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SOURCES OF OBSIDIAN FROM THREE SITES IN BAJA CALIFORNIA SUR:
AN ENERGY DISPERSIVE X-RAY FLUORESCENCE (EDXRF) ANALYSIS

by

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1 September 1992

INTRODUCTION

The following report documents the EDXRF analysis of 11 obsidian artifacts from three sites in Baja California; a projectile point from a site at San Xavier recovered by Massey in the 1940's, and obsidian debitage and utilized flakes from Cueva del Raton and El Sauce currently under investigation by the University of Barcelona, Spain. All the artifacts were most likely produced from obsidian derived from an, as yet, undescribed source near Arroyo Portezuelo near Volcán de Tres Virgenes (Eric Ritter, Personal Communication, 1991).

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 FeT), 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 France (Govindaraju 1989). Further details concerning the petrological choice of these elements in Southwestern obsidians is available in Shackley (1988, 1990, 1992).

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. Table 2 exhibits the trace element concentrations for the 11 samples, and Figures 1 through 5 exhibit concentration plots of four of the analyzed elements.
DISCUSSION

The concentration plots for four elements indicate a rather close fit between the archaeological specimens and the secondary source material from Arroyo Portezuelo. In the case of the sites in the Sierra San Francisco, this is expectable given the relatively short linear distance to the source from the sites (≈20 km). The relatively great distance (>200 km) to San Xavier, where the point collected by Massey was found, is more unusual. The lack of any other source material, and the presence of the Arroyo Portezuelo obsidian hundreds of kilometers south of the source location argues for the inference that this may be only artifact quality obsidian in central and southern Baja California. Unfortunately, the analyzed sample is small. Further geochemical studies of archaeological obsidian in the area will certainly shed more light on the problem.

The concentration plots also suggest that the source chemistry may be more variable than the seven source specimens analyzed initially indicated. This is rather typical of mid-Tertiary sources in western North America (Shackley 1990, 1992).

The analysis of these 11 artifacts forms a major contribution to regional prehistory, and forms an initial beginning for obsidian studies in the central and southern portion of the peninsula.
REFERENCES CITED

Govindaraju, K.

Hampel, Joachim H.

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

Schamber, F.H.

Shackley, M. Steven


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>TiO$_2$</th>
<th>MnO</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>2670</td>
<td>360</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 (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>
<td>1140</td>
</tr>
<tr>
<td>NBS-278 (this study)</td>
<td>n.m.</td>
<td>n.m.</td>
<td>126±1.9</td>
<td>62±2.3</td>
<td>40±2.2</td>
<td>280±3.6</td>
<td>14±1.4</td>
<td>n.m.</td>
</tr>
</tbody>
</table>

$^1$ n.r. = no report; n.m. = not measured
Table 2. X-ray fluorescence concentrations for obsidian artifacts from three sites in Baja California Sur. All measurements in parts per million (ppm).

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>Ti (ppm)</th>
<th>Mn (ppm)</th>
<th>Fe (ppm)</th>
<th>Rb (ppm)</th>
<th>Sr (ppm)</th>
<th>Y (ppm)</th>
<th>Zr (ppm)</th>
<th>Nb (ppm)</th>
<th>Source</th>
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<tr>
<td>San Xavier</td>
<td>1066.96</td>
<td>273.62</td>
<td>11982</td>
<td>106.166</td>
<td>90.143</td>
<td>27.37</td>
<td>139.369</td>
<td>11.156</td>
<td>All specimens from &quot;Arroyo Portezuelo&quot;</td>
</tr>
<tr>
<td>El Sauce</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35-1</td>
<td>1166.76</td>
<td>292.85</td>
<td>13041</td>
<td>113.979</td>
<td>95.655</td>
<td>23.50</td>
<td>149.736</td>
<td>7.107</td>
<td></td>
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<tr>
<td>35-2</td>
<td>993.13</td>
<td>295.42</td>
<td>12852</td>
<td>104.939</td>
<td>87.932</td>
<td>24.07</td>
<td>144.573</td>
<td>7.718</td>
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<tr>
<td>35-3</td>
<td>950.32</td>
<td>245.03</td>
<td>12274</td>
<td>111.858</td>
<td>93.105</td>
<td>26.39</td>
<td>145.186</td>
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<tr>
<td>35-4</td>
<td>849.18</td>
<td>263.66</td>
<td>10972</td>
<td>98.914</td>
<td>82.965</td>
<td>24.53</td>
<td>135.539</td>
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<td>35-5</td>
<td>913.31</td>
<td>261.93</td>
<td>12155</td>
<td>108.243</td>
<td>91.412</td>
<td>26.05</td>
<td>142.781</td>
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<tr>
<td>Cueva del Raton</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>47-1</td>
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<td>262.49</td>
<td>11549</td>
<td>103.179</td>
<td>88.217</td>
<td>22.27</td>
<td>141.892</td>
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<tr>
<td>47-2</td>
<td>911.87</td>
<td>276.63</td>
<td>11843</td>
<td>102.772</td>
<td>91.213</td>
<td>27.50</td>
<td>140.598</td>
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<tr>
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<td>254.47</td>
<td>11500</td>
<td>100.243</td>
<td>83.77</td>
<td>24.61</td>
<td>134.408</td>
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<tr>
<td>47-4</td>
<td>914.48</td>
<td>240.11</td>
<td>11682</td>
<td>108.139</td>
<td>87.794</td>
<td>22.21</td>
<td>142.351</td>
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<tr>
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<td>31.56</td>
<td>146.749</td>
<td>4.282</td>
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Figure 1. Y versus Sr concentration plot for source and archaeological obsidian from Baja California. T=Arroyo Portezuelo (Tres Virgenes); 3=El Sauce; 4=Cueva del Raton; $=multiple occurrences.

Figure 2. Rb versus Sr concentration plot for source and archaeological obsidian from Baja California. T=Arroyo Portezuelo (Tres Virgenes); 3=El Sauce; 4=Cueva del Raton; $=multiple occurrences.
Figure 3. Sr versus Zr concentration plot for source and archaeological obsidian from Baja California. T=Arroyo Portezuelo (Tres Virgenes); 3=El Sauce; 4=Cueva del Raton; $=multiple occurrences.

Figure 4. Rb versus Zr concentration plot for source and archaeological obsidian from Baja California. T=Arroyo Portezuelo (Tres Virgenes); 3=El Sauce; 4=Cueva del Raton; $=multiple occurrences.
Figure 5. Ti versus Zr concentration plot for source and archaeological obsidian from Baja California. T=Arroyo Portezuelo (Tres Virgenes); 3=El Sauce; 4=Cueva del Raton; $=multiple occurrences.