SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THE YUMA WASH SITE—AZ AA:12:122 (ASM), AZ AA:12:311 (ASM), AND AZ AA:12:312 (ASM)

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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM LOCUS AZ AA:12:312 (ASM) OF THE YUMA WASH SITE, SOUTHERN ARIZONA

by

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Report Prepared for

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INTRODUCTION

The analysis here of 22 obsidian artifacts from Classic contexts at the Yuma Wash Site (south) in southern Arizona, indicates a rather typical pattern in Classic contexts in southern Arizona (Shackley 2005). A dominance of local Sonoran Desert sources with some western New Mexico sources is also typical.

LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION

This assemblage was analyzed on a Spectrace/Thermo *QuanX* energy-dispersive x-ray spectrometer at the Geoarchaeological XRF Laboratory, Department of Anthropology at the University of California, Berkeley. All samples were analyzed whole with little or no formal preparation. 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 spectrometer is equipped with an electronically cooled Cu x-ray target with a 125 micron Be window, an x-ray generator that operates from 4-50 kV/0.02-2.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTrace™ reduction software. The x-ray tube is operated at 30 kV, 0.14 mA, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity $K\alpha$-line data for elements titanium (Ti), manganese (Mn), iron (as Fe^T), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). Weight percent iron ($Fe_2O_3^T$) can be derived by multiplying ppm estimates by 1.4297(10-4). Trace element intensities were converted to concentration estimates by employing a least-squares calibration line 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). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1992, 1995, 2005; also Mahood and Stimac 1990; and Hughes and Smith 1993). Specific standards used for the best fit regression calibration for elements Ti through Nb include G-2 (basalt), AGV-1 (andesite), GSP-1, SY-2 (syenite), BHVO-1 (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), all US Geological Survey standards, and BR-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France, and JR-1 and JR-2 obsidian standards from the Japan Geological Survey (Govindaraju 1994). In addition to the reported values here, Ni, Cu, Zn, Th, and Ga were measured, but these are rarely useful in discriminating glass sources and are not generally reported.

The data from both systems 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. An analysis of RGM-1 analyzed during each run is included in Table 1. Source nomenclature follows Shackley (1988, 1995, 1998, 2005). 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 Figure 1).

This assemblage, unlike some of the others, contained a number of samples that were near the smallest size that can be reliably analyzed with EDXRF (see Davis et. al. 1998; Lundblad et al. 2007; Table 1 here). It is likely that, at least some, if not all those sources that could not be assigned to source ("too small") could be from known sources, but the elemental concentrations are too low to confidently assign to source. Similarly, the source assignments with question marks (*) are just outside the source standard elemental concentrations, and cannot as confidently be assigned to source. Nevertheless, the general pattern seems consistent with Classic and Late Classic obsidian source provenance in southern Arizona.

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

FN	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
14	1174	417	8527	139	62	32	164	30	Sauceda Mts*
63	429	368	7453	204	0	42	88	29	Mule Cr/AC-MM
64	927	376	8117	124	53	27	140	18	Sauceda Mts*
68	385	384	7416	200	8	47	100	28	Mule Cr/AC-MM
69	842	355	6613	114	28	13	106	12	too small
82	994	361	7733	122	51	25	146	25	Sauceda Mts*
152	1245	435	9584	150	65	39	178	22	Sauceda Mts*
170	600	510	5621	103	5	24	79	27	Superior
227	129	292	5624	134	7	17	55	17	Superior
228	1496	485	10708	170	72	33	197	22	Sauceda Mts
275	680	564	5843	110	11	23	74	28	Superior
281	1147	417	9003	142	66	35	180	19	Sauceda Mts
708	910	332	7537	114	49	27	150	16	Sauceda Mts*
783	967	399	8838	141	62	32	171	18	Sauceda Mts
237-1	1204	407	9333	156	65	33	192	28	Sauceda Mts
237-2	1285	393	8607	139	55	31	169	27	Sauceda Mts
596-1	543	440	8063	212	6	36	95	22	Mule Cr/AC-MM
596-2	454	312	5863	152	6	31	69	2	too small
74-1	1184	299	8964	128	78	18	121	10	Sauceda Mts*
74-2	474	424	7736	212	5	36	96	15	Mule Cr/AC-MM
81-1	1021	333	7121	116	48	34	137	34	too small
81-2	649	304	5464	85	27	13	82	3	too small
RGM-1	1544	343	13033	152	103	24	220	12	standard

* These samples were difficult to assign to source due to small sample sizes, angular debris configurations or simply slightly outside the elemental concentrations for the source standard data (see Davis et al. 1998).

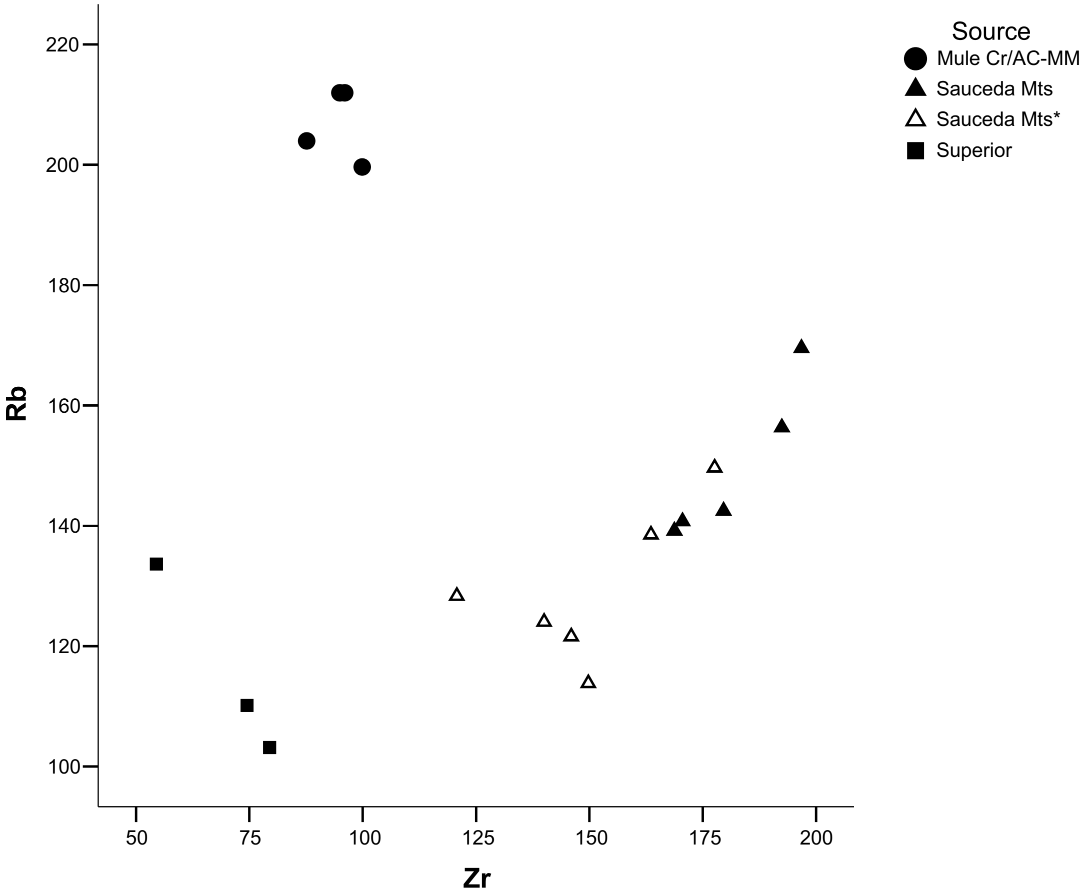

Figure 1. Rb versus Zr biplot of the elemental concentrations for the artifacts.

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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THE CLEARWATER AND YUMA WASH SITES, TUCSON BASIN, ARIZONA

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INTRODUCTION

The analysis here of obsidian artifacts from four sites in the Tucson Basin is quite diverse including sources from the Sonoran Desert, the San Francisco Volcanic Field and western New Mexico. The one large projectile point from AZ BB:13:6 (ASM) is produced from obsidian from the Antelope Creek locality at Mule Creek, western New Mexico. The size of the projectile point indicates procurement of the original rock at the primary domes and not in secondary deposits.

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).

The trace element analyses were performed in the Geoarchaeological XRF Laboratory, Department of Anthropology, University of California, Berkeley, using a ThermoScientific *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 with 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. 1998; Shackley 2005).

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 Southwest obsidians is available in Shackley (1988, 1990, 1992, 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, 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 software for manipulation and on into SPSS for Windows for statistical analyses when necessary (Figures 1 and 2). In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. RGM-1 is analyzed during each sample run for obsidian artifacts to check machine calibration (Table 1). Other appropriate standards from the above list are used for other volcanic rocks. Source assignments made by reference to Archaeological XRF Lab standards as reported in Shackley (1998, 1995, 2005).

DISCUSSION

The mix of sources in the late period Yuma Wash sites in the Marana area is rather typical of Classic sites (Shackley 2005; Tables 1 and 2 here; Figures 1 and 2). Superior (Picketpost Mountain) is generally rare in Phoenix Basin sites during the Classic, but not as much so in the Tucson Basin (Shackley 2005).

More unique is the large corner-notched Early Agricultural projectile point from AZ BB:13:6 (FN 789) that was produced from obsidian originally procured from the Antelope Creek locality domes at Mule Creek in western New Mexico (see image on cover page). This dome complex is over 220 linear kilometers east of the site. The point, over 70 mm in length is near the maximum nodule size that I have seen at the domes in over 25 years experience with the sources at Mule Creek (Shackley 1988, 1992, 1998, 2005). Besides the excellent craftsmanship of some knapper over 3000 years ago, the artifact size suggests that the availability of large nodules at the source was somewhat larger than evident today, and that the western New Mexico area may have had utility to Early Agricultural people from the Tucson Basin. The morphology of the point is unique for this time period, but may have been more common in the western New

Mexico region, although I haven't seen a type like that in New Mexico (Jane Sliva, personal communication, 26 May 2009).

Additionally, the elemental composition of the Antelope Creek locality is quite similar to the Partridge Creek (Round Mountain) source on the Coconino Plateau, discriminated best with Nb and Ba (Shackley 1995). An additional analysis for Ba was acquired, and as evident in the biplot of these two elements in Figure 2, the point was certainly produced from Antelope Creek/Mule Creek rather than Partridge Creek.

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

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba	Source
<u>BB:13:6</u>										
789	913	346	9878	233	13	42	106	27	72	Mule Cr/AC-MM
<u>AA:12:122</u>										
5234	1032	482	8462	125	12	28	96	32		Superior
5323	1761	322	12270	171	104	24	178	22		Sauceda Mts
6120	882	592	9324	445	4	72	107	128		Mule Cr/N Sawmill Cr
6314	1526	287	11420	162	104	26	184	18		Sauceda Mts
<u>AA:12:312</u>										
3026	1783	388	12012	183	75	35	202	24		Sauceda Mts
3060	856	539	10300	110	77	20	77	51		Government Mtn
3061-1	1513	376	11251	168	73	34	200	26		Sauceda Mts
3061-2	790	510	10271	111	76	22	83	55		Government Mtn
<u>AA:12:311</u>										
1386	1472	308	11344	160	102	25	187	20		Sauceda Mts
1521-2	1514	368	10891	164	69	36	192	23		Sauceda Mts
1521-1	1563	377	11477	170	71	29	195	23		Sauceda Mts
1531	1520	375	11254	160	73	35	196	25		Sauceda Mts
1585	912	522	10002	107	76	20	79	50		Government Mtn
2652	1481	409	10242	168	78	33	197	21		Sauceda Mts
2661	1685	298	11777	164	107	29	182	19		Sauceda Mts
2685	1657	324	11695	162	103	29	184	19		Sauceda Mts
2703	1452	402	10052	170	76	36	191	20		Sauceda Mts
2752-2	1437	381	9884	167	75	32	194	21		Sauceda Mts
2752-1	921	380	8921	239	17	39	108	22		Mule Cr/AC-MM
2855	1102	478	8286	125	16	23	91	31		Superior
9339	1463	320	10649	159	70	32	190	22		Sauceda Mts
10332	1455	347	9007	129	36	20	117	21		Superior
RGM1-H	1623	294	13649	145	104	25	215	9		standard
RGM1-S4	1604	290	13072	153	107	26	213	8		standard
RGM1-S4	1523	325	12791	153	105	24	219	9	815	standard

Table 2. Crosstabulation of source by site.

			Sample				
			12:122	12:311	12:312	13:6	Total
Source	Government Mtn	Count	0	1	2	0	3
		% within Source	.0%	33.3%	66.7%	.0%	100.0%
		% within Sample	.0%	7.1%	50.0%	.0%	13.0%
		% of Total	.0%	4.3%	8.7%	.0%	13.0%
	Mule Cr/AC-MM	Count	0	1	0	0	1
		% within Source	.0%	100.0%	.0%	.0%	100.0%
		% within Sample	.0%	7.1%	.0%	.0%	4.3%
		% of Total	.0%	4.3%	.0%	.0%	4.3%
	Mule Cr/Antelope Cr	Count	0	0	0	1	1
		% within Source	.0%	.0%	.0%	100.0%	100.0%
		% within Sample	.0%	.0%	.0%	100.0%	4.3%
		% of Total	.0%	.0%	.0%	4.3%	4.3%
	Mule Cr/N Sawmill Cr	Count	1	0	0	0	1
		% within Source	100.0%	.0%	.0%	.0%	100.0%
		% within Sample	25.0%	.0%	.0%	.0%	4.3%
		% of Total	4.3%	.0%	.0%	.0%	4.3%
	Sauceda Mts	Count	2	10	2	0	14
		% within Source	14.3%	71.4%	14.3%	.0%	100.0%
		% within Sample	50.0%	71.4%	50.0%	.0%	60.9%
		% of Total	8.7%	43.5%	8.7%	.0%	60.9%
	Superior	Count	1	2	0	0	3
		% within Source	33.3%	66.7%	.0%	.0%	100.0%
		% within Sample	25.0%	14.3%	.0%	.0%	13.0%
		% of Total	4.3%	8.7%	.0%	.0%	13.0%
Total		Count	4	14	4	1	23
		% within Source	17.4%	60.9%	17.4%	4.3%	100.0%
		% within Sample	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	17.4%	60.9%	17.4%	4.3%	100.0%

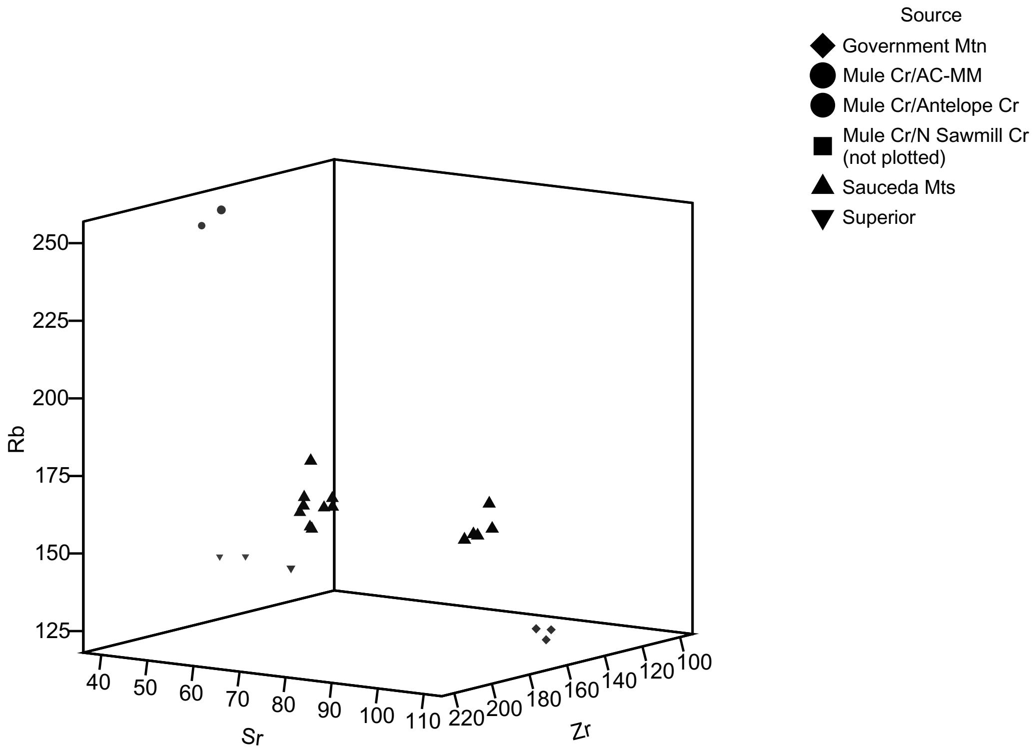

Figure 1. Rb, Sr, Zr three-dimensional plot of the elemental concentrations for all archaeological specimens. The high Rb Mule Creek/N Sawmill Creek specimen removed for clarity.

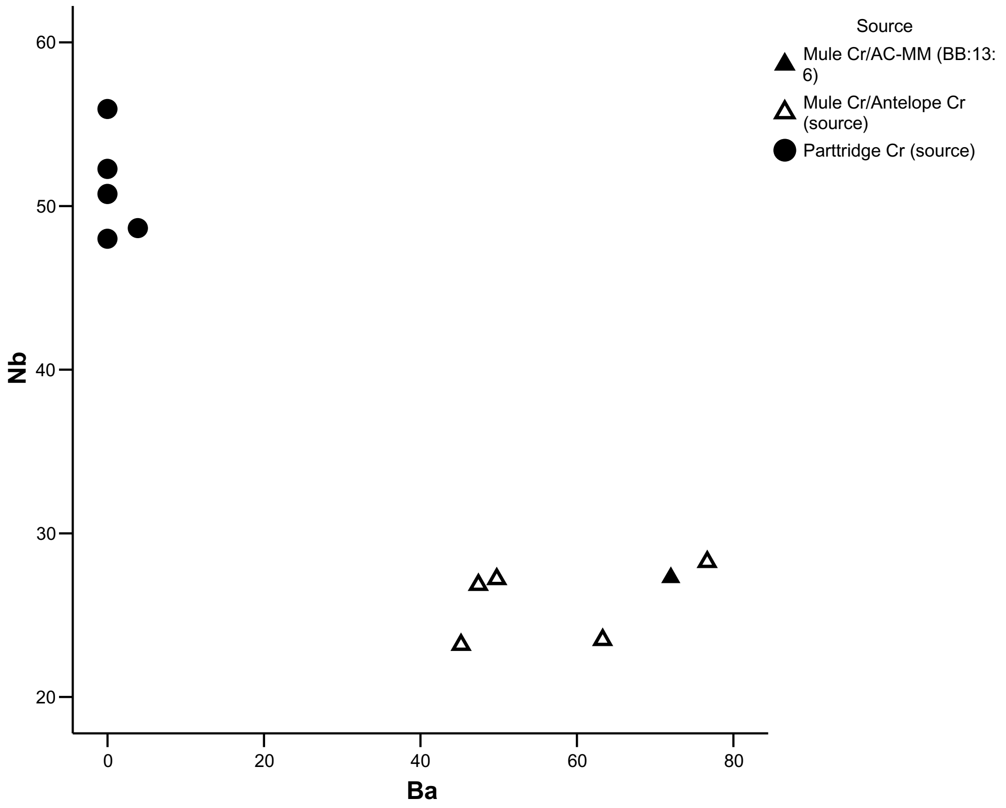

Figure 2. Nb versus Ba biplot of the elemental concentrations for the AZ BB:13:6, FN 789 projectile point and Mule Creek/Antelope Creek and Partridge Creek source standards (see Shackley 1995, 1998, 2005).

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PORTABLE XRF (PXRF) SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THE YUMA WASH SITE (AZ AA:12:311 ASM) and AZ AA:12:18 (ASM), TUCSON BASIN, ARIZONA

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Report Prepared for

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17 July 2009

INTRODUCTION

The analysis here of 29 obsidian mostly Classic period artifacts from the Yuma Wash Site in the Tucson Basin is quite diverse including sources from the Sonoran Desert, eastern Arizona, western New Mexico, and northern New Mexico. The source provenance of these associated funerary obsidian artifacts is somewhat different than the non-funerary artifacts analyzed earlier (Shackley 2009a). While the instrumental precision and number of elements acquired by the ThermoScientific *NITON* portable XRF instrument is not as great as desktop instruments, the source assignments here appear to be accurate.

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).

The trace element analyses were performed at Desert Archaeology, Inc. in Tucson, Arizona, using a ThermoScientific *NITON XLt portable* energy dispersive x-ray fluorescence spectrometer. The spectrometer is equipped with a low power (1.0W) x-ray tube with an Ag anode target. Data is acquired through a Si-PiN Peltier cooled detector and translated into NITON software.

For Ti, Mn, Rb, Sr, Zr elements acquired here, using a number of instrument selected filters in an air path at 240 seconds livetime to generate x-ray intensity $K\alpha_1$-line data for elements titanium (Ti), manganese (Mn), rubidium (Rb), strontium (Sr), and zirconium (Zr). Trace element intensities were converted to concentration estimates by employing a least-squares calibration line established for each element from the analysis of international rock standards certified by the the US. Geological Survey (USGS; see Govindaraju 1994). Line fitting is linear for all elements. Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1988, 1992, 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 the elements, 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.

The data from the NITON software were translated directly into Excel for Windows software for manipulation and on into SPSS for Windows for statistical analyses (Tables 1 and 2; Figures 1, 2, 3). RGM-1 was analyzed periodically to check machine calibration (Table 1). Source assignments were made by reference to Geoarchaeological XRF Lab standards as reported in Shackley (1998, 1995, 2005; 2009b).

DISCUSSION

The mix of sources in the Classic period Yuma Wash site in the Marana area is rather typical of Classic sites (Shackley 2005, 2009a; Tables 1 and 2 here; Figures 1 through 4). Superior (Picketpost Mountain) is generally rare in Phoenix Basin sites during the Classic, but not as much so in the Tucson Basin, as indicated here (Shackley 2005). What is most surprising is that the mix of sources from funerary contexts is quite different from the non-funerary contexts at Yuma Wash (Shackley 2009a; Table 2 here). While artifacts produced from Sauceda Mountains, Superior, and a few Mule Creek sources were evident in the non-funerary study, no Cow Canyon or Bear Springs Peak (northern New Mexico) occurred. The relatively small sample here makes confident inferences hazardous, but it is possible that these, mainly projectile points, from the funerary contexts could indicate kin-relationships from the eastern Arizona region, preference for Cow Canyon raw material by a tool maker, exchange of complete arrows or points, or any number of other socially constrained relationships. It's important to remember, however, that both Cow Canyon and Mule Creek obsidian is available as secondary deposits in the Gila River in the Safford Valley considerably nearer Yuma Wash than the primary sources, and Mule Creek was present in the non-funerary assemblage (see Shackley 1992, 1998, 2005).

The one sample of Bear Springs Peak is unique this far west (Shackley 2009b). This Tertiary source in the southern Jemez Mountains of northern New Mexico is a small nodule source that has been found as far south as Las Cruces in secondary deposits of the Rio Grande River (Church 2000; Shackley 1998). So, it is impossible to determine the exact provenance of the original raw material. Nevertheless, this is hundreds of kilometers east of the Yuma Wash site and a rather minor source, although present in historic period contexts at Zuni (Shackley 2005).

A word about the quality of PXRF instrumentation is useful. While the NITON instrument is empirically calibrated similar to laboratory instrumentation, the low power of the portable and limited number elements acquired limits the confidence of source assignment (Shackley 2009c). We found in this analysis that the primary incompatible elements acquired (Rb, Sr, Zr) consistently yielded concentrations a bit lower than the standard (see Table 1). Nevertheless, given the constraints of having to analyze outside the laboratory, the source assignments seem good. We are in the process of running tests of two portable instruments against laboratory EDXRF instruments at Berkeley and with empirical calibration the results are promising.

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Table 1. X-ray fluorescence concentrations for selected trace elements for RGM1-S5 (n=3) in this study. ± values represent first standard deviation computations for the group of measurements. All values are in parts per million (ppm) as reported by USGS and this study. RGM-1 is a U.S. Geological Survey obsidian standard.

SAMPLE	Ti	Mn	Rb	Sr	Zr
RGM-1 (USGS)	1600±120	279±3	150±8	110±10	220±20
RGM-1 (this study)	1591±37	275±37	141±3	101±2	201±1

Table 2. Elemental concentrations and source assignments for the archaeological specimens. All measurements in parts per million (ppm).

SAMPLE	**Ti**	**Mn**	**Rb**	**Sr**	**Zr**	**Source**[1]	**Comment**
AA:12:18							
103	239	583	139	22	121	Superior	burned
AA:12:311							
1319	1186	424	201	136	218	Sauceda Mts ?	
1370	1153	438	149	76	189	Sauceda Mts	
1472	385	245	221	15	205	Los Vidrios	
1837	883	268	121	85	157	Sauceda Mts	(small)
2309	438	469	117	19	100	Superior	
2424						too small	
2945	595	409	120	128	117	Cow Canyon	
2946	443	373	93	113	109	Cow Canyon	
2948	611	378	108	124	114	Cow Canyon	
2949	580	416	103	143	118	Cow Canyon	
9452	1186	234	147	94	169	Sauceda Mts	
9800	423	369	205	35	117	Mule Creek/AC-MM	burned
9831	362	226	235	15	210	Los Vidrios	
9836	850	300	135	69	173	Sauceda Mts	
9912-9	446	480	104	31	101	Superior	
9912-40	753	360	128	80	167	Sauceda Mts ?	burned
9912-3	440	546	124	51	111	Bear Springs Peak?	burned
9912-29	529	481	130	131	120	Cow Canyon	
9912-25	397	392	95	28	91	Superior?	
9912-21	373	447	106	41	99	Superior	
9912-1						too burned	
10093	580	503	112	155	122	Cow Canyon	
10179-9	582	452	119	112	122	Cow Canyon	
10179-8	636	364	116	116	117	Cow Canyon	
10179-7	631	422	120	125	118	Cow Canyon	
10179-6	530	387	111	113	115	Cow Canyon	
10179-10	414	505	113	24	96	Superior	
10371	938	355	147	65	183	Sauceda Mts	

[1] The samples noted by "?" are those that are slightly outside the elemental concentrations of published source standard data for these source, but do not match any other source in the Southwest (Davis et al. 1998; Shackley 2005, 2009c).

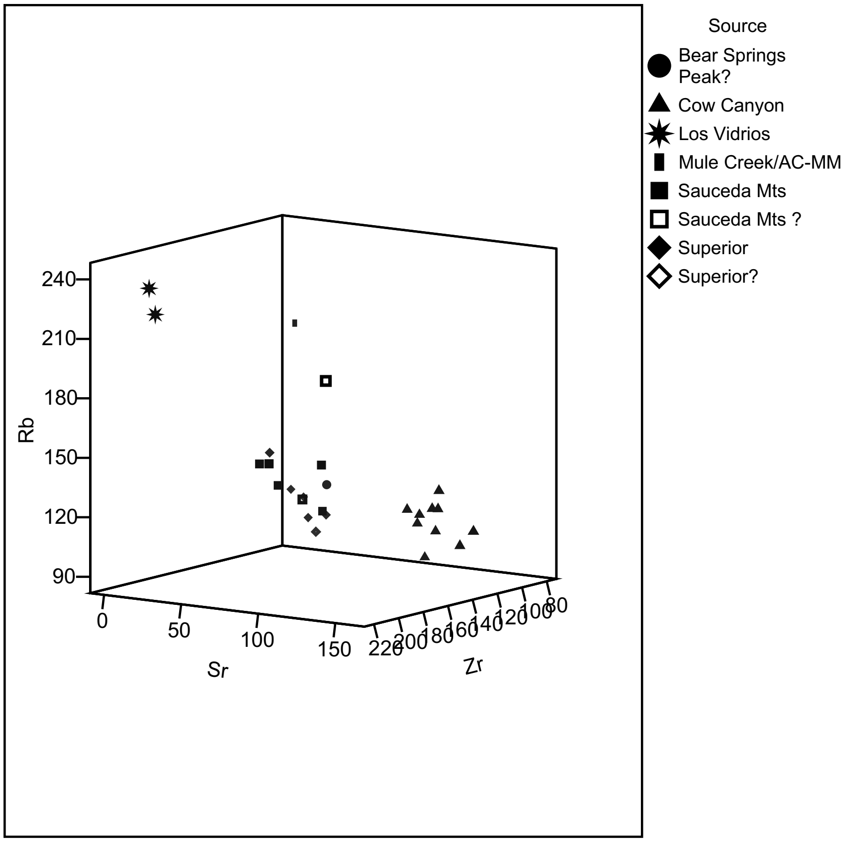

Figure 1. Rb, Sr, Zr three-dimensional plot of the elemental concentrations for all archaeological specimens.

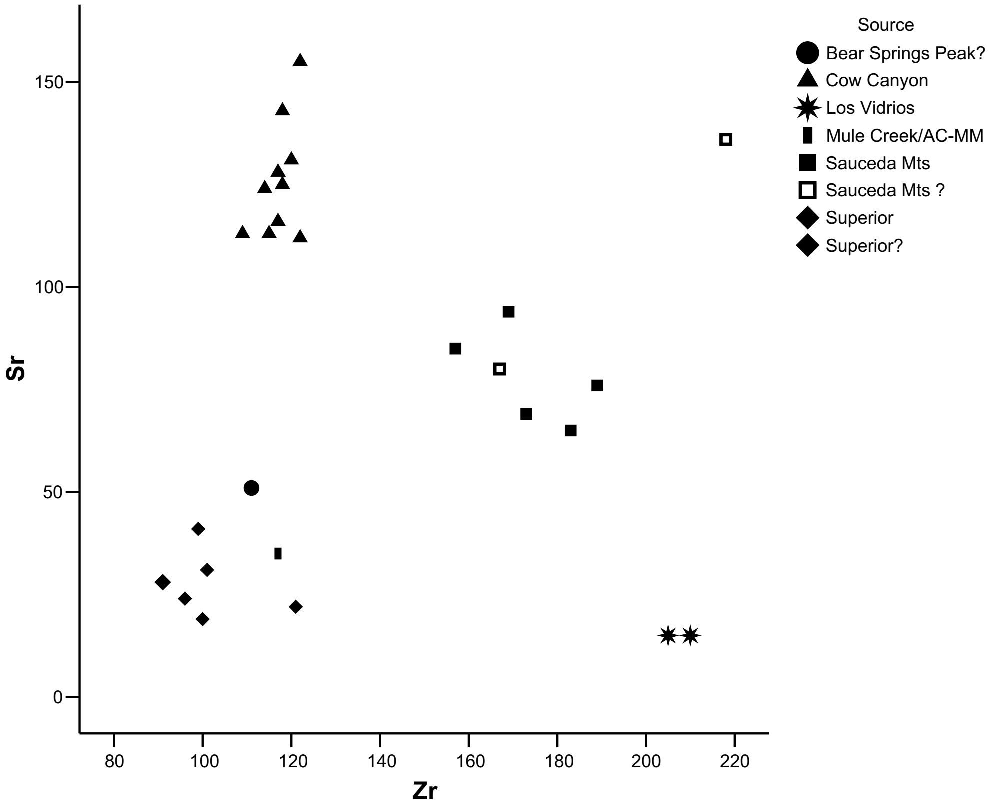

Figure 2. Sr versus Zr biplot of the elemental concentrations all the specimens. Note the overlap between Mule Creek and Superior, separated in Figure 1.

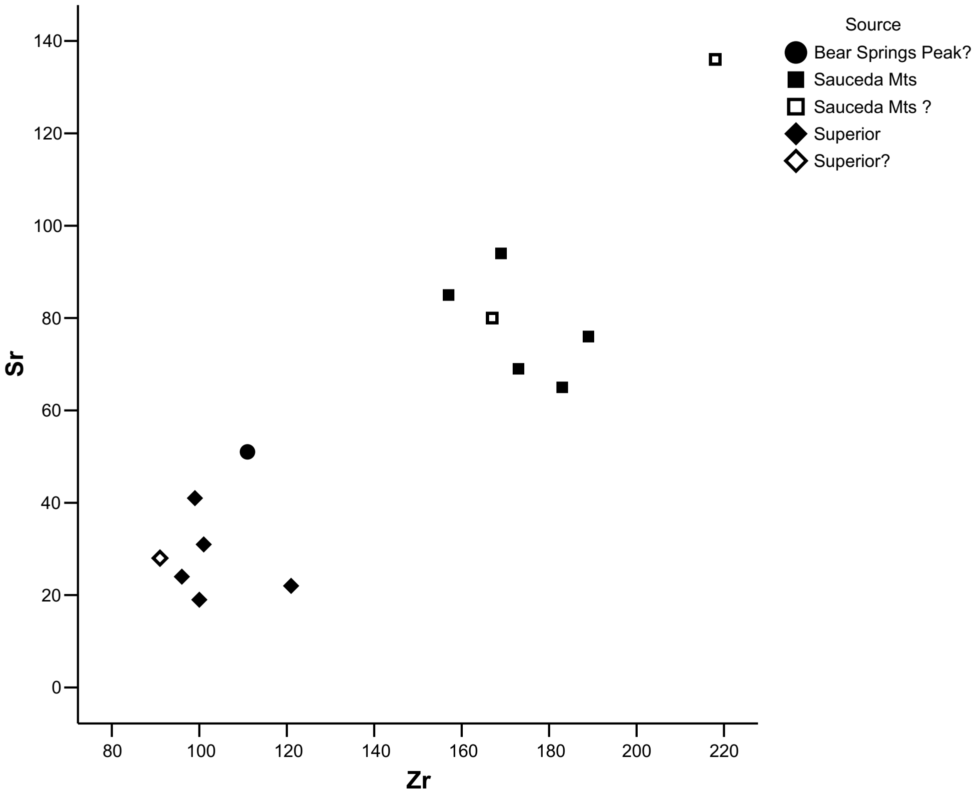

Figure 3. Sr versus Zr biplot of the elemental concentrations for the Bear Springs Peak, Sauceda Mountains and Superior specimens.

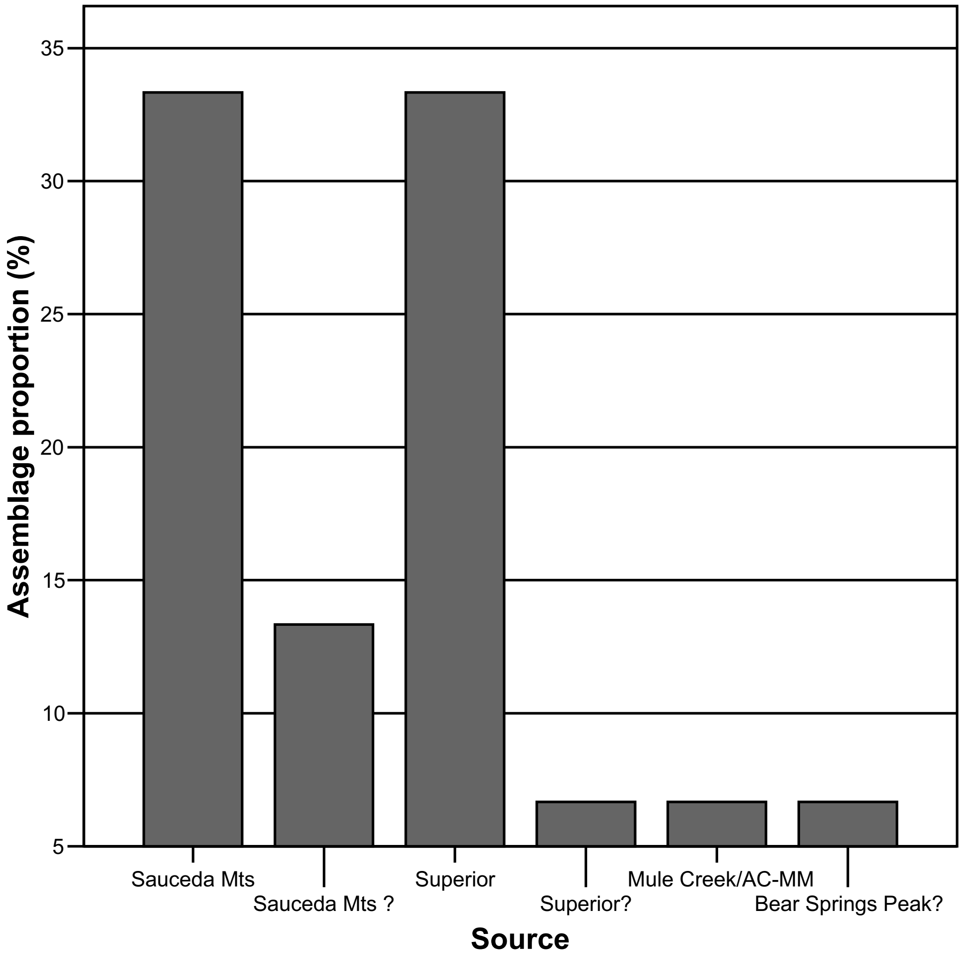

Figure 4. Distribution of source provenance of all the specimens.

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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM LOCUS AZ AA:12:311 (ASM) OF THE YUMA WASH SITE, SOUTHERN ARIZONA

by

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Report Prepared for

Desert Archaeology, Inc.
Tucson, Arizona

4 December 2009

INTRODUCTION

The analysis here of obsidian artifacts from the Yuma Wash Site (AZ AA:12:311) in the Tucson Basin is just as diverse as the previous analysis at this site including sources from the Sonoran Desert, the San Francisco and Mount Floyd Volcanic Fields and western New Mexico (Shackley 2009).

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).

The trace element analyses were performed in the Geoarchaeological XRF Laboratory, Department of Anthropology, University of California, Berkeley, using a ThermoScientific *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 with 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. 1998; Shackley 2005).

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. 1998). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1988, 1990, 1992, 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, 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 software for manipulation and on into SPSS for Windows for statistical analyses when necessary

(Figures 1 and 2). In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. RGM-1 is analyzed during each sample run for obsidian artifacts to check machine calibration (Table 1). Other appropriate standards from the above list are used for other volcanic rocks. Source assignments made by reference to Archaeological XRF Lab standards as reported in Shackley (1998, 1995, 2005).

DISCUSSION

The mix of sources in the late period Yuma Wash Site in the Marana area is rather typical of Classic sites (Shackley 2005; Tables 1 and 2 here; Figures 1 and 2). Superior (Picketpost Mountain) is generally rare in Phoenix Basin sites during the Classic, but not as much so in the Tucson Basin, although unlike the previous analysis only one of the artifacts was produced from Superior here (Shackley 2005).

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

Feature/Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
MHPY									
416	766	275	11618	251	10	63	215	31	Los Vidrios
496	1058	514	6908	124	18	25	92	30	Superior
412	758	266	12397	256	12	69	214	33	Los Vidrios
481-2	719	251	11595	244	8	64	205	31	Los Vidrios
457	1572	322	10929	167	107	28	179	16	Sauceda Mts
418	1508	418	10066	169	71	34	196	25	Sauceda Mts
472	870	411	9295	254	16	40	109	24	Mule Cr/AC-MM
481-1	708	412	9594	269	17	43	114	30	Mule Cr/AC-MM
811	1687	372	10139	161	70	34	184	19	Sauceda Mts
539	1597	432	10281	160	72	29	189	23	Sauceda Mts
541	1703	426	10337	162	73	31	184	22	Sauceda Mts
MSM									
943	1652	386	10049	164	74	34	185	24	Sauceda Mts
2032	820	455	10087	281	18	41	114	27	Mule Cr/AC-MM
1015	749	462	8098	242	4	38	86	51	Partridge Cr
2078	1585	412	10613	176	77	37	192	19	Sauceda Mts
881	825	407	9136	244	16	39	109	26	Mule Cr/AC-MM
2165	747	401	9325	264	18	39	117	32	Mule Cr/AC-MM
934	773	412	9332	254	18	46	111	19	Mule Cr/AC-MM
DR311									
101	1524	401	10528	172	78	32	201	23	Sauceda Mts
145	742	247	12207	255	13	73	216	29	Los Vidrios
188-1	1477	384	9750	163	73	33	196	23	Sauceda Mts
188-2	741	220	10565	238	11	64	205	27	Los Vidrios
188-3	1457	393	10128	173	74	34	200	27	Sauceda Mts
188-4	1498	388	10047	168	72	35	189	20	Sauceda Mts
188-5	1495	399	10352	169	70	34	193	20	Sauceda Mts
188-6	1446	363	10016	168	74	36	191	27	Sauceda Mts
188-7	1655	322	10355	152	97	24	162	16	Sauceda Mts
188-8	649	529	8867	109	77	23	82	54	Government Mtn
RGM1-S4	1620	303	12997	152	107	26	213	8	standard
RGM1-S4	1624	301	12990	156	108	26	215	7	standard

Table 2. Crosstabulation of source by feature.

			FEATURE			
			DR311	MHPY	MSM	Total
Source	Government Mtn	Count	1	0	0	1
		% within Source	100.0%	.0%	.0%	100.0%
		% within V1	10.0%	.0%	.0%	3.6%
		% of Total	3.6%	.0%	.0%	3.6%
	Los Vidrios	Count	2	3	0	5
		% within Source	40.0%	60.0%	.0%	100.0%
		% within V1	20.0%	27.3%	.0%	17.9%
		% of Total	7.1%	10.7%	.0%	17.9%
	Mule Cr/AC-MM	Count	0	2	4	6
		% within Source	.0%	33.3%	66.7%	100.0%
		% within V1	.0%	18.2%	57.1%	21.4%
		% of Total	.0%	7.1%	14.3%	21.4%
	Partridge Cr	Count	0	0	1	1
		% within Source	.0%	.0%	100.0%	100.0%
		% within V1	.0%	.0%	14.3%	3.6%
		% of Total	.0%	.0%	3.6%	3.6%
	Sauceda Mts	Count	7	5	2	14
		% within Source	50.0%	35.7%	14.3%	100.0%
		% within V1	70.0%	45.5%	28.6%	50.0%
		% of Total	25.0%	17.9%	7.1%	50.0%
	Superior	Count	0	1	0	1
		% within Source	.0%	100.0%	.0%	100.0%
		% within V1	.0%	9.1%	.0%	3.6%
		% of Total	.0%	3.6%	.0%	3.6%
Total		Count	10	11	7	28
		% within Source	35.7%	39.3%	25.0%	100.0%
		% within V1	100.0%	100.0%	100.0%	100.0%
		% of Total	35.7%	39.3%	25.0%	100.0%

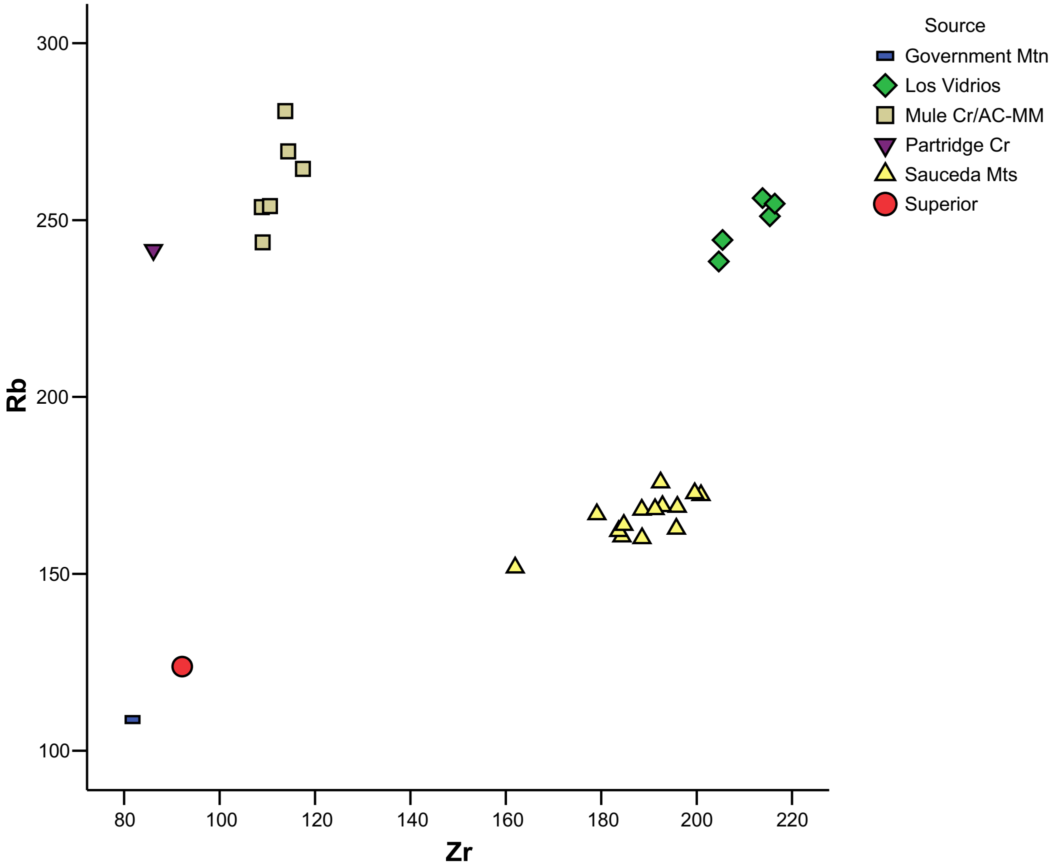

Figure 1. Rb, versus, Zr bivariate plot of the elemental concentrations for all archaeological specimens.

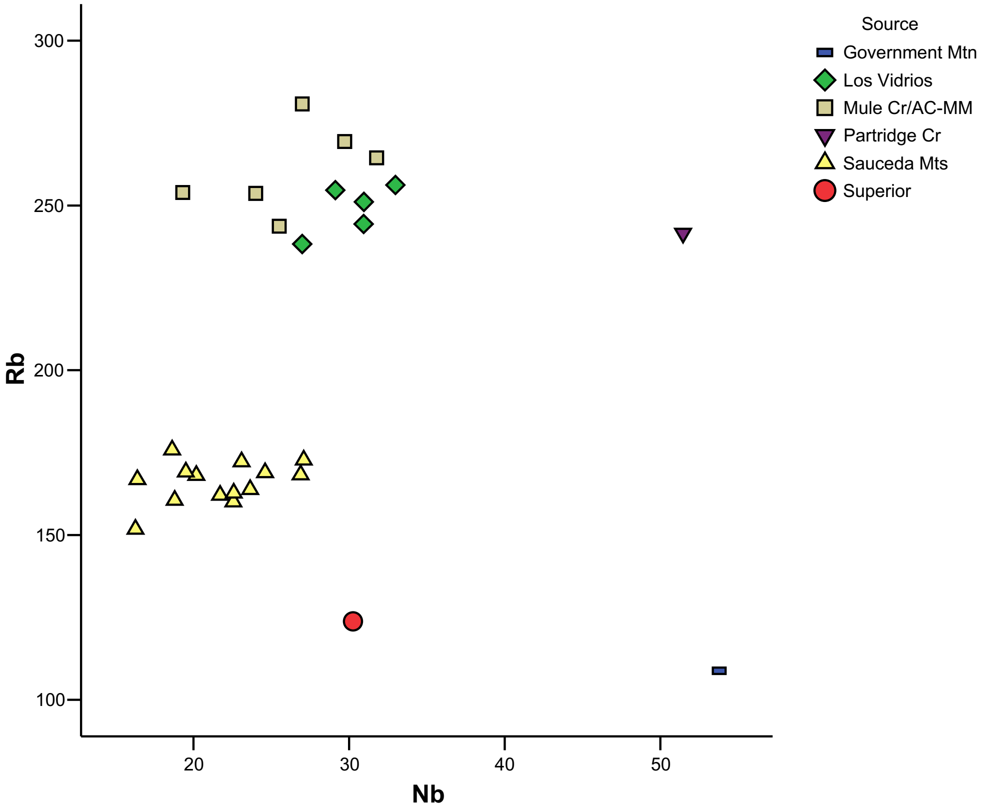

Figure 2. Rb versus Nb bivariate plot of the elemental concentrations more effectively discriminating Superior and Government Mountain.