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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS AND ELEMENTAL ANALYSIS OF TWO SHELL BEAD ARTIFACTS FROM THE LONG VIEW SITE (41RB112), CANADIAN RIVER VALLEY, NORTH EASTERN TEXAS

by

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Report Prepared for

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INTRODUCTION

The analysis here of 49 obsidian artifacts from the Long View Site indicates that they were all produced from the Cerro Toledo Rhyolite obsidian source in the Valles Caldera, Jemez Mountains, northern New Mexico. The two bead samples are comprised nearly entirely of calcium (calcium carbonate) based on the qualitative analysis.

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 NSF Geoarchaeological XRF Laboratory, Department of Anthropology, University of California, Berkeley, 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 2005). For samples over 10 mm in smallest diameter, a 8.8 mm tube collimator is used. If the samples are smaller, a 3.5 mm tube collimator is substituted to concentrate emitted x-rays into a smaller pattern (see 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 $K\alpha_1$-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. 1998). 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, 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).

For the two bead samples, a qualitative scan of the Low Zc x-ray spectrum was acquired to determine the presence of calcium (Appendix). The instrument is operated at 12 kV and 1.98 mA for 12 to 34 live seconds.

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 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).

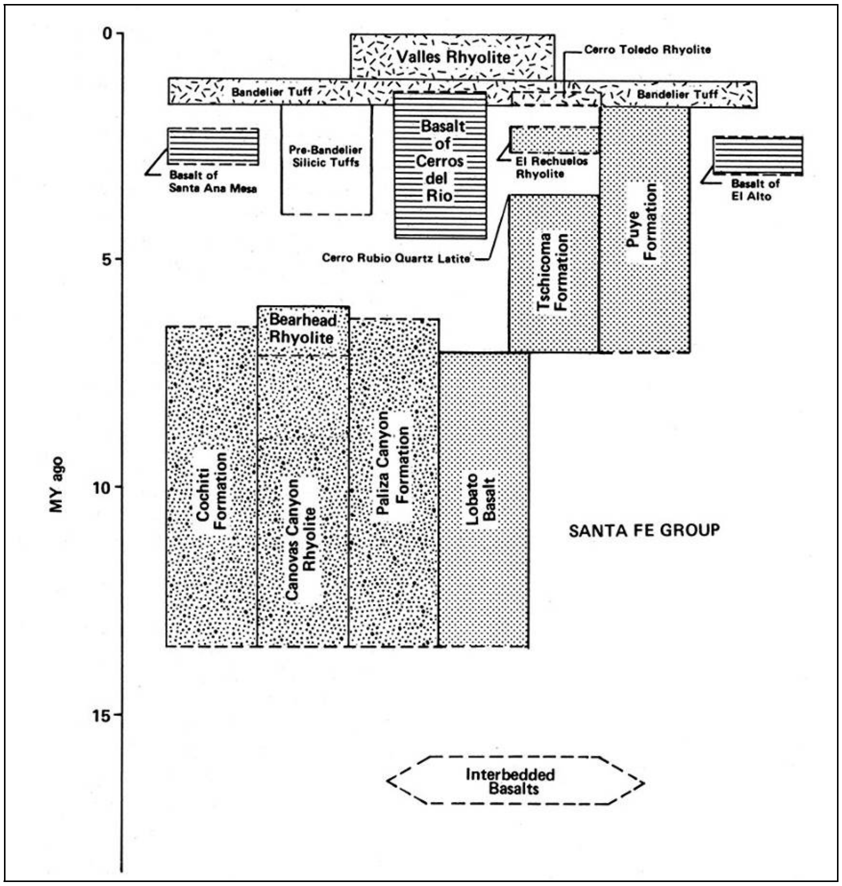

Figure 1. Generalized stratigraphic relations of the major volcanic and alluvial units in the Jemez Mountains (from Gardner et al. 1986). Note the near overlapping events at this scale for the Cerro Toledo and Valles Rhyolite members, and the position of Cerro Toledo Rhyolite at the upper termination 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 2009a). 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 2009a).

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).

About 1.4 mya, the first caldera collapse occurred in the Jemez Mountains, called Cerro Toledo Rhyolite, the obsidian used to produce the stone artifacts in this assemblage (Figure 2). 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, 2010). While Cerro Toledo Rhyolite is present in the Rio Grande alluvium, many of these artifacts are very angular with abundant spherulites suggesting that the obsidian was originally procured at the primary source.

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 Government Mountain in the San Francisco Volcanic Field. This source 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 one sample here importantly does not erode outside the caldera, and had to be originally procured in the caldera proper (Shackley 2005). While Valles Rhyolite is often present in Texas Panhandle sites, it is absent in this collection

Source Provenance Discussion

Most of these artifacts analyzed produced from Cerro Toledo Rhyolite exhibit angular cortex when present and abundant spherulites. This is typical of much of the Cerro Toledo Rhyolite obsidian at the source, but secondary deposits of this obsidian are typically waterworn and the spherulites absent due to frequent breaking and release in the stream basin. This suggests to me that the cores used to produce these artifacts were originally procured at the primary domes either Cerro Toledo or Rabbit Mountain, nearly 500 linear kilometers west of the Long View Site. Also, I noticed that both the translucent and opaque black varieties are present in the assemblage indicating that there were at least two cores used to produce this debitage or any artifacts from those cores.

Shell Beads

A qualitative scan of the two beads (one fragment) was used to detect the potential presence of calcium, the major component of marine shell (Krinsley and Bieri 1959; Appendix here). Carbon, the other element in the compound calcium carbonate is not detectable with XRF. These two beads are certainly shell, and likely marine shell beads.

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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	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
32	519	10985	200	10	59	173	92	Cerro Toledo Rhy
48	508	10471	201	8	60	172	90	Cerro Toledo Rhy
73	525	10878	216	10	67	175	97	Cerro Toledo Rhy
683	599	11919	241	10	71	181	100	Cerro Toledo Rhy
686	499	10426	204	9	60	165	93	Cerro Toledo Rhy
692	481	10249	202	10	64	170	95	Cerro Toledo Rhy
697	452	10097	192	10	60	166	92	Cerro Toledo Rhy
698	489	10247	205	9	64	172	95	Cerro Toledo Rhy
700	507	10717	209	8	65	175	102	Cerro Toledo Rhy
701	501	10539	208	8	58	168	92	Cerro Toledo Rhy
702	457	10111	192	9	61	166	88	Cerro Toledo Rhy
708	494	10506	196	8	62	168	87	Cerro Toledo Rhy
731	495	10237	204	9	63	178	97	Cerro Toledo Rhy
765	505	10487	203	8	59	170	89	Cerro Toledo Rhy
799	482	10203	202	9	64	167	99	Cerro Toledo Rhy
843	496	10622	209	8	67	177	98	Cerro Toledo Rhy
845	486	10326	203	8	60	164	99	Cerro Toledo Rhy
888	602	12118	213	8	58	165	89	Cerro Toledo Rhy
905	507	10496	208	8	66	181	101	Cerro Toledo Rhy
935	501	10451	200	9	67	167	95	Cerro Toledo Rhy
955	519	10846	220	11	67	171	98	Cerro Toledo Rhy
961	485	10230	203	11	61	165	91	Cerro Toledo Rhy
964	522	10620	198	8	62	162	88	Cerro Toledo Rhy
965	472	10159	188	8	60	156	87	Cerro Toledo Rhy
972	491	10187	202	8	65	169	99	Cerro Toledo Rhy
977	454	10253	186	12	53	164	87	Cerro Toledo Rhy
979	491	10462	206	10	63	171	95	Cerro Toledo Rhy
981	492	10301	196	9	62	164	95	Cerro Toledo Rhy
983	499	10321	209	8	62	173	95	Cerro Toledo Rhy
988-1	511	10655	205	8	63	168	93	Cerro Toledo

								Rhy
988-2	482	10262	199	8	63	167	93	Cerro Toledo Rhy
998	513	10518	204	8	59	167	90	Cerro Toledo Rhy
1004	537	11252	223	11	69	176	95	Cerro Toledo Rhy
1005	484	10063	204	9	64	171	100	Cerro Toledo Rhy
1014	524	10779	208	9	60	165	92	Cerro Toledo Rhy
1016-1	489	10417	202	11	62	169	89	Cerro Toledo Rhy
1016-2	490	10469	200	10	67	164	92	Cerro Toledo Rhy
1021	501	10204	204	8	62	170	96	Cerro Toledo Rhy
1026	618	12242	227	9	64	169	89	Cerro Toledo Rhy
1039	474	9934	198	8	64	163	93	Cerro Toledo Rhy
1040	485	10349	205	11	62	167	91	Cerro Toledo Rhy
1061	488	10328	210	8	61	174	101	Cerro Toledo Rhy
1084	500	10322	202	8	61	164	93	Cerro Toledo Rhy
1087	454	9973	189	10	58	159	91	Cerro Toledo Rhy
1110	482	10201	199	9	61	173	94	Cerro Toledo Rhy
1116	474	10379	199	8	60	164	87	Cerro Toledo Rhy
1125	618	12065	212	9	57	152	87	Cerro Toledo Rhy
1126	527	10476	211	11	67	168	97	Cerro Toledo Rhy
1251	540	11098	202	10	65	173	97	Cerro Toledo Rhy
RGM1-S4	296	13165	148	108	26	218	8	standard
RGM1-S4	268	13173	148	107	23	215	8	standard

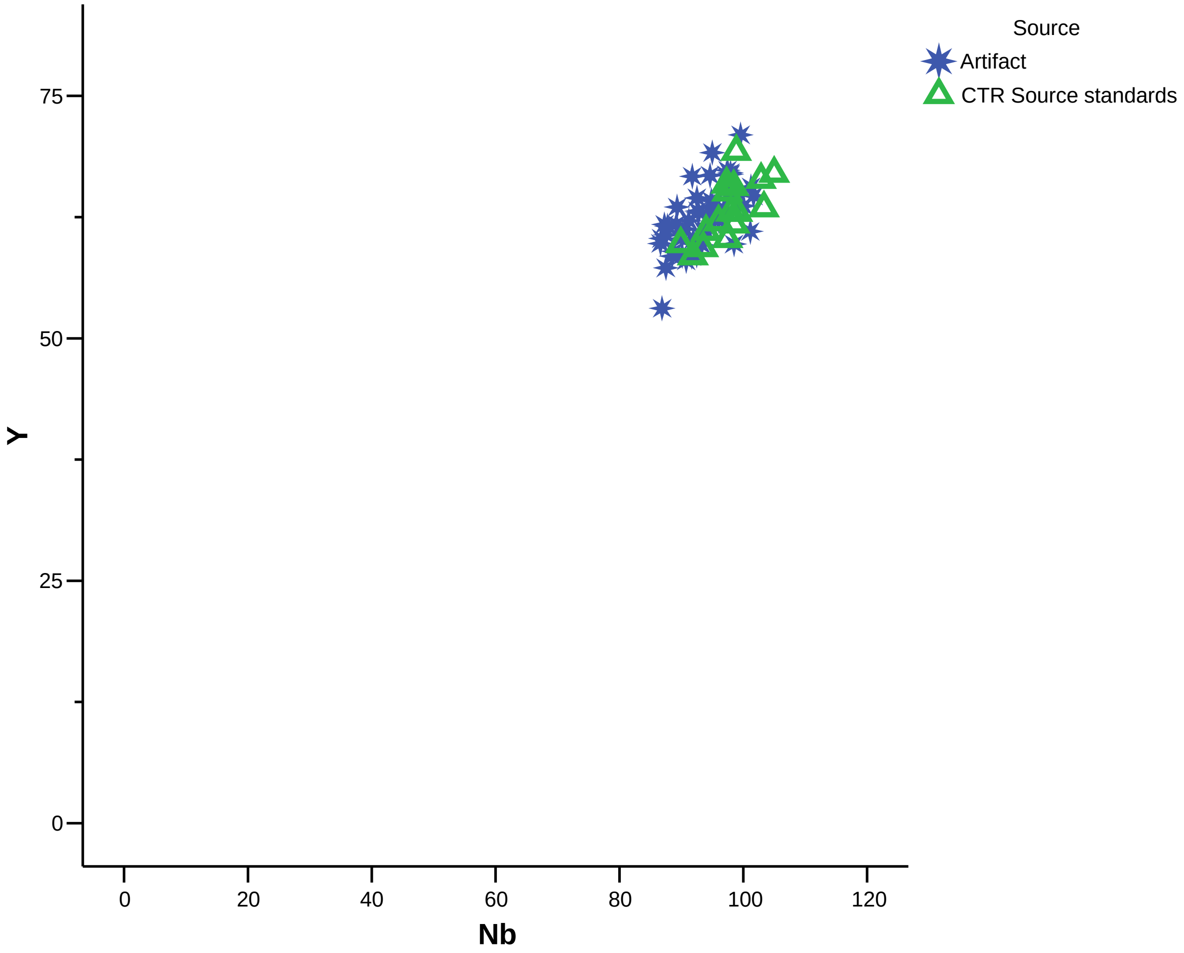

Figure 2. Nb versus Y biplot of the archaeological specimens, and source standards from Cerro Toledo Rhyolite (Cerro Toledo and Rabbit Mountain), Jemez Mountains, New Mexico. All measurements in parts per million (ppm).

APPENDIX

Spectral analysis of two bead samples showing large Ca peak. Elements Ar and Te artifacts of the analysis in air path.