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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM FROM FOUR SITES SOUTH OF SANTA FE, NEW MEXICO

by

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INTRODUCTION

The analysis here of 20 obsidian artifacts from four sites near Santa Fe, New Mexico indicates that all the artifacts were produced from one of three sources in the Jemez Mountains: Cerro Toledo Rhyolite, El Rechuelos Rhyolite, and Valles Rhyolite (Cerro del Medio; Table 1 and Figure 1). These three obsidian sources were the most commonly procured from the Jemez Mountains sources, and of course the nearest sources to these sites (Shackley 2005; Shackley et al. 2016; Steffen 2016).

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, 2019b; 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 SPSS ver. 21 and/or 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; also http://swxrflab.net/jemez.htm). 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).

Sample	Site	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
1	LA 19505	794	380	12115	104	161	17	43	169	49	29	27	Valles Rhy (Cerro del Medio)
14	LA 19505	677	412	11996	103	159	17	48	173	53	21	21	Valles Rhy (Cerro del Medio)
21	LA 19505	1129	410	11767	118	150	17	38	155	53	27	22	Valles Rhy (Cerro del Medio)
24	LA 19505	668	423	12128	130	171	14	42	160	56	24	24	Valles Rhy (Cerro del Medio)
53	LA 123007	803	382	12078	114	167	16	49	172	54	28	32	Valles Rhy (Cerro del Medio)
54	LA 123007	663	430	10271	60	149	16	25	69	46	28	27	El Rechuelos Rhy
70	LA 123007	668	379	11900	153	159	12	49	172	59	24	23	Valles Rhy (Cerro del Medio)
78	LA 123007	703	400	12215	114	159	13	43	169	61	24	22	Valles Rhy (Cerro del Medio)
101	LA 123007	907	474	12411	87	169	11	45	172	53	28	18	Valles Rhy (Cerro del Medio)
150	LA 123007	685	425	10253	43	157	14	24	79	41	26	19	El Rechuelos Rhy
2	LA 193454	556	551	12235	120	217	13	64	178	92	35	27	Cerro Toledo Rhy
3	LA 193454	563	448	11827	99	201	14	64	179	98	35	38	Cerro Toledo Rhy
1	LA 193455	638	502	12075	131	206	9	59	172	89	35	26	Cerro Toledo Rhy
19	LA 193455	675	464	12127	182	209	10	63	177	100	35	32	Cerro Toledo Rhy
43	LA 193455	649	434	11727	117	192	10	63	179	90	31	24	Cerro Toledo Rhy
56	LA 193455	706	476	12130	144	200	12	65	174	94	35	20	Cerro Toledo Rhy
105	LA 193455	586	505	11914	121	211	14	61	178	91	32	29	Cerro Toledo Rhy
140	LA 193455	648	465	11742	158	191	13	61	172	87	32	21	Cerro Toledo Rhy
143	LA 193455	599	438	11601	99	200	13	64	179	92	35	23	Cerro Toledo Rhy
146	LA 193455	641	363	11711	71	163	9	40	163	57	25	14	Valles Rhy (Cerro del Medio)
RGM1-S6		1529	303	13699	15	146	107	27	211	13	20	9	standard

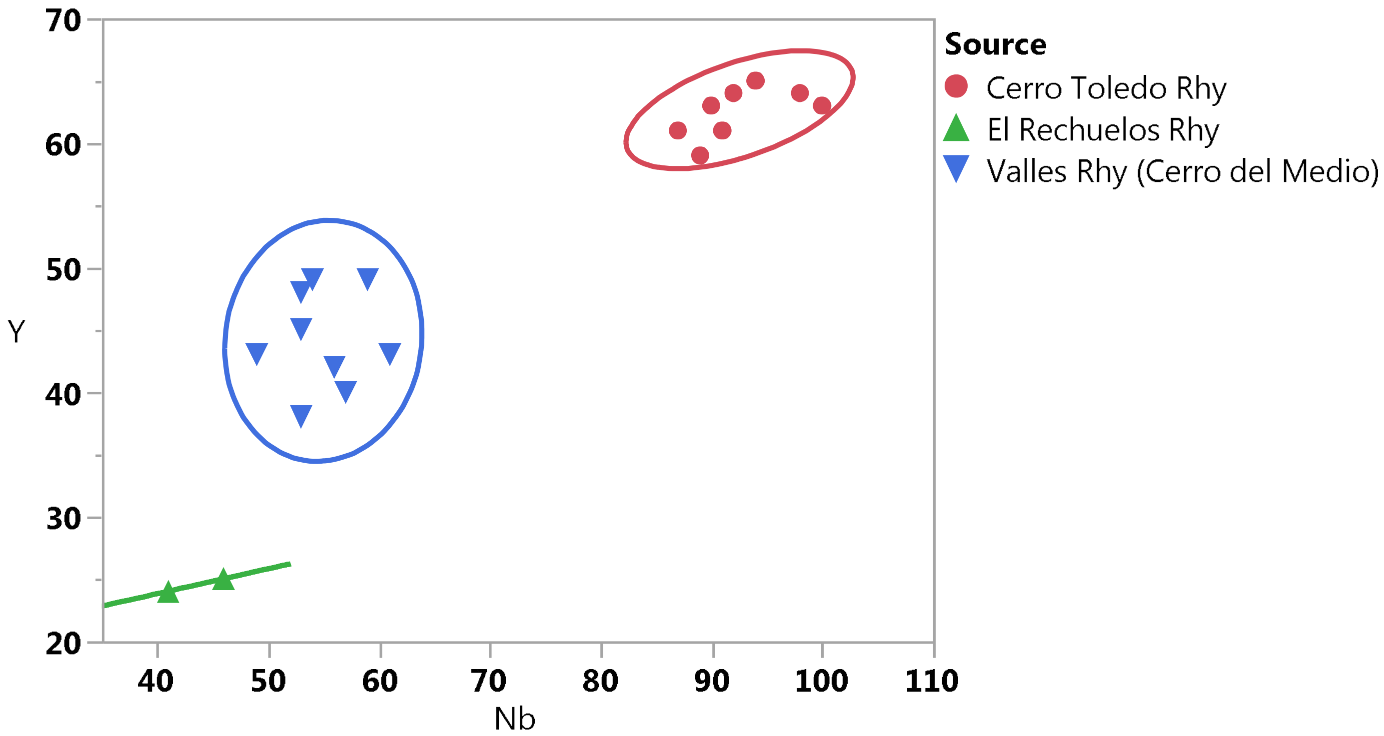

Figure 1 Nb/Y bivariate plot of the archaeological samples. Confidence ellipses and lines at 95%.