SOURCES OF OBSIDIAN FROM THE GATLIN SITE (AZ Z:2:1 ASM) SOUTHWESTERN ARIZONA: AN ENERGY DISPERSIVE X-RAY FLUORESCENCE (EDXRF) ANALYSIS

by

M. Steven Shackley, Ph.D.

Phoebe Hearst Museum of Anthropology
University of California, Berkeley

A Project Funded by the City of Gila Bend, Arizona

Dr. David Doyel, Project Director

18 September 1992

INTRODUCTION

The character of obsidian procurement during all periods of Hohokam occupation in Arizona is, at best, in a very preliminary form, particularly for the pre-Classic period contexts (Shackley 1992a). The recent geochemical analysis of 220 obsidian artifacts from Classic period contexts at Pueblo Grande suggested that this procurement is quite complex and both direct access and exchange occurs during this time period (Peterson et al. 1992). At Pueblo Grande the high diversity of obsidian source provenience may have been due to unequal utilization of sources by different segments of the population. Whether these inferences are truly an effect of social complexity within the greater Hohokam society, or a unique effect at Pueblo Grande is still a testable inference.

So few studies of pre-Classic period Hohokam obsidian have been undertaken, that it is difficult to derive inferences concerning the probable source provenience (Shackley 1986). The majority of archaeological obsidian geochemical studies have focused on early hunter-gatherer or Classic period contexts (Peterson et al. 1992; Shackley 1989, 1990). This analysis constitutes the largest pre-Classic Hohokam obsidian study thus far.

Quite expectably, over 89% of the obsidian analyzed was derived from the nearby Sauceda Mountains source. However, one piece each of Superior and Vulture obsidian was included, and four pieces of what I have identified as Unknown A in the Pueblo Grande study were also present (Shackley 1992a).

ANALYSIS AND INSTRUMENTATION

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 Spectrace 440 (United Scientific Corporation) energy dispersive x-ray fluorescence spectrometer. The spectrometer is equipped with a Rh x-ray tube, a 50 kV x-ray generator, with a Tracor X-ray (Spectrace) TX 6100 x-ray analyzer using an IBM PC based microprocessor and Tracor reduction software. The x-ray tube was operated at 30 kV, .20 mA, using a .127 mm Rh primary beam filter in a vacuum path at 250 seconds livetime to generate x-ray intensity data for elements titanium (Ti), manganese (Mn), iron (as FeO^T), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). Trace element intensities were converted to concentration estimates by employing a least-squares calibration line established for each element from the analysis of up to 26 international rock standards certified by the U.S. Bureau of Standards, the U.S. Geological Survey, Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1989). Further details concerning the petrological choice of these elements in Southwestern obsidians is available in Shackley (1988, 1990, 1992b).

In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards. Table 1 shows a comparison between values recommended for two international rock standards, one rhyolite (RGM-1) and one obsidian (NBS-278). One of these standards is analyzed during each sample run to insure machine calibration. The results shown in Table 1 indicate that the machine accuracy is quite high, and other instruments with comparable precision should yield comparable results.

Trace element data exhibited in Tables 1 and 2 are reported in parts per million (ppm), a quantitative measure by weight. Source probability is based on a comparison with 1-sigma levels of variability. Table 2 exhibits the trace element concentrations for the 55 samples, and Figures 1 through 4 exhibit concentration plots of five of the analyzed elements.

DISCUSSION

The mix of obsidian source provenience in the Gatlin Site assemblage is quite expectable (Table 3 and Figure 5). As I have noted elsewhere, the Sauceda Mountain source material may actually be available in alluvium all the way to the north bank of the Gila River near Gila Bend (Shackley 1988, 1990). This is a very complex Tertiary age source suggesting extreme fractionation and probably more than one eruptive episode from a single magma chamber. The two distinct geochemical modes evident in Figures 3 and 4 demonstrate this well.

Vulture is the next nearest source and was present as a "cortical flake". More interesting is the presence of a "Sacaton-like" projectile point produced from obsidian obtained from Superior (Picketpost Mtn) over 180 km west. Superior obsidian is relatively uncommon in all Hohokam periods, suggesting some form of control by the Salado groups occupying the region, or at least limited access by Hohokam tool makers (Peterson et al. 1992; Shackley 1991, 1992c). Given that the specimen is a projectile point, it is *possible* that it was produced at some other site closer to the source.

The four specimens that could not be assigned to a known source (9, 10, 35, 38), are geochemically identical to four unreduced nodules recovered from Pueblo Grande (Peterson et al. 1992; Shackley 1992a). Very likely this is a Tertiary period Sonoran Desert source, like Tank Mountains that may have been located outside the Hohokam interaction sphere (Shackley 1991). This source has not appeared in any other context known to me. This unlocated source is characterized by gray-banded to nearly transparent brownish-gray glass typical of other Tertiary sources in the Southwest.

While the analysis of these 55 obsidian artifacts is an important step in the understanding of pre-Classic Hohokam obsidian procurement, the Gatlin Site's location so near to the Sauceda Mountains source indicates caution in using these data in interpreting procurement patterns at contemporaneous sites. Obsidian generally is uncommon at pre-Classic sites and the Gatlin Site is probably the exceptional case. Nevertheless, the presence of non-local obsidian in this time period is another important piece of information useful in the understanding of obsidian procurement, interaction, and exchange in the Hohokam region.

REFERENCES CITED

Glascock, Michael D.
1991 *Tables for Neutron Activation Analysis* (3rd edition). Research Reactor Facility, University of Missouri, Columbia.

Govindaraju, K.
1989 1989 Compilation of Working Values and Sample Description for 272 Geostandards. *Geostandards Newsletter* 13 (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.

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.

Peterson, Jane, Douglas R. Mitchell, and M. Steven Shackley
1992 Obsidian X-Ray Fluorescence Data from Pueblo Grande, Arizona: Modelling Social and Economic Patterns in Lithic Procurement. In Proceedings of the 28th International Symposium on Archaeometry, in press.

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
1986 Diachronic and Spatial Variability of Obsidian Procurement in the American Southwest: A Trace Element Exploration of Southwest Obsidian Sources. Paper presented at the 51st Annual Meeting of the Society for American Archaeology, New Orleans.

1988 Sources of Archaeological Obsidian in the Southwest: An Archaeological, Petrological, and Geochemical Study. *American Antiquity* 53(4):752-772.

1989 X-Ray Fluorescence Analysis (XRF) of Obsidian Artifacts from the Grand Canal, Casa Buena, and Pueblo Grande Hohokam Sites, Central Arizona. In *Archaeological Investigations at the Grand Canal Ruins: A Classic Period Site in Phoenix, Arizona*, edited by D.R. Mitchell, pp. 987-992. Soil Systems Publications in Archaeology 12. Phoenix.

1990 *Early Hunter-Gatherer Procurement Ranges in the Southwest: Evidence from Obsidian Geochemistry and Lithic Technology*. Unpublished Ph.D. dissertation, Department of Anthropology, Arizona State University, Tempe.

1991 Tank Mountains Obsidian: A Newly Discovered Archaeological Obsidian Source in East-Central Yuma County, Arizona. *Kiva* 57(1):17-25.

1992a Sources of Obsidian at Pueblo Grande: An Energy Dispersive X-Ray Fluorescence (EDXRF) Analysis. Report prepared for Soil Systems Analysis, Inc., Phoenix.

1992b The Upper Gila River Gravels as an Archaeological Obsidian Source Region: Implications for Models of Exchange and Interaction. *Geoarchaeology* 7(4):315-326.

1992c Sources of Obsidian from the Escalante Ruin Group, Central Arizona: An Energy Dispersive X-Ray Fluorescence (EDXRF) Analysis. Report prepared for The Center for Indigenous Studies in the Americas, Phoenix.

Table 1. X-ray fluorescence concentrations for selected trace elements of two international rock standards. ± values represent first standard deviation computations for the group of measurements. All values are in parts per million (ppm) as reported in Govindaraju (1989) and this study. RGM-1 is a U.S. Geological Survey rhyolite (obsidian) rock standard, and NBS-278 is a National Bureau of Standards obsidian standard.

SAMPLE	TiO_2	MnO	Rb	Sr	Y	Zr	Nb	Ba
RGM-1 (Govindaraju 1989)	2670	360	149	108	25	219	8.9	807
RGM-1 (this study)	2433.07±147.1	321.12±16.75	150±3.4	105±1.7	26±0.9	218±5	9.5±1.1	844±48.86
NBS-278 (Govindaraju 1989)	2450	520	127.5	63.5	41	295	n.r.[1]	1140
NBS-278 (this study)	2383.30	479.69	126±1.9	62±2.3	40±2.2	280±3.6	14±1.4	n.m.

1 n.r = no report; n.m. = not measured

Table 2. X-ray fluorescence concentrations for obsidian artifacts from the Gatlin Site (AZ Z:2:1 ASM). All measurements in parts per million (ppm). Multiplier for the calculation of Fe_2O_3 from Fe is 1.431 (Glascock 1991).

SAMPLE	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
1	1509.1	257.913	11075.193	159.64	102.77	20.634	182.01	17.761	Sauceda Mts
2	1551.2	285.648	11454.466	159.41	100.51	26.378	184.87	17.832	Sauceda Mts
3	1597.4	367.684	11955.163	178.19	78.74	36.13	211.75	21.763	Sauceda Mts
4	1421.4	254.786	11371.614	167.36	105.22	25.862	185.25	20.789	Sauceda Mts
5	1828.8	328.865	12989.474	181.92	121.38	26.388	204.94	16.691	Sauceda Mts
6	1736.6	282.175	11726.699	168.75	104.41	22.61	188.09	20.215	Sauceda Mts
7	1561.7	355.981	11432.582	170.72	73.04	35.688	199.01	22.229	Sauceda Mts
8	1422.3	339.745	11060.245	163.01	71.54	36.556	199.75	25.635	Sauceda Mts
9	1058.3	541.066	11253.209	168.16	10.44	37.186	252.27	32.698	Unknown A
10	1056.3	576.987	11847.356	171.66	12.34	39.326	262.68	30.133	Unknown A
11	1004.2	423.303	7699.794	115.36	19.99	21.424	88.68	34.407	Superior
12	1655.3	311.282	12607.954	176.74	110.38	25.737	196.86	21.514	Sauceda Mts
13	1367.4	346.81	10917.094	167.73	72.28	33.622	198.55	27.315	Sauceda Mts
14	1456.6	329.752	11331.25	174.88	83.32	34.79	211.8	22.934	Sauceda Mts
15	1526.6	345.022	11536.158	171.70	81.74	35.796	207.19	26.934	Sauceda Mts
16	1180.7	327.486	10720.704	160.13	74.52	32.24	201.61	23.336	Sauceda Mts
17	1408.3	293.553	11787.47	170.47	109.05	25.939	192.05	23.743	Sauceda Mts
18	2210.9	356.998	13233.153	152.57	79.84	32.827	217.29	24.108	Sauceda Mts
19	1736.3	317.804	12773.445	177.68	109.26	28.289	197.91	19.586	Sauceda Mts
20	1518.9	385.605	11792.224	168.08	74.06	31.245	207.13	20.378	Sauceda Mts
21	1737.7	427.046	12552.206	180.03	81.24	34.867	222.13	27.648	Sauceda Mts
22	1553.3	346.176	11781.322	165.23	74.79	32.734	201.98	24.829	Sauceda Mts
23	1542.4	289.502	10873.957	155.69	70.80	33.003	207.37	22.431	Sauceda Mts
24	1495.5	300.575	11635.992	161.37	109.59	29.015	194.64	19.066	Sauceda Mts
25	1214.7	331.099	10780.801	159.29	74.79	33.193	195.38	22.475	Sauceda Mts
26	1118.1	368.713	9216.954	153.04	46.95	21.999	145.63	27.596	Vulture
27	1442.8	287.01	11570.903	171.35	114.75	23.756	194.48	20.902	Sauceda Mts
28	1376.9	321.589	10209.301	151.89	69.98	29.641	197.41	25.078	Sauceda Mts
29	1713.2	361.479	11623.291	168.79	70.76	32.168	192.18	20.315	Sauceda Mts
30	1432.1	346.08	11950.602	174.29	79.99	32.521	209.67	23.281	Sauceda Mts
31	1089.0	327.126	10450.69	156.14	67.78	30.438	203.09	22.194	Sauceda Mts
32	1155.8	312.505	10354.317	157.81	71.26	34.579	188.32	22.831	Sauceda Mts
33	1224.4	251.478	10542.713	153.50	97.67	23.071	180.42	20.637	Sauceda Mts
34	1157.4	225.527	10620.908	155.06	103.56	27.996	183.45	19.413	Sauceda Mts
35	880.60	535.194	11222.604	162.70	11.16	36.839	241.16	28.189	Unknown A
36	1356.3	376.143	11845.562	176.15	79.55	34.944	220.09	26.502	Sauceda Mts
37	1186.2	250.697	10893.241	161.21	101.92	25.16	188.62	19.297	Sauceda Mts
38	923.04	497.185	11045.048	167.48	10.52	40.856	255.63	30.051	Unknown A
39	1257.2	328.648	10322.743	154.50	75.99	29.974	196.87	23.635	Sauceda Mts
40	1112.2	314.354	10149.024	153.94	70.98	30.459	196.92	17.058	Sauceda Mts
41	1259.1	262.201	10816.398	157.77	105.7	28.375	185.75	18.846	Sauceda Mts
42	1585.0	291.837	11720.855	176.79	108.45	27.223	195.63	15.285	Sauceda Mts
43	1313.6	279.892	11758.336	168.15	106.66	23.667	197.57	24.338	Sauceda Mts
44	1120.2	315.534	10701.913	166.71	73.95	31.748	204.25	21.281	Sauceda Mts
45	1106.7	306.743	10235.359	158.44	72.50	32.31	198.21	24.59	Sauceda Mts
46	1253.8	263.767	11172.148	169.58	108.34	23.168	193.93	24.801	Sauceda Mts
47	1425.4	339.902	11111.462	167.06	79.72	31.421	206.81	27.092	Sauceda Mts

SAMPLE	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
48	1173.1	291.351	10220.102	159.02	72.67	29.542	195.46	24.173	Sauceda Mts
49	1125.1	302.37	9628.57	140.49	67.60	31.708	193.52	23.77	Sauceda Mts
50	1375.2	346.749	11157.747	163.04	75.44	28.926	204.42	22.215	Sauceda Mts
51	1449.2	360.621	11762.105	175.44	78.88	40.135	217.73	23.803	Sauceda Mts
52	1371.3	230.91	10354.9	153.46	99.82	23.807	179.78	21.172	Sauceda Mts
53	1471.9	246.532	11229.364	166.06	105.18	25.089	187.89	20.751	Sauceda Mts
54	1610.0	274.403	11805.596	170.45	105.94	26.526	190.63	22.231	Sauceda Mts
55	1501.5	256.195	11986.798	166.87	104.08	25.321	190.43	18.513	Sauceda Mts

Figure 1. Fe versus Zr concentration plot for archaeological obsidian from the Gatlin Site (S=Sauceda Mts; Su=Superior; U=Unknown A; V=Vulture).

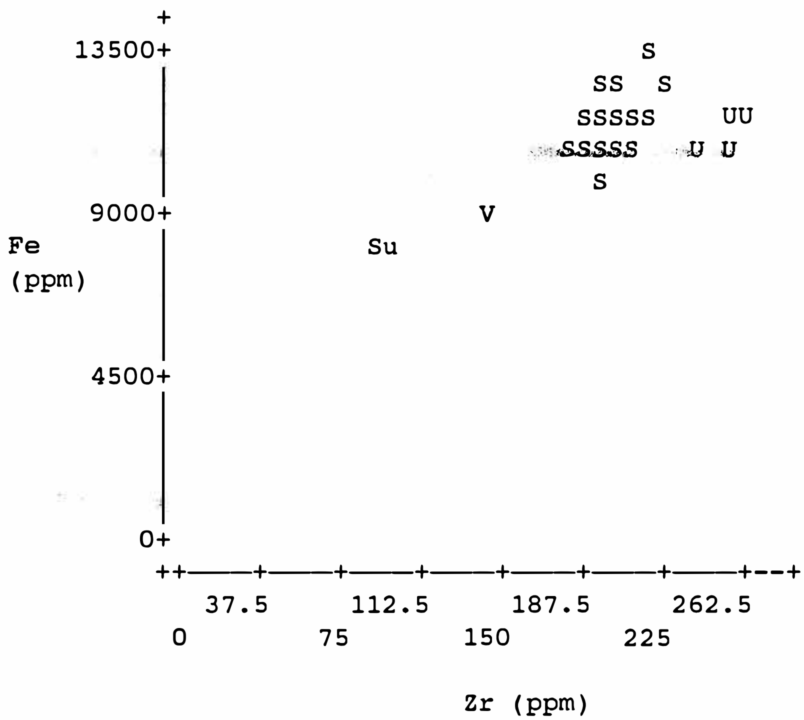

Figure 2. Ti versus Zr concentration plot for archaeological obsidian from the Gatlin Site (S=Sauceda Mts; Su=Superior; U=Unknown A; V=Vulture).

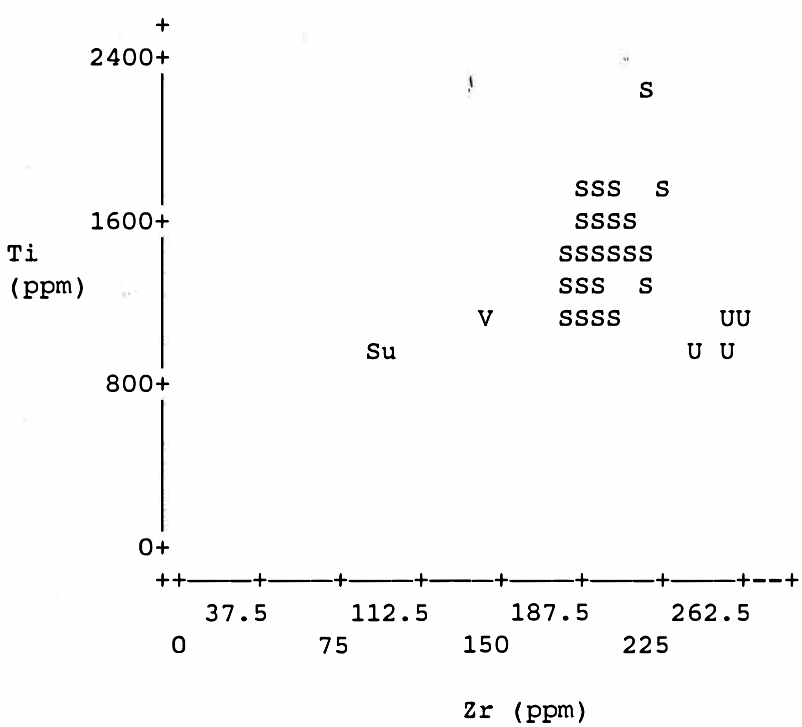

Figure 3. Rb versus Sr concentration plot for archaeological obsidian from the Gatlin Site (S=Sauceda Mts; Su=Superior; U=Unknown A; V=Vulture).

```
         +
      240+
         |
         |
         |
         |   UU                SSSSS     SSSS S
      160+   U         V     SSSSS    SSSS
Rb       |                   SS
(ppm)    |
         |      Su
         |
       80+
         |
         |
         |
         |
        0+
         ++-----+-----+-----+-----+-----+-----+-----+--+
            17.5      52.5      87.5     122.5
          0        35        70       105

                            Sr (ppm)
```

Figure 4. Sr versus Zr concentration plot for archaeological obsidian from the Gatlin Site (S=Sauceda Mts; Su=Superior; U=Unknown A; V=Vulture).

```
         +
    127.5+
         |                          SS
         |                          S
         |                        SS
         |                        S
       85+                            S S
Sr       |                          SSSS
(ppm)    |                         SSSS
         |
         |                   V
     42.5+
         |
         |
         |            Su
         |                                U UU
        0+
         ++-----+-----+-----+-----+-----+-----+-----+--+
            37.5     112.5     187.5     262.5
          0        75       150       225

                            Zr (ppm)
```

Table 3. Frequency distribution of obsidian source provenience at the Gatlin Site.

Source	Frequency	Percent
Superior	1	1.8
Vulture	1	1.8
Unknown A	4	7.3
Sauceda Mts	49	89.1
TOTAL	55	100.0

Figure 5. Frequency histogram for obsidian source provenience at the Gatlin Site.