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SOURCE PROVENANCE OF ADDITIONAL OBSIDIAN ARTIFACTS FROM THE RIO MOCTEZUMA VALLEY, SONORA



by

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Report Prepared for

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INTRODUCTION

The analysis here of 10 additional obsidian artifacts from sites in the Moctezuma Valley, Sonora indicates that some of the artifacts were produced from the recently located source of Selene in the southern end of the Sierra El Tigre in the upper Rio Bavispe basin, but again there are a significant number of samples of, as yet, unknown origin (Hinojosa-Prieto et al. 2013; Shackley 2012).

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 2010a).

All analyses for this study were conducted on a ThermoScientific *Quant'X* EDXRF spectrometer, located at the University of California, Berkeley. 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 (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 Fe₂O₃^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 2010; Shackley 2010a). 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), 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 is a USGS obsidian standard is analyzed during each sample run of obsidian artifacts to check machine calibration (Table 1).

Source assignments were made by reference to the lab data base Shackley (1995, 2005), and samples from Selene submitted by Karl Kibler, of Prewitt & Associates, Tucson, Arizona (Hinojosa-Prieto et al. 2013). Further information on the laboratory instrumentation can be found at: <http://www.swxrflab.net/>. Trace element data exhibited in Table 1 are reported in parts per million (ppm), a quantitative measure by weight (see also Figures 1 and 2).

DISCUSSION

The “unknown” artifacts exhibit that relatively high Sr composition that seems to be typical of this part of the Sierra Madre rhyolites and could very well be related to the Selene magma source (see Hinojosa-Prieto et al. 2013). This seems especially the case with the large nodule (sample 0031) that is likely procured from a nearby source and has high Sr similar to Selene, but does not match the Selene elemental profile of samples analyzed thus far (Table 1). Indeed this nodule over 9 cm in length is as large or larger than any yet recovered from Selene, and considerably larger than the Selene marekanite from this analysis, sample 702 (see Hinojosa-Prieto et al. 2013; see cover image).

Many of the other samples have an elemental composition that looks similar to Cow Canyon/111 Ranch in eastern Arizona, but the Ba composition is considerably different (Table 1, Figure 2; see Shackley 1995, 2005). Based on this, and the rather opaque character of the artifacts versus the nearly transparent character of Cow Canyon obsidian, I suspect that these samples are derived from a relatively high Sr source somewhere in northern Sonora or northwestern Chihuahua. This means that Ba will have to be routinely acquired for artifacts in this region until the source is discovered, effectively ruling out the use of portable XRF systems that cannot acquire this high Z element.

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

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba	Pb	Th	Source
0031	1642	263	12271	145	143	24	160	10	1973	14	10	unknown
702	1157	384	11265	178	147	18	119	12	1037	24	20	Selene, SON
811	1052	371	11212	178	146	15	126	17	1139	24	21	Selene, SON
823	791	374	10605	154	82	16	96	14	550	24	14	unknown
824	1145	393	11375	179	149	17	128	15	1038	28	21	Selene, SON
830	867	332	10444	140	81	14	97	16	542	23	16	unknown
836	3817	380	16130	158	145	16	130	15	1155	24	17	Selene, SON
842	963	383	11065	178	147	20	124	10	1138	23	19	Selene, SON
1320	729	340	10371	146	77	16	96	21	522	26	22	unknown
10030	961	414	10774	150	84	17	99	17	541	28	17	unknown
RGM1-S4	1572	286	13766	146	109	26	215	7	814	24	17	standard

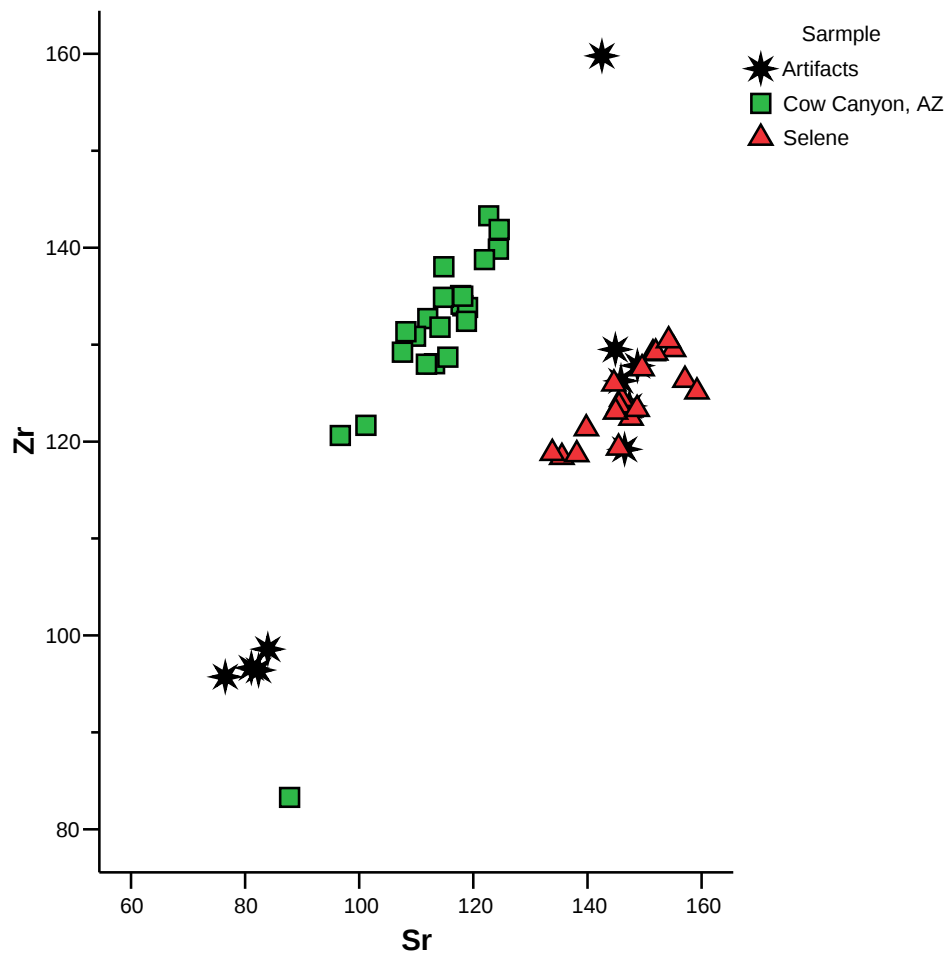


Figure 1. Sr versus Zr, bivariate plot of the elemental concentrations for all archaeological specimens, and the Selene, Sonora and Cow Canyon source standard data.

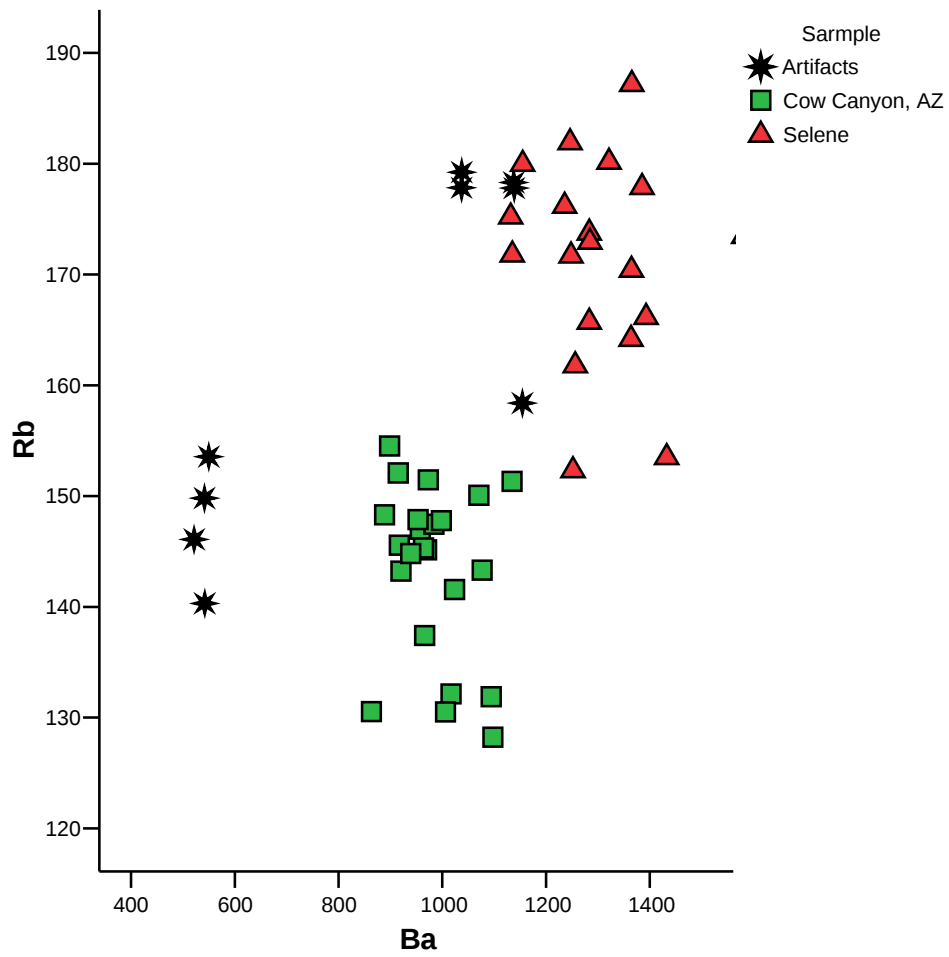


Figure 2. Ba versus Rb bivariate plot of the archaeological samples and the Selene and Cow Canyon source data. Note the differences in Ba for between the “unknown” artifacts and the Cow Canyon source standards (see text).