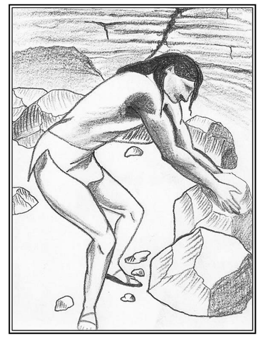
NORTH AMERICAN ARCHAEOLOGIST, Vol. 33(4) 399-427, 2012



LATE HOLOCENE LITHIC PROCUREMENT STRATEGIES IN THE NORTHWESTERN GREAT BASIN: THE VIEW FROM PAIUTE CREEK SHELTER, NEVADA*

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ABSTRACT

We present source provenance data from a sample of obsidian projectile points and unmodified flakes from Paiute Creek Shelter (PCS), a site in Nevada's Black Rock Desert that was first occupied 4,700 calendar years ago (cal BP). Significant differences between the source profiles of earlier (pre-1,450 cal BP) and later (post-1,450 cal BP) occupations suggest that toolstone procurement strategies changed over time at PCS. Before 1,450 cal BP, there was a heavy reliance on local toolstone directly procured from nearby sources. Although local toolstone remained important after 1,450 cal BP, non-local toolstone became more common at PCS, highlighting increased interactions with neighboring populations. The shift in toolstone use at PCS is but one of many changes in the archaeological record of the northwestern Great Basin after 1,500 cal BP.

*Funding for this work was provided by the Bureau of Land Management's Winnemucca Field Office, the Sundance Archaeological Research Fund (now the Great Basin Paleoindian Research Unit) and grants from Am-Arcs of Nevada, the Northwest Research Obsidian Studies Laboratory, the UNR Graduate Student Association, the Desert Research Institute, the Sven and Astrid Liljeblad Grant in Great Basin Studies, and the UNR Department of Anthropology.

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doi: http://dx.doi.org/10.2190/NA.33.4.b
http://baywood.com

INTRODUCTION

Researchers conduct source provenance studies to understand past social and economic relationships. Such studies link artifacts to geologic sources of raw materials (e.g., toolstone) and provide distributional data—a source of straightforward information about the past (but see Hughes, 1998, 2011a). Interpreting such information, however, can be complex. Hughes (1998) points out that identifying spatial or temporal patterns (distributional data) is not the same as identifying behavioral patterns (processes) and as anthropologists, we must ultimately focus on processes. Unfortunately, distributional data can be produced through myriad processes. Ethnographic accounts indicate that groups may obtain resources through formal exchange motivated by economic considerations (e.g., Steward, 1938), informal exchange motivated by social considerations (e.g., Wiessner, 1981), or direct access motivated by functional considerations (e.g., Binford, 1979). Knowing how groups obtained resources in the past is important: Kelly (2011) points out that it is the difference between groups' *physical* and *social* connections to the land, while Hughes (2011a) notes that it is the difference between *effective* (i.e., geographic) and *social* distance. Such information is critical to understanding how prehistoric populations navigated their social and physical landscapes.

Recently, researchers have increasingly considered the conditions under which we might expect different resource procurement strategies to have been employed in the past. In conjunction with traditional distributional data, this approach has led to more thorough evaluations of how prehistoric groups obtained resources (see Hughes, 2011b, for examples). Here, we follow suit by:

1. reviewing three ethnographically-documented modes of resource acquisition, with a focus on how groups procured lithic raw materials, and the social and environmental conditions under which they might be expected;
2. developing archaeological expectations for each mode of toolstone acquisition;
3. using those expectations to reconstruct the toolstone procurement strategies used by the occupants of Paiute Creek Shelter, an archaeological site in Nevada's Black Rock Desert; and
4. considering our results within the broader context of Late Holocene hunter-gatherer mobility, demography, and socioeconomic interaction in the northwestern Great Basin.

BACKGROUND: MODES OF RESOURCE PROCUREMENT

Because resources are rarely distributed uniformly in time (e.g., food) or space (e.g., toolstone), hunter-gatherers must work to ensure that their basic needs are met. To do so, they can employ various strategies:

1. consumers may move themselves to resources (Binford's (1980) residential mobility);
2. resources may be brought to consumers (Binford's (1980) logistical mobility); and
3. consumers may acquire resources from other groups (an activity herein referred to interchangeably as *trade* or *exchange*).

Residential and logistical mobility constitute *direct procurement*, a term developed by Binford (1979) upon noting that toolstone was obtained by the Nunamiut while hunting away from camp.

Binford (1979) argued that within the context of toolstone acquisition, direct procurement carries few costs if it is embedded in other activities, although Surovell (2009:128) notes that costs arise if toolstone is spatially incongruent with other resources. However, if toolstone is ubiquitous on a landscape, then Binford (1979) is right: acquiring it during other activities carries few costs. Raw materials may be obtained during groups' seasonal rounds or, like the Nunamiut, collected while pursuing other resources away from camp. Logistical trips undertaken specifically to collect toolstone are documented ethnographically (Binford and O'Connell, 1984; Gould and Saggers, 1985), but they were generally short (~20 km one-way) and directed to the closest sources of suitable material. Andrefsky (1994) notes that only in cases where toolstone is not available nearby do longer trips occur.

Direct procurement may entail energetic costs if toolstone is spatially incongruent with other resources, but it may also entail social costs if lithic sources are located in areas tied to other groups. All hunter-gatherers recognize geographic boundaries, although how they are maintained varies considerably (Kelly, 2007:185). Stable territories are only feasible when both resource density and predictably are high, and denying access to outsiders is likely only when the cost of defending resources is less than the benefits derived from them (Dyson-Hudson and Smith, 1978); for example, under conditions of limited resource availability. Such conditions were generally rare in the Great Basin (but see Steward, 1933, and Thomas, 1981a). Lithic resources, which are often widely distributed, are unlikely to have been controlled through physical boundary defense. Instead, social boundary defenses—mechanisms requiring outsiders to obtain permission to access resources—are more likely (Cashdan, 1983). Visitors seeking access to resources incur costs, typically expectations for future reciprocation (Kelly, 2007:194).

If effective or social distance precludes direct procurement, formal exchange may take place. In formal exchange, two or more groups exchange commodities to which both might not otherwise have access. In such cases, each group can benefit from the other's surpluses. Under conditions of local resource scarcity, formal exchange may be more efficient than direct procurement (Bettinger, 1982; Ericson, 1982). Formal exchange is well-documented ethnographically; for example, between horticulturalists and foragers, who trade carbohydrate-rich foods for protein-rich foods (Kelly, 2007:174-175). In the Great Basin, the Owens Valley Paiute traded pine nuts, salt, and other locally available commodities across the Sierra Nevada for acorns and other non-local commodities (Gayton, 1948:258-259). Similarly, the Northern Paiute obtained acorns, shells, and salt from the Washoe in return for antelope skins and fish (D'Azevedo, 1986:471). Although these examples primarily deal with food resources, the Yurok acquired obsidian bifaces through formal exchange networks, indicating that toolstone was also traded during ethnographic times (Hughes, 1978). The trans-Sierran movement of large bifaces from the obsidian-rich western Great Basin to obsidian-poor regions of California between ~3,000 and ~1,100 years ago (cal BP) (Gilreath and Hildebrandt, 1997, 2011; King et al., 2011), presumably in exchange for non-local resources, suggests that toolstone was procured through formal exchange in the past.

Like direct procurement, formal exchange is not without costs. Under conditions of widespread resource availability, low resource density, and the absence of physical boundary defenses—conditions that might occur on a sparsely populated landscape where toolstone is ubiquitous—direct procurement may be more profitable than formal exchange with neighboring populations. As Gould (1982:88) notes, "the more suitable a given habitat is for maximization of resources based upon strategies of individual family exploitation, the smaller and more restrictive [the social network] will be."

A third mode of toolstone procurement is the informal exchange of items for non-economic reasons. Hunter-gatherers use informal exchange, either patterned or opportunistic, to establish and maintain social connections (Hayden, 1982; Kelly, 2007:186-188). Among the Ju/'huansi, members of different groups exchange gifts to ensure access to *n!ore*—inherited tracts of land centered on water holes (Lee, 1979:334). They also establish *hxaro* networks, where items including beads, pots, and arrows move between trade partners, some living 200 km apart (Wiessner, 1981, 1982). Items are passed on and ultimately nobody gains materially through *hxaro*, but the social connections that they provide are indispensable.

In the Great Basin, informal exchange often occurred when neighboring groups came into contact either during chance encounters or planned meetings (Hughes and Bennyhoff, 1986:238). The primary cost associated with informal exchange is the expectations that may accompany it, such as during times of localized stress when neighboring groups might call upon the relationships established through it for assistance. Within the context of toolstone procurement, informal exchange clearly would not be the primary means through which groups obtained such a critical resource; however, it nevertheless has important implications for interpreting source provenance data.

The Archaeological Expectations of Different Modes of Toolstone Acquisition

The resolutions of ethnographic and archaeological data differ considerably: ethnographic fieldwork typically documents events lasting from moments to months; archaeological fieldwork typically documents palimpsests of human behavior visible only at broad timescales. Additionally, ethnographies fail to capture the full range of human behavior, how such behavior varies across archaeologically-visible units of time, and the fact that how groups behaved in the recent past is not necessarily how groups behaved in the distant past (Wobst, 1978). Despite these problems, however, the ethnographic record remains useful for generating archaeological expectations for different behaviors. In the case of source provenance studies, the ethnographic record allows us to build bridges between spatial patterns (distributional data) and the behaviors that produced them (processes). The three modes of ethnographically-documented toolstone procurement that we have described are capable of producing different archaeological signatures and we review each below.

Direct Procurement

If groups obtained toolstone directly between residential moves or while foraging near camp, then knowing where raw materials originated on the landscape would provide us with "a fair measure of . . . mobility scale" (Binford, 1979:261). If procurement took place during a seasonal round, then distributional data would reflect what Binford (1980) called annual cycles, or ranges. Annual ranges may shift according to resource availability, producing what Binford (1983) called lifetime ranges—the amount of ground cumulatively covered during a lifetime. If we knew where all of the lithic raw materials collected by foragers during their lifetime originated, then distributional data could approximate their lifetime range. Because many archaeological sites were reoccupied periodically over centuries or longer, multiple lifetime ranges are represented in some assemblages. If groups living in longer-term settlements instead obtained toolstone through logistical forays, then knowing where materials originated would approximate the ranges exploited while those settlements were occupied. Regardless of whether direct procurement occurred through residential or logistical trips, diachronic shifts in toolstone source profiles would signal changes in settlement and/or land-use strategies.

Formal and Informal Exchange

If groups instead obtained toolstone through formal exchange or informally during chance or planned encounters, then knowing where toolstone in assemblages originated would reflect the social, not necessarily just the physical, boundaries of groups' ranges. Barring major landscape alterations (e.g., the geologic formation of new lithic sources), the effective (i.e., geographic) distances between sources and sites do not vary diachronically; therefore, shifts in source profiles must document variability in social distance, perhaps reflecting changes in population density, economic activity, or relationships between neighboring groups (Hughes, 2011a). Identifying *which* factor(s) prompted changes in social distances in the past is tricky business, but recognizing that such changes *did* occur is a necessary first step towards that goal. Source provenance studies of lithic artifacts offers an avenue through which to recognize such shifts.

Unfortunately, current dating techniques lack the resolution required to identify human behavior on the timescales documented by ethnographic fieldwork. We generally cannot reconstruct individual annual ranges, or even the ranges used by multiple generations. At best, we can assign surface assemblages to particular centuries using direct dating methods or diagnostic artifacts as index fossils, and stratified sites using geologic and/or cultural strata. Because human behavior is variable, especially at archaeologically-visible timescales, distributional data provided by source provenance studies likely reflect myriad processes of toolstone procurement. However, if despite this fact we are still able to detect significant diachronic shifts, then the accumulated human behaviors responsible for those changes necessarily must have differed significantly as well. Our work at Paiute Creek Shelter (PCS), a stratified rockshelter in northwestern Nevada, has identified significant changes in toolstone source profiles across time and offers an opportunity to consider how toolstone was obtained by the site's occupants.

MATERIALS AND METHODS: OBSIDIAN ARTIFACTS FROM PAIUTE CREEK SHELTER, NEVADA

Paiute Creek Shelter is located in Nevada's Black Rock Desert (Figure 1). It is a modest east-facing rockshelter situated at the base of a 15 m high volcanic debris flow with ~55 m^2 of dry area protected from the elements within the dripline. In 2006, a crew from the University of Nevada, Reno excavated four 1-m^2 units in two 2 m × 1 m excavation blocks to ~2 m below surface using 5 cm arbitrary levels within natural geologic strata (Figure 2). Sediment was passed through 1/8th-inch mesh and all cultural material was collected. We recovered extensive lithic and faunal assemblages from 10 strata. A detailed analysis of the lithic assemblage is nearing completion (LaValley, 2013) and basic artifact counts are presented in Table 1. A preliminary analysis of the archaeofauna indicates that artiodactyls and leporids are abundant (Schmitt, 2007). Ten radiocarbon dates obtained on hearths and isolated charcoal fragments are ordered stratigraphically from youngest to oldest within each excavation block and allow us to group the strata into cultural components of known ages:

1. together, Components 1, 2, and 3 date from ~150 cal BP to ~1,450 cal BP; and

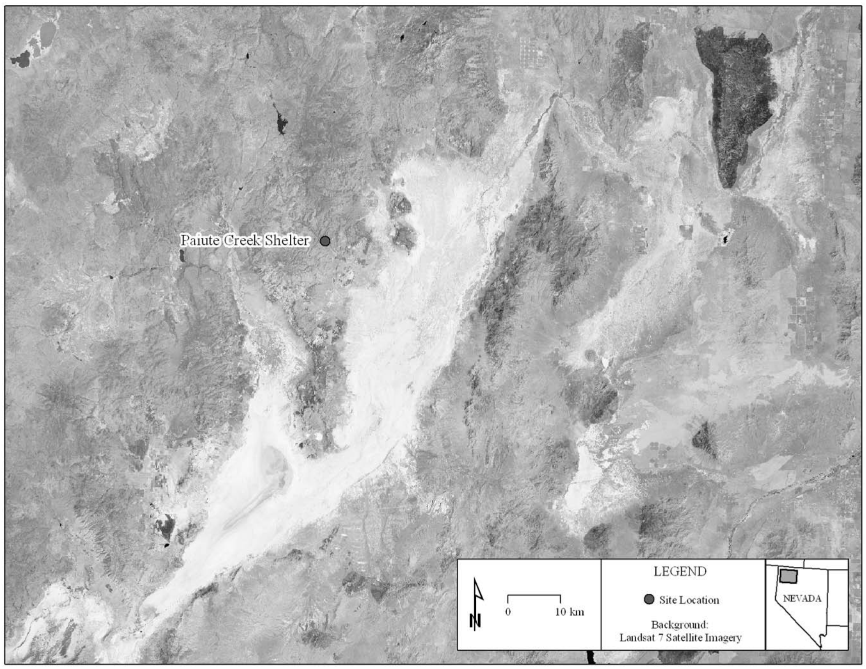

Figure 1. Location of Paiute Creek Shelter, Nevada.
Image courtesy of David Page.

2. Component 4 dates from ~1,450 cal BP to ~4,700 cal BP when PCS was first occupied (Table 2).

While additional analyses of materials from PCS will contribute to our understanding of Late Holocene lifeways, our concern here is with the obsidian artifacts and their utility in evaluating toolstone procurement strategies. Toward that goal, we submitted 53 obsidian projectile points and 92 unmodified obsidian flakes to the Northwest Research Obsidian Studies Laboratory for non-destructive X-ray fluorescence (XRF) analysis. We assigned projectile points to two categories:

1. middle period points, which predate ~1,300 cal BP and include Gatecliff, Humboldt, and Elko Series points; and
2. late period points, which postdate ~1,300 cal BP and include Rosegate and Desert Series points (Table 3).[1]

[1]Projectile point chronology based on Thomas (1981b) and Elston (1986).

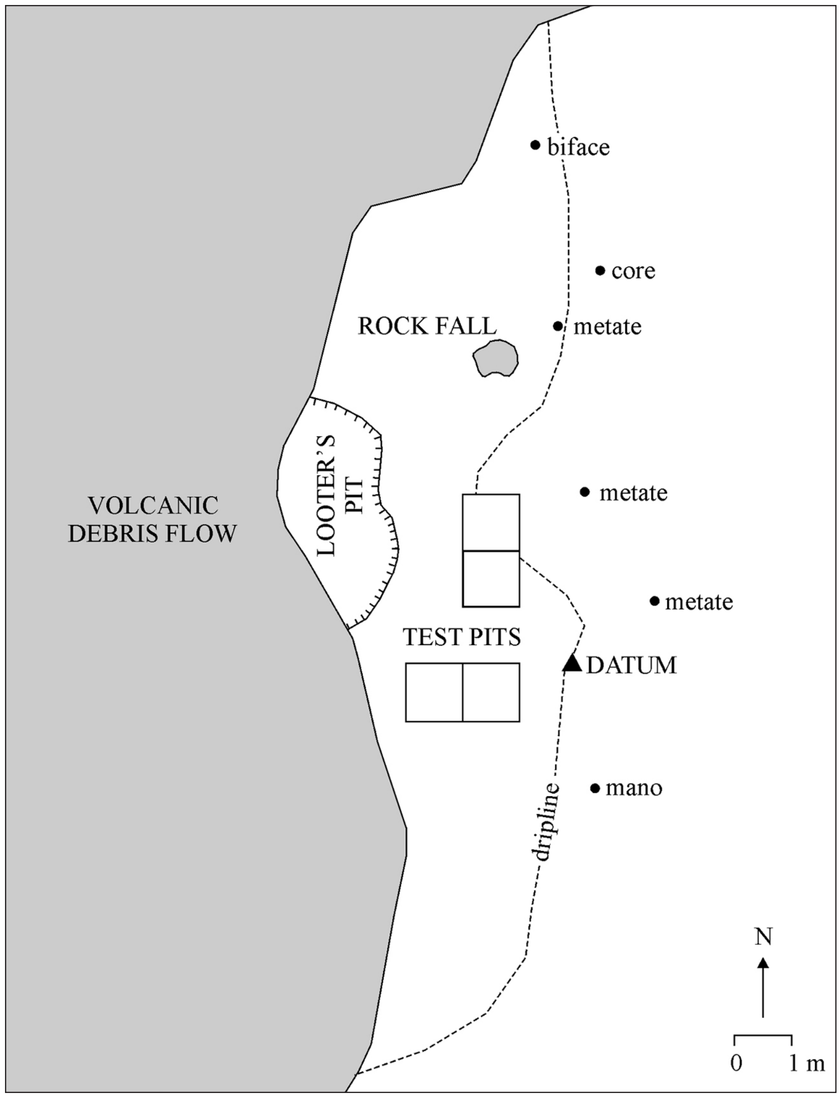

Figure 2. Planview map of Paiute Creek Shelter with location of test pits.

The break (1,300 cal BP) between these two periods does not correspond directly with the break (1,450 cal BP) in our radiocarbon-dated stratigraphic components; we employed the former to facilitate comparisons to other recent studies (see below). We also assigned unmodified flakes to these two periods based on their stratigraphic position at PCS: middle period debitage was recovered from

Table 1. Preliminary Artifact Counts for Paiute Creek Shelter

	Component		
Artifact class	1-3	4	Total
Points	110	13	123
Bifaces	347	24	371
Unifaces	159	15	174
Cores	50	5	55
Debitage	60,585	6,131	66,716
Groundstone	39	7	46

Table 2. Summary of Components, Strata, Depth Below Surface, and Calendar Ages

Component	Strata	Depth (cm)	Age (cal BP)
1	1, 2, 3, 3a	0-47	0-150
2	4a, 4	47-82	150-850
3	4a, 4	82-132	850-1,450
4	4, 5, 6, 6a, 7	132-210	1,450-4,700

Table 3. Projectile Point Sample from Paiute Creek Shelter

	Time period	
Projectile points series	Middle	Late
Gatecliff	7	
Humboldt	4	
Elko	17	
Rosegate		13
Desert		12
Total	28	25

Component 4 and late period debitage was recovered from Components 1-3. We grouped artifacts into two broad categories (middle and late) to compare our results to those of other recent studies in the region (McGuire, 2002a; Smith, 2010, 2011): they correspond roughly to the Middle and Late Archaic periods in the northwestern Great Basin (Elston, 1986; McGuire, 2002b).

To characterize toolstone procurement strategies at PCS and determine if they varied diachronically, we used source provenance data for points and debitage in three ways. First, we calculated source-to-site transport distances (in straight-line kilometers) for each artifact. For geochemical types with multiple sources, we calculated the distance from the nearest source to PCS. We averaged transport distances for points and debitage and compared them for each period.[2] Second, we compared the frequencies of local and non-local obsidian among points and debitage for each period. Local is defined here as obsidian sources within 20 km of the site—a long day's walk but one that is physically possible.[3] Finally, because source diversity is often used as a proxy for groups' physical or social connections to the landscape (Connolly, 1999; Eerkens et al., 2008; McGuire, 2002a), we calculated and compared richness for the point and debitage samples for each period.[4]

Archaeological Expectations for the PCS Obsidian Sample

Using these materials and methods, we generated expectations for the three modes of toolstone procurement discussed above.

[2]Students' *t* tests are often used to determine if two samples are significantly different; however, because the distribution of artifact transport distances are generally skewed toward local sources, they are not normally distributed. As such, artifact transport distances often violate one of the assumptions of *t* tests. We instead bootstrapped the means by pooling all the values for both artifact groups (points versus debitage, middle period vs. late period points, etc.), drawing samples of sizes n1 and n2, and comparing the difference between the new means. The two-tailed probability is calculated as the relative frequency of bootstrapped mean absolute differences greater than the absolute observed difference. Based on our experiences, the *p* values obtained using *t* tests and bootstrapping are generally similar.

[3]A 20 km one-way distance results in a roundtrip distance of 40 km. Assuming a human walks at a pace of 5 km/hour, 40 km can be covered in 8 hours.

[4]Because traditional measures of richness may be influenced by sample size (Grayson, 1984; Kintigh, 1984), following Eerkens et al. (2007) we calculated it using a bootstrapping routine. We bootstrapped larger samples (using 1,000 iterations) so that we could directly compare richness for points and flakes within each period. For example, to compare the 27 late period points to the 30 late period flakes, we drew 1,000 samples of 27 flakes each (with replacement) from the late period debitage sample and averaged the number of geochemical types represented in each sample.

Direct Procurement

If toolstone was procured directly, then most points and debitage should be made on local obsidian. This expectation is based on the fact that northwestern Nevada is one of most obsidian-rich areas in North America and high-quality Massacre Lake/Guano Valley (ML/GV) obsidian is available 19 km from PCS. If residentially-mobile groups arrived at PCS with obsidian, then they did not have to transport it very far. Alternatively, if logistically-mobile parties left PCS to collect obsidian, either during special-purpose trips or while collecting other resources, they similarly did not have to travel far. In either case, when high-quality toolstone is locally available, both formal (e.g., projectile points) and informal artifacts (e.g., unmodified flakes) tend to be made on it (Andrefsky, 1994).

Formal Exchange

If obsidian was obtained through formal exchange, presumably because the occupants of PCS did not have access to toolstone, then we expect both projectile points and most unmodified debitage—especially smaller flakes (Eerkens et al., 2007)—to be made on non-local material. Our expectation is based on the premise that the site's occupants would need large raw material packages with which to produce a variety of chipped stone tools and usable flakes (*sensu* Kelly, 1988). We might expect toolstone packages to arrive at PCS partially reduced, perhaps as large bifacial blanks field processed in advance of transport to remove lower-utility cortex (Beck et al., 2002; Elston, 1992) but still large enough to provide both sources of usable flakes and finished tools.

Informal Exchange

Finally, if some obsidian was obtained via informal exchange (e.g., neighboring groups trading finished points), then a majority of points and debitage should be manufactured on local obsidian and a minority of points should be made on non-local material. Additionally, non-local debitage should be rare because non-local points were obtained as finished tools. In this scenario, the dominance of local toolstone in both formal and informal artifact categories would reflect the day-to-day lithic economy at PCS while the low-frequency of non-local toolstone would reflect either *ad hoc* or patterned exchange with other groups. Our archaeological expectations for these modes of toolstone procurement are summarized in Table 4.

RESULTS

Nine geochemical types ranging between 19 and 236 km from PCS are represented (Table 5). The geographic distribution of Bog Hot Springs Unknown 1 obsidian is currently not well understood, so we excluded that material from our

Table 4. Summary of Expectations for Transport Distances for Toolstone Procurement Strategies

Procurement strategy	Toolstone expectation	
	Points	Flakes
Direct procurement	Near	Near
Formal exchange	Far	Far
Informal exchange	Far	Near

Table 5. Geochemical Assignments of Middle and Late Period Projectile Points and Debitage

Geochemical type	Distance (km)	Middle period		Late period	
		Points	Flakes	Points	Flakes
ML/GV	19	23	24	14	56
Coyote Springs	41	1			
BS/PP/FM	41		1		1
Badger Creek	65				1
Double H/Whitehorse	85			4	
Paradise Valley	122			2	
Burns	219	1			
Dog Hill	236			1	
Bog Hot Springs Unknown 1[a]	?	2	5	3	1
Whitehorse-BS/PP/FM[b]	?	1	1	1	2
Total	—	28	31	25	61

[a]Although geochemically distinct from other obsidian types in the region, the geographic distribution of Bog Hot Springs Unknown 1 remains poorly understood at this time.

[b]Samples could not confidently be assigned to one of the two geochemical types due to small sizes. As such, they were not used in calculations of transport or source diversity. Because the nearest sources of Whitehorse and BS/PP/FM obsidian are > 20 km, we included them in our comparisons of local vs. non-local toolstone.

calculations of transport distances and comparisons of local and non-local obsidian, but did include it in our richness calculations. Additionally, five artifacts are made on *either* Bordwell Spring/Pinto Peak/Fox Mountain (BS/PP/FM) *or* Whitehorse obsidian, which overlap in their geochemical signatures and can be problematic to assign to a particular type (Craig Skinner, personal communication, 2012). We did not include those artifacts in our calculations of transport distances or richness, but because both geochemical types do not occur within 20 km from PCS, we included them in our local vs. non-local comparisons.

Middle Period (~4,700 to 1,450 cal BP) Obsidian Use at PCS

Middle period points and debitage highlight a heavy reliance on local obsidian: 23 of 28 (82.1%) projectile points and 24 of 31 flakes (77.4%)—47 of 59 total artifacts (79.6%) are made on ML/GV obsidian (see Table 5). Transport distances do not differ significantly between points (27.9 km) and unmodified debitage (19.9 km) ($p = .250$, bootstrapping) (Table 6). Additionally, points and debitage do not differ significantly ($p > .999$, Fisher's exact test) in the proportions of local and non-local obsidian. Finally, when adjusted for sample size, richness does not differ significantly ($p = .457$, bootstrapping) between points (4.0) and debitage (2.9). In sum, between ~4,700 and ~1,450 cal BP, the occupants of PCS relied heavily on local obsidian for their toolstone needs, and both formal and informal artifacts were made on that material. These results are consistent with our expectations for direct procurement.

Late Period (Post-1,450 cal BP) Obsidian Use at PCS

After 1,450 cal BP, a different trend is evident. Late period points (51.7 km) traveled almost twice as far as middle period points, a difference that is significant

Table 6. Middle Period Projectile Point and Debitage Transport Distances, Source Diversity, and Local vs. Non-Local Origin

Artifact class	*N*	Transport distance (km)	*N*	Source diversity	Obsidian source: Local	Obsidian source: Non-local
Projectile points	25	27.9	27	4.0	23	3
Unmodified debitage	25	19.9	30	2.9	24	2
	$p = .250$ (bootstrapping)		$p = .457$ (bootstrapping)		$p > .999$ (Fisher's exact)	

at the .10 level (bootstrapping). Non-local obsidian is significantly (p = .033, Fisher's exact test) over-represented among late period points compared to middle period points. Furthermore, after 1,450 cal BP, points (51.7 km) traveled significantly (p < .001, bootstrapping) farther than unmodified debitage (20.2 km) (Table 7). When categorized as either local or non-local, the difference between the raw materials represented in the point and debitage samples is significant at the .10 level (chi-square test). Finally, points are made on significantly (p < .001, bootstrapping) more obsidian types (5.0) than unmodified flakes (2.2). In sum, during the late period, raw materials used to make projectile points and debitage originated from different sources—some near and some far. These results are consistent with our expectations for informal exchange.

DISCUSSION

Four trends are apparent in our results:

1. late period points were transported almost twice as far as middle period points;
2. non-local obsidian is more common in late period points than middle period points;
3. middle period points and debitage are both predominantly local; and
4. late period points are made on significantly more non-local obsidian than late period debitage.

We consider the implications of these results to both toolstone procurement strategies at PCS and the Late Holocene prehistory of the northwestern Great Basin below.

Toolstone Acquisition at PCS

Whether residentially-mobile groups "geared up" with obsidian before arriving at PCS or groups collected obsidian during logistical forays, direct procurement

Table 7. Late Period Projectile Point and Debitage Transport Distances, Source Diversity, and Local vs. Non-Local Origin

Artifact class	*N*	Transport distance (km)	*N*	Source diversity	Obsidian source	
					Local	Non-local
Projectile points	21	51.7	24	5.0	11	8
Unmodified debitage	58	20.2	59	2.2	56	4
	p = .001 (bootstrapping)		p = .001 (bootstrapping)		p = .070 (chi-square)	

was likely the primary means through which toolstone arrived at PCS before ~1,450 cal BP. We favor direct procurement for two reasons. First, it is unlikely that groups in northwestern Nevada, which contains one of the densest concentrations of obsidian sources in North America, "imported" local obsidian using formal exchange networks. As Hayden (1982:113) points out, "to argue that the exchange of any bulk item, especially over long distances, was important among prehistoric hunter/gatherers, there should be good reasons for believing that there was a lack of important resources in specific band-sized areas or larger." We cannot discount the possibility that groups in northwestern Nevada "exported" volcanic glass to obsidian-poor regions, as was likely the case with Bodie Hills and Coso obsidian in eastern California between 3,000 and 1,100 cal BP (Gilreath and Hildebrandt, 1997, 2011; King et al., 2011), but we currently lack the data needed to demonstrate that such behavior occurred. Second, while we acknowledge the difficulty in identifying informal exchange, we appeal to common sense when suggesting that most ML/GV obsidian—a local resource—was directly procured rather than through casual encounters with neighboring groups. Projectile points made on non-local obsidian may have been exchanged in such a manner but if this was the case, then it occurred far less frequently during the middle period than during the late period.

After 1,450 cal BP, the primary mode of toolstone acquisition likely changed at PCS. Projectile points were more commonly made on non-local obsidian while debitage continued to be made from local obsidian. Projectile points were also manufactured on more diverse obsidian types than unmodified flakes. Although cryptocrystalline silicates (CCS) and other toolstone types are not a primary focus of this study because we cannot confidently assign them to particular geologic sources, we note that they are significantly over-represented in late period (i.e., arrow) points compared to middle period (i.e., dart) points ($\chi^2 = 5.44$, $df = 1$, $p = .020$) (Table 8). Based on macroscopic differences in the CCS used

Table 8. Frequencies of Obsidian vs. Other Raw Material Types in Middle and Late Period Projectile Points

	Raw material		
Period	Obsidian	Other	*Total*
Middle	27	6	33
Late	26	22	48
Total	53	28	81

Note: $\chi^2 = 5.44$, $df = 1$, $p = .020$.

to make arrow points, we suspect that a variety of different sources are represented. If we are correct, then toolstone diversity is higher in the late period point sample than the XRF data indicate.

Because the effective (i.e., geographic) distances between PCS and toolstone sources did not change over time, the differences between our middle and late period samples indicate that the social distances shifted. We discount formal exchange as the primary mode of toolstone acquisition during the late period for the same reasons we do so for the middle period: groups using PCS would likely not trade for a commodity that was widely available to them within a short walk—a commodity so widely available that social or physical defense would neither be warranted nor possible. Furthermore, if obsidian was obtained through formal exchange, then projectile points and unmodified debitage should exhibit similar source profiles. This is not the case.

If we rule out formal exchange, then we are left with two possibilities—direct procurement and informal exchange—to account for the non-local obsidian at PCS. Both are intuitively reasonable and capable of producing similar source profiles. At this juncture, we acknowledge the difficulty of avoiding equifinality's "loving embrace" (Hughes, 2011a:7) when weighing these different possibilities. Differences in the source profiles of formal tools and debitage like that present in our late period sample are common (Eerkens et al., 2007; Smith, 2009). Arguments that rely on direct procurement to explain such disparities are typically based on the premise that projectile points were formal tools—meaning they were produced in anticipation of use, transported between sites, and maintained (Torrence, 1983)—whereas unmodified flakes were not. Within the context of Paleoindian research in the Great Basin, one of the present authors (Smith, 2007, 2010), along with other researchers (e.g., Goebel, 2007; Jones et al., 2003), has relied on this premise to argue that toolstone procurement was embedded within residential movements. Although not explicitly stated, part of Smith's reasoning for doing so is that fluted and stemmed points are large implements. Although specimens made on obsidian still typically break after only a few throws (Lafayette and Smith, 2012), the fragments are often large enough to have been reworked into new projectiles (see Beck and Jones, 2009:186-187, for a discussion of how this could have occurred) and through Paleoindians' efforts to extend their points' use-lives, projectile points may have been transported substantial distances within a mobile settlement system. Although smaller than Paleoindian points, broken dart points can also be reworked into functional projectiles (Flenniken and Raymond, 1986) and may have traveled substantial distances in part because their users extended their use-lives. However, given that small arrow points break easier than large dart points (Odell and Cowan, 1986) and require a reduced investment to manufacture them, broken arrow points were probably more often replaced than repaired (Connolly and Jenkins, 1997; Skinner et al., 2004)—a trend that is evident in Nevada's Carson Desert (see Table 9 in Kelly, 1988). As such, we do not believe that the substantial transport distances (≥ 85 km) exhibited by many (33%; $n = 7$) late period points are best explained by toolstone procurement activities embedded within residential movements.

Non-local obsidian in the late period sample could instead have been obtained via logistical trips, but we find this possibility unlikely because no subsistence resources merit the considerable round-trip distances reflected in late period points. Even if the occupants of PCS undertook logistical forays with the sole intent of acquiring toolstone, many of the non-local sources are beyond the logistical radii of many ethnographic populations (Kelly, 2011). Additionally, traveling to those non-local sources would mean that groups bypassed numerous closer sources of high quality obsidian.

We are left with one plausible scenario—informal exchange of finished points during encounters with neighboring populations—to account for the small amount of non-local obsidian at PCS after ~1,450 cal BP. Ethnographically, such behavior is well-documented: !Kung hunters trade arrows whenever they come into contact with neighboring groups (Wiessner, 1983). In the Great Basin, the Kaibab Southern Paiute traded with the Kaiparowits for arrows, while the San Juan Paiute traded arrows to the Ute (Hughes and Bennyhoff, 1986, and sources therein). Whether these exchanges took place opportunistically during chance encounters or periodic population aggregations, they could result in a small amount of toolstone moving considerable distances across the landscape.

In the end, it may be problematic to argue that a single mode of toolstone acquisition was at play for centuries or millennia at PCS. Cumulatively, however, those modes differed enough to produce dissimilar source profiles between the middle and late periods. The diachronic shifts observed at PCS are part of a much larger transition that took place in the northwestern Great Basin after 1,450 cal BP that is manifested in a variety of ways in the archaeological record. We conclude by considering our results within a regional context.

Prehistoric Change in the Northwestern Great Basin

The shift in toolstone use at PCS is one of many changes that took place in the northwestern Great Basin between ~1,500 and ~1,000 cal BP (Table 9). At many sites in northwestern Nevada and the neighboring areas, the frequency of non-local obsidian increases (McGuire, 2002a; Skinner et al., 2004; Smith, 2010), residential structures become less substantial (Elston, 1986; Jenkins, 1994; McGuire, 2002c), local:non-local toolstone ratios decrease, implying reduced occupation spans (Smith, 2011), the movement of goods between northeastern California and northwestern Nevada increases (Delacorte and Basgall, 2012), textile styles change (Adovasio, 1986), the directionality of toolstone source exploitation shifts (Connolly and Jenkins, 1997; Kelly, 2011; Skinner et al., 2004), settlements become more dispersed (Beck 1984; Connolly and Jenkins, 1997; Jones, 1984), and resource intensification increases (Carpenter, 2002; Delacorte, 2002; Elston, 1986; Leach, 1988; Weide, 1968).

Table 9. Summary of Major Shifts in the Archaeological Record of the Northwestern Great Basin and Adjacent Areas between 1,500 and 1,000 cal BP

Manifestation	Study area(s)	Reference
Directional Shift in Obsidian Movement	Drews Valley, Oregon	Connolly and Jenkins (1997)
	Carson Desert	Kelly (2011)
	Northeastern California	Delacorte and Basgall (2012)
	Fort Rock Basin, Oregon	Skinner et al. (2004)
Increased Toolstone Ratios	Northwestern Great Basin	Smith (2011)
Increased Lithic Conveyance Zones	Black Rock Desert-High Rock Country	Smith (2010)
Increased Projectile Point Transport	Black Rock Desert-High Rock Country	Smith (2010)
Increased Source Richness	Northeastern California	McGuire (2002c)
	Black Rock Desert-High Rock Country	Smith (2010)
Dispersed Residential Sites	Northern Great Basin	Jenkins (1994)
	Steens Mountain	Beck (1984)
	Steens Mountain	Jones (1984)
	Northeastern California	McGuire (2002c)
Less Substantial Residential Structures	Northeastern California	McGuire (2002b)
	Lahontan Basin, Nevada	Elston (1986)
Increased Marine Shell Beads	Lahontan Basin, Nevada	Delacorte and Basgall (2012)
	Western Great Basin	Bennyhoff and Hughes (1987)
Changes in Textile Technology	Western Nevada	Adovasio (1986)
Subsistence Intensification	Northeastern California	Carpenter (2002)
	Northeastern California	Delacorte (2002)
	Massacre Lake Basin, Nevada	Leach (1988)
	Warner Valley, Oregon	Weide (1968)
	Lahontan Basin, Nevada	Elston (1986)

These changes occurred during a time when regional population densities were likely at their highest (Figures 3 and 4)[5] and many may seem at odds with elevated populations. For example, toolstone sourcing data and changes in residential structures and settlement systems point to increased residential mobility, perhaps within larger ranges. Increased residential mobility within larger ranges could provide access to distant and diverse toolstone sources, producing the trends noted in source profiles across the region. Such a move could also account for the apparent shorter occupation spans and reduced investment in residential structures. But how could these changes have taken place during a time when high population levels would have presumably contributed to settlement contraction and territorial circumscription?

McGuire (2002a, 2002c) suggests that populations did adopt more dispersed settlement strategies but did not necessarily expand their foraging ranges; that is, they moved residential camps more frequently but not necessarily through larger ranges, like many Great Basin groups did during ethnographic times (Steward, 1938). Higher residential mobility on an increasingly crowded landscape would have brought neighboring groups into contact more often. If informal exchange of items like finished arrow points took place during these meetings, then such behavior could produce source profiles mimicking those produced by increased foraging ranges.

Whether such shifts are the product of environmental change or social change remains to be seen. Jones et al. (1999) argue that the Medieval Climate Anomaly (~1,200 to 650 cal BP) caused social upheaval across western North America including population declines and the breakdown of long-distance trade networks. With the exception of radiocarbon dates from the Fort Rock Basin (see Figure 3), we see little evidence for population decline in the northwestern Great Basin. Furthermore, while we acknowledge that some long-distance formal exchange networks in western North America may have collapsed (e.g., the trans-Sierra movement of obsidian from eastern California), we do not see evidence for this in the northwestern Great Basin. Source profiles from many sites show an increase in non-local toolstone (Smith, 2010, 2011), exactly the opposite of what we might expect if long-distance networks collapsed. Furthermore, marine shell beads increase in numbers in the Western Great Basin after ~1,500 cal BP, suggesting that some exchange networks persisted (Bennyhoff and Hughes, 1987; Delacorte and Basgall, 2012).

Noting many of the changes we have highlighted in this article, other researchers instead point to population shifts in the northwestern Great Basin after 1,500 cal BP as a primary driver of culture change. The origin of Numic-speaking groups is one of the enduring topics in Great Basin anthropology, and

[5] The temporal frequencies of projectile points and radiocarbon dates have not been corrected for potential taphonomic biases in the manner recommended by Surovell et al. (2009).

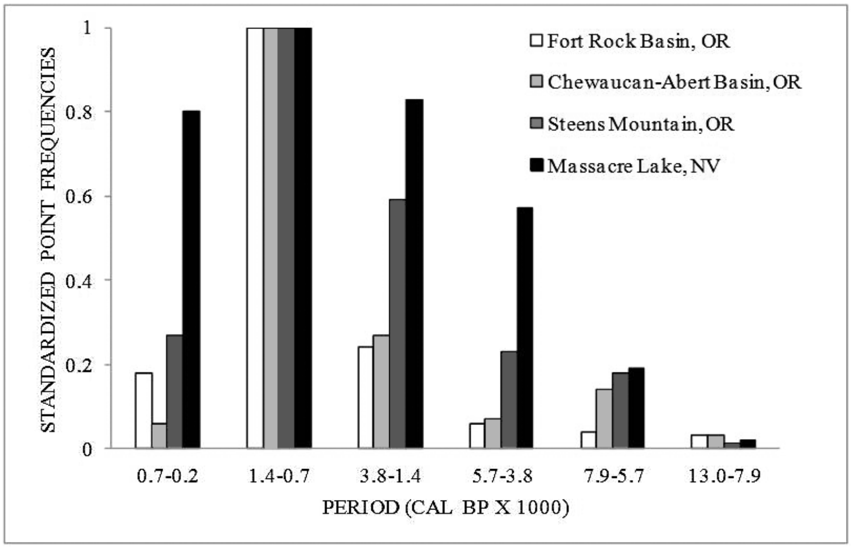

Figure 3. Time-adjusted and standardized projectile point frequencies for various locations in the northwestern Great Basin. (Bettinger's (1999) summary of these data is derived from the following primary sources: Fort Rock Basin = Aikens and Jenkins (1994); Chewaucan-Abert Basin = Oetting (1995); Steens Mountain = Jones (1984); and Massacre Lake = Leach (1988). We adjusted Bettinger's (1999) periods from radiocarbon years to calendar years using Appendix A in Grayson (2011).)

many researchers working in the northwestern Great Basin (e.g., Delacorte and Basgall, 2012; Connolly and Jenkins, 1997; McGuire, 2002c) attribute late period change to the arrival of the Numa from eastern California (*sensu* Bettinger and Baumhoff, 1982; Lamb, 1958). It is important to note, however, that many of those researchers see the arrival of the Numa occurring later (post-500 cal BP) than our arbitrary ~1,450 cal BP division (a necessity given the break in PCS components and inferred ages of diagnostic projectile points at open-air sites used in other studies). We do not discount the possibility that the arrival of new ethnic groups contributed at least in part to the wholesale changes that took place in the northwestern Great Basin, although assigning particular types of artifacts to ethnic populations can be problematic (see Madsen and Rhode, 1994, and the references contained within).

CONCLUSION

In this article, we presented source provenance data from PCS to evaluate three modes of toolstone acquisition. We recognize the difficulty in avoiding the

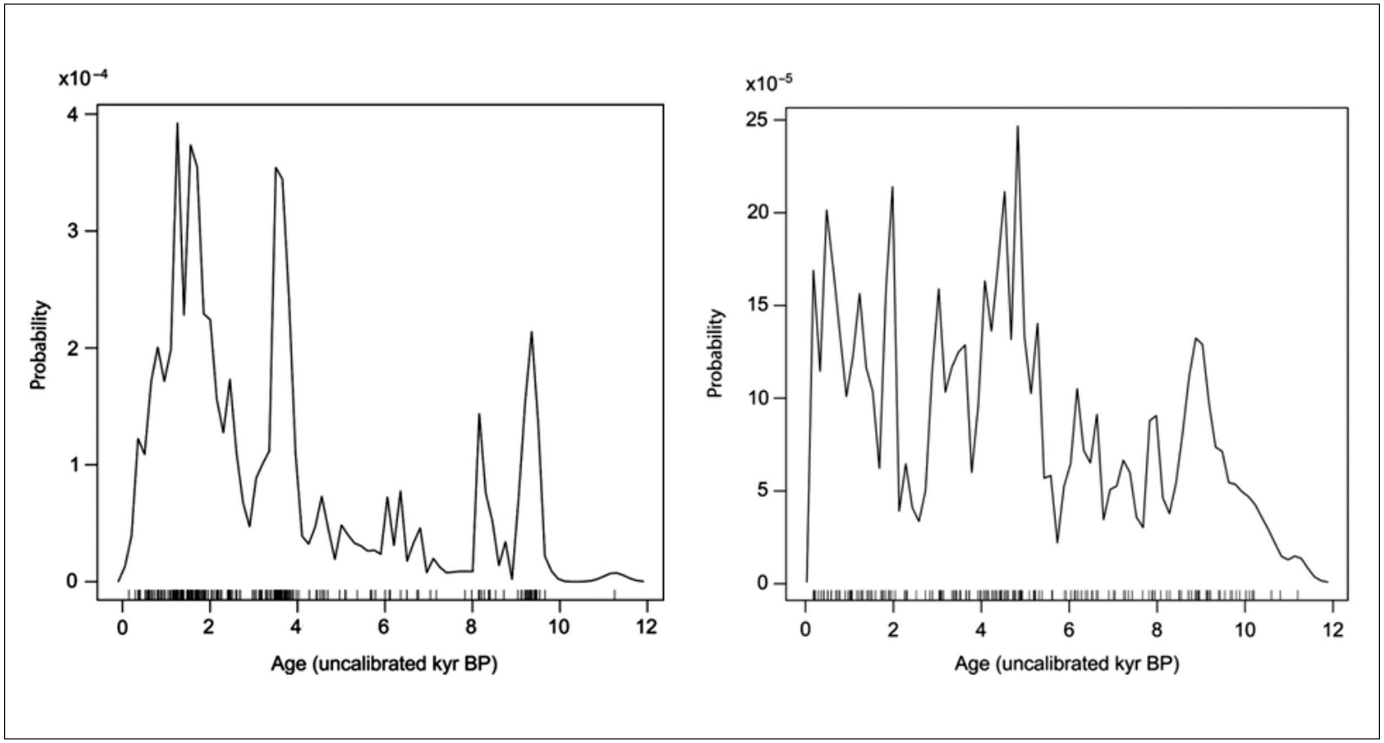

Figure 4. The summed probability distributions of radiocarbon dates from archaeological sites in the Fort Rock (left) and Lahontan (right) basins.
Figure adapted from Louderback et al. (2011) with permission from authors.

problem of equifinality when considering how toolstone arrived at a site; however, we believe that using ethnographic data and archaeological evidence together with a knowledge of regional toolstone availability is a productive approach to understanding how groups obtained raw materials. This approach is especially well-suited in northwestern Nevada, where high quality obsidian is ubiquitous and we can discount formal exchange as a common mode of toolstone acquisition there. When left with direct procurement or informal exchange as plausible mechanisms to introduce obsidian into PCS, we favor direct procurement during the middle period (~4,700-1,450 cal BP) because local ML/GV obsidian dominates both the projectile points and debitage in our sample. While we believe that the bulk of obsidian was still obtained via direct procurement during the late period (post-1,450 cal BP), we attribute the rise in non-local obsidian to increased informal exchange between neighboring groups who came into contact with one another more frequently as a result of increased residential mobility. The transition in PCS source profiles is part of a suite of changes that took place in the northwestern Great Basin, although understanding how and why those changes occurred requires continued research.

ACKNOWLEDGMENTS

Craig Skinner conducted the XRF analysis of artifacts from Paiute Creek Shelter, Geoff Smith and Joey LaValley analyzed the projectile points, and Kristina Wiggins analyzed debitage from the site. Bob Kelly, Todd Surovell, two anonymous reviewers, and the editor of *North American Archaeologist* provided feedback on earlier versions of this manuscript. The manuscript was largely written during a residency at the Playa at Summer Lake, a non-profit organization that supports artists, writers, and natural scientists working in the Great Basin. Any errors contained herein are our own.

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