GEOARCHAEOLOGICAL XRF LAB

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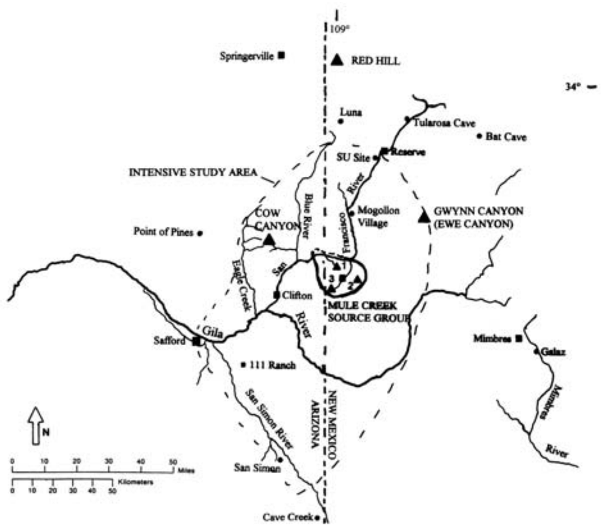
SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM PITHOUSE THROUGH CLASSIC PERIOD SITES ALONG EAGLE CREEK, APACHE NATIONAL FOREST, EASTERN ARIZONA



by

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INTRODUCTION

The analysis here of 47 obsidian artifacts from Pithouse through Late Classic Period sites in the Eagle Creek basin indicates a dominance of locally procured Cow Canyon (n=46) obsidian for tool production. Two of the artifacts were produced from two of the localities in the Mule Creek source area in western New Mexico, or from secondary deposits along the Gila River south of these sites.

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 2011).

All analyses for this study were conducted on a ThermoScientific *Quant'X* EDXRF spectrometer, located in the Archaeological XRF Laboratory, Albuquerque, New Mexico. 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 $Fe_2O_3^T$), 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 2011; Shackley 2011). 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 a USGS obsidian standard is analyzed during each sample run for obsidian artifacts to check machine calibration (Table 1). Source assignments were made by reference to Shackley (1995, 1998a, 2005; see Table 1 and Figure 1) and source standard data at this lab.

DISCUSSION

All but two of the artifacts were produced from one of the closely related chemical groups known as Cow Canyon (Shackley 2005). The other two artifacts were produced from two of the chemical groups at Mule Creek in western New Mexico; Antelope Creek and Mule Mountains. One of these artifacts is the basal portion of a straight based side-notched point typical of Late Classic points at Mule Creek and Point of Pines (Shackley 2010, 2012; see Figure 2 here). A short discussion of the Cow Canyon geology and archaeology follows (see also Shackley 1990, 2005). While the nodule sizes are small at Cow Canyon, it has been a preferred raw material since Paleoindian times given its clarity, great flaking character, and availability over a large area.

The Cow Canyon Source

It appears that the secondary depositional extent of this source is much greater than originally mapped (Shackley 1988). This Tertiary source is eroding east into the Blue River, south into the San Francisco River and west into the Gila River as originally noted, but also erodes in much higher density west into Eagle Creek west of the Blue River, and on south into the Gila River and up to 20 km south into the San Simon River Valley. A number of "pockets" of Cow Canyon glass have been located in the San Simon River Valley in Pliocene/Pleistocene lacustrine sediments of the 111 Ranch Formation the result of considerably higher sedimentation rates in these periods than currently (Figure 3). The density of nodules at the upper end of Eagle Creek approximately 15 km west of the primary contexts at Cow Canyon is up to 1 per $10m^2$, and less than 100 times lower in the Gila River (Shackley 1992a). Again, these nodules are mixed with the Mule Creek marekanites in the alluvium. Nodules up to 5 cm in diameter have been recovered in the 111 Ranch Formation, as large as those at the primary source to the north, suggesting that the sediment load during the Plio-Pleistocene was very great.

Recent unpublished analyses by the Berkeley Archaeological XRF Lab of over 300 obsidian samples from Late Middle Archaic to Early Agricultural contexts at McEuen Cave (AZ W:13:6 ASM) in the Gila Mountains about 30 km north of the Gila River at Geronimo, indicates that Cow Canyon obsidian comprises over 80% of the assemblage. Most, if not all of the raw nodules were procured from the Gila River alluvium in the Safford and San Carlos Valleys.

Cow Canyon obsidian was also the only obsidian source known from the Murray Springs Clovis site in southern Arizona. Two of the fluted points were produced from this glass, likely from nodules around 5 cm in diameter, and probably through bipolar reduction. This is the earliest indication of both obsidian procurement and bipolar technology in the southern Southwest (Shackley huckell and haynes).

The "primary source" is located in Apache National Forest, central Greenlee County, Arizona. This is a relatively small primary source along and east of Arizona Hwy 191 located in a Tertiary rhyolite body. The nodules are found within an eroded rhyolite/ash unit that appears to be a remnant dome structure. Perlite or vitrophyre was not evident. The nodules are common in a rhyolite regolith on top of the dome as well as the rhyolite/ash alluvium at the base of the slopes. Nodules up to 5 cm in diameter are available, but most of the nodules are near or less than 4 cm. The density of nodules is fairly high in places, up to 5 per m^2. Cortex is mainly a thin gray-black. The interior glass is aphyric and the color is as variable as the mid-Tertiary marekanite sources. The most common color/opacity is a near transparent brown-green sometimes with thin banding. A few specimens exhibit a nearly opaque aphyric gray-green banded megascopic character, and very few have mahogany blotches.

The nodules are eroding and funneled into the Cow Canyon Creek/Turkey Creek system possibly reaching the Blue River 15 km east. Reduced nodules and flakes occur everywhere on the regolith and in the alluvium. The pattern of reduction is similar to Vulture with sporadic bipolar reduction throughout the source area. These specific areas may reach 10-20 per m^2. Overall the rejected core/flake density is less than 1 per $5m^2$. There are no published sources on this locality other than the county geology map (Wilson and Moore 1958), and Shackley (1988, 1995, 2005).

As evident in this assemblage, Cow Canyon as a source is slightly bimodal in Sr (see Figure 1). Given the Tertiary age of the source and corresponding extensive secondary deposition of the marekanites, no are has been found that correlates with those groups. They are certainly closely magmatically related, and isn't really relevant archaeologically.

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

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
Pithouse Period											
1	1410	440	10211	137	133	20	123	13	20	15	Cow Canyon
2	1388	430	10155	139	140	19	125	13	20	10	Cow Canyon
3	1373	460	9851	142	135	18	127	16	20	18	Cow Canyon
4	1226	455	9262	132	112	21	126	18	16	11	Cow Canyon
5	1222	416	9356	132	131	21	116	15	18	16	Cow Canyon
6	1419	530	10513	145	120	26	133	21	19	13	Cow Canyon
7	1327	405	9349	133	134	21	124	13	22	21	Cow Canyon
8	1322	543	10178	146	120	27	133	21	24	15	Cow Canyon
9	1409	591	10561	154	123	28	137	21	21	11	Cow Canyon
10	1280	391	9398	133	133	17	117	13	20	14	Cow Canyon
11	1412	530	10444	143	119	22	137	20	19	15	Cow Canyon
12	1280	420	9515	140	135	21	121	16	19	11	Cow Canyon
13	1219	425	9089	132	129	17	116	16	20	14	Cow Canyon
14	1383	414	9569	128	130	20	120	14	20	11	Cow Canyon
15	1417	430	9807	138	134	17	120	17	20	18	Cow Canyon
16	1385	481	10031	139	140	20	127	16	19	11	Cow Canyon
17	1461	426	9985	139	133	16	122	11	22	14	Cow Canyon
18	1385	433	9743	138	134	18	120	18	21	14	Cow Canyon
19	1437	488	10341	148	140	21	123	14	24	15	Cow Canyon
20	1472	475	10358	136	132	18	116	11	21	18	Cow Canyon
21	1318	451	9788	138	136	19	116	14	22	17	Cow Canyon
22	1638	559	10794	149	146	22	127	15	20	12	Cow Canyon
23	1683	490	11615	148	141	19	121	15	24	15	Cow Canyon
24	1395	474	9135	145	106	19	91	11	20	14	Cow Canyon

26	1313	474	9381	135	113	21	127	21	19	8	Cow Canyon
27	1311	422	9469	132	130	20	114	15	19	19	Cow Canyon
28	1354	517	10142	144	120	24	135	23	23	20	Cow Canyon
29	1085	412	8071	163	13	23	100	30	19	28	Mule Mtns/Mule Creek
30	1343	437	9636	137	135	18	115	14	19	18	Cow Canyon
31	1718	424	11481	140	132	17	121	12	19	15	Cow Canyon
Classic Period											
32	1297	441	9587	136	138	24	119	13	16	11	Cow Canyon
33	1073	369	10448	242	24	42	112	21	28	28	Antelope Cr/Mule Creek
34	1297	448	9362	135	131	21	116	14	20	18	Cow Canyon
36	1347	470	9888	144	138	18	117	14	18	16	Cow Canyon
37	1331	440	9897	139	136	19	116	14	19	10	Cow Canyon
39	1467	438	10413	141	137	16	117	11	19	14	Cow Canyon
40	1302	536	10274	145	119	28	130	17	20	10	Cow Canyon
41	1397	445	9951	138	134	16	116	13	20	12	Cow Canyon
42	1358	431	9474	137	131	19	124	8	18	7	Cow Canyon
43	1337	440	9547	139	132	20	118	11	23	14	Cow Canyon
44	1248	511	9526	140	112	21	124	16	17	16	Cow Canyon
45	1385	480	9939	145	138	20	124	15	22	11	Cow Canyon
Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
46	1331	573	10122	146	115	22	130	17	21	14	Cow Canyon
47	1297	452	9647	143	139	16	124	15	19	12	Cow Canyon
48	1320	434	9703	131	135	18	120	14	17	10	Cow Canyon
49	1267	533	9806	140	117	23	130	14	17	9	Cow Canyon
50	1359	527	10334	152	123	23	131	21	22	13	Cow Canyon
RGM1-S4	1619	277	13297	147	108	24	216	8	21	12	standard
RGM1-S4	1392	448	9588	138	133	16	116	12	21	9	standard
RGM1-S4	1603	294	13341	146	109	23	210	5	17	15	standard

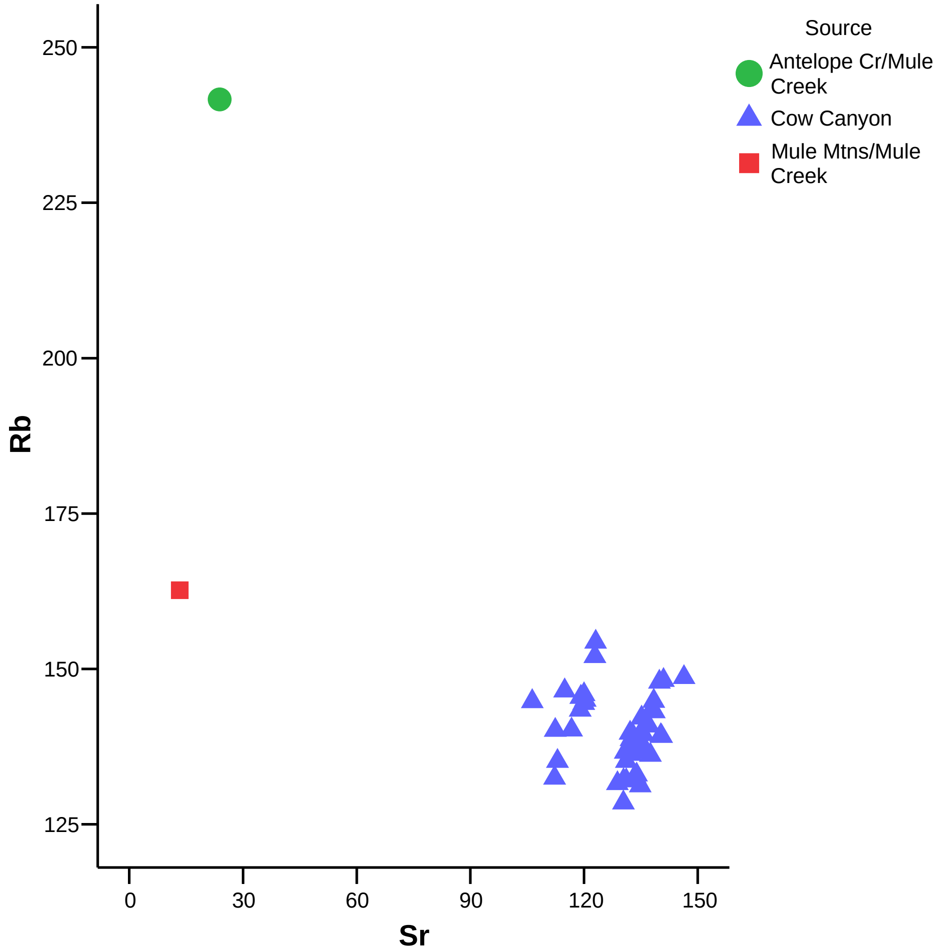

Figure 1. Sr versus Rb bivariate plot of the elemental concentrations for the archaeological specimens. Many of the Eagle Creek artifacts are more similar to the higher Sr group.

Figure 2. Projectile point forms from Point of Pines (from Shackley 2012).

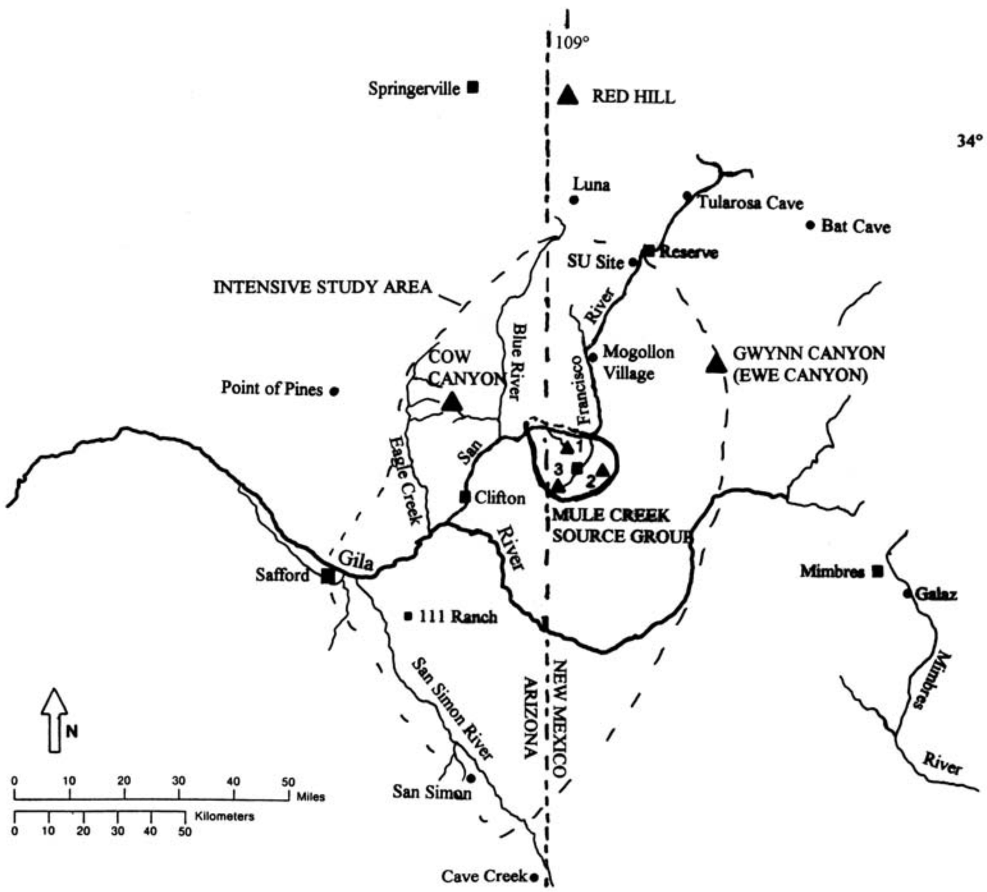

Figure 3. Location of Mogollon-Datil Volcanic Province archaeological obsidian sources and Tertiary Period Cow Canyon as well as major drainage basins (from Shackley 1998b, 2005).