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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM A SELECTED SURFACE SAMPLE AT PIEDRAS MARCADAS (LA 290), MIDDLE RIO GRANDE VALLEY, NEW MEXICO

by

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INTRODUCTION

The analysis here of 50 visually selected obsidian and dacite artifacts from the surface of Piedras Marcadas (LA 290) in the middle Rio Grande River valley indicates a similar mix of sources as the previous analyses of surface and subsurface contexts, with the exception of an increase in the number of artifacts produced from one of the Mount Taylor sources (Shackley 2009, 2013a). 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 occured 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 2013a). Mount Taylor is not available in Rio Grande Quaternary sediments this far north. The dacite artifacts are from northern New Mexico sources that have eroded into the Rio Grande Quaternary alluvium.

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 2011a).

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 $K\alpha_1$-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 $K\alpha_1$-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 the lab, and Shackley (1995, 2005, 2011b).

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; see Figure 1 here). 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).

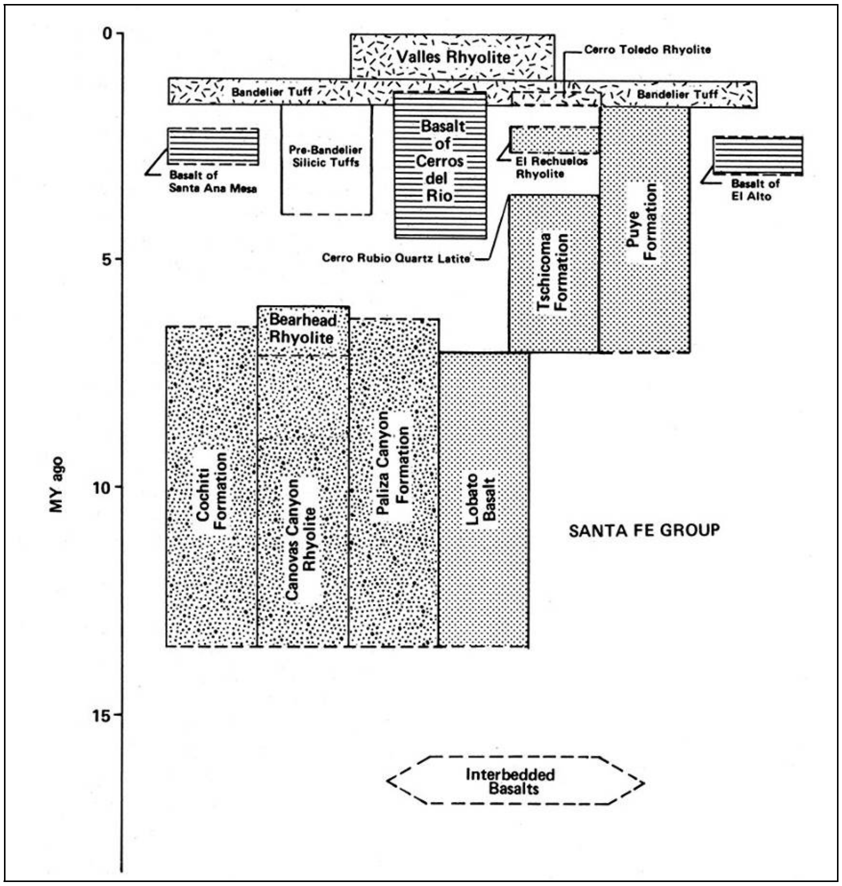

Figure 1. Generalized stratigraphic relations of the major volcanic and alluvial units in the Jemez Mountains (from Gardner et al. 1986). Note the near overlapping events at this scale for the Cerro Toledo and Valles Rhyolite members, and the position of Cerro Toledo Rhyolite at the upper termination 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 and Figure 2 here).

Part of the same Keres Member as Canovas Canyon Rhyolite is Paliza Canyon Rhyolite. They have similar elemental chemistry and are likely nearly contemporaneous (Shackley 2014). This source is rare in archaeological contexts, but occurs in Rio Grande alluvium, and is present as one sample here, as in the 2013 subsurface study.

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 2013b).

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, 2013b). Cerro Toledo Rhyolite secondary deposit nodules are present relatively near to Piedras Marcadas on Quaternary terraces above the east side of the Rio Grande, including Placitas and the Quaternary sands near Tijeras Wash south of the Albuquerque airport (Shackley 2013b).

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 of 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 subsurface and one sample here importantly does not erode outside the caldera, in any quantity and size and likely had to be originally procured in the caldera proper (Shackley 2005).

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, 2013b). 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 mix of sources in this selected assemblage mirrors the mix of sources recovered from the Rio Grande Quaternary Alluvium at Tijeras Wash almost identically (Shackley 2013a: Figure 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 (see also Shackley 2013a). 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.

DACITE ARTIFACTS

A number of dacite artifacts, mainly debitage or utilized flakes, were sampled from the surface. All but one of the artifacts were produced from either the San Antonio Mountain source in the Taos Plateau Volcanic Field, or the Cerros del Rio dacite in the Cerros del Rio Volcanic Field on the southern edge of Bandelier National Monument (see Shackley 2011b; Table 3 here). Both these sources erode into the Rio Grande and have been recovered in the alluvium at Tijeras Wash south of Piedras Marcadas. One sample is likely rhyolite or dacite, but doesn't match any known source.

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

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
100	689	469	12093	203	9	67	170	100	36	31	Cerro Toledo Rhy
101	354	572	11633	513	12	88	131	233	59	30	Horace Mesa (Mt Taylor)
103	514	465	11743	205	8	68	172	98	35	20	Cerro Toledo Rhy
104	417	583	11700	529	13	84	132	223	60	36	Horace Mesa (Mt Taylor)
105	537	483	11835	205	8	68	180	102	33	21	Cerro Toledo Rhy
106	548	469	11837	199	10	62	173	98	35	24	Cerro Toledo Rhy
107	634	489	12350	206	8	63	170	99	33	25	Cerro Toledo Rhy
108	646	564	12647	232	9	68	188	104	44	27	Cerro Toledo Rhy
110	601	540	12623	224	11	68	185	104	41	31	Cerro Toledo Rhy
111	551	500	12192	210	8	67	178	101	37	21	Cerro Toledo Rhy
112	678	478	12236	203	11	59	174	98	35	25	Cerro Toledo Rhy
113	581	456	11803	201	8	65	170	94	34	20	Cerro Toledo Rhy
114	605	480	11942	199	9	61	169	99	34	27	Cerro Toledo Rhy
115	708	404	12145	166	11	46	167	54	25	18	Valles Rhy (Cerro del Medio)
116	524	466	11643	197	11	65	172	100	31	28	Cerro Toledo Rhy
117	660	577	12835	227	9	68	183	104	42	26	Cerro Toledo Rhy
118	548	441	11544	199	8	66	171	97	32	30	Cerro Toledo Rhy
119	473	449	11614	204	9	65	174	96	35	24	Cerro Toledo Rhy
120	1121	496	10999	105	88	23	126	33	20	16	Paliza Canyon
121-1	620	419	11470	185	9	59	157	96	30	25	Cerro Toledo Rhy
121-2	526	512	12119	215	9	64	177	96	36	23	Cerro Toledo Rhy
122-1	599	401	10239	154	11	23	71	46	24	16	El Rechuelos
122-2	524	475	11730	199	10	61	173	94	33	24	Cerro Toledo Rhy
123-1	501	498	11865	207	10	66	168	98	33	21	Cerro Toledo Rhy
123-2	535	538	12242	215	8	67	177	96	38	22	Cerro Toledo Rhy
124	571	457	11661	207	16	61	163	97	33	26	Cerro Toledo Rhy
125	461	366	10961	179	8	59	161	92	26	18	Cerro Toledo Rhy
128	668	529	12219	198	10	61	171	97	33	26	Cerro Toledo Rhy

129	553	472	11901	202	10	65	174	99	33	24	Cerro Toledo Rhy
130	497	481	11828	201	8	67	169	99	35	22	Cerro Toledo Rhy
131	579	490	11885	207	8	65	177	101	32	23	Cerro Toledo Rhy
132	494	456	11648	200	10	61	167	100	32	18	Cerro Toledo Rhy
135	310	720	10845	544	12	78	118	194	59	23	Grants Ridge (Mt Taylor)
137-1	594	479	11727	206	10	65	172	98	35	26	Cerro Toledo Rhy
137-2	483	459	11638	206	10	66	169	98	33	23	Cerro Toledo Rhy
138-1	493	465	11818	208	11	63	179	99	35	30	Cerro Toledo Rhy
138-2	522	495	12005	211	8	63	179	103	38	29	Cerro Toledo Rhy
139-1	502	475	11728	202	8	61	173	97	32	23	Cerro Toledo Rhy
139-2	535	515	12313	220	11	70	177	100	39	20	Cerro Toledo Rhy
140	456	482	11851	206	9	63	172	98	35	21	Cerro Toledo Rhy
141	574	457	11945	210	8	65	176	96	38	26	Cerro Toledo Rhy
142	559	472	11800	207	9	62	174	100	33	23	Cerro Toledo Rhy
143	508	463	11736	202	8	64	173	92	34	25	Cerro Toledo Rhy
144	545	524	12067	209	10	62	174	93	36	25	Cerro Toledo Rhy
145	569	465	11827	206	9	61	172	91	33	31	Cerro Toledo Rhy
RGM1-S4	1554	285	13746	149	105	26	212	8	20	13	standard
RGM1-S4	1590	283	13772	148	106	22	218	8	20	12	standard
RGM1-S5	1534	285	13686	150	108	22	214	10	17	11	standard

Table 2. Frequency distribution of sources in the selected surface assemblage.

		Frequency	Percent
Source	Cerro Toledo Rhy	39	86.7
	El Rechuelos	1	2.2
	Mt Taylor	3	6.7
	Paliza Canyon	1	2.2
	Valles Rhy (Cerro del Medio)	1	2.2
	Total	45	100.0

Table 3. Elemental concentrations for the dacite/rhyolite samples.

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
102	3851.467	432.498	19294.69	48.634	596.563	18.476	174.996	23.081	9.519	7.867	San Antonio Mtn dacite
109	6314.205	916.665	31600.83	93.064	666.718	33.45	242.255	15.493	8.621	6.723	San Antonio Mtn dacite
126	4646.919	626.298	26011.9	48.329	859.167	17.505	208.616	21.244	12.64	3.096	Cerros del Rio dacite
133	1099.237	706.971	13527.73	147.663	15.872	66.155	397.993	39.266	29.116	21.144	rhyolite or dacite
134	4252.501	570.218	25260.16	42.539	840.703	17.807	200.52	22.429	12.526	9.303	Cerros del Rio dacite

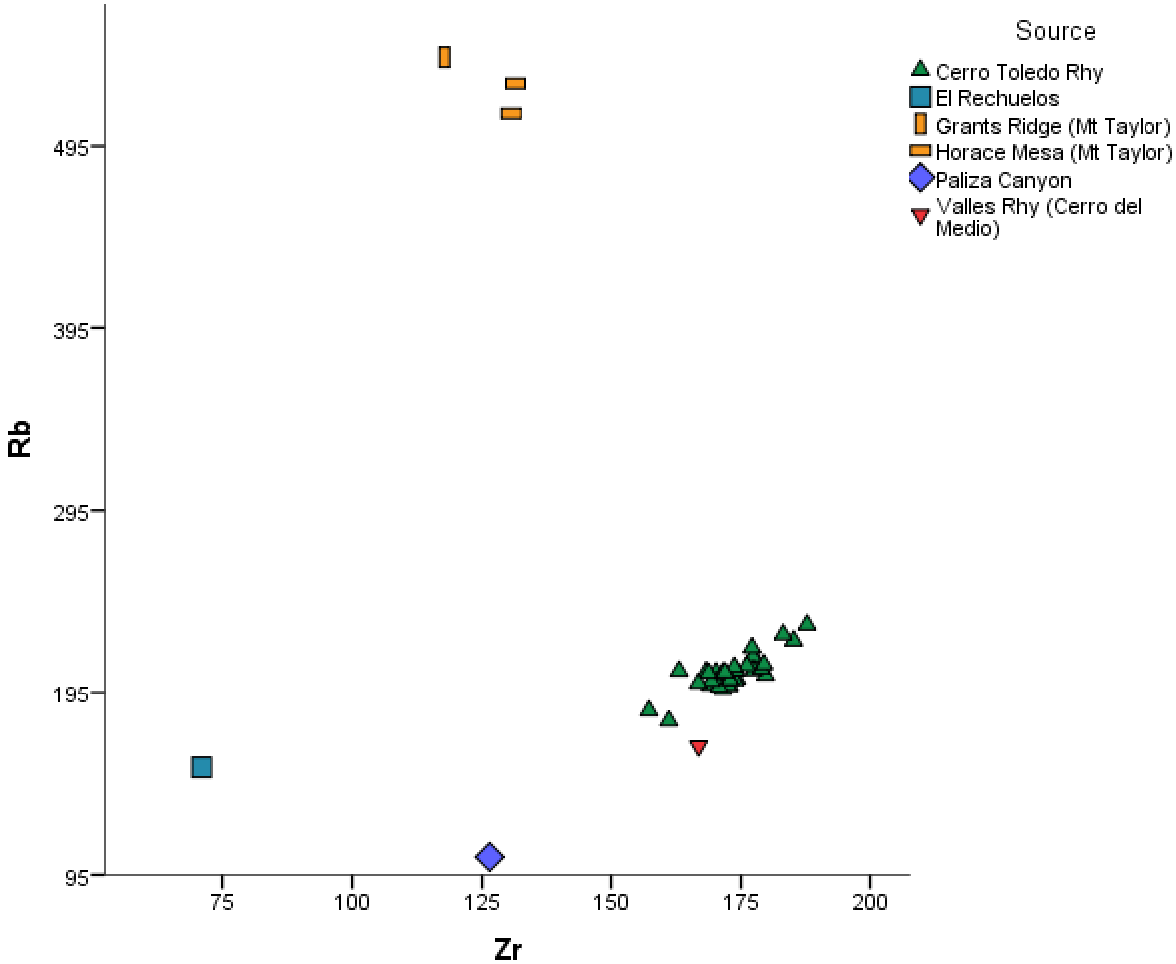

Figure 2. Zr versus Rb bivariate plot of the samples. Cerro Toledo Rhyolite and Valles Rhyolite samples discriminated by Y and Nb, not plotted here.

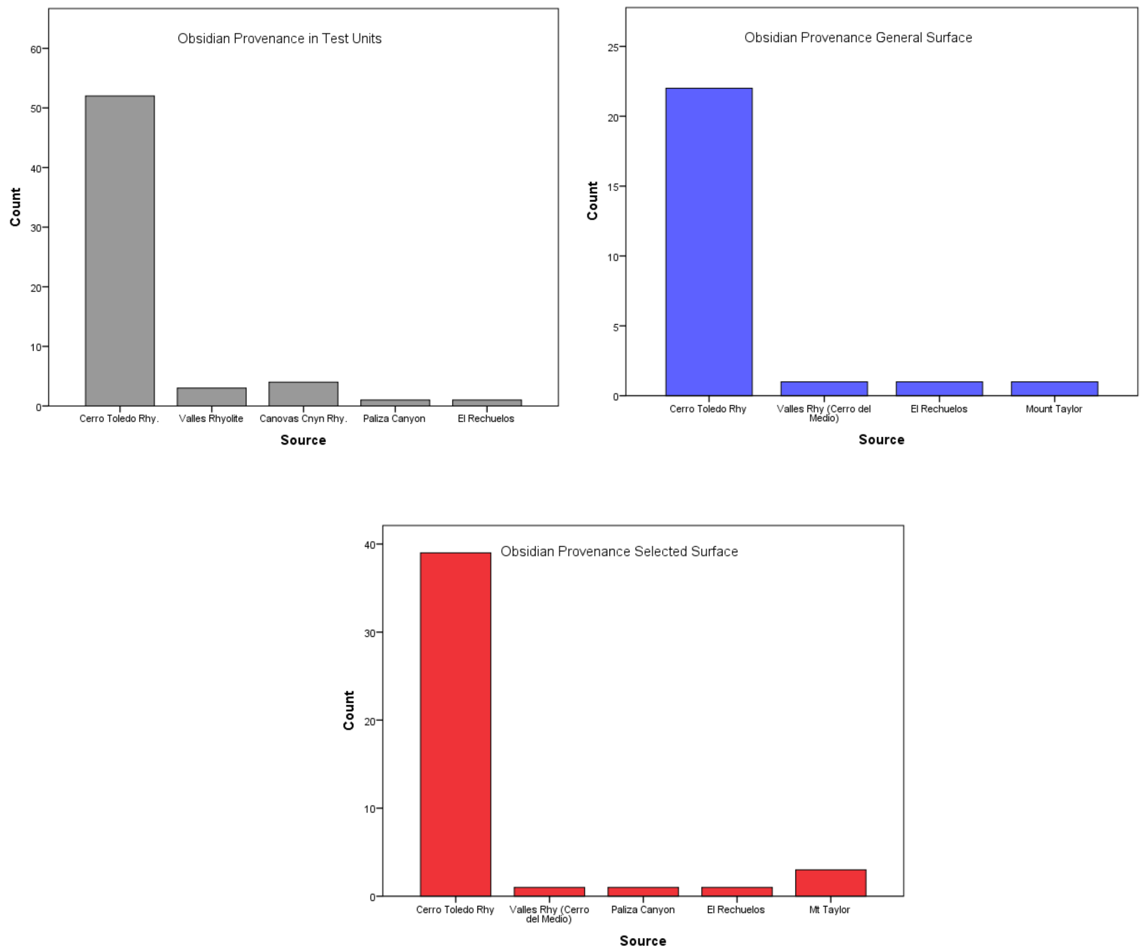

Figure 3. Frequency histograms of source provenance in the test units (top left), general surface (top right), and selected surface (bottom center)