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Source Provenance of Obsidian Artifacts from Three Subsurface Test Units at Piedras Marcadas (LA 290), Middle Rio Grande Valley, New Mexico

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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THREE SUBSURFACE TEST UNITS AT PIEDRAS MARCADAS (LA 290), MIDDLE RIO GRANDE VALLEY, NEW MEXICO

by

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Report Prepared for

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INTRODUCTION

The analysis here of 61 obsidian artifacts from three test units at Piedras Marcadas (LA 290) in the middle Rio Grande River valley indicates a slightly different provenance mix than the results from the general surface (Shackley 2009a). In the test unit case, all the artifact quality sources of archaeological obsidian present in the Jemez Mountains, both pre-caldera and caldera event sources occur in the assemblage. All these sources are present in the Rio Grande alluvium as far south as Albuquerque, although the Valles Rhyolite (Cerro del Medio) nodules are very small. No Mount Taylor obsidian was recovered sub-surface (Shackley 2012). Mount Taylor is not available in Rio Grande Quaternary sediments this far north.

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).

The trace element analyses were performed in the Geoarchaeological XRF Laboratory, Albuquerque, New Mexico, using a Thermo Scientific *Quant'X* energy dispersive x-ray fluorescence spectrometer. The spectrometer is equipped with a ultra-high flux peltier air cooled Rh x-ray target with a 125 micron beryllium (Be) window, an x-ray generator that operates from 4-50 kV/0.02-1.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTrace™ 4.1 reduction software. The spectrometer is equipped with a 2001 min^{-1} Edwards vacuum pump for the analysis of elements below titanium (Ti). Data is acquired through a pulse processor and analog to digital converter. This is a significant improvement in analytical speed and efficiency beyond the former Spectrace 5000 and *QuanX* analog systems (see Davis et al. 2011; Shackley 2011).

For Ti-Nb, Pb, Th elements the mid-Zb condition is used operating the x-ray tube 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 Kα_1-line data for elements titanium (Ti), manganese (Mn), iron (as Fe^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 is 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 acquired, the Rh tube is operated at 50 kV and 0.5 mA in an air path at 200 seconds livetime to generate x-ray intensity Kα_1-line data, through a 0.630 mm Cu (thick) filter ratioed to the bremsstrahlung region (see Davis et al. 2011). Further details concerning the petrological choice of these elements in North American obsidians is available in Shackley (1988, 1990, 1995, 2005; also Mahood and Stimac 1991; and Hughes and Smith 1993). A suite of 17 specific standards used for the best fit regression calibration for elements Ti- Nb, Pb, and Th, 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), BCR-2 (basalt), TLM-1 (tonalite), SCO-1 (shale), all US Geological Survey standards, NBS-278 (obsidian) from the National Institute of Standards and Technology, BR-1 (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 and into SPSS for statistical manipulation (Table 1). In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run (Table 1). RGM-1 is analyzed during each sample run for obsidian artifacts to check machine calibration (Table 1). Source assignments made by reference to source data at Berkeley, Baugh and Nelson (1987) and Shackley (1995, 2005).

DISCUSSION

Before a discussion of the source provenance of the samples, a short discussion of the Jemez Mountains sources is in order. Following this is a short discussion of the samples proper.

The Jemez Mountains and the Sierra de los Valles

A more complete discussion of the archaeological sources of obsidian in the Jemez Mountains is available in Shackley (2005:64-74). Distributed in archaeological contexts over as great a distance as Government Mountain in the San Francisco Volcanic Field in northern Arizona, the Quaternary sources in the Jemez Mountains, most associated with the collapse of the Valles Caldera, are distributed at least as far south as Chihuahua through secondary deposition in the Rio Grande, and east to the Oklahoma and Texas Panhandles through exchange. And like the sources in northern Arizona, the nodule sizes are up to 10 to 30 cm in diameter; El Rechuelos, Cerro Toledo Rhyolite, and Valles Rhyolite (Valles Rhyolite derived from the Cerro del Medio dome complex) glass sources are as good a media for tool production as anywhere. Until the recent land exchange of the Baca Ranch properties, the Valles Rhyolite primary domes (i.e., Cerro del Medio) have been off-limits to most research. The discussion of this source group here is based on collections by Dan Wolfman and others, facilitated by Los Alamos National Laboratory, and the Museum of New Mexico, and recent sampling of all the major sources courtesy of the Valles Caldera National Preserve (VCNP; Shackley 2005; Wolfman 1994).

There are at least four eruptive events in the last 8.7 million years that have produced the four chemical groups in the Jemez Mountains (Figure 1).

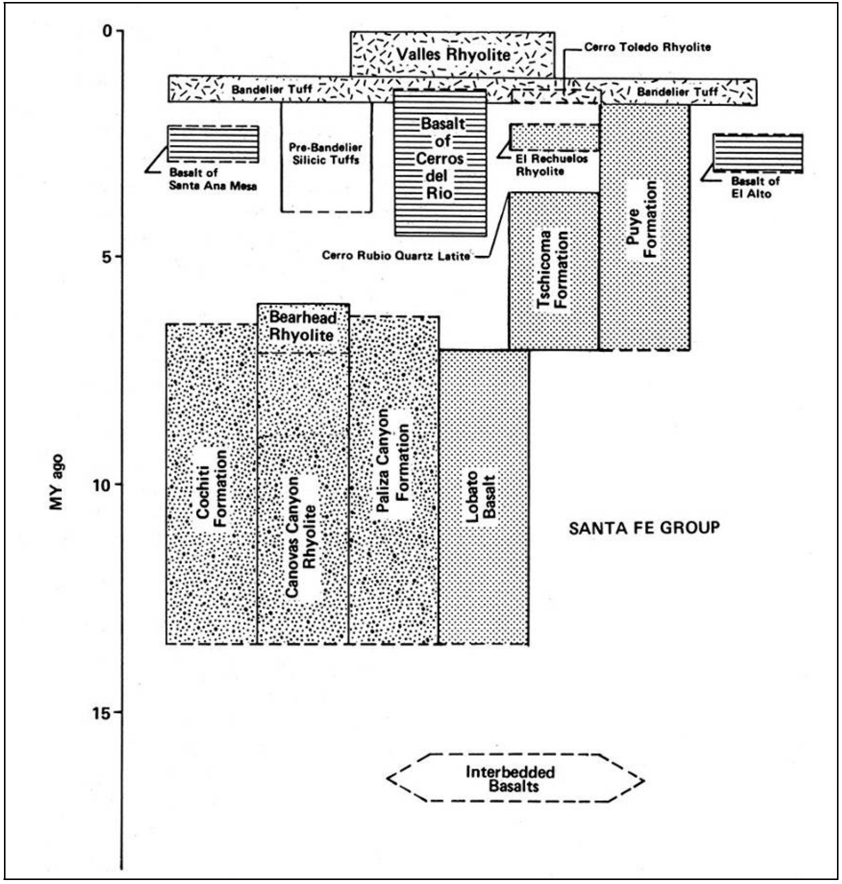

Figure 1. Generalized stratigraphic relations of the major volcanic and alluvial units in the Jemez Mountains (from Gardner et al. 1986). Note the near overlapping events at this scale for the Cerro Toledo and Valles Rhyolite members, and the position of Cerro Toledo Rhyolite at the upper termination of the Puye Formation.

The earliest is the Bear Springs Peak source, part of Canovas Canyon Rhyolite that is dated to about 8.7 mya, firmly in the Tertiary (Kempter et al. 2004; Figure 1 here). This source is a typical Tertiary marekanite source with remnant nodules embedded in a perlitic matrix. It is located in a dome complex including Bear Springs Peak on Santa Fe National Forest and radiating to the northeast through Jemez Nation land (Shackley 2009b). While the nodule sizes are small, the glass is an excellent media for tool production and has been found archaeologically at Zuni and in secondary deposits as far south as Las Cruces (Church 2000; Shackley 2012). Four of the samples were produced from this source (Table 1 and 2).

Part of the same Keres Member as Canovas Canyon Rhyolite is Paliza Canyon Rhyolite. They have similar elemental chemistry and are likely nearly contemporaneous. This source is rare in archaeological contexts, but occurs in Rio Grande alluvium, and is present as one sample here.

The second relevant eruptive event that produced artifact quality obsidian is the El Rechuelos Rhyolite. This source, present as one sample here, is what I consider the best media for tool production of the group. It dates to about 2.4 million years ago, and nodules at least 10 cm in diameter are present in a number of domes north of dacite Polvadera Peak, the incorrect vernacular name for this source. El Rechuelos has eroded through the Rio Chama into the Rio Grande and has also been found in alluvium into southern New Mexico (Church 2000; Shackley 2012).

About 1.4 mya, the first caldera collapse occurred in the Jemez Mountains, called Cerro Toledo Rhyolite. This very large event produced the Bandelier Tuffs and spread ash flows many kilometers into the area and horizontally southwest from what is now Rabbit Mountain and the Cerro Toledo domes to the east. These large ash flow sheets are responsible for the great quantity of Cerro Toledo obsidian that is present in the Quaternary Rio Grande alluvium all the way to Chihuahua (Church 2000; Shackley 2005, 2012). Cerro Toledo Rhyolite secondary deposit nodules is present relatively near to Piedras Marcadas on Quaternary terraces above the east side of the Rio Grande, including Placitas and the sands near Tijeras Wash south of the Albuquerque airport (Shackley 2005).

The second caldera collapse that produced the Valles Rhyolite member of the Tewa Formation, called Valles Rhyolite here, occurred around one million years ago and created most of the geography of the current Valles Caldera. A number or rhyolite ring domes were produced on the east side of the caldera, but only Cerro del Medio produced artifact quality obsidian. Indeed, the Cerro del Medio dome complex produced millions of tons of artifact quality glass, and is the volumetrically largest obsidian source in the North American Southwest challenged only by the Government Mountain dome complex in the San Francisco Volcanic Field. Cerro del Medio obsidian was apparently preferred by Folsom knappers, as well as those in all periods since. While Cerro Toledo probably appears in archaeological contexts in New Mexico sites with greater frequency, it is likely because it is distributed in secondary contexts. Valles Rhyolite (Cerro del Medio), present as three samples here importantly does not erode outside the caldera, in and quantity and size and likely had to be originally procured in the caldera proper (Shackley 2005). All of the four Valles Rhyolite samples are small, although the one projectile point tip indicates a size larger than nodule sizes thus far recovered in the Rio Grande alluvium, and was probably produced from raw material from Cerro del Medio proper, suggesting procurement at the source or exchange of primary source obsidian.

Source Provenance Discussion

Most of the artifacts analyzed produced from all these sources are bipolar core or flake fragments and most appear to have waterworn cortex. This suggests that most of these raw materials were procured across the river somewhere. In the case of the Mount Taylor specimen the raw material had to be procured at Mount Taylor or in the Rio Puerco or the Rio Grande south of Socorro after the Rio Puerco joins the Rio Grande (Shackley 2005, 2012). Mount Taylor sources (Grants Ridge, Horace and La Jara Mesas) are common in historic period contexts at Zuni and the source may have been “controlled” by the Zuni (Shackley 2005; Table 1 and Figure 3). The issue of the point fragment from Valles Rhyolite raw material is discussed above. The mix of sources in the test unit assemblage mirrors the mix of sources recovered from the Rio Grande Quaternary Alluvium at Tijeras Wash almost identically (Figures 2). This is the strongest argument for local procurement of obsidian toolstone at Piedras Marcadas as indicated by the test unit assemblage.

Surface versus Subsurface Results

While the samples are relatively small, the mix of sources recovered from surface contexts versus the subsurface test unit sample is somewhat different (Figure 4). While both are dominated by Jemez Mountains secondary deposit sources, the presence of Mount Taylor sources on the surface indicates procurement through direct access to the Zuni region or exchange with the Zuni. IF the subsurface material is earlier, and the surface material later, then one change seen is contact to the west rather than local procurement and/or contact north at an earlier period. It is possible that the Mount Taylor obsidian was procured by the Coronado Expedition knappers when they were at and around Zuni and transported the raw material to Piedras Marcadas during the siege as tool raw material. Again, the sample size is small.

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Table 1. Elemental concentrations for the archaeological specimens and the USGS RGM-1 standard by test unit. All measurements in parts per million (ppm).

Sample	Test Pit	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Ba	Pb	Th	Source
70-80-1	1	525	11525	183	222	8	65	170	98	10	35	27	Cerro Toledo Rhy.
70-80-2	1	531	11194	203	202	11	54	147	81	26	36	30	Cerro Toledo Rhy.
70-80-3	1	422	9841	157	194	10	62	171	95	0	32	20	Cerro Toledo Rhy.
70-80-4	1	524	10974	120	207	11	65	173	98	0	35	24	Cerro Toledo Rhy.
70-80-5	1	440	8717	60	122	43	26	106	49	415	25	26	Canovas Cnyn Rhy.
70-80-6	1	461	10196	123	195	9	59	159	89	0	32	20	Cerro Toledo Rhy.
70-80-7	1	512	10757	140	212	8	65	178	98	0	36	24	Cerro Toledo Rhy.
80-90-1	1	417	9836	88	187	10	62	171	93	0	32	23	Cerro Toledo Rhy.
80-90-2	1	504	10618	110	208	10	64	168	90	0	36	24	Cerro Toledo Rhy.
80-90-3	1	488	10521	138	203	12	64	171	94	0	35	18	Cerro Toledo Rhy.
90-100-1	1	517	11311	169	215	9	63	174	93	0	37	27	Cerro Toledo Rhy.
90-100-2	1	492	10817	145	205	8	68	170	96	0	33	24	Cerro Toledo Rhy.
110-120-1	1	484	10358	100	204	9	64	170	100	20	36	24	Cerro Toledo Rhy.
120-130S-1	1	523	10965	158	204	19	60	170	93	6	36	26	Cerro Toledo Rhy.
120-130S-2	1	510	11315	186	213	11	62	170	92	0	37	21	Cerro Toledo Rhy.
130-140-1	1	461	10285	120	195	9	63	167	92	0	33	17	Cerro Toledo Rhy.
140-150-1	1	487	10685	137	204	10	59	168	99	0	33	21	Cerro Toledo Rhy.
140-150-2	1	494	11044	144	211	11	67	173	95	0	36	20	Cerro Toledo Rhy.
140-150-3	1	473	10596	266	191	10	54	153	83	150	33	25	Cerro Toledo Rhy.
220-230-1	1	507	11341	149	210	8	62	171	101	0	41	34	Cerro Toledo Rhy.
220-230-2	1	573	12195	288	228	12	60	170	90	23	37	32	Cerro Toledo Rhy.
20-30-1	2	473	10444	136	202	9	62	174	93	38	36	26	Cerro Toledo Rhy.
20-30-2	2	547	11564	171	207	10	61	172	96	0	38	25	Cerro Toledo Rhy.
20-30-3	2	539	12110	172	219	10	64	170	92	0	35	22	Cerro Toledo Rhy.
20-30-4	2	515	11295	193	209	8	59	170	89	0	36	32	Cerro Toledo Rhy.
40-50-1	2	545	11511	223	214	11	61	166	90	0	36	18	Cerro Toledo Rhy.
50-60-1	2	495	10644	197	203	11	61	167	87	6	36	26	Cerro Toledo Rhy.
50-60-2	2	412	10699	132	155	14	43	159	52	72	28	17	Valles Rhyolite

50-60-3	2	215	5449	47	0	13	2	10	0	117	-2	3	not obsidian
60-70-1	2	558	11782	139	218	8	63	176	105	7	42	31	Cerro Toledo Rhy.
70-80-1	2	503	10988	134	211	10	66	170	96	0	36	24	Cerro Toledo Rhy.
70-80-2	2	462	10560	100	207	11	66	184	101	0	34	18	Cerro Toledo Rhy.
70-80-3	2	468	5343	20	0	22	1	10	0	728	2	6	not obsidian
70-80-4	2	407	11066	328	151	14	38	150	47	40	27	18	Valles Rhyolite
80-85-1	2	514	11161	160	218	8	62	175	96	19	39	30	Cerro Toledo Rhy.
85-90-1	2	489	10599	126	201	10	65	176	99	0	37	26	Cerro Toledo Rhy.
90-100-1	2	474	9089	212	123	51	26	103	54	477	29	32	Canovas Cnyn Rhy.
90-100-2	2	540	11375	185	220	8	64	169	93	0	40	30	Cerro Toledo Rhy.
90-100-3	2	478	10478	102	201	9	61	170	97	0	39	24	Cerro Toledo Rhy.
100-110-1	2	552	11810	131	208	9	64	174	97	0	37	25	Cerro Toledo Rhy.
100-110-2	2	553	11634	136	223	10	65	176	105	0	39	27	Cerro Toledo Rhy.
100-110-3	2	495	10932	198	206	8	66	176	96	25	35	28	Cerro Toledo Rhy.
120-130-1	2	504	10497	118	188	11	57	168	90	0	33	24	Cerro Toledo Rhy.
0-30-1	3	501	10671	179	196	10	58	158	86	0	35	25	Cerro Toledo Rhy.
0-30-2	3	568	11890	213	214	11	61	164	92	0	42	29	Cerro Toledo Rhy.
30-40-1	3	277	5390	162	0	13	1	13	0	17	2	3	not obsidian
30-40-2	3	460	10141	144	184	9	55	152	86	0	28	16	Cerro Toledo Rhy.
40-50-1	3	447	10760	218	182	13	52	141	84	66	33	25	Cerro Toledo Rhy.
50-60-1	3	506	11010	175	210	8	60	173	94	0	40	26	Cerro Toledo Rhy.
Sample	Test Pit	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Ba	Pb	Th	Source
60-70	3	504	10707	171	206	8	62	178	93	32	36	20	Cerro Toledo Rhy.
90-100-1	3	503	10759	104	209	8	68	174	98	33	35	25	Cerro Toledo Rhy.
90-100-2	3	437	8781	61	121	45	23	99	50	459	23	24	Canovas Cnyn Rhy.
90-100-3-1	3	543	11367	154	214	8	62	174	97	0	38	19	Cerro Toledo Rhy.
100-110-1-1	3	471	10231	117	196	10	64	172	90	0	35	28	Cerro Toledo Rhy.
110-120-1	3	545	10215	111	113	93	27	128	34	1532	24	12	Paliza Canyon
120-130-1-1	3	450	7916	133	173	11	27	75	50	0	26	13	El Rechuelos
120-130-2	3	526	11145	159	217	10	60	172	102	0	35	20	Cerro Toledo Rhy.
130-140-1	3	548	11327	145	209	10	66	172	94	0	35	22	Cerro Toledo Rhy.
130-140-2	3	38	1018	94	15	12	42	15	53	40	25	22	Valles Rhyolite

		7	8		9			3					
140-150-1	3	494	10749	294	191	9	50	147	81	0	36	29	Cerro Toledo Rhy.
140-150-2	3	487	10551	125	208	12	64	167	99	0	35	25	Cerro Toledo Rhy.
140-150-3	3	411	9489	219	115	64	21	107	41	858	24	20	Canovas Cnyn Rhy.
140-150-4	3	507	10996	173	205	11	63	164	94	0	35	24	Cerro Toledo Rhy.
150-160-1	3	498	10863	352	195	10	56	160	85	0	34	29	Cerro Toledo Rhy.
RGM1-S4		279	13323	35	145	108	24	216	7	877	20	15	standard
RGM1-S4		287	13223	38	146	105	24	215	8	861	18	13	standard
RGM1-S4		272	13301	35	150	107	24	213	11	872	22	16	standard
RGM1-S4		296	13323	35	148	108	23	216	5	872	17	18	standard

Table 2. Crosstabulation of source by test unit. Non obsidian removed.

			Source					Total
			Cerro Toledo Rhy.	Valles Rhyolite	Canovas Cnyn Rhy.	El Rechuelos	Paliza Canyon	
Test Pit	1	Count	20	0	1	0	0	21
		% within Test Pit	95.2%	0.0%	4.8%	0.0%	0.0%	100.0%
		% within Source	38.5%	0.0%	25.0%	0.0%	0.0%	34.4%
		% of Total	32.8%	0.0%	1.6%	0.0%	0.0%	34.4%
	2	Count	17	2	1	0	0	20
		% within Test Pit	85.0%	10.0%	5.0%	0.0%	0.0%	100.0%
		% within Source	32.7%	66.7%	25.0%	0.0%	0.0%	32.8%
		% of Total	27.9%	3.3%	1.6%	0.0%	0.0%	32.8%
	3	Count	15	1	2	1	1	20
		% within Test Pit	75.0%	5.0%	10.0%	5.0%	5.0%	100.0%
		% within Source	28.8%	33.3%	50.0%	100.0%	100.0%	32.8%
		% of Total	24.6%	1.6%	3.3%	1.6%	1.6%	32.8%
Total		Count	52	3	4	1	1	61
		% within Test Pit	85.2%	4.9%	6.6%	1.6%	1.6%	100.0%
		% within Source	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	85.2%	4.9%	6.6%	1.6%	1.6%	100.0%

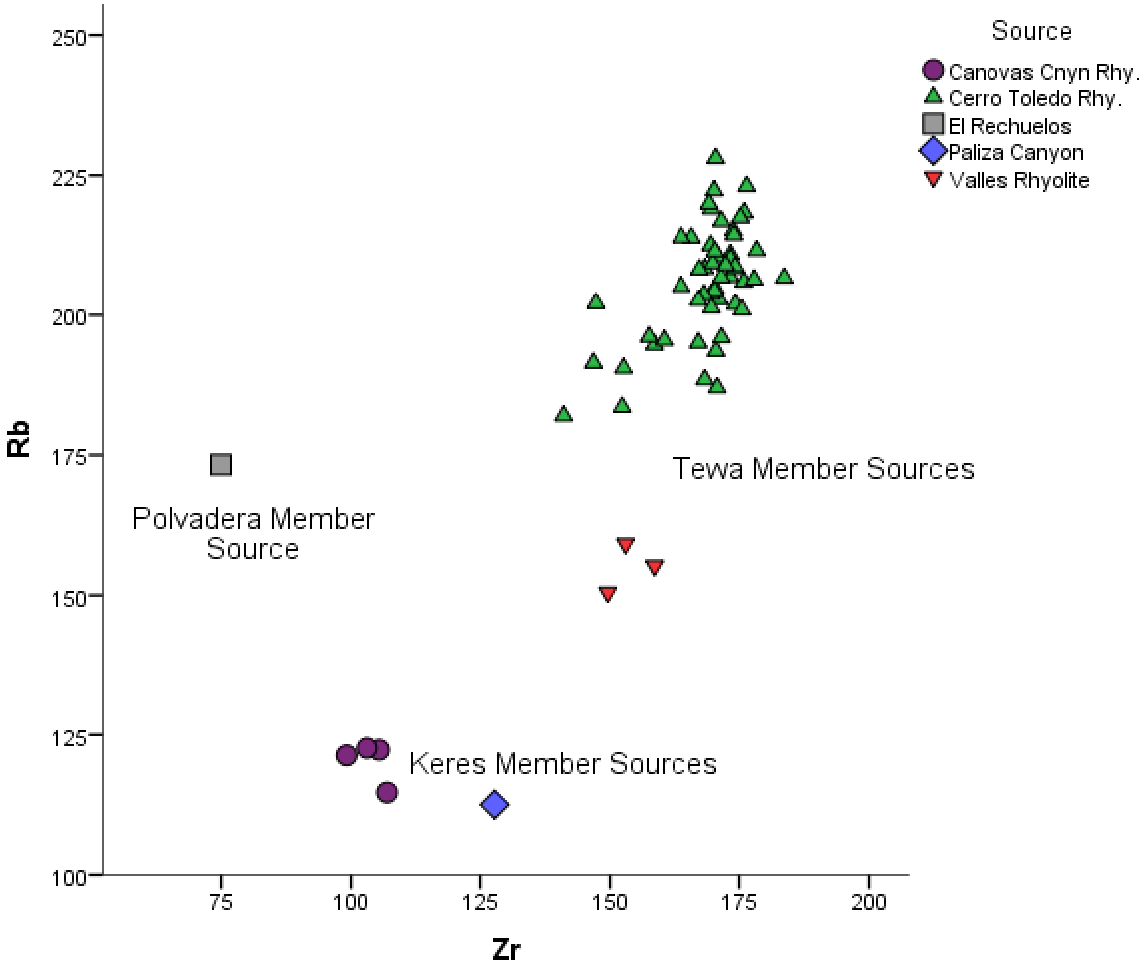

Figure 2. Zr versus Rb bivarite plot of the archaeological specimens.

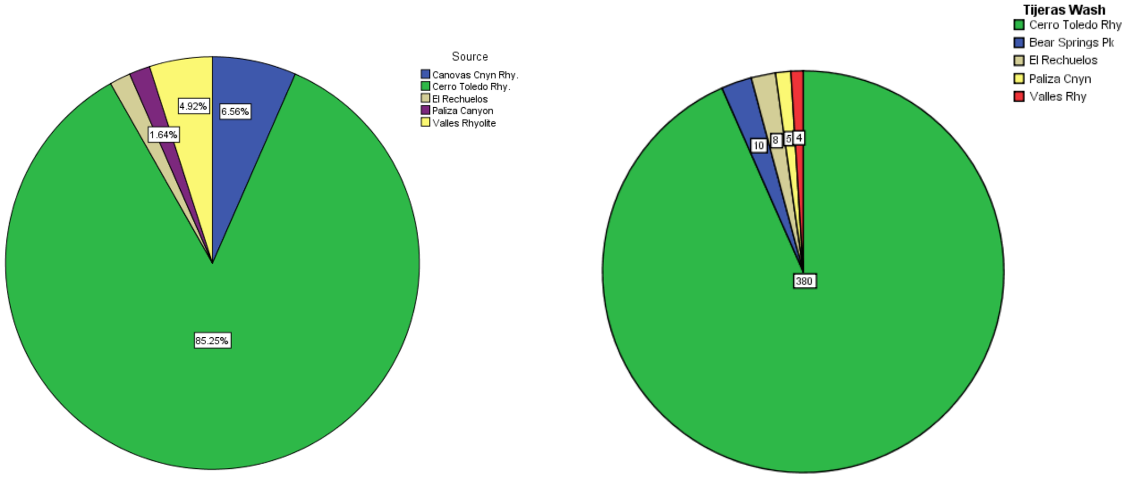

Figure 3. Frequency distribution of source provenance in the test units (%) versus the distribution recovered in Quaternary alluvium at Tijeras Wash, Albuquerque (count). Colors dissimilar.

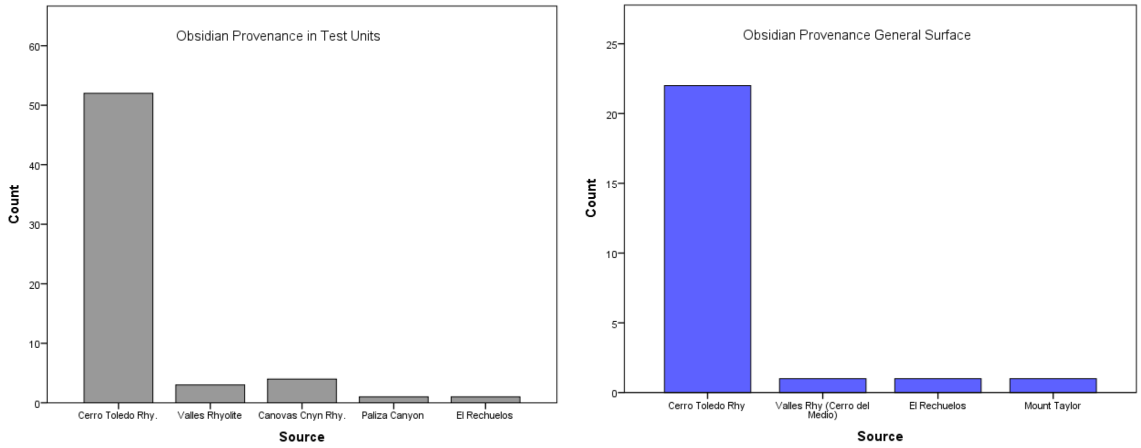

Figure 4. Frequency histograms of source provenance in the test units (left) and general surface (right)