Title
Sources Of Obsidian From The Escalante Ruin Group, Central Arizona: An Energy Dispersive X-Ray Fluorescence(EDXRF) Analysis

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Author
Shackley, M. Steven, Ph.D.

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INTRODUCTION

The character of obsidian procurement during all periods of Hohokam occupation in Arizona is, at best, in a very preliminary form. The recent geochemical analysis of 220 obsidian artifacts from Pueblo Grande suggested that this procurement is quite complex and both direct access and exchange occurs during this time period (Peterson et al. 1992). At Pueblo Grande the high diversity of obsidian source provenience may have been due to unequal utilization of sources by different segments of the population. Whether these inferences are truly an effect of social complexity within the greater Hohokam society, or a unique effect at Pueblo Grande only provided the impetus for this study.

Based on a preliminary analysis of obsidian artifacts from some other Classic period Hohokam contexts I have argued that Northern Arizona obsidian was not a common feature in late Hohokam sites (Shackley 1988, 1989). The analysis of the Pueblo Grande sample indicates that this is not the case. The sample exhibited a substantial proportion (25.9%) of obsidian from Government Mountain and Partridge Creek in north central Arizona. Indeed, the obsidian assemblage from Pueblo Grande exhibited glass from seven known and three unknown sources. The source provenience of the material did not conform to the
Law of Monotonic Decrement and other explanations were investigated (Peterson et al. 1992).

The analysis here of 29 obsidian artifacts from probable Classic Period contexts in four sites within the Escalante Ruin Group in central Arizona indicates a similar diversity in the procurement of obsidian tool stone as found at Pueblo Grande to the north.

ANALYSIS AND INSTRUMENTATION

The results presented here are quantitative in that they are derived from "filtered" intensity values ratioed to the appropriate x-ray continuum regions through a least squares fitting formula rather than plotting the proportions of the net intensities in a ternary system (McCarthy and Schamber 1981; Schamber 1977). Or more essentially, these data through the analysis of international rock standards, allow for inter-instrument comparison with a predictable degree of certainty (Hampel 1984).

The trace element analyses were performed in the Department of Geology and Geophysics, University of California, Berkeley, using a Spectrace 440 (United Scientific Corporation) energy dispersive x-ray fluorescence spectrometer. The spectrometer is equipped with a Rh x-ray tube, a 50 kV x-ray generator, with a Tracor X-ray (Spectrace) TX 6100 x-ray analyzer using an IBM PC based microprocessor and Tracor reduction software. The x-ray tube was operated at 30 kV, .20 mA, using a .127 mm Rh primary beam filter in a vacuum path at 250 seconds livetime to generate x-ray intensity data for elements titanium (Ti), manganese (Mn), iron (as FeO\textsuperscript{T}), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). Trace element intensities were converted to concentration estimates by employing a least-squares calibration line established for each element from the analysis of up to 26 international rock standards certified by the U.S. Bureau of Standards, the U.S. Geological Survey, Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in

In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards. Table 1 shows a comparison between values recommended for two international rock standards, one rhyolite (RGM-1) and one obsidian (NBS-278). One of these standards is analyzed during each sample run to insure machine calibration. The results shown in Table 1 indicate that the machine accuracy is quite high, and other instruments with comparable precision should yield comparable results.

Trace element data exhibited in Tables 1 and 2 are reported in parts per million (ppm), a quantitative measure by weight. Source probability is based on a comparison with 1-sigma levels of variability. Table 2 exhibits the trace element concentrations for the 29 samples, and Figures 1 through 4 exhibit concentration plots of five of the analyzed elements.

**SPATIAL AND CULTURAL INFERENCES**

Treating the site as a single component locus of obsidian procurement, a number of inferences and observations can be made. One of the first and basic observations directed toward provenience analyses is the determination of distance and direction to sources. A primary measure is the Law of Monotonic Decrement that states that in circumstances of uniform loss or deposition, artifacts produced from a given source material will occur in monotonically decreasing proportions as the effective distance from the source increases (Renfrew 1977).

Table 3 and Figure 5 exhibit the frequency distribution, distance to source, and direction for the Escalante Ruin Group data. As expected, a vast majority of the material was procured from relatively close sources (Sauceda Mountains - 62.1%, and Superior - 27.6%). This can be seen graphically in Figure 6, a regression scattergram of the proportions plotted against linear distance. If the Law of Monotonic Decrement were
operating perfectly we would see a perfect negative linear relationship \( (r^2=1.0) \) between proportion and distance. As you can see this is not the case, where \( r^2=0.33 \), standard error of the estimate=24.27, significant at 0.31, reflecting the large scatter of data points.

The one sample (76-87-45) from AZ U:15:22, a possible Sacaton period projectile point, was produced from Cow Canyon obsidian. The primary deposit for this source is on the western edge of the Mogollon Highlands in Greenlee County, Arizona (see Shackley 1988, 1990). Recent investigations in the Upper Gila and San Francisco River area indicates that material from this source and the Mule Creek source is eroding into the Gila River alluvium at least as far west as Safford, Arizona (Shackley 1992). However, none of the nodules located in the alluvium were as large in diameter as would be necessary to produce a projectile point of this size (>35 mm). It seems probable that the raw material for this projectile point was derived from the primary deposit area at least 195 km to the northeast, and the style of the point suggests that it was produced by a Hohokam knapper rather than a Mogollon knapper in whose territory the Cow Canyon source is located (Cordell 1984; Haury 1936). This is the first firm evidence of obsidian derived from this region in Hohokam contexts.

Table 4 is a cross-tabulation of source provenience by sites within the group. While the sample size is relatively small, there may be some variability in the diversity of procurement evident in the data. As expected, the greatest diversity is evident in the largest sample from AZ U:15:3. Interestingly, however, Government Mountain obsidian from the Colorado Plateau and Cow Canyon material from the east does not occur in the larger sample from this site, but at two other sites (AZ U:15:22&27) with much smaller sample sizes. Certainly, sampling error could be operative here, but this may not be so.
CONCLUSION AND SUMMARY

Table 3 exhibits the distance and direction to the sources detected in the analysis. Material was procured from many sources in all cardinal directions and environments from the Sonoran Desert (Sauceda Mts, Superior, Los Vidrios), to piñon-juniper woodlands (Cow Canyon), to yellow pine forest-grassland (Government Mountain). During the Archaic period, these upland environments were important resource areas exploited in the late summer and fall. The Hohokam procurement of obsidian in these environments could be the result of similar logistic forays into these environments, or a result of interaction and exchange.

One important aspect of the research here was an investigation of the presence of Superior obsidian in Hohokam contexts. At Pueblo Grande a relatively small proportion of glass material (10%) was derived from the nearest source Superior (Picketpost Mtn) only 80 km distant, possibly due to an effect of source control by Salado groups. If the source was controlled by the Salado, then Superior obsidian would not be much more common in sites in the Escalante Ruin Group even though it is much closer to the source (≤30 km). In the Escalante Ruin sample, over 27% of the obsidian was derived from the Superior source (Table 3). The source is 30 km closer to these sites suggesting that the larger proportion is, at least, in part due to proximity. Taken as a whole, however, the Law of Monotonic Decrement does not explain the dominance of Sauceda Mountain material located at least 122 km southwest, a pattern similar to Pueblo Grande material. These data along with the Pueblo Grande study increasingly suggest that the Superior material was relatively unavailable during the Classic Period. Parenthetically, it is possible that at least some of the Superior glass was procured from the Queen Creek alluvium outside Salado "influence" about 15 km north. This may explain the higher proportion of the material in these sites.

Most of the Sonoran Desert sources can certainly be said to be within Classic period Hohokam "range". Los Vidrios material, for example, is located along the Sonoita River
in northern Sonora on the route to the Gulf of California and could have been procured incidental to (or embedded within) shell procurement expeditions or exchanged with shell material from groups to the south. The Government Mountain and Cow Canyon derived material from the highlands is much more difficult to explain, but may be an effect of interaction with Mogollon or Salado groups to the east and north. The probable Sedentary Period style of the point produced from Cow Canyon glass may be an indication of changes in range or interaction through time. The small sample hinders confident conclusions.

The diversity of sources in the obsidian assemblage at Escalante Ruin is certainly provocative. The continued apparent preference for the more distant Sauceda Mountains obsidian versus Superior the nearest source among the "eastern" Classic Period Hohokam seems most likely to be related to access problems. Both Sauceda and Superior glass are equally excellent media for tool production and both are available in nodule sizes over 5 cm in diameter, and at high nodule densities at the source (Shackley 1988, 1990). Contact with other groups and/or direct procurement of obsidian in the highlands is again indicated in this sample as at Pueblo Grande. Analyses of obsidian from other Classic Period contexts in other areas may provide more clarity.
REFERENCES CITED

Cordell, Linda S.

Govindaraju, K.

Hampel, Joachim H.

Haury, Emil W.

McCarthy, J.J., and F.H. Schamber

Peterson, Jane, Douglas R. Mitchell, and M. Steven Shackley

Renfrew, Colin

Schamber, F.H.

Shackley, M. Steven


Ward, Graeme
Table 1. X-ray fluorescence concentrations for selected trace elements of two international rock standards. ± values represent first standard deviation computations for the group of measurements. All values are in parts per million (ppm) as reported in Govindaraju (1989) and this study. RGM-1 is a U.S. Geological Survey rhyolite (obsidian) rock standard, and NBS-278 is a National Bureau of Standards obsidian standard.

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>TiO₂</th>
<th>MnO</th>
<th>Rb</th>
<th>Sr</th>
<th>Y</th>
<th>Zr</th>
<th>Nb</th>
<th>Ba</th>
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<td>RGM-1 (Govindaraju 1989)</td>
<td>2670</td>
<td>360</td>
<td>149</td>
<td>108</td>
<td>25</td>
<td>219</td>
<td>8.9</td>
<td>807</td>
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<tr>
<td>RGM-1 (this study)</td>
<td>2433.07±147.1</td>
<td>321.12±16.75</td>
<td>150±3.4</td>
<td>105±1.7</td>
<td>26±0.9</td>
<td>218±5</td>
<td>9.5±1.1</td>
<td>844±48.86</td>
</tr>
<tr>
<td>NBS-278 (Govindaraju 1989)</td>
<td>2450</td>
<td>520</td>
<td>127.5</td>
<td>63.5</td>
<td>41</td>
<td>295</td>
<td>n.r.¹</td>
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<td>NBS-278 (this study)</td>
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<td>n.m.</td>
<td>126±1.9</td>
<td>62±2.3</td>
<td>40±2.2</td>
<td>280±3.6</td>
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¹ n.r = no report; n.m. = not measured
Table 2. X-ray fluorescence concentrations for obsidian artifacts from the Escalante Ruin Group. All measurements in parts per million (ppm).

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<th>SAMPLE</th>
<th>Ti</th>
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<th>FeO</th>
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<th>Y</th>
<th>Zr</th>
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<td>10635.86</td>
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<td>126.637</td>
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</tr>
<tr>
<td>SAMPLE</td>
<td>Ti</td>
<td>Mn</td>
<td>FeO</td>
<td>Rb</td>
<td>Sr</td>
<td>Y</td>
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<td>88-58</td>
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<td>21.701</td>
<td>21.244</td>
<td>106.704</td>
<td>33.544</td>
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Figure 1. Concentration plot of Ti versus Zr (C=Cow Canyon, G=Govt. Mtn., L=Los Vidrios).

Figure 2. Concentration plot of Y versus Sr (C=Cow Canyon, G=Govt. Mtn., L=Los Vidrios).
Figure 3. Concentration plot of Rb versus Sr (C=Cow Canyon, G=Govt. Mtn., L=Los Vidrios).

Figure 4. Concentration plot of Sr versus Zr (C=Cow Canyon, G=Govt. Mtn., L=Los Vidrios).
Table 3. Frequency distribution of source provenience, distance to source, and direction from all sites combined.

<table>
<thead>
<tr>
<th>Element</th>
<th>Frequency</th>
<th>Percent</th>
<th>Distance (km)</th>
<th>Direction</th>
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<td>Cow Canyon</td>
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<td>3.4</td>
<td>105-130&lt;sup&gt;a&lt;/sup&gt;</td>
<td>E</td>
</tr>
<tr>
<td>Govt. Mt</td>
<td>1</td>
<td>3.4</td>
<td>170</td>
<td>N</td>
</tr>
<tr>
<td>Los Vidrios</td>
<td>1</td>
<td>3.4</td>
<td>140</td>
<td>SW</td>
</tr>
<tr>
<td>Superior</td>
<td>8</td>
<td>27.6</td>
<td>≤20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>NE</td>
</tr>
<tr>
<td>Sauceda Mts</td>
<td>18</td>
<td>62.1</td>
<td>80</td>
<td>SW</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>29</strong></td>
<td><strong>100.0</strong></td>
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<td></td>
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</tbody>
</table>

<sup>a</sup> Straight-line distance; a Cow Canyon material has been recovered from primary deposits on the western edge of the Mogollon Highlands to secondary contexts near Safford, Arizona (Shackley 1992); <sup>b</sup> similarly Superior material is available in primary context at Picketpost Mountain and in the Queen Creek system to the west (Shackley 1988, 1990).

Figure 5. Histogram of the distribution of source provenience for all sites combined.
Figure 6. Regression scatterplot of assemblage proportion and distance to source for obsidian artifacts recovered from sites in the Escalante Ruin Group (C=Cow Canyon, G=Govt. Mtn, L=Los Vidrios, Sa=Sauceda Mts, Su=Superior).

<table>
<thead>
<tr>
<th>SOURCE -&gt;</th>
<th>Count</th>
<th>Cow Canyon</th>
<th>Govt. Mt</th>
<th>Los Vidrios</th>
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<td>2</td>
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