GEOARCHAEOLOGICAL XRF LAB

GEOARCHAEOLOGICAL X-RAY FLUORESCENCE SPECTROMETRY LABORATORY
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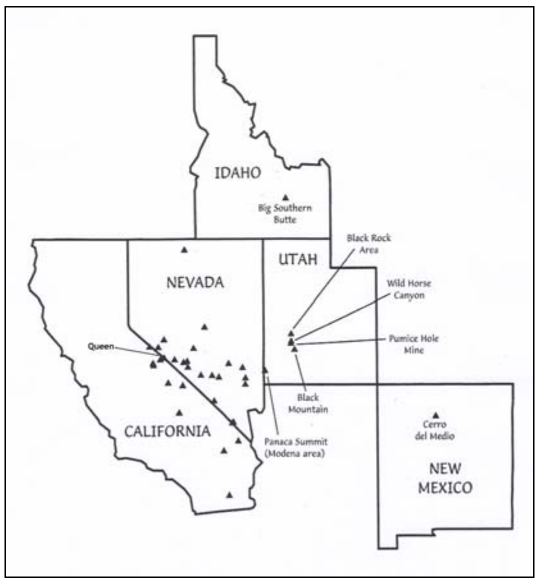
SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM ZION NATIONAL PARK, UTAH AND PIPE SPRING NATIONAL MONUMENT, ARIZONA



by

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INTRODUCTION

The analysis here of 22 obsidian artifacts from three recorded sites on Zion National Park and Pipe Spring National Monument exhibits a very diverse set of source provenances (Tables 1 and 2). While all the artifacts were produced from Great Basin sources (i.e, Nevada and Utah), site 42WS2698 exhibited artifacts most likely produced from the Queen (Truman Canyon) source on the eastern California/western Nevada border over 450 km distant (see discussion).

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 $Fe_2O_3^T$), 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 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 Southwest obsidians is available in Shackley (1988, 1995, 2005; 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

Géochimiques 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. 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 for obsidian artifacts to check machine calibration (Table 1). Source assignments were made by reference to Haarklau et al. (2005), Jack (1976), Nelson and Tingey (1997), as well as source standard data at this lab (see Tables 1 and 2, and Figure 1).

DISCUSSION

As noted above, the number of sources represented at these three sites is quite diverse (Tables 1 and 2). Most of the sources represented could be considered regional sources in southwestern and central Utah (Tables 1 and 2). More unusual, but not unprecedented, is the presence of artifacts produced from Queen (Truman Canyon or Truman Meadows) source on the California/Nevada border area about 470 km in linear distance (see Figure 2). I conferred with Craig Skinner at the Northwest Obsidian Laboratory in Covallis, Oregon, and we both agree that the elemental concentrations of these artifacts, and the relatively rare mahogany colored character of much of the debitage are a close match with the Queen (Truman Canyon) source, and does not match any other source known from North America. Keep in mind that all this debitage could come from one or two cores or bifaces. While this may seem a great distance, it is not that unusual in Great Basin prehistory, indeed North America (see Dillian et al. 2010; Ramos 2000). Research on this source by Ramos indicates that it was frequently conveyed to the east (2000). Why this distant source of obsidian raw material is present at this site, while more regional sources also occur is one of the vexing questions of archaeology (Dillian et al. 2010; Shackley 2005). Perhaps there are other data sets that indicate an interaction to the west.

REFERENCES CITED

Davis, K.D., T.L. Jackson, M.S. Shackley, T. Teague, and J.H. Hampel
2011 Factors Affecting the Energy-Dispersive X-Ray Fluorescence (EDXRF) Analysis of Archaeological Obsidian. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M.S. Shackley, pp. 45-64. Springer, New York.

Dillian, C.D., C.A. Bello, and M.S. Shackley
2010 Long Distance Exchange of Obsidian in the mid-Atlantic United States. In *Trade and Exchange: Archaeological Studies from History and Prehistory*, edited by C.D. Dillian, and C.L. White, pp. 17-36. 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 *Obsidian Studies in the Great Basin*, edited by R.E. Hughes, pp. 21-25. Contributions of the University of California Archaeological Research Facility 45. Berkeley.

Haarklau, L., L. Johnson, and D.L Wagner (editors)
2005 Fingerprints in the Great Basin: The Nellis Air Force Base Regional Obsidian Sourcing Study. U.S. Army Corps of Engineers, Fort Worth District.

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 Scale on Archaeological and Geoscientific Perspectives*, edited by J.K. Stein and A.R. Linse, pp. 79-91. Geological Society of America Special Paper 283.

Jack, R.N.
1976 Prehistoric Obsidian in California I: Geochemical Aspects. In *Advances in Obsidian Glass Studies: Archaeological and Geochemical Perspectives*, edited by R.E. Taylor, pp. 183-217. Noyes Press, Park Ridge, New Jersey.

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 *Energy Dispersive X-ray Spectrometry*, edited by K.F.J. Heinrich, D.E. Newbury, R.L. Myklebust, and C.E. Fiori, pp. 273-296. National Bureau of Standards Special Publication 604, Washington, D.C.

Ramos, B.A.
2000 *Prehistoric Obsidian Quarry Use and Technological Change in the Western Great Basin: Examining Lithic Procrurement at Truman/Queen Obsidian Source, California and Nevada*. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Davis.

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

Shackley, M. Steven
1988 Sources of Archaeological Obsidian in the Southwest: An Archaeological, Petrological, and Geochemical Study. *American Antiquity* 53(4):752-772.

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

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

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

Table 1. Elemental concentrations and source assignments for the archaeological specimens and USGS RGM-1 rhyolite standard. All measurements in parts per million (ppm).

Sample	Site	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba	Source
1843	42WS1775	1095	365	8997	196	44	23	111	25	173	Wild Horse Cnyn, UT
1844	42WS1775	833	389	9491	272	16	59	100	35	18	Black Rock, UT
1845	42WS1775	1107	346	9056	205	44	21	116	25	186	Wild Horse Cnyn, UT
1846	42WS1775	1357	351	8834	194	43	21	105	27	155	Wild Horse Cnyn, UT
1847	42WS1775	1296	345	8896	187	45	20	107	26	152	Wild Horse Cnyn, UT
1848	42WS1775	1262	403	9857	218	47	20	113	23	173	Wild Horse Cnyn, UT
1849	42WS1775	1177	335	8690	193	41	23	109	24	180	Wild Horse Cnyn, UT
1850	42WS2698	922	430	7666	140	20	22	111	34	20	Queen, CA/NV
1851	42WS2698	1142	686	10091	200	28	24	135	33	38	Queen, CA/NV
1852	42WS2698	1132	362	9161	202	45	22	113	25	167	Wild Horse Cnyn, UT
1853	42WS2698	973	525	8413	161	24	22	119	31	46	Queen, CA/NV
1854	42WS2698	1023	596	9175	172	25	24	133	37	54	Queen, CA/NV
1855	42WS2698	944	498	8307	164	26	21	125	33	28	Queen, CA/NV
1856	42WS2698	1152	666	9824	196	27	20	134	39	30	Queen, CA/NV
1857	42WS2698	1110	654	9816	193	29	22	132	37	24	Queen, CA/NV
1858	42WS2698	1017	568	8996	172	24	21	129	36	53	Queen, CA/NV
1859	42WS2698	1159	640	9659	194	26	25	134	38	0	Queen, CA/NV
1860	42WS2698	1209	763	10938	218	26	25	140	35	31	Queen, CA/NV
1	AZ B:2:9	1222	376	9635	203	50	20	110	29	177	Wild Horse Cnyn, UT
2	AZ B:2:9	1062	300	9485	193	81	26	118	17	579	Panaca Summit, Modena, UT/NV
3	AZ B:2:9	1282	353	9453	195	45	23	117	27	196	Wild Horse Cnyn, UT
4	AZ B:2:9	1146	303	9398	194	88	25	128	17	562	Panaca Summit, Modena, UT/NV
RGM1-S4		1628	299	13333	145	108	26	218	10	786	standard
RGM1-S4		1534	276	13341	149	105	22	214	10	777	standard

Table 2. Crosstabulation of site by source.

			Source				
			Black Rock	Panaca Summit, Modena	Queen	Wild Horse Cnyn	Total
Site	42WS1775	Count	1	0	0	6	7
		% within Site	14.3%	0.0%	0.0%	85.7%	100.0%
		% within Source	100.0%	0.0%	0.0%	66.7%	31.8%
		% of Total	4.5%	0.0%	0.0%	27.3%	31.8%
	42WS2698	Count	0	0	10	1	11
		% within Site	0.0%	0.0%	90.9%	9.1%	100.0%
		% within Source	0.0%	0.0%	100.0%	11.1%	50.0%
		% of Total	0.0%	0.0%	45.5%	4.5%	50.0%
	AZ B:2:9	Count	0	2	0	2	4
		% within Site	0.0%	50.0%	0.0%	50.0%	100.0%
		% within Source	0.0%	100.0%	0.0%	22.2%	18.2%
		% of Total	0.0%	9.1%	0.0%	9.1%	18.2%
Total		Count	1	2	10	9	22
		% within Site	4.5%	9.1%	45.5%	40.9%	100.0%
		% within Source	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	4.5%	9.1%	45.5%	40.9%	100.0%

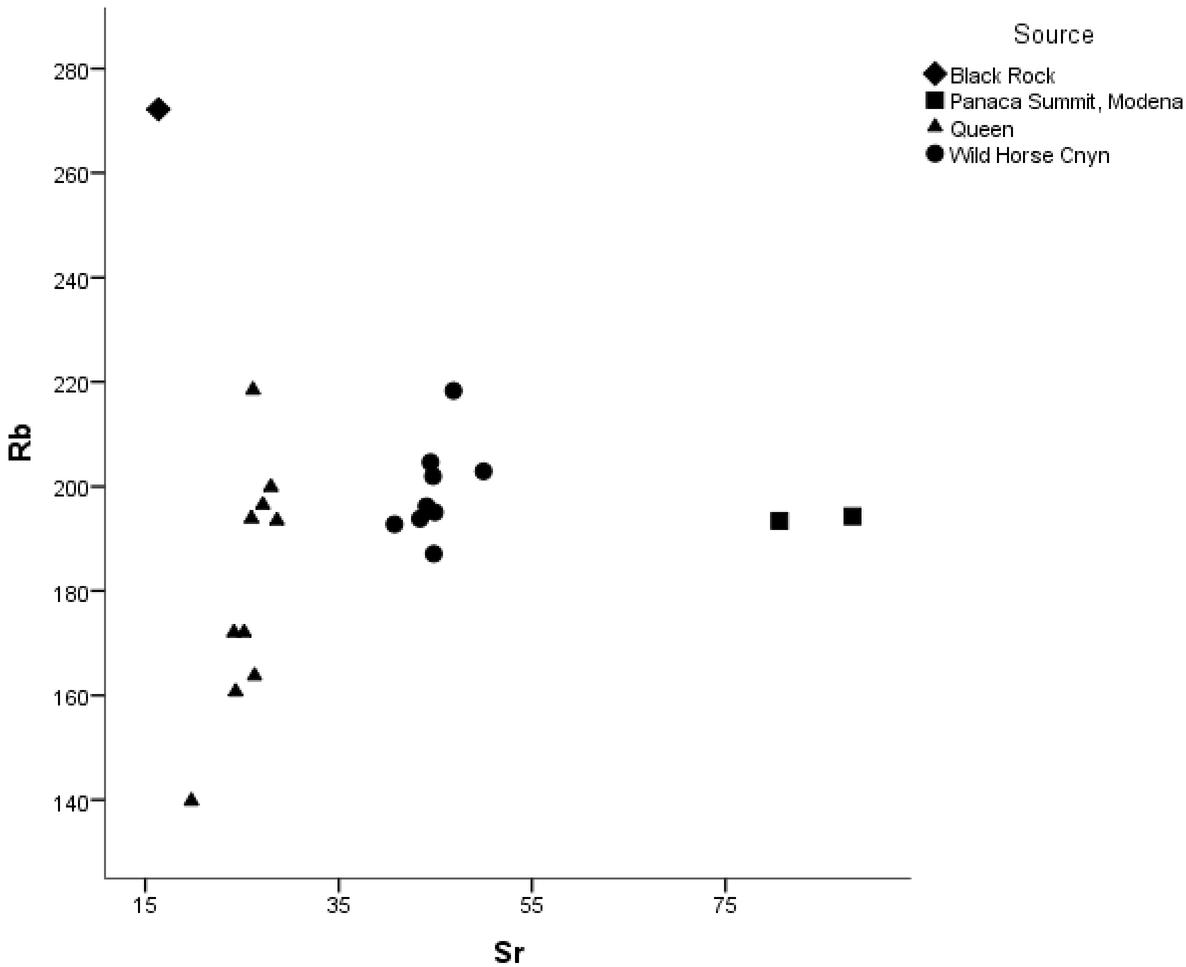

Figure 1. Sr versus Rb bivariate plot of the elemental concentrations for the archaeological specimens.

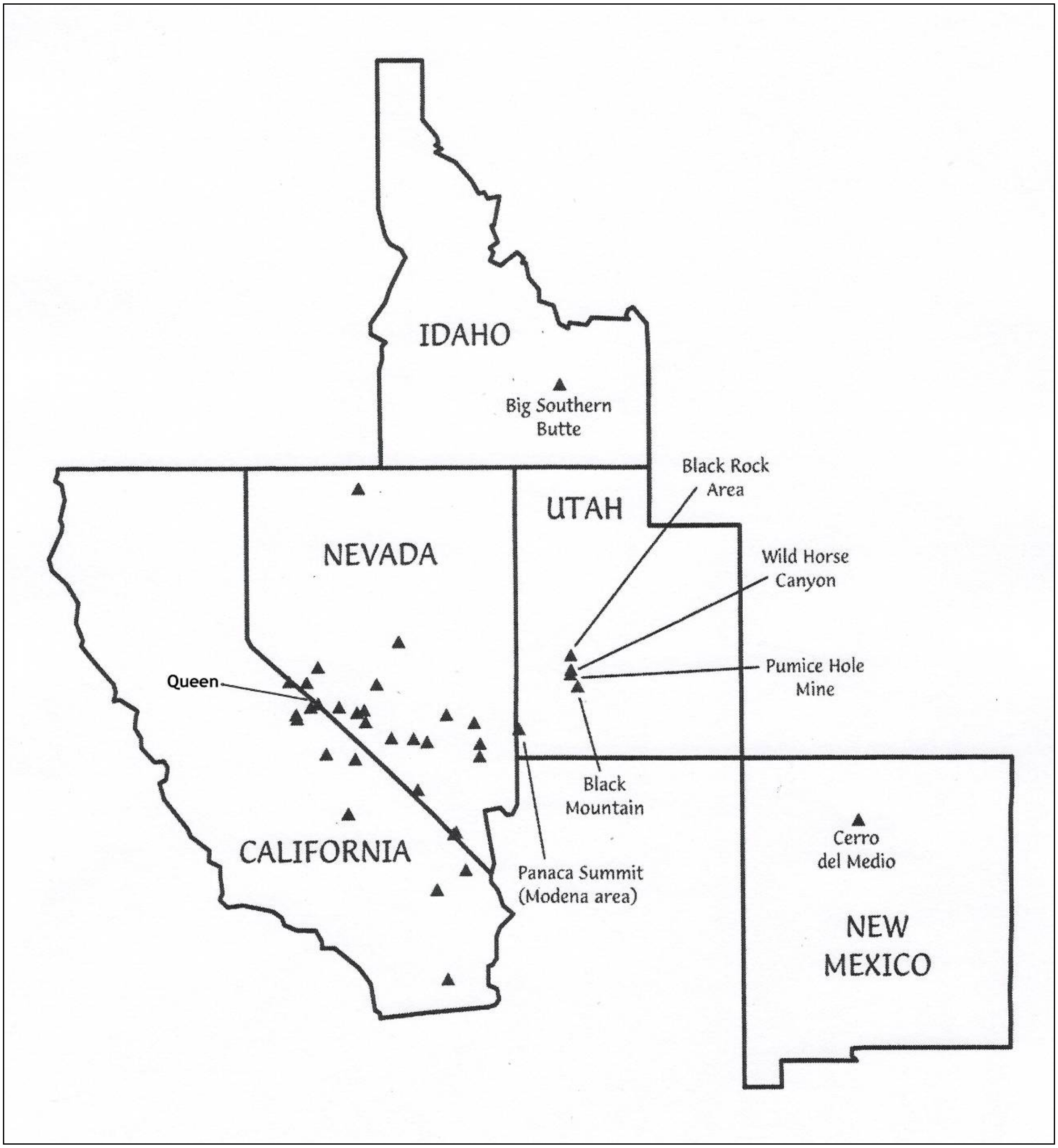

Figure 2. Obsidian sources in the region.