Title
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THE AGUA FRIA SOURCE AND SOURCE PROVENANCE OF
ARCHAEOLOGICAL OBSIDIAN FROM LATE PERIOD
ARCHAEOLOGICAL SITES ALONG THE RIO BAVISPE,
NORTHERN SONORA

by

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Report Prepared for

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INTRODUCTION

Obsidian studies in northwestern Mexico are certainly in their infancy (Fralick et al. 1998; Shackley 1995, 1998). Fralick et al. (1998) study of archaeological obsidian in west central Chihuahua to the south of this study area is virtually the first systematic geoprospective and chemical study of archaeological obsidians in Chihuahua and Sonora. The analysis of archaeological obsidian from the sites along the Rio Bavispe here, is one of the largest studies to date in the region (see Fralick et al. 1998; Shackley 1998). The results indicate a relatively diverse bipolar lithic assemblage dominated by and as yet unlocated source, which is likely a nearby source. The large proportion of "unknown" provenance obsidian is indicative of the lack of source data in the northern Mexico region.

LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION

All samples were analyzed whole with little or no formal preparation. 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™ 400 (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, 0.20 mA, using a 0.127 mm Rh primary beam filter in a vacuum path at 250 seconds livetime to generate x-ray intensity Kα-line data for elements titanium (Ti), manganese (Mn), iron (as FeT), zinc (Zn) thorium (Th), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). Weight percent iron (Fe2O3T) can be derived by multiplying ppm estimates by 1.4297×10⁻⁴. Trace element intensities were converted to concentration estimates by employing a least-squares calibration line established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the US. Geological Survey (USGS), Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1988, 1990, 1992, 1995; also Mahood and Stimac 1991; and Hughes and Smith 1993). Specific standards used for the best fit regression calibration for elements Ti through Nb include G-2 (basalt), AGV-1 (andesite), GSP-1 and SY-2 (syenite), BHVO-1 (hawaiite), STM-1 (syenite), QLM-1 (quartz latite), RGM-1 (obsidian), W-2 (diabase), BIR-1 (basalt), SDC-1 (mica schist), TLM-1 (tonalite), SCO-1 (shale), all US Geological Survey standards, and BR-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). In addition to the reported values here Ni, Cu, and Ga were measured, but these are not consistently useful in discriminating glass sources and are not generally reported. These data are available on disk by request.

The approximate practical detection limits of the elements of interest that include error imposed by inter-element interference are as follows: Ti 23 ppm; Mn 40 ppm; Fe 10 ppm; Pb 8 ppm; Rb 5 ppm; Sr 3.5 ppm; Y 7 ppm; Zr 7 ppm; Nb 8 ppm; Ba 20 ppm; La 20 ppm; Ce 20 ppm. These are the smallest amounts that can be quantitatively measured, defined as a signal which is six standard deviation units above background (6σ).
The data from the Tracor software were translated directly into Excel™ for Windows software for manipulation and on into SPSS™ for Windows for statistical analyses. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. Table 1 shows a comparison between values recommended for three international obsidian and rhyolite rock standards, RGM-1, NBS(SRM)-278, and JR-2. One of these standards is analyzed during each sample run to check machine calibration. The results shown in Table 1 indicate that the machine accuracy is quite high, particularly for the mid-Z elements, and other instruments with comparable precision should yield comparable results. Further information on the laboratory instrumentation can be found on the World Wide Web at: http://obsidian.pahma.berkeley.edu/. Trace element data exhibited in Tables 1 and 2 are reported in parts per million (ppm), a quantitative measure by weight. Classification analysis is exhibited in Table 3 and Figure 1. Elemental concentrations are also exhibited graphically in Figures 2 and 3.

**SUMMARY AND CONCLUSIONS**

The numerical dominance and the large numbers of bipolar cores in Group A suggests a nearby source, possibly the “Bavispe” source noted by Bandelier (1892), Lumholtz (1902) and others. The other three source groups do not match any known sources to the north or east, but are likely some distance from the sites (Shackley 1995; obsidian.pahma.berkeley.edu/swobsrscs.htm). A three cluster solution indicates at least four chemical groups (Table 3 and Figure 1), which are also reflected in three-dimensional and biplots of the data (Figures 2 and 3).

While in the short run, it appears that obsidian provenance studies in northern Sonora and Chihuahua will remain difficult, in the long run there is the potential to understand an apparent focus on local procurement of archeological obsidian in contrast to DiPeso’s opinion that the
obsidian from Casas Grandes (Paquimé) was derived from south in Mesoamerica (DiPeso et al. 1974; Figure 4 here). Future geoprospection in northern Sonora is crucial in this regard.
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Schamber, F.H.

Shackley, M. Steven


Table 1. X-ray fluorescence concentrations for selected trace elements of three 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 (1994) and this study. RGM-1 is a U.S. Geological Survey rhyolite standard, NBS (SRM)-278 is a National Institute of Standards and Technology obsidian standard, and JR-2 is a Geological Survey of Japan rhyolite standard. Fe\textsuperscript{T} can be converted to Fe\textsubscript{2}O\textsubscript{3}\textsuperscript{T} with a multiplier of 1.4297\textsuperscript{10\textsuperscript{-4}} (see also Glascock 1991).

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>Ti</th>
<th>Mn</th>
<th>Fe</th>
<th>Rb</th>
<th>Sr</th>
<th>Y</th>
<th>Zr</th>
<th>Nb</th>
<th>Ba</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGM-1 (Govindaraju 1994)</td>
<td>1600</td>
<td>279</td>
<td>12998</td>
<td>149</td>
<td>108</td>
<td>25</td>
<td>219</td>
<td>8.9</td>
<td>807</td>
</tr>
<tr>
<td>RGM-1 (Glascock and Anderson 1993)</td>
<td>1800±200</td>
<td>323±7</td>
<td>12400±300</td>
<td>145±3</td>
<td>120±10</td>
<td>n.r.\textsuperscript{a}</td>
<td>150±7</td>
<td>n.r.</td>
<td></td>
</tr>
<tr>
<td>RGM-1 (this study)</td>
<td>1516±58</td>
<td>259±19</td>
<td>13991±143</td>
<td>152±3</td>
<td>108±2</td>
<td>24±1</td>
<td>226±4</td>
<td>10±1</td>
<td>806±12</td>
</tr>
<tr>
<td>SRM-278 (Govindaraju 1994)</td>
<td>402</td>
<td>14256</td>
<td>127.5</td>
<td>63.5</td>
<td>39</td>
<td>290</td>
<td>18</td>
<td>1140\textsuperscript{b}</td>
<td></td>
</tr>
<tr>
<td>SRM-278 (Glascock and Anderson 1993)</td>
<td>1460±270</td>
<td>428±8</td>
<td>14200±300</td>
<td>128±4</td>
<td>61±15</td>
<td>n.r.</td>
<td>208±20</td>
<td>n.r.</td>
<td></td>
</tr>
<tr>
<td>SRM-278 (this study)</td>
<td>1376±96</td>
<td>372±17</td>
<td>15229±399</td>
<td>129±2</td>
<td>68±2</td>
<td>42±2</td>
<td>290±3</td>
<td>17±2</td>
<td>1090±38</td>
</tr>
<tr>
<td>JR-2 (Govindaraju 1994)\textsuperscript{b}</td>
<td>540</td>
<td>852</td>
<td>6015</td>
<td>297</td>
<td>8</td>
<td>51.3\textsuperscript{b}</td>
<td>97.2\textsuperscript{b}</td>
<td>19.2</td>
<td>39</td>
</tr>
<tr>
<td>JR-2 (this study)</td>
<td>343±51</td>
<td>680±17</td>
<td>7358±65</td>
<td>300±5</td>
<td>10±1</td>
<td>49±3</td>
<td>94±2</td>
<td>16±2</td>
<td>34±6</td>
</tr>
</tbody>
</table>

\textsuperscript{a} n.r. = no report; n.m. = not measured
\textsuperscript{b} values proposed not recommended
Table 2. Elemental concentrations for the archaeological specimens. All measurements in parts per million (ppm).

Figure 3. Rb, versus Sr biplot of all archaeological samples and proposed chemical groups.