

Artifact Size and Chemical Sourcing: Studying the Potential Biases of Selecting Large Artifacts for Analysis

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Introduction

Lithic sourcing or provenance analysis has become an indispensable tool in California and Great Basin archaeology, allowing us to reconstruct many facets of prehistoric lifeways, including settlement patterns, tool curation, exchange systems, territoriality, and quarrying behavior (e.g., Basgall 1989; Bettinger 1982; Bouey and Basgall 1984; Gilreath and Hildebrandt 1997; Hall 1983; Hughes 1994; Ramos 2000). In general, X-Ray Fluorescence (XRF) has been the preferred method. This popularity likely stems from the wide availability of XRF machinery, the relative low cost of XRF, and historical factors (i.e., to ensure comparability between samples).

As we demonstrate below, however, the systematic and exclusive use of XRF can lead to serious biases in our interpretation of the archaeological record. In particular, size restrictions usually require artifacts to be over 10 mm in diameter and 1.5 mm thick. Under some circumstances these limits can be lowered slightly. For example, Dr. Richard Hughes of Geochemical Research Laboratories is currently working on methods to reduce his minimum sample size (Hughes, personal communication 2002).

Articles

SourceArtifact (technique)	Casa Diablo	Mono Glass Mtn.	Fish Springs	Truman Queen	Bodie Hills	Mt. Hicks	Mono Craters	Totals
Small Flakes (INAA)	22 (47%)	11 (25%)	2 (4.2%)	9 (19%)	-	-	2 (4.2%)	47
Large Flakes (XRF)	135 (61%)	60 (27%)	18 (8.1%)	7 (3.2%)	1 (0.5%)	-	-	221
Points (XRF)	17 (57%)	7 (23%)	1 (3.3%)	5 (17%)	-	-	-	30
Bifaces (XRF)	44 (54%)	8 (10%)	4 (5%)	7 (9%)	-	2 (2%)	-	82
Flake Tools (XRF)	13 (52%)	3 (12%)	-	2 (8%)	-	-	-	25
Totals	257	102	26	38	1	2	2	428

Table 1: Comparison of source diversity by artifact category.

However, in all cases the very nature by which data are gathered in XRF requires a relatively large minimum artifact size, particularly with regards to thickness. Large sample size ensures that the technique gives reliable measurements for all elements (Davis et al. 1998). Unfortunately, these restrictions inhibit research into the behaviors that lead to the deposition of small flakes. Such behaviors, including pressure flaking to resharpen or finish the production of a tool, and tool use resulting in the removal of microdebitage (e.g., microchipping visible along flake tool margins), represent significantly different kinds of behaviors than those resulting in the deposition of large flakes, such as biface thinning. By limiting sourcing studies to the analysis of large flakes, then, we are potentially missing an important component of the archaeological record. This bias is generally acknowledged in California and Great Basin studies (Davis et al. 1998; Skinner 2001), but few have attempted to evaluate and/or resolve the

extent of this bias as it applies within an archaeological context. Concerns over the potential effects of sample size selection have also been expressed in regards to obsidian hydration analysis (i.e., Jackson 1999), but again, there has been little attempt to address these biases.

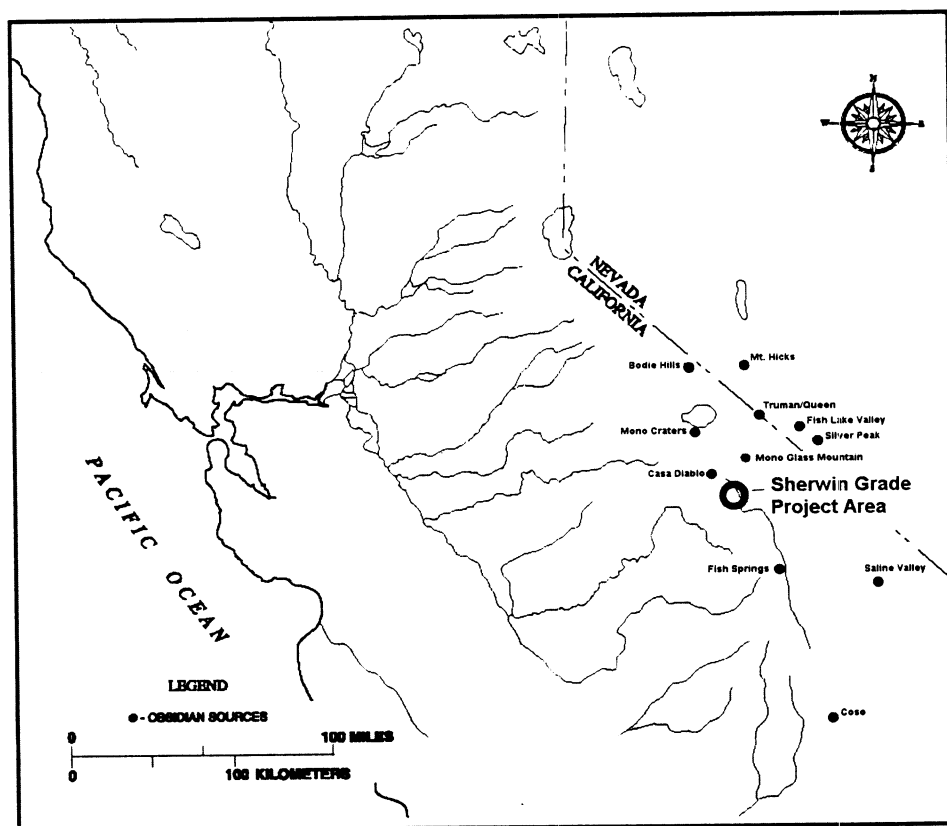
Sample Selection and Methods

To investigate the significance of the sample size restrictions in XRF sourcing studies, we compare the results of a typical XRF sample to the results of a sourcing study using Instrumental Neutron Activation Analysis (INAA) composed only of small flakes (under 10 mm in maximum diameter and 1.5 mm in thickness, and weighing approximately 200 mg). INAA does not have the same size restrictions and can be performed on samples as small as 2 mm in diameter and/or 5 mg. This small size smaller than most flakes produced during various activities, and is certainly larger than the 1/8" (3.2 mm) mesh size usually employed during excavation. Thus, INAA can handle the full range of artifacts that archaeologists in California and the Great Basin typically encounter.

Obsidian artifacts were sampled from 14 prehistoric sites in the Sherwin Summit area of southern Mono County, California (see Eerkens and King 2002). The region contains several nearby and chemically distinct obsidian sources that were exploited by prehistoric inhabitants. The location of the project area and major regional obsidian sources is shown in Figure 1.

In total, 321 artifacts were submitted for XRF analysis, including 30 projectile points, 82 bifaces, 25 flake tools, and 221 flakes over 10 mm in diameter. Figure 2 presents a sample of the artifacts from the project. Artifacts were selected at random from site assemblages and submitted to Geochemical Research Laboratories in Portola Valley, California. In addition, a smaller sample of 47 flakes under 10 mm diameter (though most less than 5 mm in

Figure 1: Sherwin Summit and major obsidian sources in the region.



diameter) were submitted for INAA at Missouri University Research Reactor (MURR), Columbia, Missouri. Samples were analyzed according to the abbreviated procedure outlined by Glascock et al. (1992).

Results

Overall, the pattern of sources compared to artifact category is consistent with the interpretation that the main focus of flintknapping within the project area was the reduction of Casa Diablo obsidian into bifaces (see Eerkens and King 2002). The majority of large flakes and tools are from this source. However, a small percentage of the tools and a larger percentage of the smaller flakes are from alternative sources, pointing out a second focus of flintknapping in the study area. These activities seem to have revolved around the resharpening of bifaces and projectile points from more distant sources such as Truman Queen and Mono Craters, among others. Table 1 presents the results of the INAA and XRF sourcing studies showing these differences.

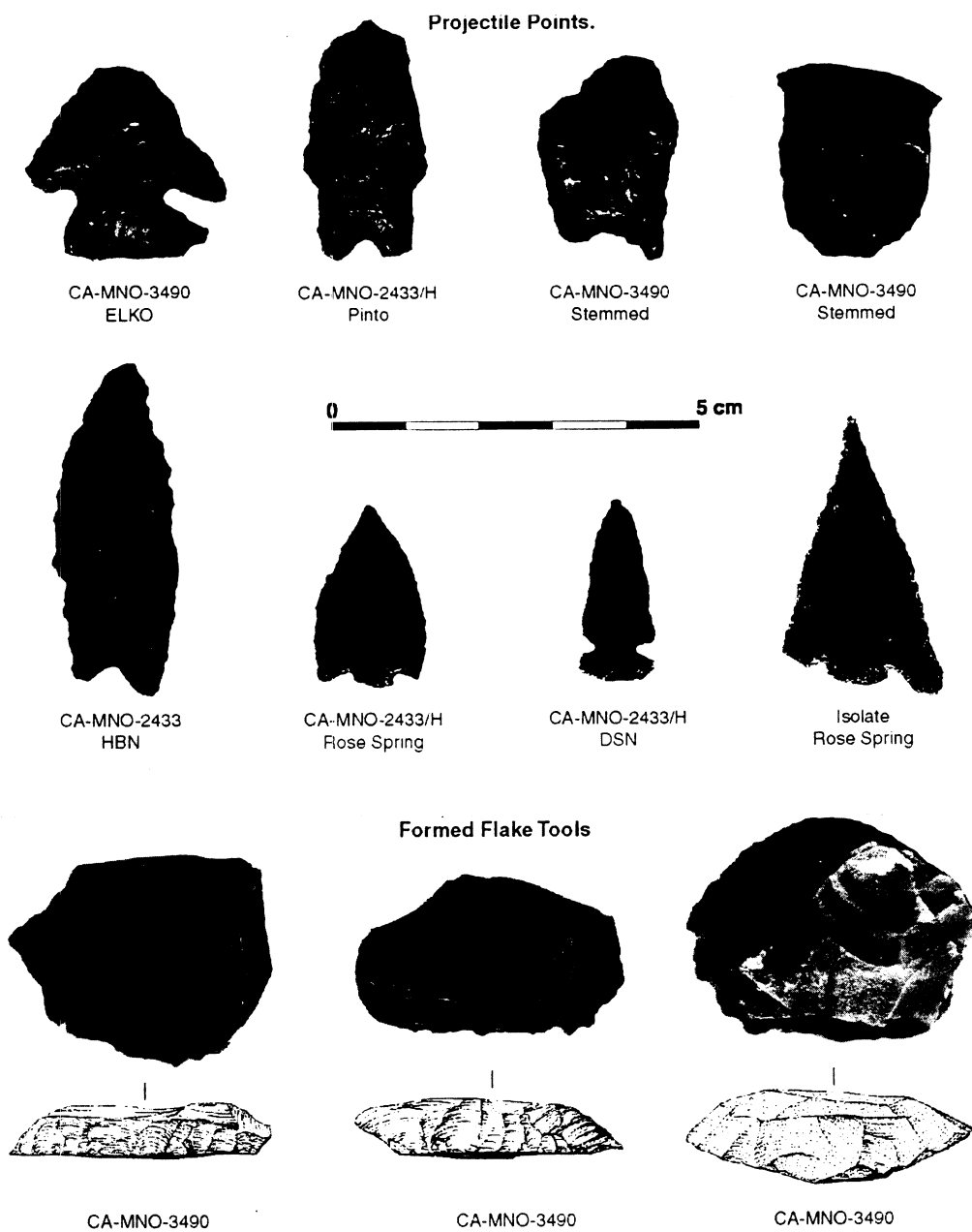
While the percentage of large and small flakes ascribed to some sources is approximately equal, such as Mono Glass Mountain (27% and 25%, respectively), others are quite different. For example, while 63% of the large flakes were assigned to the Casa Diablo source, INAA ascribed only 47% of the small flakes to this source. As well, while 3.3% of the large flakes were sourced to Truman Queen and 8.1% to Fish Springs, the percentage of small flakes was determined at 19% and 4.2% respectively.

A chi-square comparison of the frequency of Casa Diablo and Truman Queen flakes for small and large flakes is highly significant ($p = .00003$). The results of the Chi-square test suggest that Truman Queen debitage tends to be composed predominantly of smaller pressure flakes while Casa Diablo flakes are usually larger and percussion-sized (i.e., large enough to be

sourced by XRF). By comparison, a chi-square test on large and small flakes from Casa Diablo and Mono Glass Mountain is insignificant ($p = .77$), suggesting there is little difference in the size of flakes from these two sources.

Not surprisingly, Truman Queen obsidian also makes up a relatively high fraction of the projectile point assemblage (16.7%; see Table 1). All of this is consistent with a pattern where completed points from the Truman Queen source were brought into the project area in completed form and were either resharpened (accounting for the smaller debitage) or were discarded and replaced with newly knapped Casa Diablo points (accounting for the larger Casa Diablo

Figure 2: Selection of flaked stone tools from Sherwin Summit.



Articles

debitage). Very little primary reduction of Truman Queen obsidian took place within the project area. Primary reduction, instead, seems to have been limited to Casa Diablo, and to a lesser extent Mono Glass Mountain, obsidian. Although we did not recover projectile points from the Mono Craters source, the same may be true of obsidian from this source. The presence only of smaller pressure flakes from Mono Craters suggests we are capturing only the retouching activities associated with obsidians from this source. Tools from this source may have arrived to the Sherwin Summit area through trade or as part of seasonal mobility patterns that included forays into the Mono Basin. Future research will attempt to discern between these alternatives.

Thus, source diversity among the smaller flakes nearly matches that observed among the projectile points. A chi-square test comparing obsidians from Casa Diablo, Mono Glass Mountain, and Truman Queen across projectile points and small flakes only is not significant ($p = .86$), suggesting that the distribution of small pressure-sized flakes and points more closely mirror one another (these three are the only sources with sample sizes large enough to warrant including in the statistical test).

Discussion

As shown above, there are significant differences in the source distribution of small pressure-sized and large percussion-sized flakes in the Sherwin Summit region. Although not unexpected, the significance of this difference was not known. As shown, the analysis of small flakes more closely mirrors the source distribution of projectile points, and in this case expanded the range of obsidian sources observed to include Mono Craters. Inclusion of this source significantly expanded our understanding of prehistoric mobility patterns and exchange systems for the Sherwin Summit (Eerkens and King 2002). We were also able to demonstrate that resharpening finished tools was an important part of the range of activities taking place on the landscape.

In most archaeological projects, projectile point sample sizes are extremely limited. However, the number of small flakes is usually not. Source analysis of small flakes, then, may present an opportunity to estimate the original source diversity of projectile points that were at a site, but were subsequently removed (i.e., curated) and used elsewhere (depending, of course, on the technological flintknapping system in place and how the small flakes are sampled from a site).

Selecting only larger flakes for sourcing analysis can affect not only the range of different sources represented, but their overall importance as well. Because large and small flakes represent different behaviors and activities (i.e., primary reduction vs. resharpening), and because these behaviors may have a temporal component as well (i.e.,

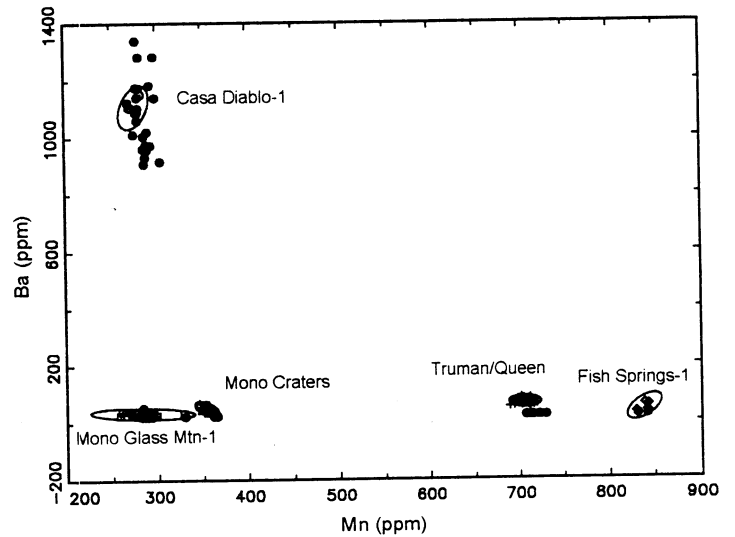


Figure 3: Bivariate plot of Mn and Ba showing separation of Eastern California obsidian sources. Solid dots represent Sherwin Summit small flakes. Ellipses represent 95% confidence intervals around analyzed source samples.

pressure flaking may be more important in late-prehistoric vs. early-prehistoric contexts), it is quite possible that limiting our analyses to larger flakes misrepresents the nature and importance of prehistoric activities through time. This is particularly relevant in situations where we depend on source-specific obsidian hydration readings to trace prehistoric activities on the landscape. If we differentially select larger pieces for analysis (due to technical limits in our methods), we may be missing certain aspects and time periods in prehistory.

Unfortunately, few studies of prehistoric sites in California and the Great Basin systematically attempt to source small flakes. Depending on how research questions are phrased, the lack of small-flake sourcing may be introducing biases into our understanding of the prehistoric record. In particular, we suggest that this bias probably results in an underestimation of the extent of prehistoric mobility and exchange and the importance of resharpening and use of obsidian tools. The bias *may* also have a temporal component, overemphasizing time periods where percussion flaking dominates. Correcting this potential bias should be a concern to all working in the region.

Why this bias against the analysis of small flakes is in place is unclear, but we believe it may extend from a lack of exposure to sourcing techniques outside of XRF. There may be a misperception that techniques such as INAA or Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), which both give reliable chemical data on small artifacts, are expensive or inaccessible. Sourcing data for small flakes is available to the public at MURR for \$40 per sample, using the best method available. In most cases this can be

accomplished using the abbreviated INAA procedure outlined by Glascock et al. (1994). However, extended INAA and ICP-MS (using laser ablation) are also available at the same cost. This compares favorably with most XRF laboratories that charge between \$25 and \$35 per sample. As shown in Figure 3, the abbreviated INAA procedure is quite capable of discriminating between all the major obsidian sources in Eastern California. The figure plots parts per million (ppm) concentrations for manganese and barium for known source samples and items from the Sherwin Summit. Unfortunately, the obsidian database at MURR for Casa Diablo is small and does not contain data for different subsources. As a result we were unable to discriminate between the Sawmill Ridge and Lookout Mountain subsources that Hughes (1994) can discern using XRF.

The major drawback of INAA and ICP-MS is that like obsidian hydration, the techniques are partially destructive (though ICP-MS with laser ablation, also available at MURR, does not have this problem). This may make retrieving both hydration and sourcing data from the same small pressure flake difficult, though certainly not impossible (i.e., depending on the size of the initial flake).

In conclusion, we hope to have dispelled some of the common misperceptions about the techniques available to source small obsidian flakes. As well, we hope to have shown that, in the Sherwin Summit case, the systematic analysis of small pressure-sized flakes, in addition to large flakes and different artifact categories, adds important information to our understanding of prehistoric lifeways. We believe California and Great Basin sourcing studies should strive to include smaller pressure flakes, in addition to traditionally-sourced artifact categories, within their sourcing studies.

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