Title
SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THE CROSSPATCH SITE SOUTHWEST COLORADO

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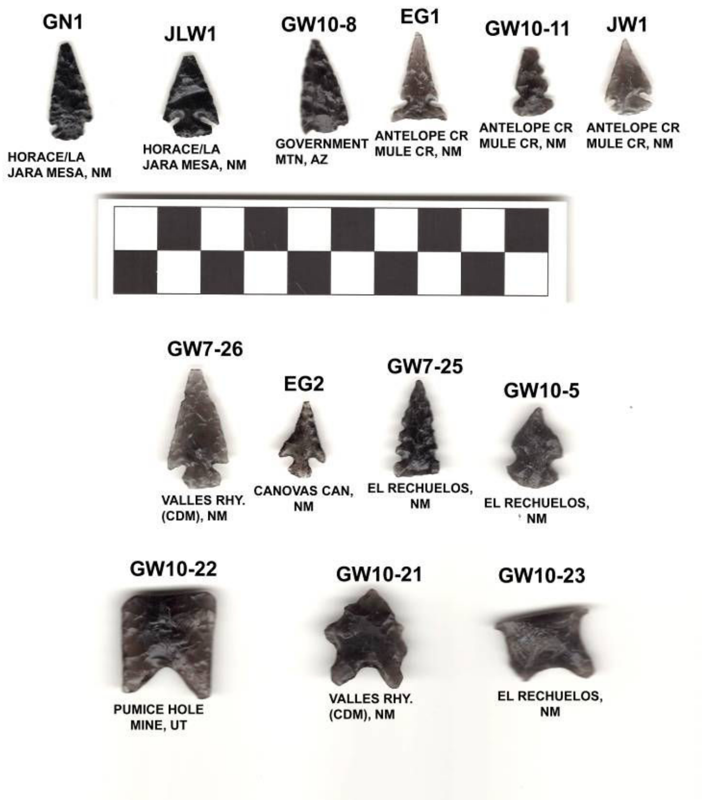

A sample of projectile points from the assemblage and source provenance

by

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INTRODUCTION

The analysis here of 71 artifacts (70 obsidian) from the Crosspatch site in southwestern Colorado indicates a very diverse obsidian provenance assemblage with artifacts produced from obsidian sources in northern and southwestern New Mexico, to northern Arizona, to southwestern Utah (Tables 1 and 2 and Figures 1 and 2). A short discussion of the results is offered below.

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 American 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 rhyolite (obsidian) standard is analyzed during each sample run of ≤19 for obsidian artifacts to verify instrument calibration (Table 1).

Source assignments were made by reference to the laboratory database (see Shackley 2005; Shackley et al. 2016, 2018; 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 3 are reported in parts per million (ppm), a quantitative measure by weight.

DISCUSSION

The obsidian provenance assemblage from the Crosspatch site is one of the most diverse in the four-corners region of the Southwest, a likely reflection of the multi-component character of the site. The projectile point styles similarly reflect this diversity, from Archaic Humboldt Concave-Base (GW10-22) a Great Basin style that is produced from the Pumice Hole Mine obsidian source in southwestern Utah, to what could be a Classic Mimbres side-notched point (EG1) produced from the Antelope Creek source at Mule Creek in southwestern New Mexico, to a rejuvenated Middle Archaic San Jose point (GW10-21) produced from Valles Rhyolite (Cerro del Medio) from the Jemez Mountains in northern New Mexico (see cover image).

A number of artifacts were produced from obsidian sources over 400 km distant (see Tables 1 and 2, and Figures 3 and 4). The Pumice Hole Mine source in the Mineral Mountains, Beaver County, southwest Utah is part of an obsidian source group in the Mineral Mountains that is distributed widely from throughout the Great Basin to the northern portion of the U.S.

Southwest (Haarklau et al. 2005). Similarly, the Government Mountain source in the San Francisco Volcanic Field of northern Arizona, has been recovered throughout the North American Southwest in all time periods (Shackley 2005). This source indicates contact with Western Pueblo groups. The Jemez Mountains sources in northern New Mexico (over 82% of the assemblage), particularly Valles Rhyolite (Cerro del Medio) is distributed throughout western North America in all time periods, and is the volumetrically largest source of obsidian raw material in the Southwest, approached only by Government Mountain (Steffen 2016). The Horace/La Jara Mesa source at Mount Taylor in northwestern New Mexico is common throughout Southwest prehistory for point production. It is particularly common in Archaic contexts (Shackley 1998, 2005).

Most interesting here is the presence of artifacts produced from Antelope Creek obsidian at Mule Creek in southwestern New Mexico nearly 500 km south of Crosspatch (see Tables 1 and 2 and Figure 3). This source used throughout prehistory in the Southwest, including the Classic Mimbres period, the source of which is in Mimbres territory, was distributed throughout the Southwest and particularly common during the Late Classic (> A.D. 1300; Mills et al. 2013; Shackley et al. 2018).

The obsidian source provenance and projectile point styles certainly reflect a long-term occupation at Crosspatch. Given that the collection is from surface contexts, not much more can be inferred. Still, this assemblage is one of the most important in the four-corners region.

REFERENCES CITED

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 *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.

Haarklau, L., Johnson, L., and Wagner, D.L. 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.

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.

Mills, B.J., J.J. Clark, M.A. Peeples, W.R. Haas, Jr., J.M. Roberts, Jr., J.B. Hill, D.L. Huntley, L. Borck, R.L. Breiger, A. Clauset, and M.S. Shackley, Transformation of Social Networks in the Late Pre-Hispanic US Southwest. *Proceedings of the National Academy of Science* 110:5785-5790.

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

Shackley, M.S. 1989, *Early Hunter-Gatherer Procurement Ranges in the Southwest: Evidence from Obsidian Geochemistry and Lithic Technology*. Unpublished Ph.D. dissertation, Department of Anthropology, Arizona State University, Tempe.

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., 1998, Geochemical differentiation and prehistoric procurement of obsidian in the Mount Taylor Volcanic Field, northwest New Mexico. *Journal of Archaeological Science* 25:1073-1082.

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., F. Goff, and S.G. Dolan, 2016, Geologic origin of the source of Bearhead rhyolite (Paliza Canyon) obsidian, Jemez Mountains, Northern New Mexico. *New Mexico Geology* 38:52-62.

Shackley, M.S., L.E. Morgan, and D. Pyle, 2018, Elemental, isotopic, and geochronological variability in Mogollon-Datil Volcanic Province archaeological obsidian, southwestern USA: solving issues of inter-source discrimination. *Geoarchaeology* 33:486-497.

Steffen, A. 2016, The high-elevation archaeological record of the Valles Caldera. *Archaeology Southwest* 30, 9-12.

Table 1. Elemental concentrations for the archaeological samples and USGS RGM-1 rhyolite standard. All measurement in parts per million (ppm).

Sample	Ti	Mn	Fe	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba	Ce	Source
BW1184	1060	400	10364	130	22	156	13	41	163	54	0	74	Valles Rhy (Cerro del Medio), NM
BW1378	897	422	10479	97	18	167	15	45	169	57	52	50	Valles Rhy (Cerro del Medio), NM
BW1489	910	402	10183	87	18	153	11	44	171	52	70	78	Valles Rhy (Cerro del Medio), NM
EG1	911	373	10247	80	19	242	20	38	120	24	67	32	Antelope Cr-Mule Cr, NM
EG2	1119	446	8802	75	18	118	51	21	116	53	397	33	Canovas Canyon Rhy, NM
GN1	647	542	9225	189	27	484	13	84	134	214	32	20	Horace/La Jara Mesa-Mt Taylor, NM
GN2	886	391	7602	40	18	150	12	23	74	45	0	28	El Rechuelos, NM
GN3	929	410	10507	79	20	164	13	48	168	57	55	61	Valles Rhy (Cerro del Medio), NM
GN4	881	502	10503	106	22	205	10	61	177	102	18	52	Cerro Toledo Rhy, NM
GN5	916	398	7903	97	18	157	13	24	78	45	0	8	El Rechuelos, NM
GW5-59	689	144	5711	30	8	0	30	4	30	1	285	13	not obsidian
GW6-31	960	423	10675	89	21	168	11	52	173	50	45	47	Valles Rhy (Cerro del Medio), NM
GW6-84	890	405	10113	85	19	153	13	46	158	52	49	57	Valles Rhy (Cerro del Medio), NM
GW7-25	925	382	10178	102	19	243	24	45	119	30	56	65	Antelope Cr-Mule Cr, NM
GW7-26	1008	422	10493	76	21	167	13	43	174	59	21	58	Valles Rhy (Cerro del Medio), NM
GW9-42	901	379	10429	85	21	160	13	45	170	54	31	35	Valles Rhy (Cerro del Medio), NM
GW9-43	954	426	7887	80	19	146	14	27	75	47	0	47	El Rechuelos, NM
GW10-1	938	378	9949	77	20	154	12	43	164	52	39	38	Valles Rhy (Cerro del Medio), NM
GW10-2	916	341	9940	74	21	160	14	47	158	52	24	32	Valles Rhy (Cerro del Medio), NM
GW10-3	961	396	10333	112	19	164	10	42	170	55	0	31	Valles Rhy (Cerro del Medio), NM
GW10-4	834	602	10032	234	30	518	11	91	138	231	0	34	Horace/La Jara Mesa-Mt Taylor, NM
GW10-5	939	380	7775	56	18	152	17	20	77	46	30	29	El Rechuelos, NM
GW10-6	939	365	10225	96	20	162	15	42	161	61	41	61	Valles Rhy (Cerro del Medio), NM
GW10-7	927	414	7884	84	19	153	15	22	76	45	24	11	El Rechuelos, NM
GW10-8	792	491	9479	77	18	112	84	20	90	51	391	26	Government Mtn, AZ
GW10-9	878	417	7863	99	19	152	11	24	75	40	41	60	El Rechuelos, NM
GW10-10	921	391	7895	75	19	161	12	23	73	44	19	30	El Rechuelos, NM
GW10-11	867	379	10213	105	19	242	19	42	120	30	89	39	Antelope Cr-Mule Cr, NM
GW10-12	900	411	10371	92	22	165	11	45	171	58	14	45	Valles Rhy (Cerro del Medio), NM
GW10-13	858	380	7513	57	19	152	13	24	82	45	9	35	El Rechuelos, NM
GW10-14	823	560	10236	235	29	515	15	85	130	220	0	13	Horace/La Jara Mesa-Mt Taylor, NM
GW10-15	898	392	8018	63	18	156	11	23	78	55	41	7	El Rechuelos, NM
GW10-16	899	407	10641	117	17	164	9	40	172	57	43	51	Valles Rhy (Cerro del Medio), NM
GW10-17	950	411	7987	116	20	152	10	24	68	36	6	21	El Rechuelos, NM
GW10-18	893	392	9815	166	19	148	10	44	159	57	61	40	Valles Rhy (Cerro del Medio), NM

GW10-19	998	399	10672	77	19	174	12	42	173	58	31	83	Valles Rhy (Cerro del Medio), NM
GW10-20	841	370	10063	70	18	158	16	44	170	56	61	95	Valles Rhy (Cerro del Medio), NM
GW10-21	953	379	10094	71	19	162	13	47	166	60	44	79	Valles Rhy (Cerro del Medio), NM

Sample	**Ti**	**Mn**	**Fe**	**Zn**	**Ga**	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Ba**	**Ce**	**Source**
GW10-22	1137	379	9321	45	19	206	50	26	124	23	229	54	Pumice Hole Mine, ID
GW10-23	929	353	7829	48	18	138	11	22	74	46	0	48	El Rechuelos, NM
GW10-24	871	409	10468	77	21	156	12	44	168	55	39	78	Valles Rhy (Cerro del Medio), NM
GW10-25	895	377	7509	47	17	146	14	28	72	44	24	21	El Rechuelos, NM
GW10-26	922	404	7983	73	20	162	12	25	76	51	29	22	El Rechuelos, NM
GW10-27	910	405	10470	102	19	161	16	43	161	53	25	64	Valles Rhy (Cerro del Medio), NM
GW10-28	912	400	10459	93	20	160	13	44	175	58	87	54	Valles Rhy (Cerro del Medio), NM
GW10-29	935	399	10168	96	22	160	11	42	166	57	14	44	Valles Rhy (Cerro del Medio), NM
GW10-30	942	402	7708	66	18	158	15	26	80	48	40	20	El Rechuelos, NM
GW10-31	1089	395	7992	148	17	149	16	23	64	42	0	34	El Rechuelos, NM
GW10-32	911	369	10377	123	19	156	14	41	172	53	74	77	Valles Rhy (Cerro del Medio), NM
GW10-33	943	394	10676	101	18	161	11	48	167	57	84	65	Valles Rhy (Cerro del Medio), NM
GW10-34	905	405	7647	74	17	157	11	24	71	49	13	40	El Rechuelos, NM
GW10-35	906	395	7535	79	16	151	15	24	69	49	9	10	El Rechuelos, NM
GW10-36	897	411	10711	168	20	163	13	44	165	53	90	53	Valles Rhy (Cerro del Medio), NM
GW10-37	984	371	10256	117	17	160	14	40	168	57	61	74	Valles Rhy (Cerro del Medio), NM
GW10-38	895	493	10616	143	23	206	11	61	177	103	33	68	Cerro Toledo Rhy, NM
GW10-39	1132	354	8740	44	18	192	44	23	119	28	231	72	Pumice Hole Mine, ID
GW10-40	1030	408	10909	81	20	168	13	44	168	58	29	60	Valles Rhy (Cerro del Medio), NM
GW10-41	948	405	10269	79	19	167	13	44	165	58	39	67	Valles Rhy (Cerro del Medio), NM
GW10-42	901	372	10281	85	20	162	11	38	165	50	42	58	Valles Rhy (Cerro del Medio), NM
GW10-43	1170	335	9052	44	19	197	49	24	113	27	217	58	Pumice Hole Mine, ID
GW10-44	894	371	7640	58	17	154	16	19	72	50	48	23	El Rechuelos, NM
GW10-45	900	410	7673	39	17	149	9	25	71	50	0	35	El Rechuelos, NM
GW10-46	897	437	7850	69	18	154	13	24	79	48	5	37	El Rechuelos, NM
GW10-47	920	376	10494	114	21	162	13	47	160	58	52	46	Valles Rhy (Cerro del Medio), NM
GW10-48	996	497	10710	150	21	202	9	58	169	98	7	47	Cerro Toledo Rhy, NM
GW10-49	894	472	10474	132	24	206	9	60	172	98	12	32	Cerro Toledo Rhy, NM
GW10-50	968	357	9705	75	19	149	13	41	164	47	47	100	Valles Rhy (Cerro del Medio), NM
GW10-51	959	373	10533	79	20	161	11	45	176	52	25	76	Valles Rhy (Cerro del Medio), NM
GW10-52	1052	380	7579	104	16	146	13	24	71	38	21	22	El Rechuelos, NM
JLW1	747	611	10391	230	33	541	14	92	144	227	22	8	Horace/La Jara Mesa-Mt Taylor, NM
JW1	948	399	10766	85	18	256	22	44	117	30	68	31	Antelope Cr-Mule Cr, NM
RGM1-S4	1545	305	13185	41	17	147	111	29	217	11	797	38	standard
RGM1-S4	1618	320	13256	40	16	149	108	26	220	12	822	28	standard

RGM1-S4	1552	296	13131	45	16	153	105	26	219	7	789	37 standard

Table 2. Frequency distribution of obsidian source provenance.

		Frequency	Percent
Source	Valles Rhy (Cerro del Medio), NM	32	45.7
	El Rechuelos, NM	21	30.0
	Cerro Toledo Rhy, NM	4	5.7
	Canovas Canyon Rhy, NM	1	1.4
	Horace/La Jara Mesa-Mt Taylor, NM	4	5.7
	Antelope Cr-Mule Cr, NM	4	5.7
	Government Mtn, AZ	1	1.4
	Pumice Hole Mine, ID	3	4.3
	Total	70	100.0

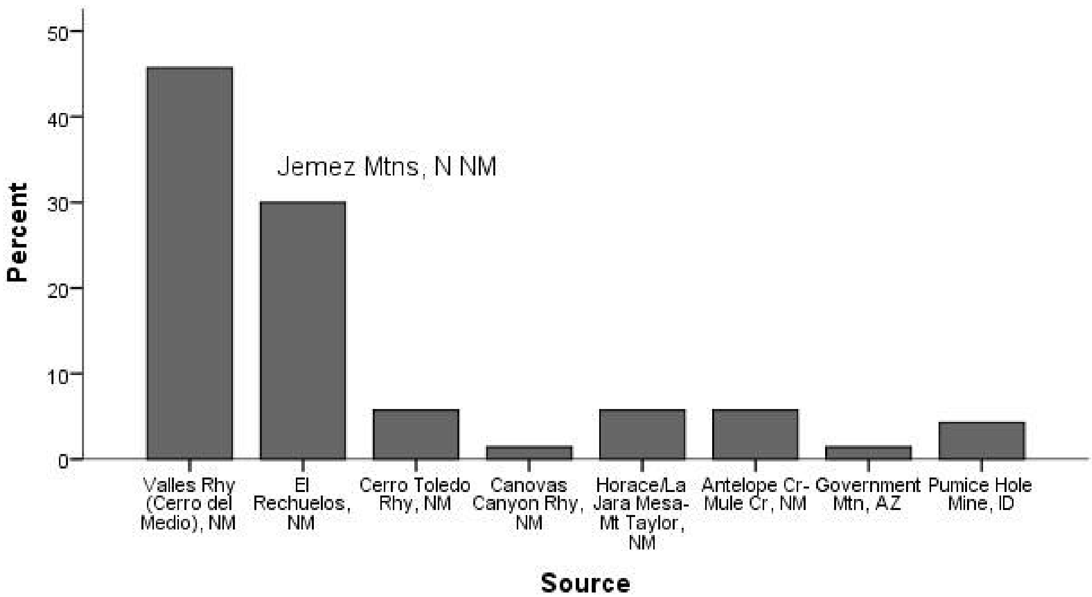

Figure 1. Frequency (%) distribution of obsidian sources in the assemblage.

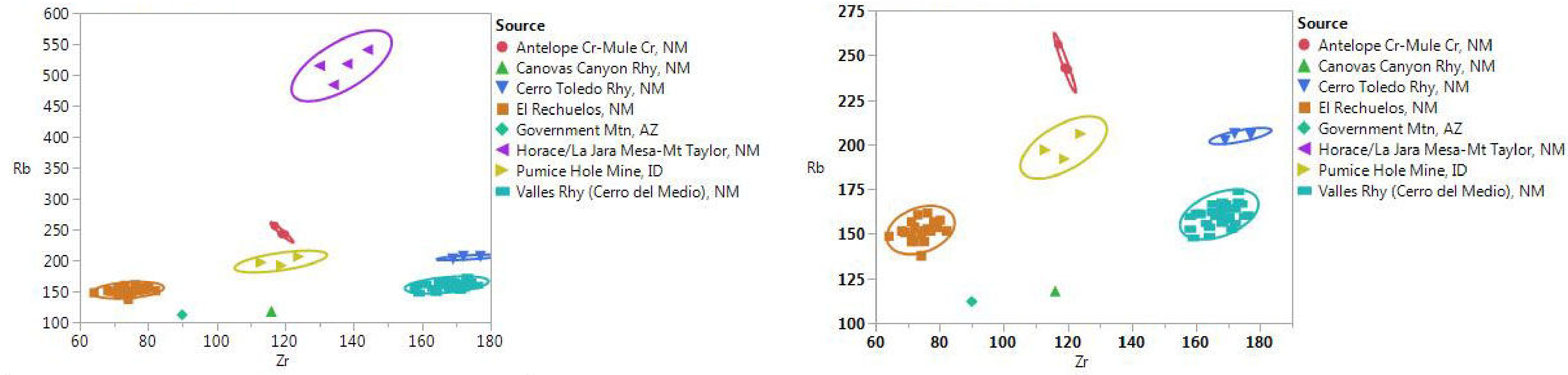

Figure 2. Rb/Zr bivariate plot of all samples (left), and the high Rb Horace/La Jara Mesa samples deleted (right). Confidence ellipses at 95%.

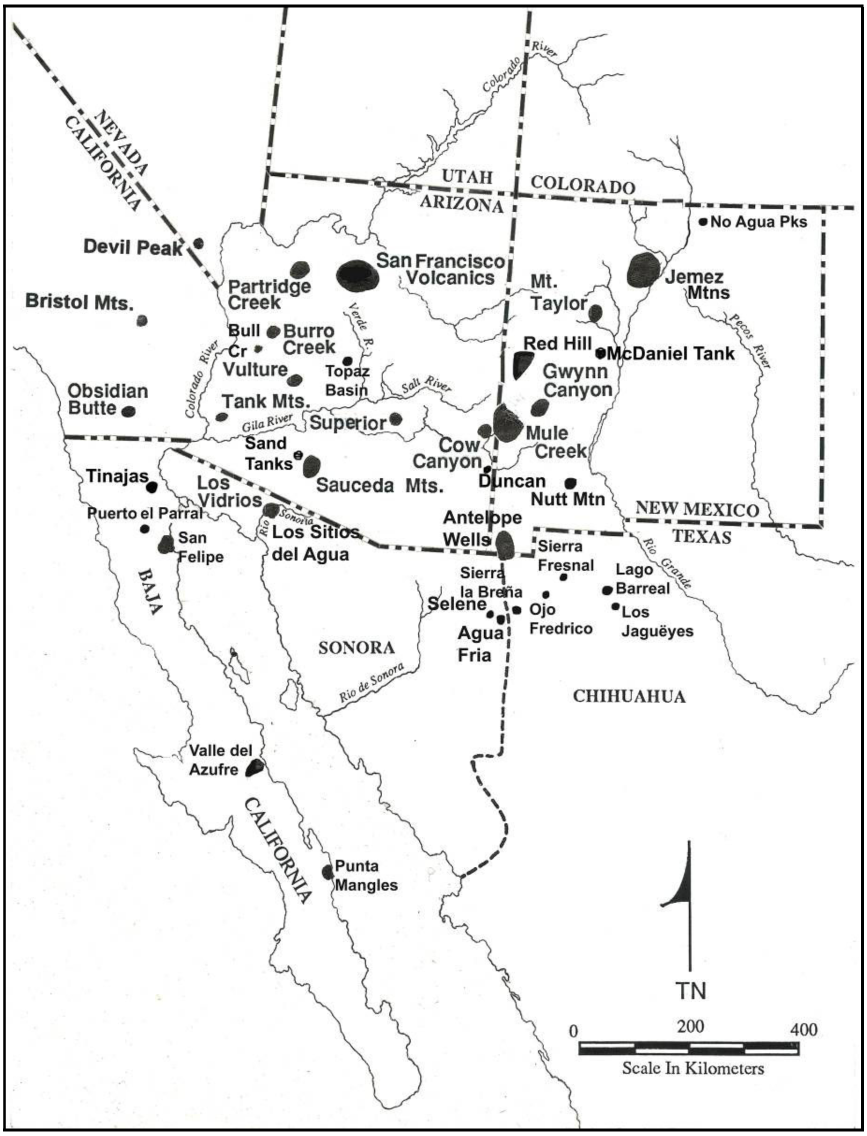

Figure 3. Location of known sources of archaeological obsidian in the North American Southwest (adapted from Panich et al. 2019; Shackley 1988, 1989, 2005, 2019; Shackley et al. 2016, 2018).

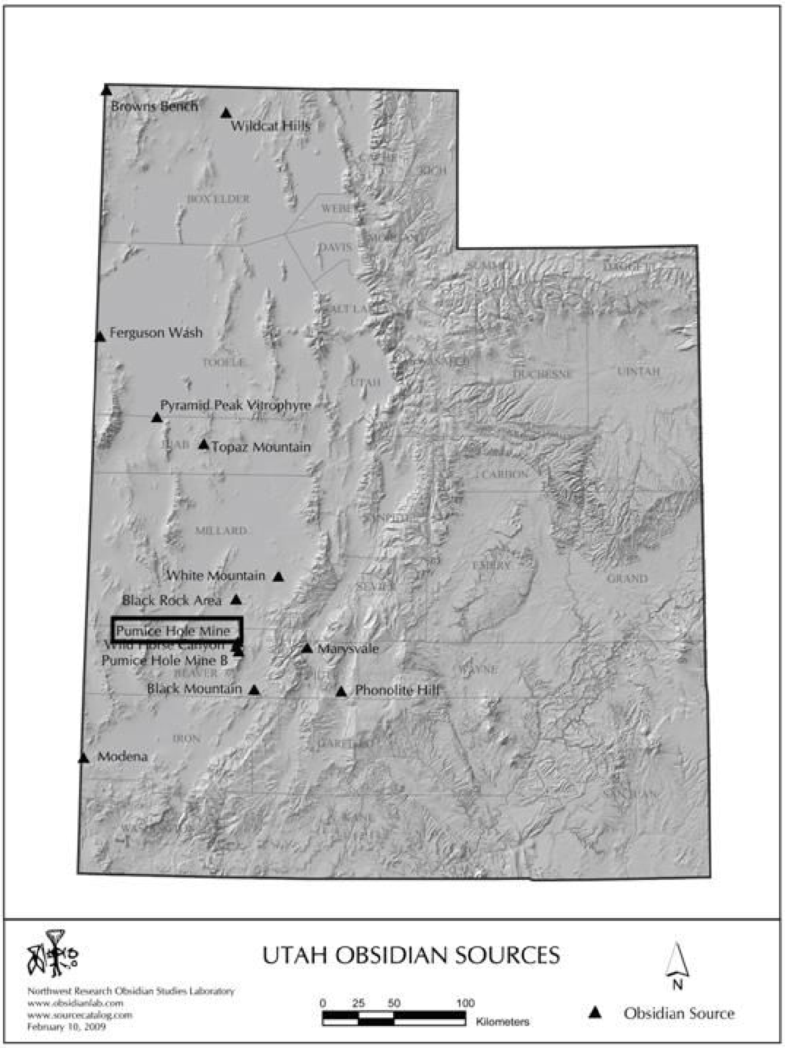

Figure 4. Utah obsidian sources with Pumice Hole Mine source location in Beaver County boxed (from IAOS obsidian source catalog: https://www.sourcecatalog.com/ut/s_ut.html).