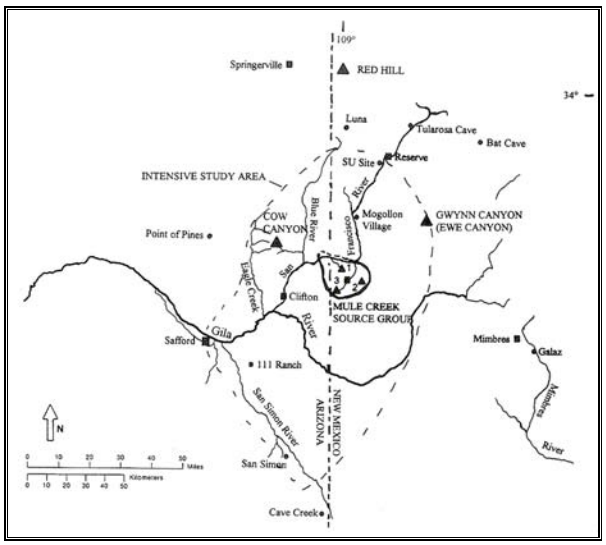
Title
Source Provenance of Obsidian Artifacts from Prehistoric Sites Along US HWY 70, Safford Valley, Southeastern Arizona

Author
Shackley, M. Steven

Publication Date
2002-09-17

Phoebe Hearst Museum of Anthropology
103 Kroeber Hall
University of California
Berkeley, CA 94720-3712

SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM PREHISTORIC SITES ALONG US HWY 70, SAFFORD VALLEY, SOUTHEASTERN ARIZONA



by

M. Steven Shackley, Ph.D.
Director

Student Assistant
Samantha Gallop

Report Prepared for
Desert Archeology, Inc.
Tucson, Arizona

17 September 2002

INTRODUCTION

The analysis here of 18 obsidian artifacts from two sites along US Highway 70 in the Safford Valley appears to indicate procurement of locally available secondary deposits of Cow Canyon and Mule Creek obsidian. The discussion begins with an outline of the analytical methods and instrumentation, followed by a concluding section that is followed by tabulated and graphic data.

ANALYSIS AND INSTRUMENTATION

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 trace element analyses were performed in the Department of Geology and Geophysics, University of California, Berkeley, using a Philips PW 2400 wavelength x-ray fluorescence spectrometer using a LiF 200 crystal for all measurements. This crystal spectrometer uses specific software written by Philips (SuperQ/quantitative) and modifies the instrument settings between elements of interest. Practical detection limits have not been calculated for this new instrument, but but the variance from established standards is shown in Table 1. Sample selection is automated and controlled by the Philips software. X-ray intensity Kα-line data with the scintillation counter were measured for elements rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). X-ray intensities for barium (Ba) were measured with the flow counter from the Lα-line. 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). Specific standards used for the best fit regression calibration for elements Ti through Nb include G-2 (basalt), AGV-1 (andesite), GSP-1 and SY-2 (syenite), BHVO-1 (hawaiite), STM-1 (syenite), QLM-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 (Govindaraju 1994).

The data from the SuperQ 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. An analysis of USGS obsidian standard RGM-1 is included in Table 1. Source nomenclature follows Shackley (1995, 1992, 1998a). Further information on the laboratory instrumentation can be found at: http://obsidian.pahma.berkeley.edu/ and Shackley (1998b). Trace element data exhibited in Tables 1 and 2 are reported in parts per million (ppm), a quantitative measure by weight (see also Figures 1 and 2).

GEOCHEMICAL RESULTS AND SUMMARY

The results of the geochemical analysis will be discussed at the assemblage wide level. No attempt will be made to address intra-site issues, although the source provenance is tabulated by site in Table 3.

A simple explanation for the procurement of obsidian in prehistory in southeastern Arizona is, unfortunately, impossible (Shackley 1998a). Two major Tertiary Period sources of archaeological obsidian, Cow Canyon and the Mule Creek source group, have been eroding into the Blue, San Francisco, and Gila River systems for over 10 million years (Houser et al. 1985; Shackley 1992, 1995, 1998a). Sometime during the Plio-Pleistocene, a dam was created in the San Carlos Valley, flooding the area now known as the San Simon and Safford Valleys, creating what is now called the 111 Ranch Formation (Houser et al. 1985; see Figure 3 here). The rivers noted above at that time issued a discharge up to 100 times the modern flood rate, depositing sediments from the Mogollon Highlands, the Mule Creek, and southern Blue Mountain areas into the Gila River system. Marekanites from Cow Canyon have been recovered in the Quaternary alluvium over 100 stream kilometers from the source as far as Geronimo west of Safford (Shackley 1992, 1998a; Figure 3 here). Marekanites of Cow Canyon and Mule Creek glass can be found in the 111 Ranch Formation as large as at the primary sources due to this high velocity discharge. So, using nodule size to infer the point of procurement is essentially impossible. This means, of course, that it is impossible in most cases to determine whether the obsidian artifacts recovered from archaeological contexts in the region were procured from primary or secondary sources.

Additionally, the elemental composition of the Mule Creek localities, are variant, a result of fractionation and other processes, and producing a complex compositional regime (see Shackley 1998a). The three major sources at Mule Creek – Antelope Creek, Mule Mountains, and North Sawmill Creek, while exhibiting elemental variability are mixed together in the alluvium, although Antelope Creek which is on the north side of the Mule Creek caldera, empties almost directly into the San Francisco River and therefore is generally numerically superior to the other Mule Creek groups in secondary deposits. The Cow Canyon/111 Ranch chemical group, however, appears to be most common everywhere, and is generally, but not always, numerically superior in assemblages in the region, including the 300+ recently analyzed objects from McEuen Cave in the Gila Mountains to the north (Shackley, not published). While it is possible that the dominance of Mule Creek obsidian in this late period assemblage is the result of procurement from the primary sources or exchange with groups (Mimbres Mogollon?) at the source, I cannot determine that with the data at hand. Various stream flooding events appear to deposit a load from one area more than another (i.e Cow Canyon versus Mule Creek), and so prehistoric knappers could easily procure all the nodules during one episode and it would appear that they were selecting from one source while all they were doing was collecting from one area of secondary deposits. Other data sets would have to be used to deal with this issue.

REFERENCES CITED

Glascock, M.D., and M.P. Anderson

1993 Geological Reference Materials for Standardization and Quality Assurance of Instrumental Neutron Activation Analysis. *Journal of Radioanalytical and Nuclear Chemistry* 174(2):229-242.

Govindaraju, K.

1994 1994 Compilation of Working Values and Sample Description for 383 Geostandards. *Geostandards Newsletter* 18 (special issue).

Hampel, Joachim H.

1984 Technical Considerations in X-ray Fluorescence Analysis of Obsidian. In *Obsidian Studies in the Great Basin*, edited by R.E. Hughes, pp. 21-25. Contributions of the University of California Archaeological Research Facility 45. Berkeley.

Houser, B.B., Richter, D.H., and Shafiqullah, M.

1985 Geologic map of the Safford quadrangle, Graham County, Arizona. Miscellaneous Investigations Series Map I-1617. USGS.

McCarthy, J.J., and F.H. Schamber

1981 Least-Squares Fit with Digital Filter: A Status Report. In *Energy Dispersive X-ray Spectrometry*, edited by K.F.J. Heinrich, D.E. Newbury, R.L. Myklebust, and C.E. Fiori, pp. 273-296. National Bureau of Standards Special Publication 604, Washington, D.C.

Schamber, F.H.

1977 A Modification of the Linear Least-Squares Fitting Method which Provides Continuum Suppression. In *X-ray Fluorescence Analysis of Environmental Samples*, edited by T.G. Dzubay, pp. 241-257. Ann Arbor Science Publishers.

Shackley, M. Steven

1992 The Upper Gila River Gravels as an Archaeological Obsidian Source Region: Implications for Models of Exchange and Interaction. *Geoarchaeology* 7:315-326.

1995 Sources of Archaeological Obsidian in the Greater American Southwest: An Update and Quantitative Analysis. *American Antiquity* 60(3):531-551.

1998a Intrasource Chemical Variability and Secondary Depositional Processes in Sources of Archaeological Obsidian: Lessons from the American Southwest. In *Archaeological Obsidian Studies: Method and Theory*, edited by M.S. Shackley, pp. 83-102. Kluwer Academic/Plenum Press, New York and Amsterdam.

1998b Geochemical Differentiation and Prehistoric Procurement of Obsidian in the Mount Taylor Volcanic Field, Northwest New Mexico. *Journal of Archaeological Science* 25:1073-1082.

Table 1. X-ray fluorescence concentrations for selected trace elements RGM-1 (n=5 runs, May 2000). ± values represent first standard deviation computations for the group of measurements. All values are in parts per million (ppm) as reported in Govindaraju (1994) and this study. RGM-1 is a U.S. Geological Survey rhyolite standard.

SAMPLE	Rb	Sr	Y	Zr	Nb	Ba
RGM-1 (Govindaraju 1994)	149	108	25	219	8.9	807
RGM-1 (Glascock and Anderson 1993)	145±3	120±10	n.r.[a]	150±7	n.r.	826±31
RGM-1 (this study)	144.6±0.55	102.2±0.45	24±0	216.4±0.55	8.8±0.45	806.4±5

[a] n.r. = no report; n.m.=not measured

Table 2. Elemental concentrations for the archaeological samples. All measurements in parts per million (ppm).

Sample	Rb	Sr	Y	Zr	Nb	Ba	Source
AZCC:2:235-1-446	236	18	42	115	27	49	Mule Cr/AC-MM
AZCC:2:235-1-450	233	19	42	112	27	74	Mule Cr/AC-MM
AZCC:2:235-1-455	239	19	43	114	27	65	Mule Cr/AC-MM
AZCC:2:235-1-507	235	19	41	114	27	60	Mule Cr/AC-MM
AZCC:2:235-1-550	229	18	41	113	27	77	Mule Cr/AC-MM
AZCC:2:235-2-450	235	19	41	115	27	61	Mule Cr/AC-MM
AZCC:2:235-2-507	233	19	41	116	28	78	Mule Cr/AC-MM
AZCC:2:235-2-550	233	20	41	114	28	75	Mule Cr/AC-MM
AZCC:2:235-3-507	139	132	21	126	15	1002	Cow Canyon/111Ranch
AZCC:2:235-3-550	424	13	73	110	121	15	Mule Cr/N Sawmill Cr
AZCC:2:235-7-11	245	19	39	112	26	50	Mule Cr/AC-MM
AZCC:2:235-7-414	249	18	42	113	28	49	Mule Cr/AC-MM
AZCC:2:235-7-426	239	17	42	114	28	65	Mule Cr/AC-MM
AZCC:2:235-7-477	232	18	41	114	27	62	Mule Cr/AC-MM
AZCC:2:235-9-561	245	21	41	117	27	77	Mule Cr/AC-MM
AZCC:2:290-0-1	133	126	20	124	15	1009	Cow Canyon/111Ranch
AZCC:2:290-0-2	128	124	20	120	14	925	Cow Canyon/111Ranch
AZCC:2:290-4-9	136	131	20	125	15	996	Cow Canyon/111Ranch

Table 3. Crosstabulation of site by obsidian source provenance.

			SOURCE			
			Cow Canyon/111 Ranch	Mule Cr/AC-MM	Mule Cr/N Sawmill Cr	Total
SITE	235	Count	1	13	1	15
		% within SAMPLE	6.7%	86.7%	6.7%	100.0%
		% within SOURCE	25.0%	100.0%	100.0%	83.3%
		% of Total	5.6%	72.2%	5.6%	83.3%
	290	Count	3			3
		% within SAMPLE	100.0%			100.0%
		% within SOURCE	75.0%			16.7%
		% of Total	16.7%			16.7%
Total		Count	4	13	1	18
		% within SAMPLE	22.2%	72.2%	5.6%	100.0%
		% within SOURCE	100.0%	100.0%	100.0%	100.0%
		% of Total	22.2%	72.2%	5.6%	100.0%

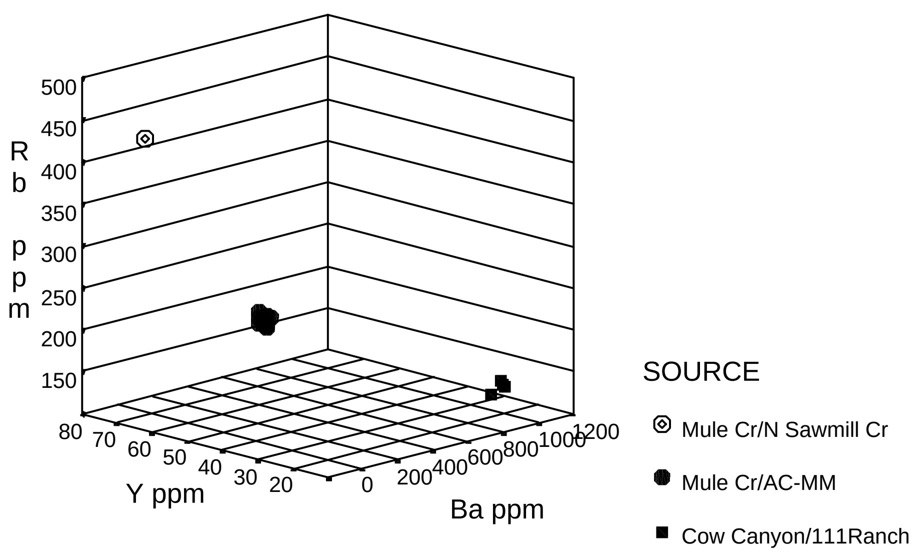


Figure 1. Rb, Y, Ba three dimensional plot of archaeological data. Mule Cr/AC-MM = Antelope Creek and Mule Mountain groups not separated here (see Shackley 1998a).

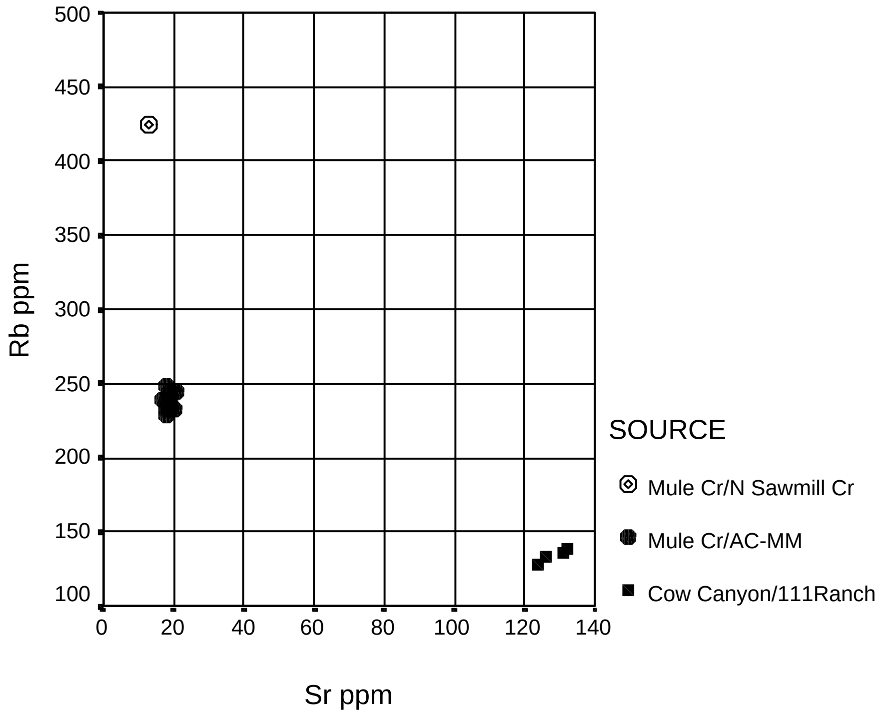


Figure 2. Rb versus Sr biplot of archaeological data. Mule Cr/AC-MM = Antelope Creek and Mule Mountain groups not separated here (see Shackley 1998a).

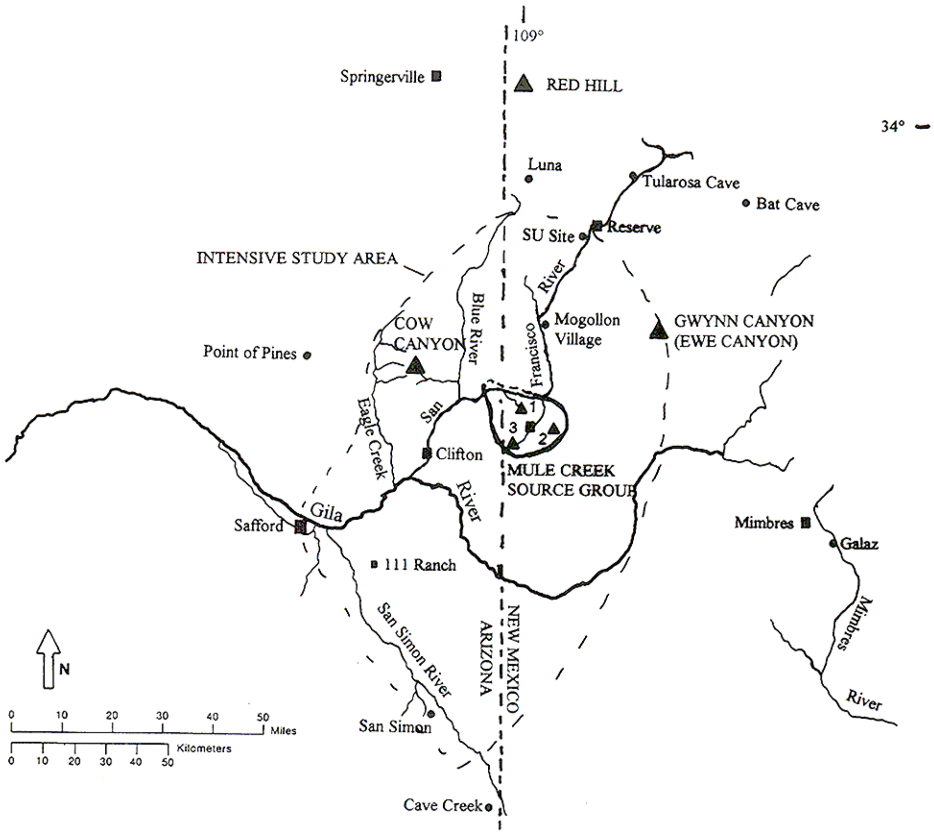


Figure 3. The eastern Arizona/western New Mexico region and sources of archaeological obsidian and the center of the 111 Ranch Formation. Sources = filled triangles; modern towns = filled squares; archaeological sites = filled circles. Mule Creek source localities = 1-Antelope Creek; 2 – Mule Mountains; 3 – North Sawmill Creek.