 18 observed vs. 24 expected).
- Is there a directional difference (north vs. south) between Rosegate Series and Elko Series points in the 161–240 km distance category? A chi-square analysis of the frequencies in table 9 suggests that they represent different statistical populations (χ^2 = 16.491, p = <0.001; φ = 0.423). Elko points from southern sources are overrepresented (N = 29 observed, vs. 19 expected; 28.7% of the chi-square variability) and, conversely, those from northern sources are underrepresented (N = 9 observed vs. 19 expected; 30% of the chi-square variability).

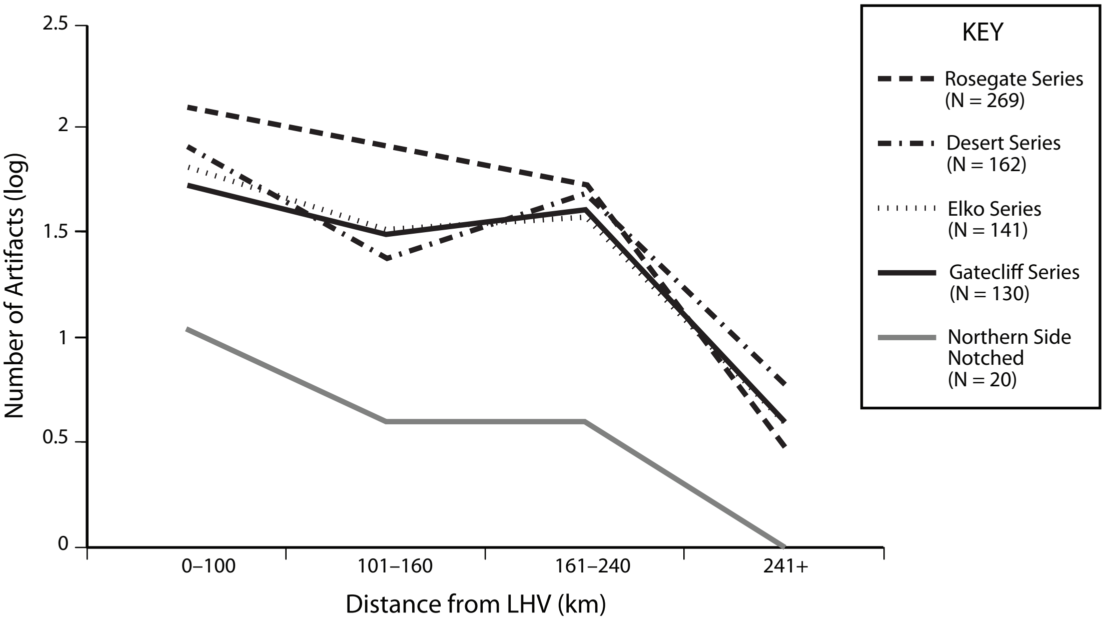


FIG. 46. The relationship between numbers of time-sensitive obsidian points and the distance to obsidian sources used in their manufacture. Data from table 9.

- Is there a directional difference (north vs. south) between Elko Series and Gatecliff Series points in the 161–240 km distance category? The data from table 9 support the conclusion that these distributions could represent the same statistical population ($\chi^2 = 0.631$, $p = 0.427$).
- Are there overall differences (north vs. south) among time-sensitive points in the 161–>240 km category? Table 9 frequencies reveal a very significant difference among them ($\chi^2 = 20.160$, df = 3, $p = <0.001$; $\varphi = 0.333$; K-S $D = 0.273 > D_{0.01} = 0.243$). In this case 56% of the chi-square variability is due to the overrepresentation of Rosegate series points from the north (N = 36 observed vs. 24 expected) and their underrepresentation in sources from the south (N = 18 observed vs. 30 expected). Northern Side-notched point frequencies were not considered due to small sample size.

Summary: A significant difference by north-south direction in the 161–>240 km category was identified between Desert series and Rosegate series, and between Rosegate and Elko points. Elko and Gatecliff point distributions were not different, and could have been drawn from the same statistical population. However, unlike the northern source group, in which fall-off by distance was evident, the artifacts in the southern group show just the opposite tendency—closer sources are much less frequently represented than those located farther away. This distinction is documented further below.

North/South Nonlocal Sources Frequencies Compared

Comparisons between these northern and southern areas reveals something quite different than either result alone.

Again drawing on data in table 9, a 2×2 contingency analysis shows a significant difference ($\chi^2 = 8.101$, df = 2, $p = 0.017$; $\varphi = 0.318$), between

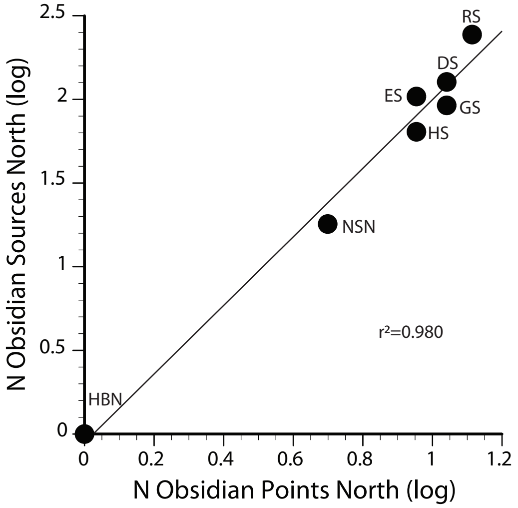


FIG. 47. Bivariate diagram of the relationship between the numbers of time-sensitive obsidian points and the number of obsidian sources located north of the lower Humboldt Valley. Data from tables 2 and 7. Point type abbreviations follow those listed in table 4.

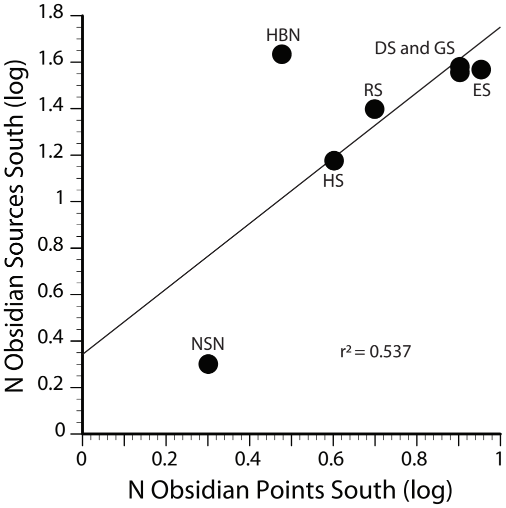


FIG. 48. Bivariate diagram of the relationship between the numbers of time-sensitive obsidian points and the number of obsidian sources located south of the lower Humboldt Valley. Data from tables 2 and 7. Point type abbreviations follow those listed in table 4.

Desert Series points from the north and those from the south between 101–160 km and >161 km of the lower Humboldt Valley, where 69.9% of the combined chi-square variability is due to the underrepresentation of Desert Series points from southern sources 101–160 km distant (N = 5 observed vs. 11 expected) and the overrepresentation (N = 19 observed vs. 13 expected) in the northern distance category. However, a K-S test does not support the significance of this result ($D = 0.220 < D_{0.05} = 0.288$).

Rosegate series points also differ by geographic direction in these distance categories ($\chi^2 = 16.507$, df = 1, p = <0.001; $\varphi = 0.340$), with 47% of the chi-square variability due to the overrepresentation of points from southern sources 161–>240 km distant (N = 19 observed vs.10 expected), and another 33% by underrepresentation in 161–240 km distant southern sources (N = 6 observed vs. 15 expected). A K-S test supports the significance of this result ($D = 0.438 > D_{0.01} = 0.359$).

Elko series points also vary ($\chi^2 = 20.992$, df = 1, p = >0.001; $\varphi = 0.529$). In this case 29% of the chi-square variability due to the underrepresentation of points from southern sources 101–160 km distant (N = 6 observed vs.16 expected), and their overrepresentation in 101–161 km distant northern sources (N = 27 observed vs. 17 expected; 27% of the chi-square variability).

Gatecliff series points vary along the same dimensions as do Elkos; ($\chi^2 = 15.745$, df = 1, p = >0.001; $\varphi = 0.455$), with 59% of the chi-square variability due to the combined effect of underrepresentation of points from southern sources 101–160 km distant (N = 5 observed vs.16 expected), and their overrepresentation in sources 101–161 km distant to the north (N = 24 observed vs. 16 expected).

Very few Northern Side-notched points were recorded in these distance bins, but a Fisher's Exact test the observed frequencies are not statistically significant (p = 0.444).

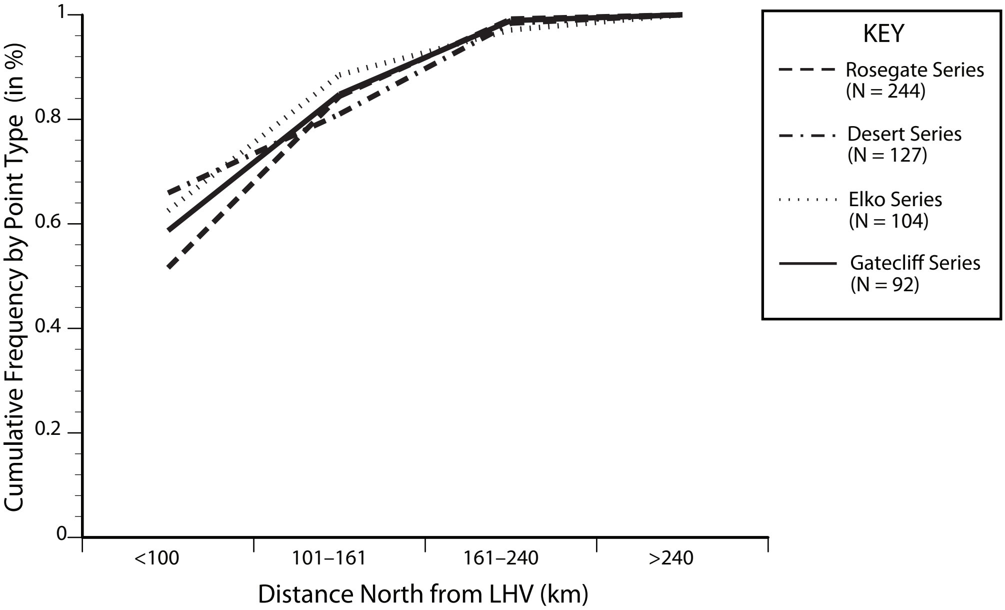


FIG. 49. Bivariate diagram of cumulative frequencies of all time-sensitive obsidian points and distance to obsidian sources located north of the lower Humboldt Valley. Data from table 9.

NONLOCAL DIRECTION AND DISTANCE CATEGORIES COMPARED

We can now combine all nonlocal distance categories to investigate the impacts of geographic direction through time (see table 12). As noted above, the small frequencies of specimens from >240 km distant were pooled into a single category (161–>240) for these analyses. Figures 49 and 50 illustrate the distributions detailed below.

- Is there a difference between Desert Series and Rosegate Series points from the north? Yes. A 2×2 contingency table indicates that these distributions represent different statistical populations (χ^2 = 8.171, p = 0.004; φ = 0.225), though it is not judged significant by a K-S test. The majority of chi-square variability (61%) derives from more Desert Series points from the 161–>240 south (N = 25 observed vs. 17 expected) and relatively fewer Rosegate artifacts from the same distance category south (N = 38 observed vs. 46 expected; 25%).
- Is there a difference between Rosegate and Elko Series points from the north? No. A 2×2 contingency table indicates that these distributions could represent the same statistical population (χ^2 = 0.028, p = 0.867).
- Is there a difference between Elko Series and Gatecliff Series points from the north? No. A 2×2 contingency table indicates that these point frequencies are randomly distributed (χ^2 = 0.317, p = 0.573).
- Is there a difference between Gatecliff Series and Northern Side-notched points from the north? No. Although the sample of Northern Side-notched points is extremely small, a Fisher's Exact test (p = 1.00) indicates that these frequency distributions could have arisen by chance.
- Is there a difference between Desert Series and Rosegate Series points from the south? No. A 2×2 contingency table indicates that these frequency distributions

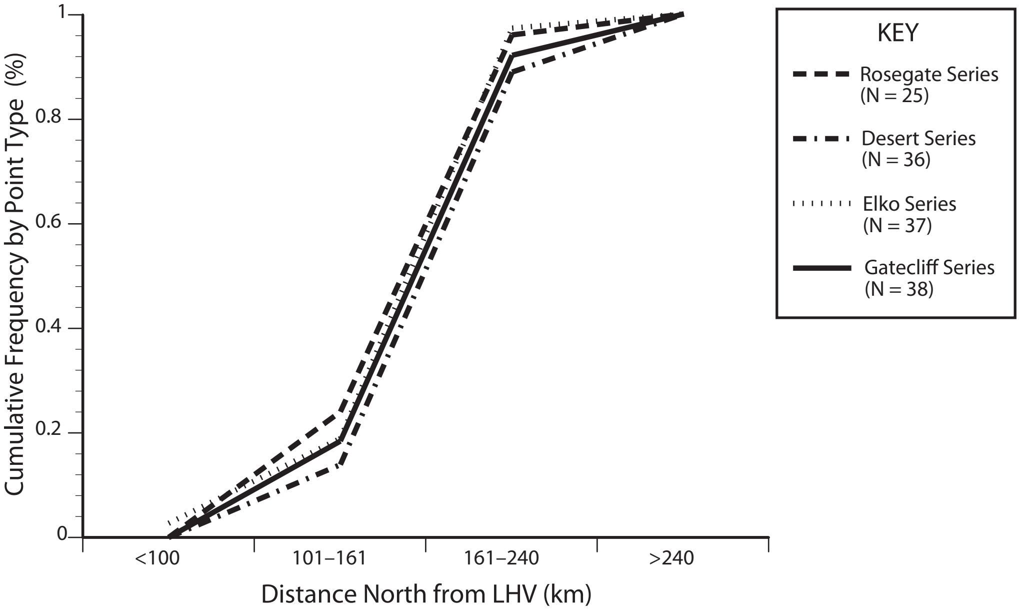


FIG. 50. Bivariate diagram of cumulative frequencies of all time-sensitive obsidian points and distance to obsidian sources located south of the lower Humboldt Valley. Data from table 9.

could have been drawn from the same underlying statistical population (χ^2 = 1.021, p = 0.312).

- Is there a difference between Rosegate and Elko Series points from the south? No. A 2×2 contingency table indicates that these distributions could represent the same statistical population (χ2 = 0.502, p = 0.479).
- Is there a difference between Elko Series and Gatecliff Series points from the south? No. A 2×2 contingency table indicates that these frequency distributions could have been drawn from the same underlying statistical population (χ2 = 0.039, p = 0.842).
- Is there a difference between Gatecliff Series and Northern Side-notched points from the south? No. Although the sample of Northern Side-notched points is extremely small, a Fisher's Exact test (p = 1.00) indicates that these frequency distributions could have arisen by chance.

Arrows vs. Darts

The data in table 12 can be used to investigate the potential relationship between distance and weapon armament. Desert and Rosegate series points are combined into an "arrow" category, and Elko, Gatecliff series, and Northern Side-notched are categorized as "darts." Comparisons are made using the three predominant (0–100, 101–161, >161 km) distance categories.

Is there a difference in the distance and direction arrow points were made? Yes. A 2×3 chi-square test indicates that these distributions represent significantly different statistical populations (χ^2 = 120.48, p = <0.001, df = 2, Cramer's V = 0.528; K-S D = 0.650 >$D_{0 \cdot 01}$ = 0.225). Here the majority of chi-square variability is due to the complete absence of arrow points made from local (1–100 km) southern obsidian source material.

Is there a difference in the distance and direction dart points were made? Yes. These distributions also represent nonrandomly distributed statistical populations (χ^2 = 127.471, p = >0.001; df = 2; Cramer's V = 0.663; K-S D =

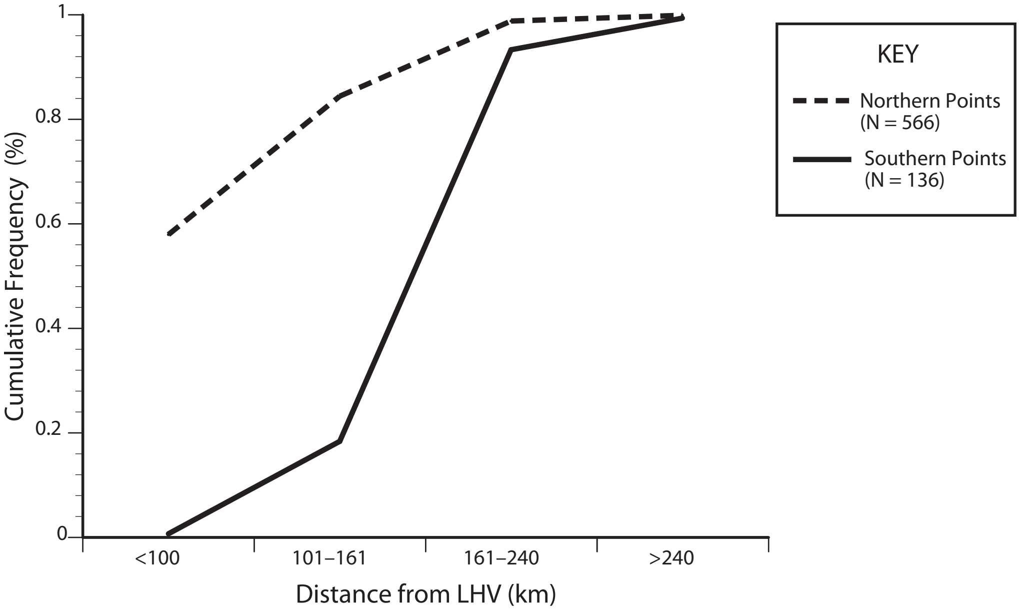


FIG. 51. Bivariate diagram of the cumulative frequencies of all time-sensitive obsidian points by distance to obsidian sources identified in archaeological collections from the lower Humboldt Valley. Data from table 9.

$0.678 > D_{0 \cdot 01} = 0.219$). Seventy-three percent of the chi-square variability here is attributable to the overrepresentation of dart points from southern sources >161 km distant (N = 61 observed vs. 23 expected) and 25% to the underrepresentation of darts 0–100 km south (N = 1 observed vs. 34 expected).

Additional data can be invoked that contribute finer detail to these generalizations. For example: Elko series points differ by distance and direction ($\chi^2 = 63.765$, df = 2, p = <0.001; $\varphi = 0.675$), with 51% of the chi-square variability due to the overrepresentation of points from >161 south (N = 28 observed vs. 10 expected) and their underrepresentation in the local (<100 km south) category (N = 1 observed vs. 17 expected). Gatecliff series points differ significantly ($\chi^2 = 57.18$, df = 2, p = <0.001; $\varphi = 0.663$) with most of the chi-square variability due to the absence of any points from local southern sources.

Combining Elko and Gatecliff results, a chi-square test ($\chi^2 = 120.975$, df = 2, p = <0.001; $\varphi = 0.669$) indicates a very significant difference.[26] Forty-seven percent of the overall chi-square total consists of the overrepresentation of dart points in the southern >161 km distance category (N = 59 observed vs. 23 expected) and another 25% is attributable to the underrepresentation of these dart forms in the local northern distance group (N = 1 observed vs. 33 expected). K-S test results also support the conclusion that these north/south distributions represent different statistical populations (D = 0.676 $> D_{0.01} = 0.223$).

If these totals are combined to include all points from nonlocal sources that are most likely arrow points (i.e., small corner-notched [n = 3], small stemmed [n = 2], small side-notched [n = 2], and Carson points [n = 4]) and those that are most likely dart points (n = 3), the preceding pattern becomes even more pronounced.[27]

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[26] Because of small sizes in the >240 km category, these occurrences were pooled with data in the 161–240 km category.

[27] Including these specimens, the difference in geographic direction between arrow points from southern and from northern sources remains very significant ($\chi^2 = 35.055$, df = 1, p = <0.001; $\varphi = 0.387$; K-S D = 0.434 $> D_{0.01} = 0.239$; $N_1 = 170$;

TABLE 12

Distance and Direction from Archaeological Sites and Localities in the Lower Humboldt Valley

See table 9 legend for excluded specimens.

	Local (< 100 km) Obsidian		Obsidian 101–160 km Distant		Obsidian 161–>240 km Distant		Total
Point Type	North	South	North	South	North	South	
Desert Series	84	0	19	5	25	31	164
Rosegate Series	126	0	80	6	38	19	269
Elko Series	66	1	27	6	12	28	140
Gatecliff Series	54	0	24	7	14	31	130
Northern Side-notched	11	0	4	0	3	2	20
Artifact Class							
Arrow	210	0	99	11	63	50	433
Dart	131	1	55	13	29	61	290

Summary of Nonlocal North/South Distributions: The north-south comparison yielded evidence for contrasting patterns by distance and by time period (fig. 52). The northern group—regardless of time period—shows consistent use of closer obsidian sources (those ca. 0–100 km distant) during the time arrow points were in use. These data show that as distance to the north increases fewer specimens were made from those sources— a “fall-off” pattern reflecting increasing distance (Renfrew, 1975, 1977). By contrast, data from southern sources show the opposite—the few closer sources (those ca. 75–160 km distant) were used much less frequently to make arrows than those located at greater distance (ca. 161–240 km), and darts were more frequently made from these distant (160–>240 km) glasses than from those to the north.

COMPARING THE DISTRIBUTIONS OF NONTIME MARKERS

Although the focus of this study is on possible temporal/spatial changes in the conveyance of obsidian points in the lower Humboldt Valley, a significant number of points were analyzed that do not currently enjoy time-marker status in the Great Basin. Table 8 shows that the two most frequently identified in this study are Humboldt Concave Base (Humboldt series) and Humboldt Basal-notched. Even though we can’t assign restricted temporal ranges to either form (but see below) the sample sizes for both types can be examined to see if any distance or directional trends exist.

Humboldt Series Points: Are there direction/distance differences (north vs. south) in Humboldt Series points? Data presented in table 13 and figure 53 show that no Humboldt series point were made from obsidian sources located >240 km distant, and a K-S test shows that the observed frequencies among all distance categories are significantly different (K-S D = 0.593 >$D_{0.01}$ = 0.468). Humboldt Concave Base points were overwhelmingly made from northern (local) sources <100 km distant.

Humboldt Basal-notched Points: Are there direction/distance differences (north vs.

N_2 = 64). Here 73% of the chi-square variability is due to the underrepresentation of arrows from southern sources (N = 11 observed vs. 31 expected) and their overrepresentation in the 161–240 category (N = 53 observed vs. 33 expected). The same overall pattern holds for dart points (χ^2 = 38.142, df = 1, p = <0.001; φ = 0.483; K-S D = 0.481 >$D_{0.01}$ = 0.256; N_1 = 85; N_2 = 78). In this case 62% of the overall chi-square variability is due to the overrepresentation of darts from nearby northern sources (N = 56 observed vs. 37 expected, and their underrepresentation in sources 101–160 km to the south (N = 14 observed vs. 34 expected).

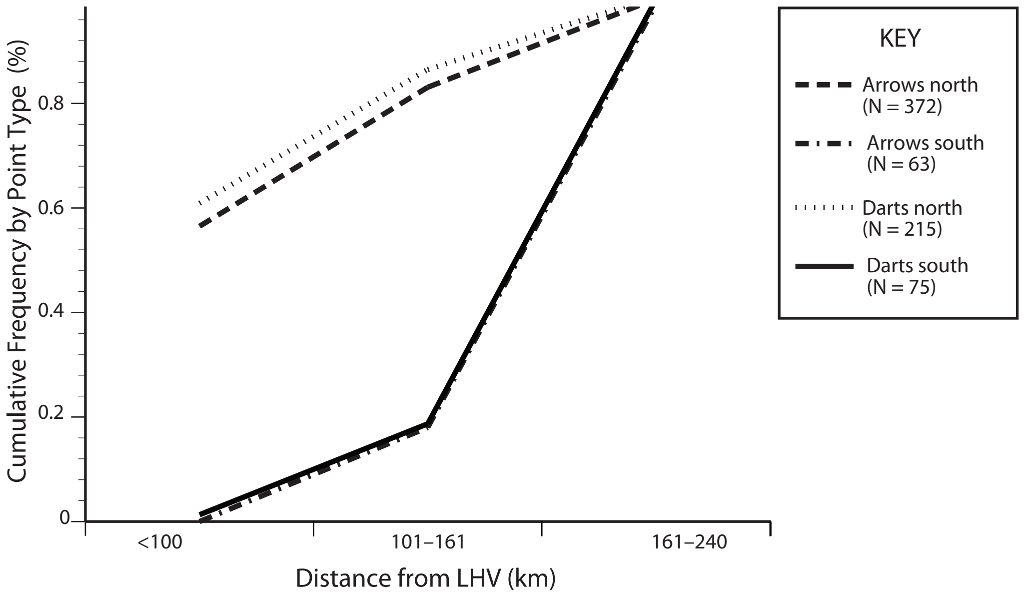

FIG. 52. Cumulative frequency of arrow points and dart points by direction and distance from the lower Humboldt Valley. Data from table 12.

south) evident in Humboldt Basal-notched points? As was the case with Humboldt Concave Base points, the data in table 13 show that no Humboldt Basal-notched points were identified from obsidian sources located >241 km distant. No statistical tests are necessary here. Forty-three of 44 Humboldt Basal-notched points were made from three southern obsidian sources (Bodie Hills, Mt. Hicks, and Queen) located between 160–240 km south of the lower Humboldt Valley (table 8).

CONTEXTUAL CONSIDERATIONS

The differing nonlocal north and south patterns identified here can be more broadly considered and contextualized. As previously noted, at the local level there is no southern counterpart to the nearby northern Majuba Mountain material. Other artifact-quality sources do occur, but they contain smaller nodules and appear to have been exploited infrequently in the lower Humboldt Valley. Buffalo Hills (a northern source) is only about 25 km farther from the lower Humboldt Valley than Sutro Spring (a southern source) yet this latter, closer source, is never numerically dominant in the lower Humboldt Valley, although it was heavily used father south in the Truckee Meadows area (Hutchins and Simons, 2000). In addition, the distances between and among nonlocal categories are significant—much greater than could reasonably be expected for people to travel on a regular basis.

For example, on the basis of worldwide data, Steward (1936: 333) generalized that: “The area which the band can conveniently forage averages some 100 square miles and seldom exceeds 500 square miles, a tract roughly 20 miles to a side,” while Binford’s (2001: table 8.04) data compilation on North American foragers in “desert and desert scrub” environments suggest moves, on average, of about 175 miles per year. Kelly (2011) considered aspects of the “distance issue” in his attempts to discern differences between direct access (i.e., foraging radius) and “trade” in the Carson desert. Although biophysical differences do exist between the Carson and Humboldt sinks, his discussion has clear implications for the lower Humboldt

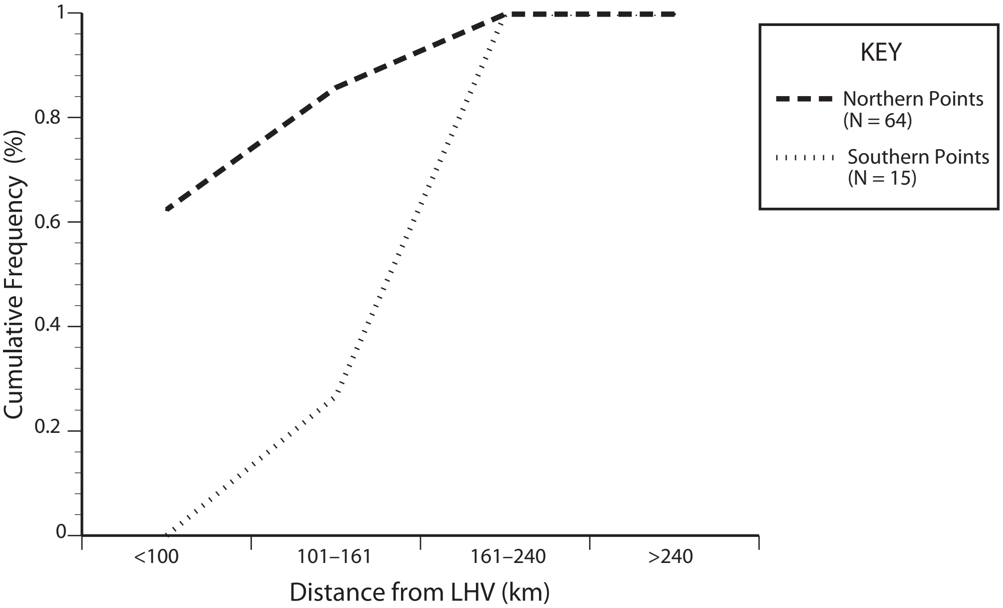

FIG. 53. Cumulative frequency diagram of the geographic distribution of Humboldt series points from the lower Humboldt Valley. Data from table 13.

Valley. Assuming, as Kelly (2011) does, about a 10 km per day foraging radius from base camp, even the closest of the "closer" nonlocal sources could have required up to a week to reach, assuming the acquisition was casually embedded in more general subsistence pursuits. The travel time would have been shorter if obsidian-acquisition expeditions were task specific—focused principally on getting there and back as quickly as practicable—but nonetheless these treks would have been time and energy consuming. As Kelly (2011: 193) discussed, increasing areal distances much beyond 20,000 km^2 conflicts with the majority of data compiled from ethnographic and actualistic studies (see also Kelly, 1995, 2013), making it difficult to accommodate a large foraging radius with some sort of direct access/embedded local acquisition regimen. However, the blend of source-specific and direction data recorded in the lower Humboldt Valley could just as easily represent something more akin to extended lifetime "bins," consisting of a diverse mixture of acquisitions, through occasional direct access or conveyances and inheritance via proximate and distant relatives, over long periods of time. By this view, the "lifetime range" (Kelly, 2011: 193) would be more geographically (and socially) expansive than one based principally on relatively circumscribed subsistence foraging.[28]

Assuming that task-specific expeditions were mounted with the explicit goal of procuring obsidian—as happened during the historic period (Fowler, 1989: 71)—it's clear from data presented here that they focused on the northern "closer" sources, although the more distant (ca. 161–240 km) southern sources were frequently represented during times when darts were in use. This is demonstrated by pooling all time-sensi-

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[28] The increasing examples of long-distance obsidian point conveyance may require that we rethink the views we currently hold about the distances people traversed, or had firsthand knowledge about (cf. Steward, 1934). For example, Wuzzie George knew of the obsidian source at Mt. Hicks, probably the one at Bodie Hills, and perhaps at Buffalo Hills (Fowler, 1992: 105). Davis-King (in 2011, see supplement S24, https://doi.org/10.5531/sp.anth.0105; and Davis and Snyder (2010) highlight in rich detail the importance and extent of some trails linking California and the Great Basin, documented by Sample (1950) and Davis (1960) decades ago.

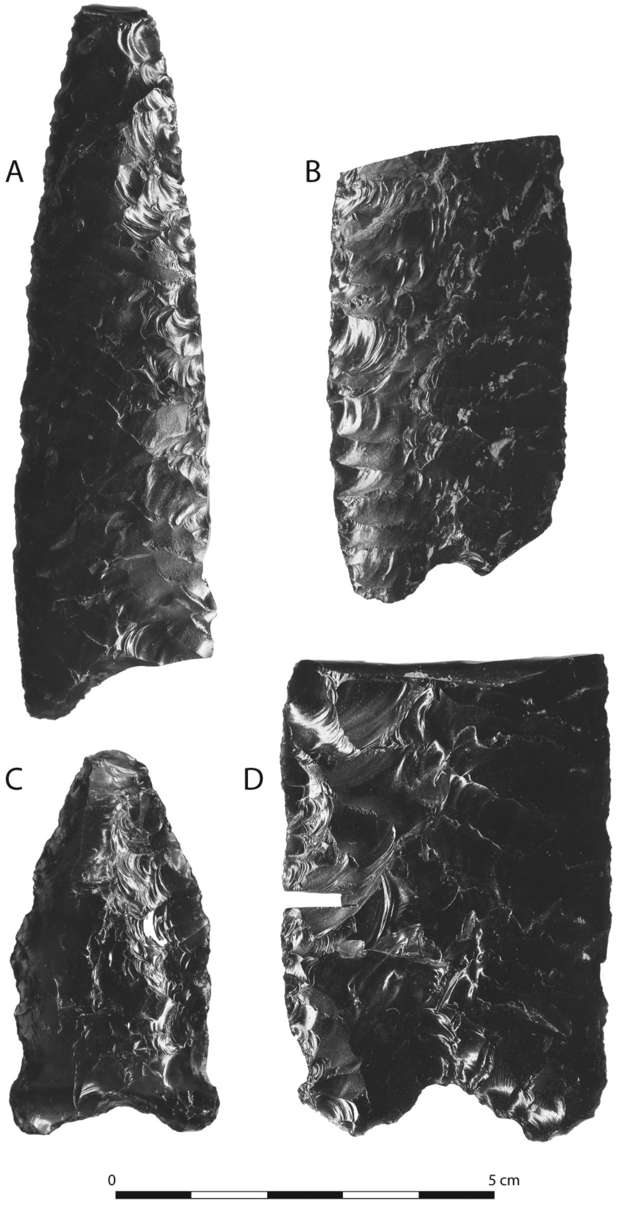

FIG. 54. Obsidian Humboldt Basal-notched bifaces from sites in central California. **A.** L-17551 (SJo-107); **B.** 1-55007 (SJo-59); **C.** 81-5-1322 (SJo-91); **D.** 81-5-813 (SJo-91). Catalogue number listed first, with site designation within parentheses. The 81- catalog numbers are those assigned by the Archaeological Curation Facility, California State University, Sacramento.

TABLE 13

Distance and Direction Data for Humboldt Obsidian Bifaces and Points from Archaeological Sites and Localities in the Lower Humboldt Valley

Distance (km)	Humboldt Basal-notched		Humboldt Series	
	North	South	North	South
0–100	–	–	40	–
101–160	–	–	15	4
161–240	1	43	9	11
> 240	–	–	–	–
Totals	1	43	64	15

tive point data (Desert, Rosegate, Elko, Gatecliff, and Northern Side-notched) and comparing them only on the basis of distance (table 12).[29]

EVALUATING THE PATTERNING

As noted above, several of the time-marker projectile point series used to investigate possible temporal change were used over different temporal intervals. As discussed by Hughes and Thomas (2020), Desert Series arrow points were in use for about five centuries, Rosegate Series arrow points for about six centuries, but Elko series and Gatecliff series dart points over much longer periods of time (about 22 and 23 centuries, respectively). This means, of course, that we cannot use type-specific raw frequencies alone as a straightforward indicator of occupational or area-use intensity—temporal duration must be taken into consideration. In this lower Humboldt Valley sample 269 Rosegate points are attributable to source, and only 141 Elkos. How to evaluate those differences? One way, as others (e.g., Bettinger, 1999) have done, is to simply divide the number of points by the number of centuries each type was used. Applying this metric (see above for durations), 33.2 Desert series, 44.8 Rosegate series, 6.4 Elko series, and 5.7 Gatecliff series obsidian points were lost or discarded (on average) at lower Humboldt Valley sites every century. Although we must be mindful of differences in the temporal duration of each point "bin," these figures indicate that over five times more Desert and Rosegate series points were lost or discarded and deposited per century than Elko or Gatecliff points, which may inform on differences in occupational intensity/environmental exploitation of the area during arrow point vs. dart point times.

REVISITING THE REWORKING AND REFABRICATION SCENARIOS

With the source-specific and diversity data now in hand, we can revisit the issue of reworking/refabrication. For reworking to have been the principal factor affecting the observed distributions, we need to acknowledge that some sort of a "dart-rejuvenation landscape"—consisting of X sources in Y frequencies—would have to have been "fixed" in the lower Humboldt Valley prior to subsequent reworking. Since projectile point rejuvenation is a subtractive process, it follows that the obsidian sources for the derived forms

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[29] Comparing all types and distance categories <100 km, 101–160, and >161 (because of small cell size in the 240–299 and >300 km distance categories) in table 11 yields a highly significant chi-square value (χ^2= 23.285, df = 8, p = 0.003, Cramer's V = 0.127). In this case, 27.8% of the variability is attributable to underrepresentation Desert series points from 101–160 km distant (N = 24 observed vs. 40 expected) and another 26.2% to the overrepresentation of Rosegate series point from this same distance (N = 86 observed vs. 66 expected). Rosegate points also are underrepresented in the >161 km category (N = 57 observed vs. 76 expected). We have reviewed above how these comparatively general results can be parsed into finer directional categories.

(arrows fashioned from earlier darts) can't be represented by fewer obsidian sources (i.e., be less diverse) than the ancestral parent (dart) populations from which they originated. Arrows might show the same diversity profile as darts, but not one less diverse. Consequently, if artifact reworking was a significant factor in the lower Humboldt Valley, one would anticipate that the diversity of sources in the parent population (i.e., dart points) should be very similar to the derived groups (arrow points) if the latter were systematically refabricated from the former. If more dart points were made from southern obsidian source material, more of them should have been lying around at various sites and localities available for reworking and reshaping later in time into smaller (arrow) forms. Therefore, we would expect that—if more darts were made from southern than from northern obsidian sources—greater numbers of southern source obsidian points should be found in later (i.e., arrow category) assemblages. Conversely, if more darts were made from northern than from southern sources, greater numbers of northern source obsidians should be found in later (i.e., arrow category) assemblages. How do the lower Humboldt Valley data square with these expectations? The diversity data reviewed above show that, as a group, arrow point sources are less diverse than those of dart point times—just the opposite of what would be expected. In fact, we'd expect source diversity (i.e., the number of sources observed in each class [dart vs. arrow]) to increase gradually as new sources were incorporated through time into to arrow-users' kitbags.

The systematic reworking argument also is weakened empirically by the finding that very distant obsidian source material (e.g., from Cannonball Mountain, Idaho; the Coso Volcanic field, southeastern California; Panaca Summit, eastern Nevada; East Medicine Lake, northern California) is expressed almost exclusively as late (arrow) points. Of the 25 points identified as having been made from very distant (>240 km away) obsidian sources in this study, 16 of them (64% of the total) were arrow points. This finding is consistent with what would be anticipated due to expanding source use base though time; there were not nearly enough larger dart points made from these distant obsidians to support the possibility that they served systematically as refabrication material for arrow points.

In addition, because obsidian point breakage typically occurs as a result of impact, it's to be expected that the arrow points refabricated from broken darts would be shorter, but that breakage would not necessarily require any modification to the point's neck width. A dart point made reserviceable during dart point times might be shorter, but there would have been no need to modify the neck width if it were destined for use on the same weapon. Conversely, a dart point found and retooled to the purpose of an arrow point would not only require resharpening, but reduction in neck width to accommodate the thinner arrow shaft. As Zeanah and Elston (2001) point out these activities are time intensive and may be at odds with the perceived benefits of expediency (see also Loendorf et al., 2018, 2019).

The point here is not to deny that retooling activity took place on a casual basis, but to emphasize that data from this study are incongruous with the view that systematic, reworking and repurposing of older artifacts was so pervasive that it masks any former pattern that may have existed. To accommodate the observed results with a refabricating scenario, it would be necessary to posit that distant southern obsidian dart points must have been—for some reason—targeted (i.e., given special preference in reworking) over more abundant obsidian dart points made from nearby local sources. This seems very improbable.

To the contrary, it seems more likely that all the obsidian sources represented in refurbished/reworked artifacts became more numerous through time as "new" sources were encountered or conveyed to the valley as a result of increasing foraging radius and/or increasing contacts with peoples in, and closely proximate to, areas where these different obsidians occurred. As noted above, this is not supported by lower Humboldt Valley diversity data in which, with the exception of Humboldt Basal-notched bifaces, the differences in diversity indexes support the view that obsidian source-use diversity between and among dart points was greater than it was during subsequent arrow point times.

ADDRESSING THE RESEARCH QUESTIONS

We can now combine the results of the preceding analyses to address the research questions posed at the outset of this study (see Introduction).

(1) Were there significant changes in obsidian source use through time in the lower Humboldt Valley?

The answer to this question essentially revolves around whether or not the null hypothesis of no association can be rejected. That is, can the proposition that there was no change in the sources or directions from which obsidian projectile points were conveyed into the lower Humboldt Valley over the last 5000 years be rejected? The evidence presented above makes it clear that there were significant changes through time, particularly evident in a contrast between the direction and distances over which darts were conveyed to the valley, as opposed to direction and distance patterning detected during arrow point times, and the direction and distance patterning of Humboldt Basal-notched bifaces.

(2) Is there a significant relationship between point type, distance to source, and geographic direction from the lower Humboldt Valley?

Although there were no significant differences by point type and distance within direction categories, there were marked difference between them (north vs. south). For example, the majority of Desert Series and Rosegate series points 161–240 km distant from the lower Humboldt Valley were made from obsidian sources located to the north of the valley, while the Elko and Gatecliff points came predominantly from obsidian sources located to the south.

(3) Were arrow points made more frequently from distant or local obsidian sources? Are directional trends (i.e., north/south) evident?

To address this question, we return to the basic data summarized in table 12. The chi-square statistic for these data is highly significant (Yates's continuity corrected $\chi^2 = 64.62$, df = 1, p= <0.001; $\varphi = 0.393$), representing the complete absence of arrows made from local southern sources. The preceding calculations pertain only to recognized time-marker types; if we expand the comparison and include additional points for which there is good reason to categorize at least as arrows (in table 9) the same pattern is evident, reinforcing the distinctions recognized with the time-marker types. In short, arrows were overwhelmingly made from local northern obsidian sources.

(4) Were dart points made more frequently from distant or local sources? Are directional trends (i.e., north/south) evident?

Table 12 presents the frequencies of local vs. nonlocal obsidian use by dart point type. A chi-square test shows that darts are nonrandomly distributed with respect to local vs. nonlocal and direction of obsidian use ($\chi^2 = 79.637$, df = 1, p = <0.001). Forty percent of the chi-square variability is due to the paucity of darts from southern local source (N = 1 observed vs. 34 expected) and the overrepresentation of nonlocal darts from the south (N = 74 observed vs. 41 expected; 33.7%). So, dart points were made predominantly from distant southern sources.

(5) Was reworking and recycling a significant factor in interpreting the results?

This issue was evaluated above and the conclusion was reached that—although obsidian points were definitely refashioned and reworked on occasion—this process was not adequate, by itself, to account for the observed distance/direction/obsidian source contrasts between arrows and darts in the lower Humboldt Valley.

(6) Does linear distance to source predict relative frequencies of the obsidian sources used to make projectile points during particular phases or through all temporal periods in the lower Humboldt Valley?

The regression analysis data summarized in figures 49–52 indicate very different relationships between local and nonlocal northern and southern obsidian source use through time. Northern sources account for the majority of arrow and dart points at the local level, and the relationship does not change significantly with increasing distance north. The relationship to the south is different. Due partly to the absence of large obsidian cobbles at local southern sources, a very low percentage of arrow and dart points were made from these glasses. These frequencies increased dramatically for both darts and arrows the 161–240 km distance range, illustrated by the marked north/south contrasts in figures 46–49. Thus, geographic direction—not linear distance alone—was an important factor in both arrow and dart obsidian source-use frequencies.

(7) Are the number of obsidian sources used during dart times more (or less) diverse than those observed during the time arrow points were in use?

The diversity data presented in table 10 (discussed above) suggest that as a group dart point sources are more diverse than those utilized during arrow point times.

(8) Is there an association between climatic change and change in projectile point type?

Table 1 shows the inferred relationship between climate and archaeological response in the study area. There is considerable variability in the inferred human responses to changes in wetter/dryer episodes; at certain times increasing mobility appears to have been the response to drying conditions, while at other times wetter conditions are marked by a scanty archaeological ^{14}C record. Nonetheless, it's impossible to ignore the uncanny coincidence of the Medieval Climatic Anomaly (MCA; cal AD 800–1350) and the change in weaponry and direction and intensity of obsidian source use documented here. As originally proposed by Stine (1994, 2000) the effects of this climatic change have been investigated at length in California (Jones et al., 1999; Jones and Schwitalla, 2008; Schwitalla and Jones, 2012; Schwitalla et al., 2014, among others) and more recently in the Great Basin (Mensing, 2013; Thomas, 2020a, in press a) where its consequences on human populations appear to have varied considerably depending on geographic/hydrographic setting. Mensing et al. (2013) have identified a significant dry period between about 3000–2000 cal BP in the central Great Basin, but their data suggest wetter conditions prevailed in the northern Great Basin, runoff from which would have fed the Humboldt River. In what way/s did this affect Rosegate obsidian source use? Are the residential moves postulated for the Lahontan basin reflected in any way in the sources used to manufacture Rosegate series obsidian points? The fact that six of the ^{14}C dates on superimposed house floors at Ch-15 (Livingston, 1988: table 4.6) fall within 980 ± 80–1370 ±110 BP (cal. AD 955–1230 and cal. AD 892–431)—squarely within the MCA—suggests that the local biophysical environment was not impacted as severely as other parts of the Lahontan Basin and that inflow from the Humboldt River must have been sufficient to support local aquatic and avifaunal resources and at least semi-permanent occupation. If so, the significant increase in obsidian from comparatively distant northern sources beginning at Rosegate times could reflect the deleterious drying effects of the MCA in the north, encouraging people to move south and establish closer social connections with those living in the better-watered areas and more reliable resource base proximate to the Humboldt River.[30] This also could have had

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[30] In this regard, McGuire et al. (2018) report a virtually nonexistent terminal prehistoric record (ca. 600 cal BP–Contact) in the Black Rock Desert. Although the Black Rock area is ca. 100 km northwest of the lower Humboldt Valley, activities during that time interval are certainly not absent in the lower Humboldt; the abundance of Rosegate and Desert series projectile points suggests, to the contrary, intensive use of the latter area. The abundance of northern obsidian sources in the late prehistoric record of the lower Humboldt Valley suggests the possibility that: (1) environmental conditions to the north had deteriorated during this time, encouraging peoples from that area to move southward to more reliable resource patches, and/or (2) people resident in the lower Humboldt Valley extended foraging range to take advantage of new northern resource habitats opened up by use of the bow and arrow (sensu Bettinger, 2013; also Smith, 2021). The latter alternative seems less likely, however; if new habitats had been opened up

social ramifications and repercussions; in large areas of low population density: "the cost of allowing unregulated visitors can be high….. [and] foragers regulate physical access through social access, the strength of which is related to the cost of denying visitors the right to use resources versus the potential that visitors have to reciprocate in the future (Kelly, 2013: 165).

Thus, the climatic effects of the MCA could have provided a context wherein mutually reinforcing social obligations and sharing developed, with one element of the material consequences evident in the shift in the sources for obsidian projectile points.

If this occurred, it is somewhat ironic that deteriorating climate at the regional level, offset locally by inflow from the north via the Humboldt River, apparently sustained resources plentiful enough to support small hamlets or villages at strategic places along the fluctuating shoreline of Humboldt Lake. The Ch-15 housepits suggest that these special places may have been occupied periodically, then abandoned, over the centuries as aquatic and avifaunal resources in the lower Humboldt Valley waxed and waned evocative of Taylor's (1964) "tethered nomadism."[31] The diachronic presence and magnetism of these resource-rich "sweet spots" must have been of longstanding significance, as Steward, Heizer and others posited over a half century ago.[32]

Similar environmental conditions appear also to have existed in the neighboring Carson Sink and Stillwater Marsh, where the majority of identified structures (and human burials) dated between ca. cal AD 1300–750. Compared to the lower Humboldt Valley there were very few typable obsidian points recovered from archaeological sites and survey here (Tuohy, 1987a: Drews, 1988; Elston, 1988; Kelly, 2001) although, just as in the lower Humboldt Valley sites, Rosegate points—marking the period between ca. cal. AD 750–1300—were the most frequent. As Tuohy (1987b: 314) put it, "information released about the Humboldt Lakebed sites…is very reminiscent of the past 2000 years of the Stillwater Marsh. The archaeological features are the same; the house floors, the cache pits, the storage pits, and the accumulated middens are nearly identical in conformation and abundance."

Table 8-26 of Hughes (2001) shows the source-specific distribution of the 48 typable obsidian points analyzed from the Carson Sink area.[33] Small sample size prevents detailed comparisons using the more refined distance/direction categories employed in the lower Humboldt Valley but, if partitioned by the general distance/direction, we find that the percentage of Rosegate points is evenly split (N = 11 of 22 specimens; 50%) between northern[34] and southern sources (see fn. 36). This stands in marked contrast with the lower Humboldt Valley distribution ($\chi^2 = 26.645$, df = 1, p = <0.001), which features a predominance of northern source material. Nine of the 15 Elko series points from the Carson Desert sites came from southern sources, and the 2×2 contingency table analysis

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to the north, there's every reason to expect that local residents would have taken advantage of them.

[31] Livingston (1988: 228) reports that at Ch-15 "More than 182 houses, many with superimposed floors [were recorded]… neatly stacked one on top of another, up to 7′ deep, suggesting that people were not simply returning to the same site, but that they we reusing the same depression" (my addition). The deepest (earliest) houses had Elko points associated, the intermediate houses had Rosegate points, and the most recent had Desert Side-notched points in association (Livingston, 1988: 63–67).

[32] From this overall perspective Elston's (1982, 1986) syntheses are as relevant today as when he wrote them. The lower Humboldt Valley data presented here are certainly broadly consonant with what would be expected during Medithermal "good times" in the western Great Basin, but they provide a somewhat more nuanced picture of the human behavioral activities and regional connectivity than could have been detected 40 years ago.

[33] This analysis of did not include 17 of the typable obsidian specimens reported by Tuohy (1987a: table 55), the 32 obsidian points reported by Drews (1988: table 27), nor the four artifacts (one Humboldt Series and three Carson points) for which temporal spans are uncertain.

[34] The geological source for "Unknown B" obsidian in Hughes (2001) has now been identified (see fn. 6). In that regard, the three obsidian projectile points (20.4/1291, a Gatecliff Contracting Stem; 2/32696, a Humboldt Series point; and 20.3/9920, a Gatecliff Split Stem point) from Hidden Cave were identified as Unknown in Hughes (1985: table 78) can now be attributed to obsidian of the Buffalo Hills chemical type (Hughes, 2019).

suggests that they were drawn from a different statistical population than Elkos from the lower Humboldt Valley ($\chi^2 = 6.714$, df = 1, p = <0.01). Too few points occurred in other categories for comparative analysis to be informative. More generally Majuba Mountain was not the dominant overall source for points here; in this case 20 of 48 points (42%) were fashioned from distant source material erupted south of the Mono Lake area, with Majuba Mountain accounting for only 21% (N = 10 of 48 points) of the aggregate time-sensitive total. Just in the lower Humboldt Valley, the majority of Desert series point from the Carson Desert were made from northern obsidian sources, while Elko and Gatecliff points were made mostly from glasses erupted to the south (Kelly, 2011: 195). With respect to Humboldt Basal-notched forms, only one obsidian example appears to have been recovered from these sites (Kelly, 2001: fig. 4-13, no. 3326)—it was made from Bodie Hills obsidian (Hughes, 2001: table 8-24).

DISCUSSION

Whatever meaning(s) we attribute to changes in the sources and direction of obsidian projectile point conveyance, these necessarily took place in a variety of environmental (and social) contexts that influenced the observed outcomes. We currently have more precise knowledge of climate change in the western Great Basin than we did a few decades ago, and past human responses to those changes no doubt took several forms—a dynamic mix of semisedentism when environmental conditions allowed, with opportunistic foraging of seasonally available birds and plants within a wider ranging mobile settlement system. Even if climate change was so prolonged and/or extreme to alter the flora and fauna of the region (as seems likely during some periods of time), the human response would probably have been toward greater group mobility to places affording—at least temporarily—better access to reliable resources. These responses were of longstanding in the Great Basin, as Madsen and Kelly (2008) eloquently describe.

The introduction of new technology (i.e., the replacement of the atlatl dart by bow and arrow) adds new considerations to the mix. The notion that technological replacement ushered in a different settlement/subsistence arrangement in the Great Basin (e.g., Bettinger, 2013) is intriguing, but others have considered this and reached different conclusions about its possible effect (e.g., Davis, 1966; Heizer, 1966; Kelly, 1997). There's also no reason to expect that the dramatic difference in technology made it apparent to all that it had to be adopted immediately (cf. Pfaffenberger, 1992). Such a change may have happened in certain highly populated areas where the bow opened up new habitats for exploitation, conferring an advantage to the adopters at the expense of neighbors perhaps still using the atlatl/dart. A technology that affords an advantage in one environment may not be so beneficial in another. Likewise, there's no necessary reason to believe that the change in technology was exclusive, nor that it happened overnight. We still see 1960s Volkswagens on the road today alongside 2022 Fords. As long as making a living ("getting the job done") could still be effective using "old" technology, cultural conservatism (and ease of use, cf. Grund, 2017) could have inhibited acceptance of and eventual shift to the "new" technology so long as there were insufficient incentives for doing so.

If there was no immediate advantage to arrow acceptance by peoples at a local level, retention of older dart forms may have been—for a time—emblematic of a dimension of group cohesion and identity in the face of impending technological and social change. Resource depletion of game most often hunted during "dart times" could have been one trigger to taking the road to "arrow" acceptance, but the nature of any such depletions was no doubt contingent on human population increases and/or local environmental conditions. In areas where population increases were not evident, there's no necessary reason to expect technological change to be abrupt. As the data in figure 6A support, darts probably persisted alongside arrows for variable periods of time in different parts of the American west (Massey, 1961; Beck, 1995, 1998; Yohe, 1998; VanPool, 2006; Grayson, 2011: 310), consonant with Heizer and Baumhoff's (1961: 128) conjecture that "the Elko Eared point was in use at the time the bow and arrow was first introduced in this region and that the basic form of this point was retained but the size was reduced so that it could be used as an arrow point" (see also Lanning, 1963: 252).

THE SPECIAL CASE OF HUMBOLDT BASAL-NOTCHED BIFACES

To this point there has been little discussion of one of the more interesting results of this project—the source-specific composition of the sample of Humboldt Basal-notched bifaces (table 8). The source-specific patterning for these artifacts in the lower Humboldt Valley sample is remarkable, mirroring in more dramatic fashion the results from immediately south in the Carson Sink at Hidden Cave. At Hidden Cave, 17 of 18 Humboldt Basal-notched specimens were manufactured from Mono Basin obsidian sources (Hughes, 1985: table 74), and the lower Humboldt Valley sample (table 8) provides strong independent evidence to reinforce this source-use pattern. Humboldt Basal-notched bifaces are comparatively rare in the western Great Basin, but when they are found—at sites near Fallon (e.g., sample 16-1 from 26Ch3388 made from Mt. Hicks glass [Hughes, 2016b]), at Spirit Cave (Hughes 2013b), and in Monitor Valley in the central Basin (Hughes, 2018b: artifact nos. 67 and 68)—they are almost invariably manufactured from obsidian from a Mono Basin area source.[35] Supporting data for this source-use patterning also come from California sites (see fig. 54, fn. 24, supplementary data table S21), where all of the specimens identified and analyzed were made from Mono Basin area obsidians.[36] It may prove significant, however, that Bodie Hills is the dominant obsidian source for Humboldt Basal-notched bifaces in the western Great Basin (followed by Mt. Hicks), whereas in central California, Bodie Hills is followed and accompanied by obsidian from the Casa Diablo area. Humboldt Basal-notched bifaces made from Casa Diablo area obsidians have not yet been identified in the central western Great Basin, and Mt. Hicks Humboldt Basal-notched bifaces—rare in central California—are the more frequent in the numerically small sample from SJo-91.

A strong type-specific source-use pattern is apparent from this study, but the age estimates from central California and western Nevada data contrast with data generated farther south in the Owens Valley area. As reviewed above, in this latter area Humboldt Basal-notched bifaces appear to date much later than those from central California and the Carson Sink. The cross-dated central California occurrences reviewed are primarily of late Early and Early/Middle Transition period age (ca. cal 1000 BC–cal AD 500) but earlier appearances—during the Early/Middle Transition at SJo-91 and terminal Early period (based on diagonal ribbon flaking[37] on

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[35] A Humboldt Basal-notched point from the southern Pine Grove Hills—with classic collateral ribbon flaking (Rhode, 1987: fig. 10.7, row 2, middle specimen; cat. no. 313-1-3)—has recently been analyzed by EDXRF. It is made from Mt. Hicks volcanic glass (Hughes, unpublished data).

[36] Nearly 50 years ago, Thomas Jackson used xrf spectrometry to identify a "disruption" in obsidian source use during what was then referred to as the Middle Horizon in central California, remarking that "the large exotic blades and points from the Delta-Valley area which exhibit the fine "ripple" or "ribbon" flaking are generally made from the Bodie Hills…or Casa Diablo [obsidian sources]" (Jackson, 1974: 80; my addition). More recent research suggest that these features may have even greater time depth; a terminal Early period association for Humboldt Basal notched point (s) with diagonal ribbon flaking was reported at SJo-91 where the form may date as early as 2985 ± 160 BP (818–1536 cal. BC) along with *Olivella* Split, Beveled (class C1), *Olivella* Saucer (class G2) and *Haliotis* disk beads (Johnson, 2008: 16). It thus appears that this particular technological feature (diagonal ribbon flaking) not only marks a very restricted time range in central California prehistory—the terminal part of the Early period, the Early/Middle period transition, and the very early portion of the Middle period—but that it is clearly associated with the exclusive use of trans-Sierra Mono Basin area sources.

[37] Diagonal ribbon flaking was widely considered to mark Early/Middle transition period assemblages to the extent that the occurrence of a specimen at Late period site Sol-2 (Treganza and Cook, 1948: pl. XXVII, no. 1) was interpreted as an example of prehistoric "grave robbing" (p. 295) rather

large dart points) at SJo-112—would support a general temporal equivalence between central California and the dated specimens from Hidden Cave.[43] Taken together, these fine-grained cross-dated comparisons—providing more precise temporal resolution because of time-sensitive *Olivella* and *Haliotis* shell bead associations—would support an Early Lovelock to early Transitional Lovelock age range for Humboldt Basal-notched bifaces in the lower Humboldt Valley, making them roughly coeval with Gatecliff and Elko points. To my knowledge there are no well-dated examples of Humboldt Basal-notched bifaces in central California or the central western Great Basin as late as those from Owens Valley.

In light of the foregoing, there are three possibilities for assigning a date range to Humboldt Basal-notched bifaces in the lower Humboldt Valley.[38] First, they date to the same time period as they do ca. 50 km south at Hidden Cave, that is, ca. 3600–3800 BP. Second, they date to a much later time period (ca. 600–1300 AD), as they do in central eastern California and Owens Valley. Third, Humboldt Basal-notched bifaces appeared early (as they do at Hidden Cave) but persisted for a very long time.

With respect to the first alternative, although there's no direct evidence for their age in the lower Humboldt Valley, it is difficult to imagine (though certainly not impossible) that two geographic areas separated by <50 km would contain Humboldt Basal-notched bifaces dated nearly 3000 years apart. Given the strong probability that peoples utilizing what is now the Humboldt and Carson sinks and south Carson Lake areas were in communication—very likely composed at different times of intermarrying individuals and related families—a rigid social boundary rationale for this temporal disparity seems unlikely.

The second alternative could be supported if one posits that nearly all the Humboldt Basal-notched bifaces recovered from lower Humboldt Valley sites made of Mono Basin area obsidians were conveyed north from the Mono Basin area later (i.e., after ca. 4000 years ago) than their occurrence at Hidden Cave. This cannot be ruled out on current grounds, but it does seem unlikely. We know that Hidden Cave provides one early benchmark for the age of Humboldt Basal-notched bifaces in the area, but it doesn't inform about their overall use-life history.

The third possibility, advanced by Garfinkle and Yohe (2004), is that Humboldt Basal-notched bifaces had two floruitsin the southwestern Great Basin: one between ca. 6000–2500 BP, the other from 2500–1200 BP. These date ranges would accommodate the Humboldt Basal-notched occurrence at Hidden Cave, but in effect it is the same as saying that the overall range for type is 6000 BP to 1200 BP. The authors (Garfinkel and Yohe 2004: 111) explore some tentative metric distinctions that might identify the earlier ("narrow") from later ("wide") forms in southwestern Great Basin sites, but further study will be necessary to show that the wide variant they propose is metrically/technologically distinct from Chowchilla-phase (ca. 800 BC–AD 550) Sierra Concave base points (Moratto, 1984: fig. 7.11e). More generally, a 6000–1200 BP range is considerably longer than any well-dated Archaic projectile form and, parenthetically, I can't think of an example of a projectile (or distinctive biface) form used for several thousand years, after which it disappeared, then reappeared some thousands of years later in the same size and shape (except as an heirloom; e.g., Thomas, 1976b). To be clear, Garfinkel and Yohe did not suggest that their results applied outside the southwestern Great Basin. Long-distance cross-dating perils are well known, and its never inappropriate to reempha-

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than as an heirloom. Recent ^{14}C dates on more than 12 human burials from SJo-112 reported by Eerkens et al. (2017: table 1) and Barton et al. (2019: table 1) span a very narrow range from 2950 ± 45 BP (ca1. 1286–1012 BC) to 3260 ± 40 BP (cal. 1617–1444 BC).

[38] The obvious solution to disentangling these alternatives is direct dating. Unfortunately, none of the Humboldt Basal-notched bifaces in this study were recovered from datable contexts (i.e., by ^{14}C or with shell bead and ornament associations) nor has obsidian hydration analysis been performed on any of them. Consequently, interpretive alternatives must be pursued using other lines of reasoning.

size the pitfalls of assuming that the age range from one area (i.e., the Owens Valley and the southwestern Great Basin) applies to a more distant one (the lower Humboldt Valley) absent empirical evidence from the latter.

But what's been reviewed above excludes a particularly salient feature of this study's findings. The Humboldt Basal-notched bifaces recovered from the lower Humboldt Valley (as well as those from Hidden Cave and in the Carson Sink) were made overwhelmingly from Mono Basin area obsidians—predominantly Bodie Hills and Mt. Hicks—just as were those recovered from California sites on artifacts displaying diagonal/collateral ribbon flaking. California data suggest that diagonal/collateral ribbon flaking persisted from the end of the Early period until the early part of the Middle period (ca. 3000–2000 BP); I am unaware of any earlier occurrences in California.

This compelling source-use pattern does not apply to any projectile form in the lower Humboldt Valley—data reviewed above show different relationships between local vs. nonlocal obsidian use and distance. Given this, it's hard to imagine that such a tight-knit relationship between form and obsidian source area would arise and persist over thousands of years, with Humboldt Basal-notched bifaces made from Mono Basin area obsidian dribbling north to the lower Humboldt Valley.

Are They Really That Old?

Lacking independent chronological data from the lower Humboldt Valley, I have relied heavily on the stratigraphic record from Hidden Cave (Davis, 1985) for dating Humboldt Basal-notched bifaces in the Humboldt-Carson Sink areas. But a major objection could be raised here: Hidden Cave was clearly used for caching; 22 cache pits were identified (Thomas, 1985: 299–305) and stratum II was reported as origin for many of them. The ^{14}C date reported for the top of stratum II is 1880 ± 90 BP (51 cal. BC–cal. AD 382) and the oldest (deepest?) date is 3850 ± 110 B.P (2585–2012 cal. BC)—a time span of 1950 years. Could the cache pit digging and rodent activity have resulted in the mixing of upper (later) parts into the lower parts of the stratum? If so, could the Humboldt Basal-notched points documented in stratum II actually derive from the uppermost part(s) of the stratum?

Possibly, but there is evidence against this interpretation. As Pendleton (1985: table 50) shows, 35 of 55 (64%) typable points recovered in stratum II were Gatecliff series and another 13 (24%) were Humboldt Basal-notched. Comparison of the frequencies of both types in the surface, I, I/II, II, and II/III strata shows that they could have been drawn from the same statistical population (K-S $D = 0.207 < D_{0.05} = 0.371$, $N_1 = 64$, $N_2 = 17$). In short, the distribution of Gatecliff series points in these strata at Hidden Cave is indistinguishable from Humboldt Basal-notched bifaces. Therefore, if the stratigraphic "mixing" alternative is correct, this mixing would have to apply to Gatecliff series points as well as to Humboldt Basal-notched.

But let's imagine further that some sort of distributional difference between these types actually exists, but is not adequately reflected in their stratigraphic occurrence. How to evaluate this? We do have good evidence from other sites (particularly Gatecliff Shelter) for the age span of Gatecliff series points and they do not date nearly as late as the topmost of stratum II at Hidden Cave (ca. 50 cal BC). In one of the few directly dated local occurrences, Tuohy (1980: 51) reported a ^{14}C date of 3830 ± 110 BP (2574–1961 cal BC) from Kramer Cave on atlatl foreshaft to which a Gatecliff Split stem obsidian point was attached. Thomas's (1985: 97) interpretation of the Hidden Cave stratigraphy is that "Strata IV, III, and II were deposited over only a few hundred years, and the top of stratum II represented a depositional hiatus of about 2000 years." This makes a late date for Gatecliff series points at Hidden Cave less likely, just as is does for Humboldt Basal-notched bifaces.

But what about the possibility of intrusion from overlying stratum I, which contained a few

Rosegate points? In the Owens Valley area, Rosegate points and Humboldt Basal-notched bifaces occupy approximately the same time range, so perhaps—if dating for Humboldt Basal-notched points in the Owens Valley area applies also to the lower Humboldt Valley—the Humboldt Basal-notched bifaces at Hidden Cave could have intruded into underlying stratum II at this later (stratum I) date, around 810 ± 80 BP (between cal. AD 1036–1302). This, too, is a possibility with no empirical support. Referring again to the tabulation presented by Pendleton (1985: table 50) the frequencies of both types (Rosegate and Humboldt Basal-notched) in the surface, I, I/II, and II strata show that they represent different statistical populations (K-S $D = 0.490 < D_{0.05} = 0.646$; $N_1 = 6$, $N_2 = 17$). So, the distribution of Rosegate points in these strata at Hidden Cave is clearly distinguishable from Humboldt Basal-notched bifaces. We would not expect this to be the case if "mixing" and intrusion applied equally to both types.

Finally, of the 27 shell beads recorded as coming from stratum II, 10 of them (four *Olivella* Split Ovals [Class C3], five *Olivella* Large Saucers [Class G2], and a single Olivella Thick Rectangle [L2]) are consistent with Early period occurrences and the apex of marine shell exchange between California and the Great Basin (Bennyhoff and Hughes, 1987: 159). The bead data do not bear directly on the age of Humboldt Basal-notched bifaces—they contribute mainly as independent evidence relevant to evaluating the integrity of the strata from which age has been inferred.

Summing up

I am acutely aware of the Martin Rees's maxim that "absence of evidence does not imply evidence of absence," but, on the basis of what we now know, I take these data to support the view that Humboldt Basal-notched bifaces—at least in central-western Nevada—date from approximately the same period as Elko series points, but, as Hidden Cave shows, they are probably somewhat older[39] (as Gatecliff Shelter [Thomas, 1981: 13], Tufa Village [Young and Hildebrandt, 2017: 18–19], and the Karlo site [Riddell, 1960b; Bennyhoff and Hughes, 1987: 163, component G] data indicate for the relationship between Gatecliff and Elko series points).[47] Because we have no local counterpart, a tentative "starting" date for Humboldt Basal-notched points in the lower Humboldt Valley has been extrapolated from Hidden Cave. It seems relatively certain that the points must be of approximately the same age in the adjacent lower Humboldt Valley as they were at Hidden Cave, but the same cannot be said for duration or an "ending" date. That's currently uncertain.

The foregoing remarks pertain only to time and source. Some of the Humboldt Basal-notched bifaces recovered from Hidden Cave were hafted and use-wear analysis suggests that they were used as knives, or at least employed in cutting functions (Pendleton, 1985: 198–199). I have no reason to dispute these findings, but in the lower Humboldt Valley case it is hard to understand why—in the presence of much closer, high-quality obsidian—not a single Humboldt Basal-notched biface was made from local obsidian. In fact, pooling the source-specific data from Hidden Cave ([n= 18], Hughes, 1985: table 74) the Carson Sink ([n= 1] Hughes, 2001: table 8-24; Kelly, 2001; fig. 4-13) and the lower Humboldt Valley ([n= 44], reported herein) shows that 97% of these artifacts were manufactured from Mono Basin area sources. That's pretty remarkable.

There's also a correspondence between the first appearance of Mono Basin area Humboldt Basal-notched bifaces, diagonal ribbon flaked points in central California, and a late Holocene dry period experienced in the Lahontan basin ca. 850 cal BC–cal AD 100 (Thomas, in press a). This correspondence should not be uncritically accepted as an environmental driver; barring cataclysmic

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[39] The agreement between obsidian hydration rim measurements on Humboldt Basal-notched and Gatecliff series points made from Bodie Hills obsidian supports this view (see Jackson, 1985: table 80; Hughes, 1985: table 79).

events (e.g., Hall, 1983, Schwitalla, 2013; Schwitalla et al., 2014), there's no reason to expect an immediate shift in human response to such changes, which archaeology typically reveals over decades or centuries. However, if environmental conditions were less severe south of the Humboldt Valley during this time, mobility and/or increased contact with populations in that area would have situated people more proximate to the obsidian sources from which Humboldt Basal-notched obsidian bifaces were manufactured.

WIDENING THE PERSPECTIVE

Anthropologists—at least from Firth (1939, 1965) and Bohannon (1955) through Sahlins (1965, 1972) and Dalton (1969, 1977)—have long emphasized that human life—be it economic, religious, ceremonial, and/or political—is by definition social. People forage, typically in family/kin groups, during which many important things in addition to the purely "economic" happen. Someone learns about an ill relative living some distance away and plans are made to visit, perhaps to take food and other gifts and/or to offer assistance and social support. A death, poisoning, or other significant misfortune experienced in an adjacent valley may result in that valley being viewed as dangerous and "off limits" for a considerable time and, through time and the generations, new relations are forged with peoples living in other places, thereby reshaping the preexisting social and subsistence landscape (cf. Gordillo, 2002). A certain resource appears in abundance in a particular part of the group's foraging "territory," so plans are made for a gathering in which people and families from adjacent valleys are invited to attend (something akin to the fandango, or trade fair).[40] Information, gossip, artifacts, and genes no doubt circulated widely in such contexts (cf. Steward, 1938: 45–46; also Cohen, 1983); Steward (1934, 1955) was quite explicit about the importance of social factors among Great Basin inhabitants and how these conditioned and influenced subsistence pursuits. Just as all of these interactions and activities, enacted within differing social and environmental settings, serve to remind us to appreciate the myriad of contexts within which artifacts were used, refurbished, lost, and discarded through the millennia, that recognition poses formidable challenges to any simple archaeological interpretation.

Up to this point, the focus of this study has been largely on pattern exploration and documentation—investigating which obsidian sources were used to manufacture morphologically and temporally distinct projectiles conveyed to archaeological sites in the lower Humboldt Valley from different geographic directions and distances, at different periods of time. This description is critical—it imposed order, allowing comparisons and contrasts to be drawn between and among patterns—but now, what about interpretation? How to make sense of it all?

Given my emphasis on the pervasiveness of the social in human life, it will come as no surprise that I doubt that there's one simple, clear-cut account or explanation for the patterning that's been found. In the spirit of Chamberlin's (1897) method of multiple working hypotheses, I have sprinkled interpretive alternatives and conjecture throughout, which take seriously the "messiness" of archaeological data (Hauser, 2012:184) and the mutually reinforcing and amplifying possibilities for long-term changes in the networks of human interactions (e.g., Cameron, 2013; Mills, 2017) brought about by what may have initially been small scale change (sensu Maruyama, 1963). Notwithstanding this acknowledgement there's still a need to set forth

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[40] The fandango, or trade fair, has been appealing as an ethnographic/historic period model for describing how materials may have been moved during prehistoric times (e.g., Griswold, 1970; Wood, 1972; Janetski, 2002), but this assumes that the same, or very similar, forces shaped social life during different prehistoric periods. We have no justification for the latter assumption, and have a difficult time finding unambiguous material correlates for such gatherings in the archaeological record. The trade fair may have been a rather late phenomenon, much like the long-distance Walla Walla expeditions to California (Heizer, 1942) which occurred after the advent of the horse and population decline following Euroamerican contact, or it may have much deeper roots (Beck and Jones, 2011).

the lessons learned from this study in light of available evidence.

At the outset of this study, I posed the rhetorical question about what we might be able to learn from obsidian provenance analysis of large surface assemblages. The results presented here provide some general, and some specific, answers:

(1) Counter to what might have been anticipated solely on the basis of proximity, table 7 shows that the majority of time-sensitive obsidian points recovered from these lower Humboldt Valley sites were not manufactured from the closest artifact-caliber source. This finding underscores the role of other factors (temporal shifts in foraging radius, conveyance patterns, season-specific treks to areas outside the valley for social and/or familial kin obligations, etc.) in understanding the larger contexts impacting source-specific distributions of obsidian projectile points (cf. Hughes and Pavesic, 2005). The cumulative material outcomes of various combinations of social factors (be they family and kinship, foraging, religious and/or ceremonial associations and linkages) were reflected here—at different times—over and above simple least-cost, space-utility (effective distance) considerations. Having said that, any number of combinations of these factors could have been—and very likely were— paramount during one or more time slices within the periods tracked by projectile point chronology. This is particularly critical for time periods when darts were in use, because as noted above, the temporal spans of these weapons was on the order of 20–25 centuries—even longer for Paleoindian/Paleoarchaic forms. A lot can happen during that amount of time. Arrow point chronologies currently are of shorter temporal duration than darts, but they don't provide—in themselves—any better ability to disentangle the variable effects of changes in social vs. effective distance. This conundrum is endemic because the comparisons are, by definition, categorically constrained by type-specific temporal units that may subsume (and mask) significant behavioral and adaptive variability. Human life is social life, social life can be complex, and—to the extent that we believe that artifact distributions are in some ways archaeological proxies for these social activities—we should expect archaeological distributions would have varying material correlates and archaeological visibility at different points in time.

(2) There were significant changes, at different points in time, in the direction and distances over which obsidian projectile points were conveyed into the lower Humboldt Valley. Dart points, made from nonlocal obsidian sources located far south of the valley, were represented in greater relative frequency than similar forms made from nonlocal northern sources. That relationship changed when arrow points came into use. Thereafter, arrow points were made more frequently from nonlocal obsidian located north of the valley, while the numbers of arrow points from nonlocal southern sources diminished.

The possibility that this pattern and change is simply a reflection of systematic reworking of older, larger dart points into smaller arrow points was entertained but seems remote in part because the arrow points were found to be disproportionately made only from nonlocal northern sources (see above). If the observed ancestral pool of darts in the lower Humboldt Valley consisted of nearly equal numbers of nonlocal northern and southern obsidians, we would expect the reduction ratio for northern sources to apply equally to southern ones. That is clearly not what has been observed in this case. In addition, dart points were found to have greater source diversity than arrow points—a finding also at odds with what would be expected in a pervasive reworking regimen. Although other factors surely were in play, adoption of the bow and arrow and opening of new sources of foraging habitat should have increased—not decreased—through time the number of obsidian sources encountered and used as a consequence of increased mobility, extended foraging range, or lifetime range afforded by adoption of this technology.

(3) The directional and source-specific pattern evident in Humboldt Basal-notched points was

reinforced and amplified by the lower Humboldt Valley source results; these bifaces were made overwhelmingly from obsidians erupted south of Mono Lake—not from any local source. These source/distance direction data suggest to me that while these bifaces certainly may have been used sometimes as hafted knives, they were not just "ordinary" knives. They reveal a special, temporally sensitive, and comparatively short-lived(?) relationship between form, source area, and distance that conjoined peoples in the lower Humboldt Valley, Carson Sink, and beyond in a social nexus different from, though overlapping temporally with, that identified in projectile points. These unique features are likely to have been emblematic of a distinct network of social connectedness, marked by material correlates of social identity analogous to those expressed in more dramatic fashion in the late prehistoric–early historic archaeological sites of northwestern California and southwestern Oregon (Hughes, 1978, 1990b). At the very least, these findings indicate that the "pull" of proximate obsidian sources or assumptions about least-effort procurement cost cannot be assumed uncritically to apply to all classes of obsidian artifacts (Hughes, 1978; Hughes and Bettinger, 1984).

(4) The opposite directional orientations identified between Humboldt Basal-notched and Humboldt series (Humboldt Concave Base) points in the lower Humboldt Valley serves as an example of information loss accrued by not paying enough attention to possible spatial (and temporal?) distinctions between these forms. Despite the difficulty in identifying discrete morphological differences within these largely ill-defined categories, this lower Humboldt Valley study shows clearly that—if conventional "lumping" practices had been followed (i.e., if all had been considered "Humboldt Concave Base")—no differences in source use would have been identified between Humboldt Basal-notched and Humboldt series (Humboldt Concave Base) points.

In fact, this study shows that Humboldt Series points were made overwhelmingly from obsidian source materials located to the north of the valley, while Humboldt Basal-notched bifaces were almost exclusively made from distance obsidians erupted far to the south. We can debate the reasons for this, but we would have nothing to discuss absent recognizing that the differences exist. Thomas (1981: 37) once proposed that Humboldt series points were associated with hunting intercept strategy sites, Pendleton (1985) has mustered use-wear analysis to suggest that Humboldt Basal-notched bifaces were used principally as knives (also Bettinger 1978). I have argued here, consistent with the general principles discussed by Wilmsen (1973) and Fredrickson (1989), that source specific-distance-directional affinities of Humboldt Basal-notched bifaces were emblematic of a socially bounded (sensu Cohen, 1969) interaction network that may have involved status, kinship, and/or elements of social identity different from, but cooccurring temporally with, projectile points. These proposals are not incompatible, except for the categorical statement that Humboldt Basal-notched bifaces are "certainly late in time" (Bettinger, 1989: 69), which may be true in Owens Valley, but is far from certain in the Carson Sink area unless one is somehow willing to dismiss or fundamentally reinterpret the stratigraphic and ^{14}C evidence from Hidden Cave reviewed above. The more general lesson from the lower Humboldt Valley study is that acknowledging and taking into account material direction differences will enhance overall understanding of changes and continuities in land use and social interactions during different periods of time This underscores Thomas's (2013: 146) call for "intensified (rather than diminished) typological conversations in the Great Basin—and elsewhere."

(5) Based on the evidence adduced here, it appears that from around 3800 cal BC to ca. AD 750 peoples utilizing the resources of the lower Humboldt Valley were relatively more aligned socially with peoples (extended families, kin, and interest groups) living to the south, and that these relations changed subsequently to a more northerly orientation. One possible stimulus for

that change could have been the introduction of the bow and arrow. As noted above Heizer and Baumhoff (1961) long ago suggested that Rose Spring points may have come into being as a response to the size requirements of tipping a new kind of weapon—the arrow. They posited that when bow and arrow technology was introduced, the extant tip on atlatls—Elko series points—was reduced in size to accommodate use as tips on arrows. In practical terms, this would imply that, if the technological replacement process was gradual, some of the smaller Elko points might represent early transitions to Rose Spring/Rosegate (arrow) technology and, likewise, that some larger Rose Spring points may still have been perfectly adequate to serve as dart tips.

Heizer and Baumhoff's conjecture may well account for the change in the size and shape of weapon tips, but it doesn't inform on the geographic direction from which that technological change may have come. Ames et al. (2010: 321) argue for bow and arrow use on the Columbia Plateau by 4400 BP, but northern Great Basin data suggest later use to the south (Aikens et al., 2011: 47; Smith et al., 2013; Hockett et al., 2014). Specific dating issues aside, the source-specific results of this lower Humboldt Valley study document a significant shift in obsidian source use toward nonlocal northern sources beginning with Rosegate series arrow points, providing independent evidence for a northern—as opposed to a southern—point of introduction of the technology.

(6) Considering only the frequencies of obsidian dart points in the collection and comparing them with those for arrow points, we'd have to conclude that the lower Humboldt Valley was not a particularly attractive habitat to live in prior to around cal 750 AD, although it was clearly utilized for task-specific purposes that involved caching. This presumes, of course, that lack of evidence for sustained and systematic reworking of dart points into arrow points is correct. If not, the argument is simple: the reason we don't see evidence in the obsidian points for earlier use of the lower Humboldt Valley is that the majority of the obsidian dart points were collected and repurposed as arrow points by later inhabitants of the area. I have not adopted this view for reasons detailed earlier.

If we grant that sustained, systematic reworking does not satisfactorily account for the observed outcome, two other lines of evidence come to the fore: the more than twofold increase in the number of Rosegate obsidian points in the valley and the advent of the bow and arrow technology. There are any number of things that could have been at work here: a change in local environmental productivity, facilitated by sustained inflow from the Humboldt River, invited much more intensive exploitation of the area so that the lower parts of the valley remained attractive for humans and the aquatic and avifaunal resources on which they depended. This could have happened in concert with bow and arrow technology moving from the north (as the obsidian sourcing evidence suggests) to the south to take advantage of the favorable conditions. As discussed above, there is no need to see this change as a population displacement, but rather as a technological change that may have taken many generations to play out within a dynamic flux of proximate families and social communities (cf. Simms, 1999). Even if population change was an element, "Surely, people who could respond to extended severe drought, decimation of large animal herds in one heavy winter's snow, or widespread destruction of marshes due to flooding in only a couple of years could adapt well to resource stress caused by immigration of a relatively few people over what must have been decades" (Elston, 1994: 151).

Adaptive responses to a changing biophysical resource base may have prompted this technological change, but it's difficult to imagine any small group of people not recognizing and evaluating the situational utility of implements other folks used to get their food—particularly if they happen to be very successful. If bow and arrow technology was actually a better way to make a living, in that environment at that period of time, indigenous people would easily have been able to avail themselves of that technology though social encounters and intermarriage, much like the information gathering social and genetic exchange exemplified by the fandango. Like bad news, good news also travels fast commensurate with intermarriage and information passed along from families to other families during foraging activities. Notwithstanding any cultural conservatism that may have impacted the speed and timing of bow and arrow acceptance, people don't starve because they refuse to change eating habits while their neighbors are doing just fine (contra Morgan and Bettinger, 2012: 195). Old habits may die hard, but not that hard. Regardless of cause(s), the evidence from the obsidian projectile points suggests that the more sustained, long distance contacts/relations with peoples living to the south changed significantly at Rosegate times.

Lastly, these frequency changes, by themselves, do not allow us to distinguish between: (1) more people living in the lower Humboldt Valley during Rosegate times or (2) fewer people living there, but with more intensive use of the more abundant and seasonally reliable resources the valley offered. Given the temporal frame of reference available using only projectile points, its impossible to decide between these extremes: the answer almost certainly is that people were confronted with choices in an ever-changing combination, and they responded based on centuries of experience and information acquired via networks of social relations that likely cut across the static boundaries of our current projectile point chronology.

The social/directional connectivities I have advanced here are best considered as working hypotheses and propositions that follow from assuming that similar kinds of imperatives (both opportunities and constraints) impinge among all traditional, kinship-based small-scale human foragers. This is not to say that the specific cultural/archaeological outcomes are determined by these, but to acknowledge that a variable temporal mix of factors is always in play. The temporal and spatial interrelations proposed are, of course, relevant to only a part of a much larger picture, which must eventually include better specification of the ranges over which projectile types were in use (and overlapped), incorporate even more fine-grained paleoclimatic, faunal, settlement/subsistence data, and integrate quarry-centric studies (such as those conducted by Singer and Ericson, 1977; Ericson, 1984; Elston and Zeier, 1984; Gilreath and Hildebrandt, 1997; Ramos, 2008; Elston, 2013; Elston and Raven, 2018; and Shott, 2021; also Fritz, 2021).[41]

Skeptics to the conclusions presented here might point out that the simple reason one sees overwhelming use of northern sources is that they are the closest to the lower Humboldt Valley and they contain the highest quality nearby obsidian. These individuals could cite as support the near-perfect correlation between the number of northern sources used and the numbers of obsidian points presented in figure 47**.** By this view, the number of sources represented in the arrow point category would be expected to increase gradually from the dart baseline as a consequence of reworking of older obsidian darts and the incorporation of "new" sources encountered as a byproduct of increased foraging radius accompanying use of the bow-and- arrow.

There are at least three empirically grounded objections to this view. First, the high-quality sources most proximate north of the lower Humboldt Valley (Majuba Mountain and Buffalo Hills) were emplaced geologically hundreds of thousands of years prior to any evidence of human activity. So, if proxemics and least-effort "pull" factors were the paramount human use considerations, we'd expect that these sources would have been the first to have been used and that their relative numbers in lower Humboldt Valley projectile point collections should increase through time (for reasons discussed earlier).

First, data in table 7 show that 56.0% (N = 93) of 166 Desert Series points, 68.4% (N = 184) of 269 Rosegate points; 58.2% (N = 82) of 141 of

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[41] Parenthetically, a quarry-based study at the Queen source (Ramos, 2008) suggests a floruit consonant with its use in the lower Humboldt Valley.

the Elko Series, 56.2% (N = 73) of 130 Gatecliff series, and 60% (N = 12) of 20 Northern Side-notched points were attributable to these two major northern sources. Congruent with the century-specific "abundance index" calculated in the Evaluating the Patterning section above, there was more extensive use of these northern sources during Rosegate times and, perhaps more germane to the recycling argument, relatively fewer Desert Series points were made from these sources—exactly the opposite of what one would expect if the range of obsidian sources used increased through time.

Second, if the proximity argument works in one direction (the north), it should hold for the south. As noted previously, there are extenuating geological factors that condition where obsidian erupted and, in this case, there are none proximate in a southerly direction that could compete with Majuba Mountain and Buffalo Hills. Regardless, we'd still expect that a "fall-off" pattern similar to the one found in the north would apply to the south if proxemics and least-effort factors predominated. As reviewed above, this is clearly not the case; the number of distant southern dart points actually exceeds those from equally distant northern sources.

Third, if the prediction following from the assumption about increasing source-use diversity attending the shift from dart to arrow is correct, more obsidian sources should be evident in the latter category. In fact, relative to sample size, diversity measures computed here show that dart points actually are more diverse (i.e., represent more sources) than arrow points. This outcome is antithetical to the result predicted.

Enlarging the Lithic Landscape: In earlier publications (Hughes, 2011, 2020b) I've attempted to understand and situate the temporally mutable relation between geographic features and social space by using the terms *effective distance* (that, is the linear or least-cost direct distance to the resource or feature in question) and *social distance* (in this case the social factors that might impinge on decisions about when, or whether, to go to that feature or resource), leaving aside the very important issue of how resources may have been differentially identified through time (see Bender, 2002). These terms are heuristic devices to guide thinking about and grappling with the ways different factors can influence responses—in human social life there is nearly always push-pull at work on some level.

Varying intersections between social obligations enacted within particular environmental contexts and effective distance incorporate the concepts of "bounded rationality" (Simon, 1956:129ff.) or "constrained choice"—terms that designate rational behavioral alternatives that take into account the cognitive limitations of the decision maker—limitations of knowledge, computational capacity, and opportunity. Just as we all operate and get by on less-than-perfect information in everyday life, so we "get along" by making less than perfect (i.e., nonoptimal) decisions. This is so because the notion of optimal itself presumes a degree of knowledge about outcomes that is highly situational and requires data/information no human possesses. Hence, to paraphrase Simon, people "satisfice" their way through life, making the best decisions they can based on limited information, conflicting and competing interests, and serendipity. The mélange of connections among the social, environmental, ceremonial, and spiritual contexts in which lives played out in the lower Humboldt Valley must have influenced the ways in which obsidian points were understood and these no doubt varied along both static and dynamic dimensions (cf. Kelly, 1999; Hughes, 2020b). Changes and continuity among these elements of human life through the centuries were every bit as dynamic as we consider our own, and disentangling what are essentially inseparable elements expressed in the material record remains one of archaeology's biggest challenges; "interpretive narratives find their expression in situated explanations—a grounding in the messy idiosyncrasies of evidence-context-culture-history that run counter to more ambitious inclinations to craft explanatory models of history at larger scales" (Hauser, 2012: 114).

CONCLUDING REMARKS

To a certain extent this study exemplifies the tension and mutualism that exists between particularistic studies and those more broadly synthetic and "theoretical." Over 60 years ago, John Rowe (1959) pointed out that the ability to address nuanced processual questions was inextricably dependent on fine-grained chronological control. The extension of this observation here is that the ability to detect fine-scale change in the sources and direction of arrow and dart point use carries implications for any and all studies that attempt broader generalization, or explanation, of the social and environmental forces that account for those particulars. Just as generalizations that don't adequately account for—or ignore—relevant particulars can be substantively vacant, so particularistic studies devoid of attempts at some broader applicability of their findings can remain "just so" stories.

Standing in isolation, no study of variability in obsidian source use will provide answers to "big picture" or macroevolutionary questions, but—at this scale—it is not designed to do so. The goal of this study, simply stated, was to use empirical evidence to evaluate the null hypothesis that there was no significant change in obsidian source use in the lower Humboldt Valley over the past 5000 years. Statistically supported differences through time were identified, and their possible cause(s) have been explored. No doubt any number of variables (climatic and social) articulated differently through time—like Venn diagrams of varying size contracting and expanding in response to the exigencies of local and regional biophysical and social conditions.[42] At the very least, the patterning identified in obsidian point conveyance in the lower Humboldt Valley is a palimpsest of uses by successive peoples, documenting continuity and contrast in directional interconnections and social distance through time.[43]

At a more general level, obsidian provenance (and obsidian hydration dating) studies have allowed us to track broad changes in source use through long periods of time in Nevada prehistory. Beck and Jones's (1990a, 1990b, 1994, 2009, 2011) and Jones et al.'s (2003, 2012) pioneering work in eastern Nevada, Delacorte's (1997), Milliken and Hildebrandt's (1997), Smith's (2007, 2008, 2010, 2011; Smith et al., 2012; Smith and Harvey, 2018), and Hockett's (1995) in northwestern Nevada, and the recent Ruby Pipeline results (Hildebrandt, et al., 2016; King, 2016) reveal a high diversity in obsidian source use during Paleoindian/Paleoarchaic times, remarkably low diversity in source use during Early and Middle Archaic times, and a return to high source use diversity during Late Archaic/Terminal Prehistoric times. Delacorte and Basgall (2012) and Delacorte (2020) presented cogent summaries of complementary data for the western area.

These region-specific patterns need to be evaluated in other areas. Current Humboldt Sink data suggest that during the Late Archaic there was—compared with Middle Archaic times—greater use of nearby northern obsidian, which may correlate with a more intensive focus on the resources around Humboldt Lake and decreasing contact with peoples and areas

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[42] The availability of piñon also may have been a factor influencing these distributions. Grayson (2011: fig. 8-16) and Charlet (2020) document the slow south-to-north spread of piñon from the White Mountains northward to the Bodie Hills by ca. 5000 BP Bodie Hills obsidian is prominent in lower Humboldt Valley sites just after this time, suggesting that more intensive social interactions with peoples living to the south (e.g., affines, ceremonial/religious partners, marriage arrangements) may have occurred during times when piñon resources were plentiful enough to support short-term higher population density. The presence of a single piñon hull in a Lovelock Cave coprolite (Ambro, 1967: 38) suggest that piñon was not a major food source in the LHV during Early/Transitional Lovelock times, but comparable local data are lacking for later periods.

[43] It is important to emphasize that the primary data presented here were generated entirely nondestructively from museum collections. This underscores the vital role of well-maintained museum repositories in a future archaeology that may include fewer and fewer actual excavations (see Surovell et al., 2017). We will always need new, more precise, and better-targeted information on particular problems that can be obtained only through excavation, but there are untapped resources in extant museum collections that may bear directly on one's research problem (see Griffin, 1981; Winters, 1981; Childs and Warner, 2019), and they are well worth the effort to "discover."

to the south. These conclusions, of course, apply only to the lower Humboldt Valley, but differential proximity to bedrock geology (Thomas, 2012) and effective distance would certainly have impacted the ways social distance variables influenced decisions peoples made about obtaining and conveying obsidian projectile points during different periods of time in the Great Basin (Hughes, 2020b).

If "each drainage system [in the Great Basin] could have its own prehistory" (Davis, 1966: 151) we will need to pay even more attention to the temporal and spatial aspects of social and material interrelatedness between and among these places before we can advance meaningful generalizations about the underlying forces (or processes) driving the observed outcomes. As others have noted (e.g., O'Connell et al., 1982; O'Connell and Elston, 1999; Zeanah and Simms, 1999) theoretically grounded research (e.g., Goodale and Andrefsky, 2015; James et al., 2022) will be extremely important to help guide and inform examination of the intersection(s) among these factors—particularly theoretically grounded predictions that have specific material consequences that can be measured and tested archaeologically. All this will require thorough consideration of problem-specific, empirical evidence on a valley-by-valley basis—the present study contains examples of some of the things we might learn from, and build on, in future investigations.

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APPENDIX 1

CONCORDANCE OF ARCHAEOLOGICAL SITE DESIGNATIONS, LOWER HUMBOLDT VALLEY, NEVADA

Abbreviations: **UCB,** University of Caifornia at Berkeley; **NSM,** Nevada State Museum; **HLB,** Humbolt Lakebed

Loud Site	**UCB**	**NSM**
1	NV-Pe-67	26PE101
2	26-Pe-2	26PE303
3	26-Pe-3	26PE304
4	26-Pe-4	26PE305
5	26-Pe-5	26PE306
6	26-Pe-6	26PE307
7	26-Ch-7	26CH37
8	26-Ch-8	26CH38
9	26-Ch-9	26CH39
10	26-Ch-10	26CH40
11	26-Ch-11	26CH41
12	26-Ch-12	26CH42
13	26-Ch-13	26CH43
14	26-Ch-14	26CH44
15	26-Ch-15	26CH45
16	26-Ch-28	26CH60
17	26-Pe-27	26PE9
18	26-Ch-18	26CH5
19	26-Ch-24	26CH4
—	HLB	—
—	26-Ch-35	26CH9
—	—	26CH159
—	26-Pe-7	26PE308
—	26-Pe-8	26PE309
—	26-Pe-14	26PE6
—	26-Pe-17	26PE17
—	26-Pe-66	26PE66

Obsidian Projectile Point Conveyance Patterns in the Lower Humboldt Valley, Nevada Obsidian artifacts ubiquitous on the surface of archaeological sites throughout western North America have traditionally been viewed as unworthy of serious study because of the difficulty in dating them. However, the time sensitivity of certain Great Basin projectile point types established over the last four decades brings the importance of surface collections more center stage because—coincident with the refinement of geochemical methods—obsidian artifacts from these sites can be analyzed using nondestructive instrumental methods and matched to their geological eruptive origin ("source"/chemical type) on the basis of trace and rare earth element chemistry. Many surface assemblages in the Great Basin—the lower Humboldt Valley in particular—contain considerable numbers of obsidian projectile points that, when matched to their chemical source of origin, open up entirely new ways to investigate change and continuity in past land use and social relations.

The present study was devoted to answering a very simple question: was there any significant change in obsidian source-use over the past 5000 years in the lower Humboldt Valley of the western Great Basin? To address this question, more than 900 obsidian projectile points and bifaces were analyzed from 24 archaeological sites and localities within the lower Humboldt Valley and their geological sources determined using nondestructive energy-dispersive X-ray fluorescence (EDXRF) analysis. Significant temporal and spatial changes in obsidian source use were identified in the direction and distance-to-source of arrow points vs. dart points, and in the source and direction of Humboldt series points and of Humboldt Basal-notched bifaces. These changes implicate directional shifts through time in social relations among peoples using and—during some periods—living at sites in the lower Humboldt Valley and provide independent data to evaluate current views about land use, artifact conveyance, social relations, and technological change in the western Great Basin.

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On the cover: The lower Humboldt Valley viewed from the mouth of Lovelock Cave (Ch-18) on December 1, 2007. Humboldt Lake in center, Trinity Range in the distance. Photo courtesy of Jack Hursh, Nevada Bureau of Mines and Geology.

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