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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM GREENSTONE PUEBLO AND WALLACE RUIN (5MT6970), SOUTHWESTERN COLORADO

by

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INTRODUCTION/DISCUSSION

The analysis here of 18 obsidian artifacts from two sites, Wallace Ruin and Greenstone Pueblo (5MT6970, same site number for both sites), indicates a diverse source provenance assemblage with artifacts produced from the following sources in western North America: Jemez Lineament sources in northern New Mexico, Cerro Toledo Rhyolite, Valles Rhyolite (Cerro del Medio), El Rechuelos Rhyolite in the Jemez volcanic field, and Grants Ridge in the Mount Taylor volcanic field; northern Arizona, Government Mountain in the San Francisco volcanic field (see Shackley 2005), and sources in southeastern Idaho (Malad), and Wild Horse Canyon of southwestern Utah (Skinner/Shackley North American Obsidian Database; see Table 1 and Figure 1). Both Wild Horse Canyon and Government Mountain have been recovered from sites examined by Crow Canyon Archaeological Center (Shackley 2014, 2017). The Malad, Idaho source (over 600 km north of these sites) is not uncommonly recovered in Paleoindian and Archaic context throughout the West, particularly in the Southwest (Beck and Jones 2011). In this region it is even more common than Obsidian Cliff in Yellowstone, one of the most commonly exchanged and recorded sources in North America (Beck and Jones 2011; Davis et al. 1995; Scheiber and Finley 2011). While the sample is small, the obsidian from Greenstone Pueblo was the most diverse with all the sources from outside northern New Mexico, and indeed outside the Southwest. Whether this is a real pattern or sampling error is impossible to know (see Table 1 and Figures 1, 2 and 3)

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 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) and the Skinner/Shackley North American Obsidian Database. 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 2 are reported in parts per million (ppm), a quantitative measure by weight.

REFERENCES CITED

Beck, Charlotte and George T. Jones, 2011, The Role of Mobility and Exchange in the Conveyance of Toolstone During the Great Basin Paleoarchaic. In R. E. Hughes (Ed.) Perspectives on Prehistoric Trade and Exchange in California and the Great Basin, pp. 55-82. The University of Utah Press, Salt Lake City, Utah.

Davis, L.B., S.A. Aaberg, J.G. Schmitt, and A. M. Johnson, 1995, *The Obsidian Cliff Plateau Prehistoric Lithic Source, Yellowstone National Park, Wyoming*. National Park Service, Division of Cultural Resources Selection Series 6, Denver, Colorado.

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 M.S. Shackley (Ed.) *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, pp. 45-64. Springer, New York.

Govindaraju, K., 1994 , 1994 Compilation of Working Values and Sample Description for 383 Geostandards. *Geostandards Newsletter* 18 (special issue).

Hampel, Joachim H., 1984, Technical Considerations in X-ray Fluorescence Analysis of Obsidian. In R.E. Hughes (Ed.) *Obsidian Studies in the Great Basin*, pp. 21-25. Contributions of the University of California Archaeological Research Facility 45. Berkeley.

Hildreth, W., 1981, Gradients in Silicic Magma Chambers: Implications for Lithospheric Magmatism. *Journal of Geophysical Research* 86:10153-10192.

Hughes, Richard E., and Robert L. Smith, 1993, Archaeology, Geology, and Geochemistry in Obsidian Provenance Studies. In J.K. Stein and A.R. Linse (Eds.) *Scale on Archaeological and Geoscientific Perspectives*, pp. 79-91. Geological Society of America Special Paper 283.

Mahood, Gail A., and James A. Stimac, 1990, Trace-Element Partitioning in Pantellerites and Trachytes. *Geochemica et Cosmochimica Acta* 54:2257-2276.

McCarthy, J.J., and F.H. Schamber, 1981, Least-Squares Fit with Digital Filter: A Status Report. In K.F.J. Heinrich, D.E. Newbury, R.L. Myklebust, and C.E. Fiori (Eds.) *Energy Dispersive X-ray Spectrometry*, pp. 273-296. National Bureau of Standards Special Publication 604, Washington, D.C.

Schamber, F.H., 1977, A Modification of the Linear Least-Squares Fitting Method which Provides Continuum Suppression. In T.G. Dzubay (Ed.) *X-ray Fluorescence Analysis of Environmental Samples*, pp. 241-257. Ann Arbor Science Publishers.

Scheiber, Laura L., and Judson B. Finley, 2011, Obsidian Source Use in the Greater Yellowstone Area, Wyoming Basin, and Central Rocky Mountains. *American Antiquity* 76:372-394

Shackley, M.S., 1988, Sources of Archaeological Obsidian in the Southwest: An Archaeological, Petrological, and Geochemical Study. *American Antiquity* 53:752-772.

Shackley, M. S.,1995, Sources of Archaeological Obsidian in the Greater American Southwest: An Update and Quantitative Analysis. *American Antiquity* 60(3):531-551.

Shackley, M.S., 2005, *Obsidian: Geology and Archaeology in the North American Southwest*. University of Arizona Press, Tucson.

Shackley, M.S., 2011, An Introduction to X-Ray Fluorescence (XRF) Analysis in Archaeology. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, M.S. Shackley (Ed.), pp. 7-44. Springer, New York.

Shackley, M.S., 2014, Source Provenance of Obsidian Artifacts from Various Sites in the Goodman Point Project, Montezuma County, Southwest Colorado. Report prepared for Crow Canyon Archaeological Center, Cortez, Colorado.

Shackley, M.S., 2017, An Energy-Dispersive X-Ray Fluorescence Analysis of Obsidian Artifacts from Four Sites in Southwestern Colorado. Report prepared for Crow Canyon Archaeological Center, Cortez, Colorado.

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	Rb	Sr	Y	Zr	Nb	Ba	Ce	Pb	Th	Source
20	Wallace Ruin	888	539	10897	218	10	65	179	97	0	46	34	30	Cerro Toledo Rhy, NM
66	Wallace Ruin	1005	399	10343	159	12	43	172	49	48	35	28	27	Valles Rhy (Cerro del Medio), NM
106	Wallace Ruin	682	705	9014	552	10	74	115	195	28	28	59	29	Grants Ridge, Mt Taylor, NM
221	Wallace Ruin	878	434	9722	191	11	58	175	97	0	60	31	19	Cerro Toledo Rhy, NM
401	Wallace Ruin	983	582	12086	251	9	67	183	106	55	27	46	27	Cerro Toledo Rhy, NM
476-9	Wallace Ruin	994	419	11187	172	13	42	167	61	60	58	30	23	Valles Rhy (Cerro del Medio), NM
476-30	Wallace Ruin	923	366	9894	161	12	43	158	58	60	60	24	14	Valles Rhy (Cerro del Medio), NM
479-19	Wallace Ruin	990	440	11169	175	14	43	175	56	28	83	26	23	Valles Rhy (Cerro del Medio), NM
479-39	Wallace Ruin	1015	388	10501	167	13	42	168	59	19	36	27	21	Valles Rhy (Cerro del Medio), NM
480	Wallace Ruin	916	427	10518	172	15	42	172	57	47	36	26	20	Valles Rhy (Cerro del Medio), NM
501	Wallace Ruin	925	408	10527	163	16	47	161	48	34	83	23	26	Valles Rhy (Cerro del Medio), NM
504	Wallace Ruin	939	386	7760	154	15	24	71	54	3	43	26	25	El Rechuelos Rhy, NM
5	Greenstone Pueblo	854	508	10179	115	78	21	82	50	379	20	33	17	Government Mtn, AZ
46	Greenstone Pueblo	997	405	10884	173	13	44	162	51	0	21	28	24	Valles Rhy (Cerro del Medio), NM
96	Greenstone Pueblo	1015	402	7970	151	13	18	68	47	0	3	32	28	El Rechuelos Rhy, NM
201-8	Greenstone Pueblo	985	418	11152	179	13	40	174	54	0	39	24	21	Valles Rhy (Cerro del Medio), NM
201-25	Greenstone Pueblo	1397	402	10665	111	82	29	111	13	1477	21	18	10	Malad, ID
301	Greenstone Pueblo	1293	366	9225	201	50	23	120	24	260	53	28	26	Wild Horse Canyon, UT
RGM1-S4		1576	286	13412	144	107	28	224	10	800	56	19	17	standard

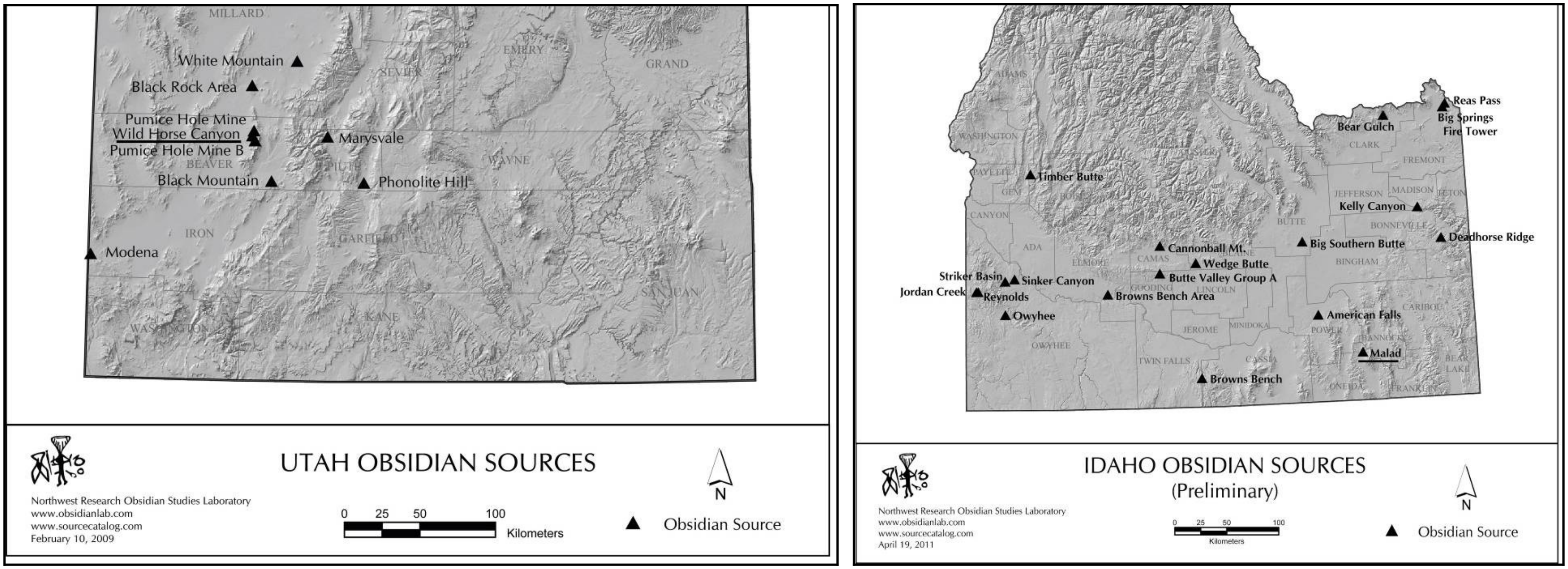

Figure 1. Location of obsidian sources in (left) southern Utah (Wild Horse Canyon underlined) and (right) southern Idaho (Malad underlined). Image from https://www.sourcecatalog.com/

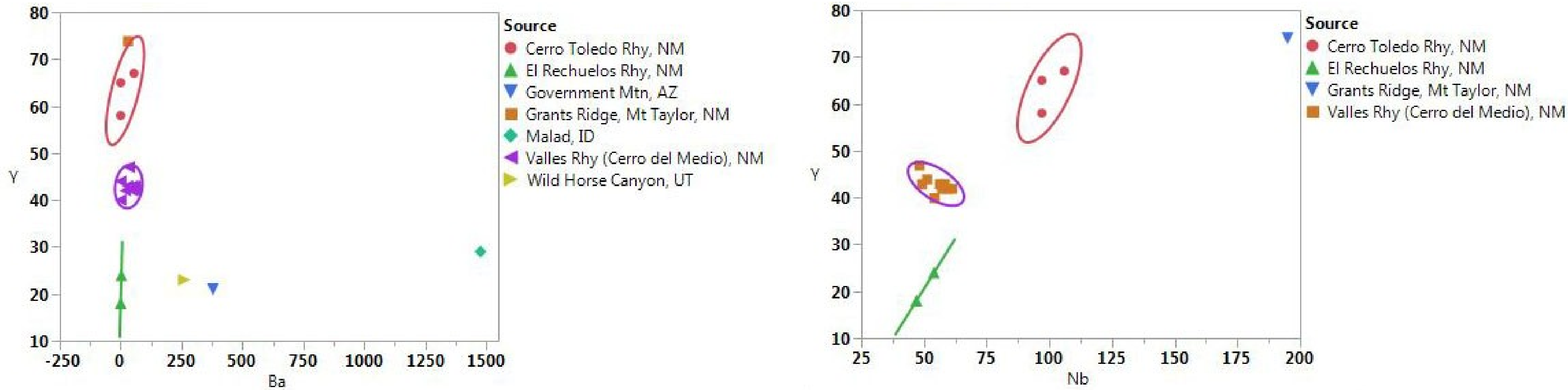

Figure 1. Ba/Y bivariate plot of all samples (left) and Nb/Y bivariate plot of the northern New Mexico Jemez Lineament samples (right). Confidence ellipses and lines at 95%.

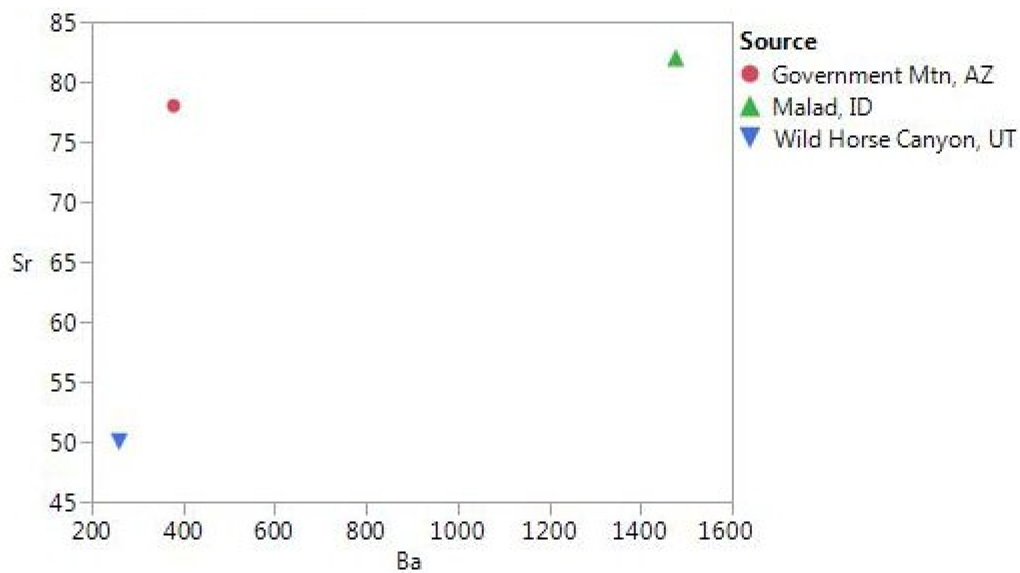

Figure 2. Ba/Sr bivariate plot of the high Sr samples from Arizona, Idaho, and Utah providing greater discrimination.