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# SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THREE SITES IN PARK COUNTY, CENTRAL COLORADO

by

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## INTRODUCTION

The analysis here of 16 obsidian artifacts from three sites in central Colorado indicates a dominance of artifacts produced from the Valles Rhyolite (Cerro del Medio) dome in the Jemez Mountains of northern New Mexico. One artifact was produced from the El Rechuelos Rhyolite domes in the Jemez Mountains, and one artifact was produced from the Cochetopa Dome in Saguache County, Colorado. An earlier study of 5PA4803 also indicated procurement of obsidian from these two Jemez Mountains sources (Shackley 2017).

## 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 at the Geoarchaeological 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 from 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.

**Trace Element Analysis**

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 100 seconds livetime to generate x-ray intensity $K\alpha_1$-line data for elements titanium (Ti), manganese (Mn), iron (as $Fe_2O_3^T$), 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 linear 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. 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 North Amerian obsidians is available in Shackley (1988, 1995, 2005; Shackley et al. 2016; 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, and 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 Géochimiques in France, and JR-1 and JR-2 (obsidian) from the Geological Survey of Japan (Govindaraju 1994).

**Statistical and Graphical Source Assignment.**

The data from the WinTrace™ software were translated directly into Excel for Windows software for manipulation and on into JMP 12.0.1 for statistical analyses. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. RGM-1 a USGS obsidian standard is analyzed during each sample run of ≤19 for obsidian artifacts to check machine calibration (Table 1).

Source assignments were made by reference to the laboratory database (see Shackley 2005; Shackley et al. 2016). Further information on the laboratory instrumentation and source data can be found at: http://www.swxrflab.net. Trace element data exhibited in Table 1 and Figure 1 are reported in parts per million (ppm), a quantitative measure by weight.

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Table 1. Elemental concentrations for the archaeological samples and USGS RGM-1 rhyolite standard. All measurement in parts per million (ppm).
* This sample is very small and the elemental concentrations are slightly lower that the source standards, but likley from this source (Davis et al. 2011).

| Sample | Site | Ti | Mn | Fe | Rb | Sr | Y | Zr | Nb | Ba | Ce | Pb | Th | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 5PA4782 | 938 | 654 | 8841 | 224 | 13 | 29 | 133 | 35 | 5 | 49 | 30 | 25 | Cochetopa Dome, CO |
| 3 | 5PA4782 | 970 | 410 | 8355 | 155 | 17 | 24 | 77 | 47 | 6 | 22 | 23 | 27 | El Rechuelos Rhy, NM |
| 2 | 5PA4786 | 913 | 412 | 10554 | 163 | 14 | 45 | 169 | 58 | 40 | 75 | 21 | 24 | Valles Rhy (Cerro del Medio), NM |
| 7 | 5PA4803 | 1119 | 413 | 10926 | 168 | 16 | 43 | 165 | 54 | 53 | 46 | 26 | 21 | Valles Rhy (Cerro del Medio), NM |
| 15 | 5PA4803 | 966 | 409 | 10982 | 178 | 13 | 45 | 171 | 60 | 40 | 2 | 30 | 15 | Valles Rhy (Cerro del Medio), NM |
| 17 | 5PA4803 | 1083 | 425 | 11765 | 174 | 12 | 48 | 174 | 61 | 75 | 41 | 28 | 20 | Valles Rhy (Cerro del Medio), NM |
| 22 | 5PA4803 | 923 | 449 | 11590 | 176 | 12 | 46 | 166 | 50 | 12 | 43 | 28 | 29 | Valles Rhy (Cerro del Medio), NM |
| 29 | 5PA4803 | 900 | 379 | 9948 | 159 | 14 | 46 | 168 | 56 | 56 | 59 | 22 | 22 | Valles Rhy (Cerro del Medio), NM |
| 30 | 5PA4803 | 990 | 418 | 10572 | 156 | 14 | 43 | 172 | 57 | 55 | 65 | 25 | 23 | Valles Rhy (Cerro del Medio), NM |
| 31 | 5PA4803 | 1093 | 433 | 11335 | 172 | 15 | 45 | 167 | 55 | 0 | 24 | 28 | 26 | Valles Rhy (Cerro del Medio), NM |
| 32 | 5PA4803 | 842 | 365 | 9429 | 147 | 9 | 48 | 159 | 59 | 52 | 53 | 24 | 20 | Valles Rhy (Cerro del Medio), NM |
| 33 | 5PA4803 | 1174 | 360 | 9415 | 134 | 12 | 34 | 151 | 44 | 45 | 45 | 22 | 14 | Valles Rhy (Cerro del Medio), NM* |
| 34 | 5PA4803 | 928 | 436 | 10924 | 169 | 15 | 48 | 171 | 56 | 50 | 36 | 27 | 20 | Valles Rhy (Cerro del Medio), NM |
| 35 | 5PA4803 | 1006 | 418 | 10688 | 167 | 11 | 43 | 172 | 56 | 24 | 42 | 25 | 21 | Valles Rhy (Cerro del Medio), NM |
| 36 | 5PA4803 | 1037 | 492 | 11837 | 191 | 12 | 43 | 173 | 62 | 15 | 51 | 30 | 22 | Valles Rhy (Cerro del Medio), NM |
| 37 | 5PA4803 | 1291 | 475 | 12005 | 180 | 15 | 45 | 171 | 54 | 22 | 40 | 31 | 17 | Valles Rhy (Cerro del Medio), NM |
| RGM1-S4 | | 1540 | 286 | 13146 | 154 | 106 | 27 | 225 | 14 | 842 | 50 | 23 | 12 | standard |

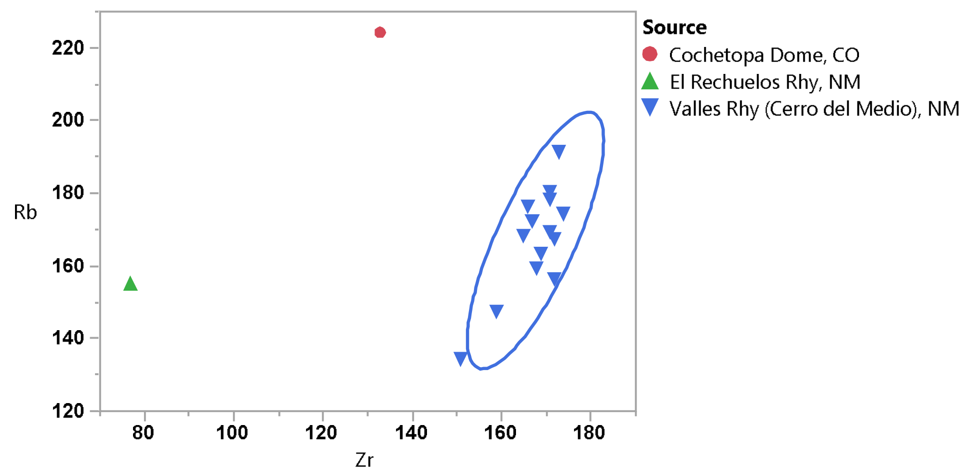


Figure 1. Zr/Rb bivariate plot of the archaeological samples. Confidence ellipses at 95%.