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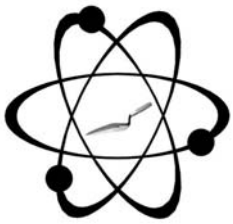

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SOURCE PROVENANCE OF A BIPOLAR OBSIDIAN ARTIFACT ASSEMBLAGE FROM FIVE SITES IN SOUITHERN NEW MEXICO

by

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INTRODUCTION

The analysis here of 27 obsidian artifacts from five sites in southern New Mexico indicates procurement most likely from nearby Rio Grande Quaternary alluvium (Church 2000; Shackley 2012; Tables 1 and 2). The dominant source is Cerro Toledo Rhyolite, the most common secondarily deposited obsidian in the Rio Grande alluvium, the primary sources of which are at Valles Caldera, Jemez Mountains, followed by the two Mount Taylor sources that have eroded into the Rio Puerco and into the Rio Grande, and the Tertiary Period pre-caldera Canovas Canyon Rhyolite (Bear Springs Peak) source that has been found as far south as the Las Cruces area (Church 2000). The mix of sources by site is probably not significant, based on an encounter strategy in procurement (see Tables 1 and 2).

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

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(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),

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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 Shackley (1995, 2005) and source standard data at this lab (Table 1, Figures 1 and 2).

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.

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.

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.

www.escholarship.org/uc/item/8530f9kp

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.

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.

2012 The Secondary Distribution of Archaeological Obsidian in Rio Grande Quaternary Sediments, Jemez Mountains to San Antonito, New Mexico: Inferences for Prehistoric Procurement and the Age of Sediments. Poster presentation at the Society for American Archaeology, Annual Meeting, Memphis, Tennessee.

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

Site	Sample	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
LA 169064	23.1	537	469	11801	99	202	8	64	171	92	36	16	Cerro Toledo Rhy
LA 169064	219.1	291	182	84345	14	-1	10	1	99	4	0	9	not obsidian
LA 169064	242.1	640	488	12138	14	205	8	64	175	97	35	25	Cerro Toledo Rhy
LA 169064	243.1	768	377	10480	46	117	42	24	99	51	24	25	Canovas Canyon Rhy
LA 169064	341.1	524	481	11774	11	196	10	63	165	95	34	27	Cerro Toledo Rhy
LA 169064	414.1	602	489	12090	11	205	9	64	177	10	37	34	Cerro Toledo Rhy
LA 169064	488.1	729	480	12047	12	197	9	62	164	98	34	22	Cerro Toledo Rhy
LA 169064	546.1	538	460	11639	10	200	8	63	165	93	35	28	Cerro Toledo Rhy
LA 169064	563.1	540	451	11640	92	198	8	61	169	97	32	23	Cerro Toledo Rhy
LA 169064	587.1	589	478	12037	92	205	9	64	173	94	34	24	Cerro Toledo Rhy
LA 169064	601.1	679	503	12167	10	204	11	63	168	94	37	25	Cerro Toledo Rhy
LA 169064	630	590	456	11705	10	194	9	63	168	89	38	17	Cerro Toledo Rhy
LA 169064	659.1	565	528	11784	18	487	13	86	131	22	54	29	Mt Taylor/Horace Mesa
LA 169064	663.1	595	546	12599	15	232	9	64	178	10	41	31	Cerro Toledo Rhy
LA 169064	668.1	798	696	13097	36	581	13	86	136	21	68	20	Mt. Taylor/Horace Mesa
LA 169066	4.1	756	539	12673	12	213	8	64	172	10	38	32	Cerro Toledo Rhy
LA 169066	21.1	961	472	12213	16	198	8	59	163	94	37	22	Cerro Toledo Rhy
LA 169066	69.1	416	685	10935	17	545	10	80	114	19	62	27	Mt Taylor/Grants Ridge
LA 169066	79.1	853	567	13270	25	228	8	64	172	96	43	28	Cerro Toledo Rhy
LA 169077	12.1	678	483	12281	10	208	8	61	174	98	37	20	Cerro Toledo Rhy
LA 169077	27.1-1	622	416	11432	99	182	9	59	161	90	32	23	Cerro Toledo Rhy
LA 169077	27.1-2	689	492	12357	12	216	10	60	180	99	37	27	Cerro Toledo Rhy
LA 169077	28.1	640	487	12261	10	209	10	61	178	10	35	23	Cerro Toledo Rhy
LA 169077	36.1	830	498	12855	11	218	8	62	179	10	37	27	Cerro Toledo Rhy
LA 169077	47.1	780	480	12123	11	196	12	62	162	92	34	21	Cerro Toledo Rhy
LA	6	718	555	12854	19	224	8	63	171	10	38	24	Cerro Toledo Rhy

169075			6	3	0	5			7	0			
LA	182	642	49	1225	11	22	8	65	17	95	37	22	Cerro Toledo Rhy
169065			7	0	8	0			2				
standard	RGM1-S4	1600	28	1374	37	14	10	23	21	7	23	20	standard
			9	4		9	9		5				
standard	RGM1-S4	1511	28	1379	36	15	10	25	22	8	22	16	standard
			0	6		4	6		2				

Table 2. Site by source crosstabulation.

Site * Source Crosstabulation

			Source					
			Canovas Canyon Rhy	Cerro Toledo Rhy	Mt Taylor/Grants Ridge	Mt Taylor/Horace Mesa	not obsidian	Total
Site	LA 169064	Count	1	11	0	2	1	15
		% within Site	6.7%	73.3%	.0%	13.3%	6.7%	100.0%
		% within Source	100.0%	50.0%	.0%	100.0%	100.0%	55.6%
		% of Total	3.7%	40.7%	.0%	7.4%	3.7%	55.6%
	LA 169065	Count	0	1	0	0	0	1
		% within Site	.0%	100.0%	.0%	.0%	.0%	100.0%
		% within Source	.0%	4.5%	.0%	.0%	.0%	3.7%
		% of Total	.0%	3.7%	.0%	.0%	.0%	3.7%
	LA 169066	Count	0	3	1	0	0	4
		% within Site	.0%	75.0%	25.0%	.0%	.0%	100.0%
		% within Source	.0%	13.6%	100.0%	.0%	.0%	14.8%
		% of Total	.0%	11.1%	3.7%	.0%	.0%	14.8%
	LA 169075	Count	0	1	0	0	0	1
		% within Site	.0%	100.0%	.0%	.0%	.0%	100.0%
		% within Source	.0%	4.5%	.0%	.0%	.0%	3.7%
		% of Total	.0%	3.7%	.0%	.0%	.0%	3.7%
	LA 169077	Count	0	6	0	0	0	6
		% within Site	.0%	100.0%	.0%	.0%	.0%	100.0%
		% within Source	.0%	27.3%	.0%	.0%	.0%	22.2%
		% of Total	.0%	22.2%	.0%	.0%	.0%	22.2%
Total		Count	1	22	1	2	1	27
		% within Site	3.7%	81.5%	3.7%	7.4%	3.7%	100.0%
		% within Source	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	3.7%	81.5%	3.7%	7.4%	3.7%	100.0%

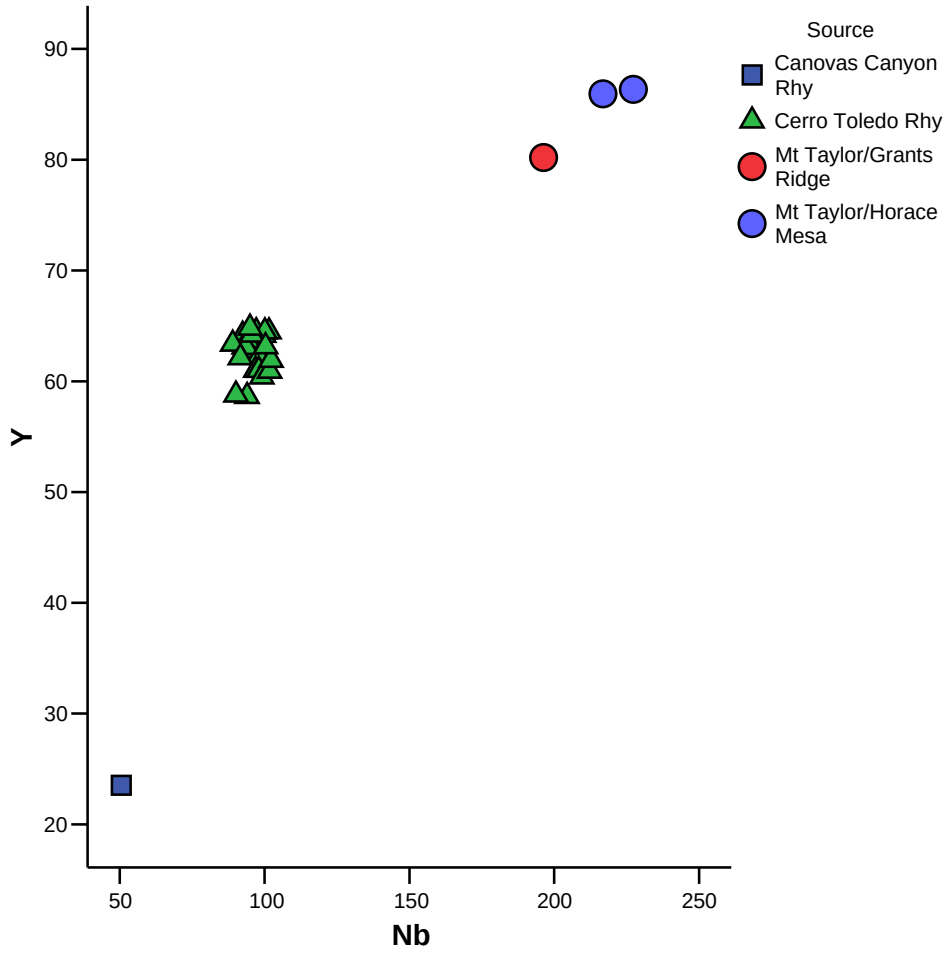

Figure 1. Y versus Nb bivariate plot of the archaeological specimens.

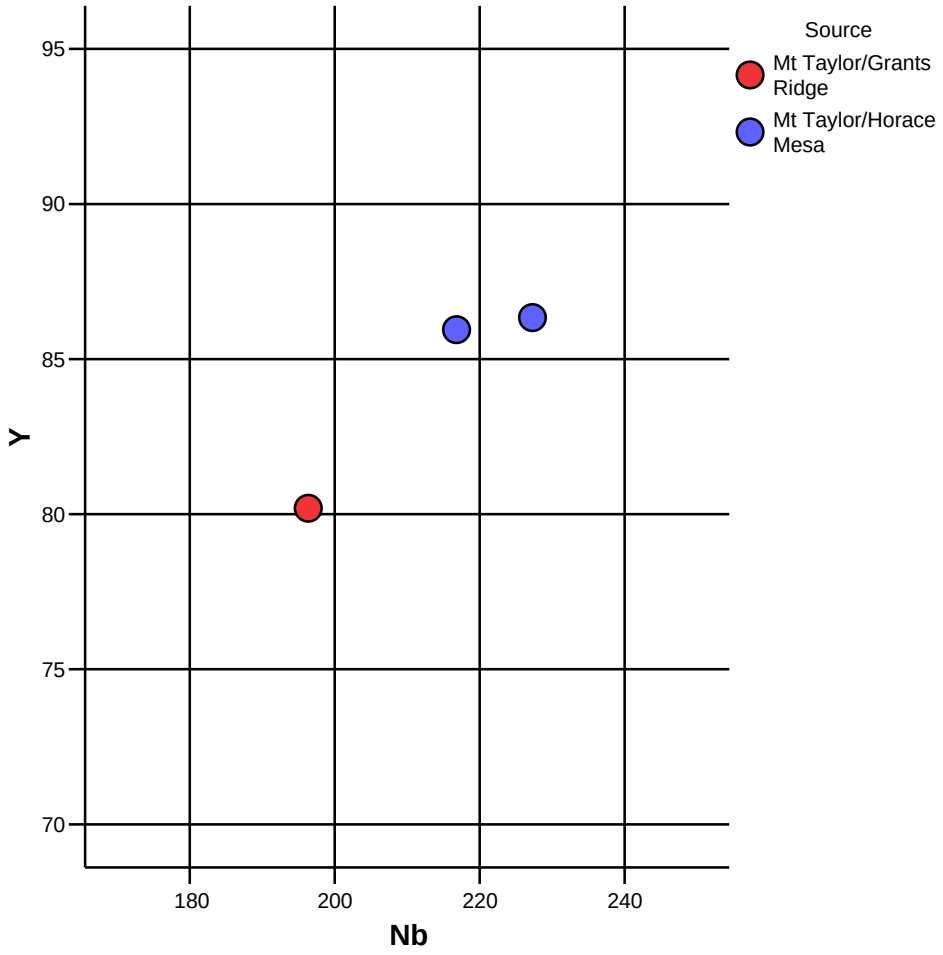

Figure 1. Y versus Nb bivariate plot of the Mount Taylor source locality assignments providing better discrimination (see Shackley 2005: 58-64).