Title
An Energy Dispersive X-Ray Fluorescence (EDXRF) Analysis of Obsidian Artifacts from Archaeological Sites in The San Quintin-El Rosario Region, Baja California

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AN ENERGY DISPERSIVE X-RAY FLUORESCENCE (EDXRF) ANALYSIS OF OBSIDIAN ARTIFACTS FROM ARCHAEOLOGICAL SITES IN THE SAN QUINTIN-EL ROSARIO REGION, BAJA CALIFORNIA

by

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INTRODUCTION

The following report documents the EDXRF analysis of 14 obsidian artifacts recovered archaeological contexts in the San Quintín-El Rosario region of Baja California. The obsidian assemblage is comprised of a relatively diverse set of source provenance’s, but only one sample could be assigned to a known source (Arroyo Matomí). At least two as yet unlocated sources of archaeological obsidian are present in the assemblage.

ANALYSIS AND INSTRUMENTATION

All samples were analyzed whole, with no intensive sample 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), rubidium (Rb), strontium (Sr), ytttrium (Y), zirconium (Zr), and niobium (Nb). Weight percent iron (Fe2O₃T) can be
derived by multiplying ppm estimates by $1.4297 \times 10^{-4}$. 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 1989). 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 1989). In addition to the reported values here, Pb, Ni, Cu, Zn, Ga, and Th were measured, but these are rarely useful in discriminating glass sources and are not generally reported. These data are available on disk by request.

The data from the Tracor software were translated directly into Quattro Pro 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. Source assignment was made by comparison to source standards at Berkeley (Shackley 1995; the data are also available at the URL noted above).

**DISCUSSION**

The location and character of archaeological obsidian sources in Baja California are not well understood (Banks 1971; Bouey 1984; Douglas 1981; Shackley et al. 1996). Unlike the North American Southwest and California, little systematic work has been directed toward the understanding of artifact quality sources of obsidian in Baja California. Intensive analyses of archaeological obsidian has been undertaken in sites at Bahia de los Angeles (Shackley 1994, 1997) and the region around San Ignacio including El Desierto Vizcaíno and the Tres Virgenes volcanic field (Shackley 1993; Shackley et al. 1996). Only one of the samples could be assigned to any of the known sources in central Baja California (Valle del Azufre, Punta Mangles) or northern Baja California (Arroyo Matomi/San Felipe, Isla Angel de la Guarda, San Luis Gonzaga), Arizona or California sources. The two groups of “unknowns” indicated in Figure 1 do not match any of the unknown groups in sites at Bahía de los Angeles (Shackley 1995, 1997). It appears that there are at least four or five as yet unlocated sources of archaeological obsidian in central and northern Baja California. Given the volcanic character of much of the Peninsular Ranges, it seems reasonable that there
would be a number of artifact quality obsidian sources on the peninsula. I would suggest that
the large group of unknown samples are probably from a source not too distant from the
sites.

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Shackley, M. Steven


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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 (1989) 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. FeT can be converted to Fe$_2$O$_3$T with a multiplier of 1.4297(10-4) (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 1989)</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.</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 1989)</td>
<td>1469</td>
<td>402</td>
<td>14256</td>
<td>127.5</td>
<td>63.5</td>
<td>41</td>
<td>295</td>
<td>n.r.</td>
<td>1140b</td>
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<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></td>
</tr>
<tr>
<td>JR-2 (Govindaraju 1989)a</td>
<td>540</td>
<td>852</td>
<td>6015</td>
<td>297</td>
<td>8</td>
<td>51</td>
<td>98.5</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>

a n.r. = no report; n.m.=not measured
b values proposed not recommended
Table 2. X-ray fluorescence concentrations for the archaeological data. All measurements in parts per million (ppm).

<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>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASE-102</td>
<td>1184.9</td>
<td>217.0</td>
<td>13036.2</td>
<td>138.1</td>
<td>61.3</td>
<td>32.9</td>
<td>214.6</td>
<td>14.1</td>
<td>Unknown</td>
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<tr>
<td>PASE-185</td>
<td>3315.0</td>
<td>546.9</td>
<td>32068.2</td>
<td>88.2</td>
<td>117.9</td>
<td>52.5</td>
<td>412.8</td>
<td>14.6</td>
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<tr>
<td>PASE-161</td>
<td>1261.4</td>
<td>286.1</td>
<td>15383.0</td>
<td>148.6</td>
<td>68.8</td>
<td>35.4</td>
<td>222.8</td>
<td>12.4</td>
<td>Unknown</td>
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<tr>
<td>PASE-138</td>
<td>1112.0</td>
<td>217.2</td>
<td>12971.0</td>
<td>135.0</td>
<td>56.9</td>
<td>35.0</td>
<td>210.1</td>
<td>12.9</td>
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<tr>
<td>151-1</td>
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<td>244.3</td>
<td>13946.5</td>
<td>133.6</td>
<td>58.9</td>
<td>38.4</td>
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<td>111.4</td>
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<td>32.2</td>
<td>135.5</td>
<td>11.3</td>
<td>Arroyo Matomi</td>
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<tr>
<td>3</td>
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<td>266.5</td>
<td>14539.0</td>
<td>156.4</td>
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<td>34.3</td>
<td>222.4</td>
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</tr>
<tr>
<td>4</td>
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<td>266.5</td>
<td>14958.3</td>
<td>136.3</td>
<td>59.1</td>
<td>37.8</td>
<td>216.2</td>
<td>12.3</td>
<td>Unknown</td>
</tr>
<tr>
<td>5</td>
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<td>Unknown</td>
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<tr>
<td>6</td>
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<td>13335.9</td>
<td>138.2</td>
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<td>10.4</td>
<td>Unknown</td>
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<tr>
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<td>142.2</td>
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<td>61.0</td>
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<td>214.9</td>
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<td>16687.4</td>
<td>161.0</td>
<td>72.6</td>
<td>39.7</td>
<td>233.2</td>
<td>13.1</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Figure 1. Rb, versus Zr biplot of elemental concentrations for archaeological samples, with plotted mean values for selected source standards from Baja California.