SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM MEZMAISKAYA CAVE, CAUCUSUS MOUNTAINS, RUSSIA

by

M. Steven Shackley, Ph.D., Director
Geoarchaeological XRF Laboratory
University of California, Berkeley

Report Prepared for
Drs. Liubov Golovanova and Vladimir Doronichev

6 December 2011
INTRODUCTION

This report documents the EDXRF analysis of 18 additional obsidian artifacts from Mezmaiskaya Cave in the Caucasus of Russia. As with the previous analysis, and based on these data and the literature it appears that three of the obsidian samples were produced from the Zayukovo source and the rest may be from the Kojun Dağı (Paravan) source in southern Georgia (Golovanova et al. 2010).

LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION

All archaeological samples are analyzed whole. 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; Shackley 2011).

All analyses for this study were conducted on a ThermoScientific Quant’X EDXRF spectrometer, located in the Archaeological XRF Laboratory, Albuquerque, New Mexico. It is equipped with a thermoelectrically Peltier cooled solid-state Si(Li) X-ray detector, with a 50 kV, 50 W, ultra-high-flux end window bremsstrahlung, Rh target X-ray tube and a 76 µm (3 mil) beryllium (Be) window (air cooled), that runs on a power supply operating 4-50 kV/0.02-1.0 mA at 0.02 increments. The spectrometer is equipped with a 200 l min⁻¹ Edwards vacuum pump, allowing for the analysis of lower-atomic-weight elements between sodium (Na) and titanium (Ti). Data acquisition is accomplished with a pulse processor and an analogue-to-digital converter. Elemental composition is identified with digital filter background removal, least squares empirical peak deconvolution, gross peak intensities and net peak intensities above background.
The analysis for mid Zb condition elements Ti-Nb, Pb, Th, the x-ray tube is operated at 30 kV, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity Ka-line data for elements titanium (Ti), manganese (Mn), iron (as Fe$_2$O$_3$), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), lead (Pb), and thorium (Th). Not all these elements are reported since their values in many volcanic rocks are very low. Trace element intensities were converted to concentration estimates by employing a least-squares calibration line ratioed to the Compton scatter 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). Line fitting is linear (XML) for all elements but Fe where a derivative fitting is used to improve the fit for iron and thus for all the other elements. When barium (Ba) is analyzed in the High Zb condition, the Rh tube is operated at 50 kV and up to 1.0 mA, ratioed to the bremsstrahlung region (see Davis 2011; Shackley 2011). Further details concerning the petrological choice of these elements in obsidian is available in Shackley (1988, 1995, 2005, 2011; also Mahood and Stimac 1991; and Hughes and Smith 1993). Nineteen specific pressed powder standards are used for the best fit regression calibration for elements Ti-Nb, Pb, Th, and Ba, include G-2 (basalt), AGV-2 (andesite), GSP-2 (granodiorite), SY-2 (syenite), BHVO-2 (hawaiite), STM-1 (syenite), QLO-1 (quartz latite), RGM-1 (obsidian), W-2 (diabase), BIR-1 (basalt), SDC-1 (mica schist), TLM-1 (tonalite), SCO-1 (shale), NOD-A-1 and NOD-P-1 (manganese) all US Geological Survey standards, NIST-278 (obsidian), U.S. National Institute of Standards and Technology, BE-N (basalt) from the Centre de Recherches Pétrographiques et
Géochimi ques in France, and JR-1 and JR-2 (obsidian) from the Geological Survey of Japan (Govindaraju 1994).

The data from the WinTrace software were translated directly into Excel for Windows software for manipulation and on into SPSS for Windows for statistical analyses when necessary. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run (Table 1). RGM-1 is analyzed during each sample run for obsidian artifacts to check machine calibration. Other appropriate standards from the above list are used for other volcanic rocks. Many of these samples were quite small for EDXRF analyses (Davis et al. 2011). The trend of the data, however, suggests a similarity to the sources as assigned.

**DISCUSSION**

The similarity of source provenance with the earlier study from the cave suggest consistent procurement of obsidian through the Late Middle to Early Upper Paleolithic transition (Golovanova et al. 2010). While it is hazardous to assign obsidian artifacts to source with a small sample of source standards, it appears that seven of the samples submitted from Mezmaiskaya were produced from the Zayukovo source analyzed earlier (Table 1 and Figures 1 and 2). The other samples appear to be produced from obsidian procured from the Kojun Dağı (Paravan) source located to the southwest of the Caucasus in southern Georgia (Keller et al. 1994; Poidevin 1998). The elemental concentrations of the artifacts are clustered around the Kau 10 data from Kojun Dag as listed in Poidevin (1998:200), similar to the earlier study (see Figures 1 and 2 for plots of his source data).

As in the earlier study, this larger study suggests that the inhabitants of the Upper Paleolithic levels at Mezmaiskaya Cave had some contact with areas quite a distance from this part of the Caucasus.
REFERENCES CITED

Davis, M.K., T.L. Jackson, M.S. Shackley, T. Teague, and J. Hampel
2011 Factors Affecting the Energy-Dispersive X-Ray Fluorescence (EDXRF) Analysis of
Archaeological Obsidian. In X-Ray Fluorescence Spectrometry in Geoarchaeology,

Golovanova, L.V., V.B. Doronichev, N.E. Cleghorn, M.A. Koulkova, T.V. Sapelko, and M.S.
Shackley
2010 Significance of Ecological Factors in the Middle to Upper Paleolithic Transition.
Current Anthropology 51:655-691.

Govindaraju, K.
1994 Compilation of Working Values and Sample Description for 383

Hampel, Joachim H.
1984 Technical Considerations in X-ray Fluorescence Analysis of Obsidian. In Obsidian
University of California Archaeological Research Facility 45. Berkeley.

Hildreth, W.

Hughes, Richard E., and Robert L. Smith
1993 Archaeology, Geology, and Geochemistry in Obsidian Provenance Studies. In Scale
on Archaeological and Geoscientific Perspectives, edited by J.K. Stein and A.R.

Keller, J., R. Djerbashian, E. Pernicka, S. Karapetian, and V. Nasedkin
1994 Armenian Obsidian Occurrences as Sources for the Neolithic Trade: Volcanological
Setting and Chemical Characteristics. Paper presented at the 29th International
Symposium on Archaeometry, Ankara, Turkey.

Mahood, Gail A., and James A. Stimac
1990 Trace-Element Partitioning in Pantellerites and Trachytes. Geochemica et

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

Poidevin, J-L.
1998 Les Gisements D'Obsidienne de Turquie et de Transcaucasie: Géologie, Géochimie et
Chronométrie. In L'Obsidienne au Proche et Moyen Orient: Du Volcan à l’outil, edited
by M-C. Cauvin, A Gourgaud, B. Gratuce, N. Arnaud, G. Poupeau, J.L. Poidevin, and C.
Chataigner, pp. 105-203. BAR International Series 738.
Schamber, F.H.

Shackley, M. Steven


Table 1. Elemental concentrations for the archaeological specimens and two source standards. All measurements in parts per million (ppm).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Ti</th>
<th>Mn</th>
<th>Fe</th>
<th>Zn</th>
<th>Rb</th>
<th>Sr</th>
<th>Y</th>
<th>Zr</th>
<th>Nb</th>
<th>Ba</th>
<th>Th</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>873</td>
<td>477</td>
<td>9351</td>
<td>62</td>
<td>291</td>
<td>53</td>
<td>23</td>
<td>71</td>
<td>17</td>
<td>229</td>
<td>26</td>
<td>Zayukovo</td>
</tr>
<tr>
<td>2</td>
<td>1220</td>
<td>402</td>
<td>8237</td>
<td>74</td>
<td>264</td>
<td>54</td>
<td>25</td>
<td>65</td>
<td>14</td>
<td>292</td>
<td>27</td>
<td>Zayukovo</td>
</tr>
<tr>
<td>3</td>
<td>1152</td>
<td>468</td>
<td>8960</td>
<td>92</td>
<td>152</td>
<td>87</td>
<td>18</td>
<td>82</td>
<td>21</td>
<td>833</td>
<td>22</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>4</td>
<td>1340</td>
<td>455</td>
<td>9773</td>
<td>52</td>
<td>135</td>
<td>113</td>
<td>19</td>
<td>121</td>
<td>18</td>
<td>1247</td>
<td>16</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>5</td>
<td>1024</td>
<td>381</td>
<td>8116</td>
<td>48</td>
<td>126</td>
<td>83</td>
<td>20</td>
<td>85</td>
<td>21</td>
<td>855</td>
<td>25</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>6</td>
<td>1059</td>
<td>426</td>
<td>8267</td>
<td>51</td>
<td>131</td>
<td>82</td>
<td>17</td>
<td>84</td>
<td>25</td>
<td>833</td>
<td>18</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>7</td>
<td>1241</td>
<td>433</td>
<td>8576</td>
<td>63</td>
<td>139</td>
<td>81</td>
<td>14</td>
<td>81</td>
<td>23</td>
<td>967</td>
<td>11</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>8</td>
<td>1085</td>
<td>475</td>
<td>8844</td>
<td>115</td>
<td>144</td>
<td>82</td>
<td>15</td>
<td>82</td>
<td>21</td>
<td>641</td>
<td>18</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>9</td>
<td>1156</td>
<td>493</td>
<td>9132</td>
<td>119</td>
<td>148</td>
<td>87</td>
<td>17</td>
<td>85</td>
<td>20</td>
<td>816</td>
<td>21</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>10</td>
<td>1019</td>
<td>487</td>
<td>9320</td>
<td>177</td>
<td>285</td>
<td>57</td>
<td>28</td>
<td>67</td>
<td>16</td>
<td>256</td>
<td>26</td>
<td>Zayukovo</td>
</tr>
<tr>
<td>11</td>
<td>1031</td>
<td>426</td>
<td>8214</td>
<td>63</td>
<td>133</td>
<td>81</td>
<td>16</td>
<td>80</td>
<td>20</td>
<td>818</td>
<td>17</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>12</td>
<td>887</td>
<td>598</td>
<td>10531</td>
<td>71</td>
<td>334</td>
<td>59</td>
<td>30</td>
<td>73</td>
<td>18</td>
<td>254</td>
<td>34</td>
<td>Zayukovo</td>
</tr>
<tr>
<td>13</td>
<td>813</td>
<td>494</td>
<td>9358</td>
<td>97</td>
<td>298</td>
<td>59</td>
<td>24</td>
<td>69</td>
<td>17</td>
<td>230</td>
<td>29</td>
<td>Zayukovo</td>
</tr>
<tr>
<td>14</td>
<td>1390</td>
<td>475</td>
<td>8954</td>
<td>165</td>
<td>147</td>
<td>84</td>
<td>13</td>
<td>76</td>
<td>23</td>
<td>678</td>
<td>16</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>15</td>
<td>1015</td>
<td>470</td>
<td>9344</td>
<td>201</td>
<td>290</td>
<td>53</td>
<td>26</td>
<td>66</td>
<td>14</td>
<td>181</td>
<td>26</td>
<td>Zayukovo</td>
</tr>
<tr>
<td>16</td>
<td>1365</td>
<td>556</td>
<td>9719</td>
<td>231</td>
<td>151</td>
<td>84</td>
<td>16</td>
<td>81</td>
<td>23</td>
<td>778</td>
<td>19</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>17</td>
<td>1093</td>
<td>468</td>
<td>8601</td>
<td>215</td>
<td>133</td>
<td>75</td>
<td>11</td>
<td>75</td>
<td>19</td>
<td>693</td>
<td>16</td>
<td>Kojun Daği</td>
</tr>
<tr>
<td>18</td>
<td>840</td>
<td>512</td>
<td>9306</td>
<td>89</td>
<td>297</td>
<td>58</td>
<td>30</td>
<td>75</td>
<td>12</td>
<td>233</td>
<td>29</td>
<td>Zayukovo</td>
</tr>
<tr>
<td>RGM1-S4</td>
<td>1571</td>
<td>279</td>
<td>13274</td>
<td>38</td>
<td>147</td>
<td>107</td>
<td>24</td>
<td>218</td>
<td>9</td>
<td>821</td>
<td>15</td>
<td>standard</td>
</tr>
<tr>
<td>RGM1-S4</td>
<td>1610</td>
<td>284</td>
<td>13292</td>
<td>40</td>
<td>146</td>
<td>108</td>
<td>23</td>
<td>218</td>
<td>7</td>
<td>857</td>
<td>22</td>
<td>standard</td>
</tr>
</tbody>
</table>

1 Source data from (Poidevin 1998).
Figure 1. Ba versus Zr biplot of the elemental concentrations for the archaeological artifacts and source data from this study and Poidevin (1998).
Figure 12. Rb versus Zr biplot of the elemental concentrations for the archaeological artifacts and source data from this study and Poidevin (1998).