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**SOURCES OF OBSIDIAN FROM THE CLASSIC PERIOD HOHOKAM
COMMUNITY OF MARANA (AZ AA 12:251 ASM): AN ENERGY
DISPERSIVE X-RAY FLUORESCENCE (EDXRF) ANALYSIS**

by

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INTRODUCTION

The character of obsidian procurement during all periods of Hohokam occupation in Arizona is, at best, in a very preliminary form. The recent geochemical analysis of 220 obsidian artifacts from 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 provided the impetus for another study of obsidian artifacts from the Escalante Ruin Group near Florence, Arizona, and this project.

Based on a preliminary analysis of obsidian artifacts from some other Classic period Hohokam contexts I have argued that Northern Arizona obsidian was not a common feature in late Hohokam sites (Shackley 1988, 1989). The analysis of the Pueblo Grande sample indicates that this is not the case. The sample exhibited a substantial proportion (25.9%) of obsidian from Government Mountain and Partridge Creek in north central Arizona. Indeed, the obsidian assemblage from Pueblo Grande exhibited glass from seven known and three unknown sources. The source provenience of the material did not conform to the Law of Monotonic Decrement and other explanations were investigated (Peterson et al. 1992).

The analysis here of 108 obsidian artifacts from Classic Period contexts at Marana in south-central Arizona indicates a similar diversity in the procurement of obsidian tool stone as found at Pueblo Grande and the Escalante Ruin Group to the north with a few important exceptions.

ANALYSIS AND INSTRUMENTATION

All samples were analyzed whole, and were washed in distilled water before analysis. 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 $K\alpha$ -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 ($Fe=Fe_2O_3^T$) can be derived by multiplying ppm estimates by 1.431 (Glascok 1991). 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 Southwest obsidians is available in Shackley (1988, 1990, 1991, 1992a; also Mahood and Stimac 1991).

The data from the Tracor software were translated directly into Quattro Pro 4.0 software for manipulation and on into SPSSPC+ 3.0 for statistical analyses. 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 continued machine calibration. The results shown in Table 1 indicate that the machine accuracy is quite high.

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 level of variability. Table 2 exhibits the trace element concentrations for the 108 samples. Figures 1 through 5 display bivariate plots of the data using six of the measured elements. For separating Vulture and Superior, Mn and Ba (not measured) are most effective (see Figure 5). Saucedo Mountains and Cow Canyon data are most effectively separated with Y and Zr. All the other sources separate readily using many measured elements (see Shackley 1990, 1991 1992a).

SPATIAL AND CULTURAL INFERENCES

Treating the site as a single component locus of obsidian procurement, a number of inferences and observations can be made. One of the first and basic observations directed toward provenience analyses is the determination of distance and direction to sources. A primary measure is the Law of Monotonic Decrement that states that in circumstances of uniform loss or deposition, artifacts produced from a given source material will occur in monotonically decreasing proportions as the effective distance from the source increases (Renfrew 1977).

Table 3 and Figure 6 exhibit the frequency distribution, distance to source, and direction for the Marana data. Immediately apparent is that the nearest source, Superior, is relatively uncommon in the assemblage (4.6%), with twice as much material from the Vulture source (9.3%) over twice the distance in the opposite direction. As is the case in all Classic period Hohokam contexts analyzed thus far, the vast majority of obsidian (77.8%) is derived from the Saucedo Mountains source 130 km west (Peterson et al. 1992, Shackley 1992b). The distance/assemblage proportion relationship can be seen graphically in Figure 7, a regression scattergram of the proportions plotted against linear distance. If

the Law of Monotonic Decrement were operating perfectly we would see a perfect negative linear relationship ($r^2=1.0$) between proportion and distance. As you can see this is not the case, where $r^2=0.15$ (standard error of the estimate=65.06, significant at 0.52) reflecting the large scatter of data points and the dominance of one source provenience (Sauceda Mountains).

Two pieces of Cow Canyon material and five pieces of Mule Creek glass were also present in the analyzed assemblage (Tables 2 & 3). The primary deposit for Cow Canyon is on the western edge of the Mogollon Highlands in Greenlee County, Arizona, and the large Mule Creek source is south and east of Cow Canyon in eastern Arizona and western New Mexico (see Shackley 1988, 1990). Recent investigations in the Upper Gila and San Francisco River area indicate that material from Cow Canyon and Mule Creek is eroding into the Gila River alluvium at least as far west as Safford, Arizona (Shackley 1992a). It is important to note that all but one of the artifacts assigned to these two highland sources are projectile points, and could very likely have been exchanged or otherwise procured as complete artifacts. Four of the points are simple triangular concave-based points common throughout North America, or they may be late stage preforms (see Whittaker 1987). One of the points (Spec# 96) is a triangular side-notched style rather typical of Classic period Hohokam styles, suggesting it was produced by a Hohokam knapper rather than a Mogollon knapper in whose territory the Cow Canyon and Mule Creek sources are located (Cordell 1984; Haury 1936). A projectile point produced from Cow Canyon material was also recovered from the Escalante Ruin Group (Shackley 1992b).

The two pieces of obsidian designated *Unknown A* are from an as yet unlocated source that occurs with some regularity in Hohokam sites including Pueblo Grande and the Gatlin Site near Gila Bend. Most likely, this source is located somewhere in the Sonoran Desert, probably somewhere south of Saucedo Mountains and possibly north of Los Vidrios, although the generally small proportions in these assemblages suggest that it may be located some distance from the Hohokam "heartland."

CONCLUSION AND SUMMARY

Obsidian raw material or finished artifacts at Marana were procured from many sources to the northeast, northwest, and west including a variety of environments from the Sonoran Desert (Sauceda Mts, Superior, Vulture), to piñon-juniper woodlands (Cow Canyon, Mule Creek). During the Archaic period, these upland environments were important resource areas exploited in the late summer and fall. The Hohokam procurement of obsidian in these environments could be the result of similar logistic forays into these environments, or a result of interaction and exchange.

One important aspect of the research here was an investigation of the presence of Superior obsidian in Hohokam contexts. At Pueblo Grande a relatively small proportion of glass material (10%) was derived from the nearest source Superior (Picketpost Mtn) only 80 km distant, possibly due to an effect of source control by Salado groups. In the Escalante Ruin Group assemblage even though it is much closer to the source (≤ 30 km) only about 27% of the obsidian was derived from the Superior source. The source is at least 30 km closer to these sites suggesting that the larger proportion is, at least, in part due to proximity. Taken as a whole, however, the Law of Monotonic Decrement does not explain the dominance of Sauceda Mountain material located at least 122 km west of all these sites. These data along with the Pueblo Grande and Escalante Ruin Group study increasingly suggest that the Superior material was relatively unavailable during the Classic Period.

Most of the Sonoran Desert sources (Sauceda Mountains, Vulture) can certainly be said to be within Classic period Hohokam "range". The Cow Canyon and Mule Creek derived material from the highlands is much more difficult to explain, but may be a effect of interaction with Mogollon or Salado groups to the east and north, also suggested by the continuing presence of Superior glass in these Hohokam contexts.

The diversity of sources in the obsidian assemblage at Marana is certainly provocative. The continued apparent preference for the more distant Saucedo Mountains obsidian versus Superior the nearest source among the "eastern" Classic Period Hohokam seems most likely to be related to access problems. Both Saucedo and Superior glass are equally excellent media for tool production and both are available in nodule sizes over 5 cm in diameter, and at high nodule densities at the source (Shackley 1988, 1990). Contact with other groups and/or direct procurement of obsidian in the highlands is again indicated in this sample as at Pueblo Grande and Escalante. Analyses of obsidian from other Classic Period contexts in other areas may provide more clarity.

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Table 1. X-ray fluorescence concentrations for selected trace elements of two international rock standards. $\pm$ 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. Element-to-Oxide conversions from Glascock (1991).

SAMPLE	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb
RGM-1 (Govindaraju 1989)	1600	279	12998	149	108	25	219	8.9
RGM-1 (this study)	1513.24 $\pm$ 46	232.86 $\pm$ 15	13813 $\pm$ 59	149.58 $\pm$ 4.05	108.03 $\pm$ 3	22.7 $\pm$.86	226.8 $\pm$ 2	10 $\pm$.28
NBS-278 (Govindaraju 1989)	1468	402	14256	127.5	63.5	41	295	n.r. ¹
NBS-278 (this study)	1405 $\pm$ 93	365 $\pm$ 8	15399 $\pm$ 394	130 $\pm$ 2	68 $\pm$ 2	43 $\pm$ 1.7	290 $\pm$ 4	18 $\pm$ 2

¹ n.r. = no report

Table 2. X-ray fluorescence concentrations for obsidian artifacts from Marana. All measurements in parts per million (ppm).

SAMPLE	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	SOURCE
1	823.4	345.6	7960.6	139.7	35.6	20.4	129.7	24.7	Vulture
2	777.3	316.7	7556.4	124.9	35.1	20.2	118.5	25.7	Vulture
3	617.7	469.6	6671.0	119.0	13.7	24.1	90.9	28.2	Superior
4	951.9	263.9	7532.1	130.9	33.2	20.0	117.9	26.7	Vulture
5	1723.1	422.0	12160.4	182.2	83.4	30.1	213.4	25.3	Sauceda Mts
6	1006.7	368.5	8323.1	142.6	37.5	21.5	124.3	23.0	Vulture
7	1408.7	282.4	10735.3	162.8	107.4	24.4	183.7	16.8	Sauceda Mts
8	1349.2	268.3	10079.2	152.9	93.9	25.8	180.5	15.5	Sauceda Mts
9	1393.4	319.0	10046.8	160.4	72.4	32.8	196.6	22.8	Sauceda Mts
10	1301.9	181.7	9077.0	135.3	87.7	25.2	146.4	13.9	Sauceda Mts*
11	533.9	284.4	8380.1	222.2	13.4	33.0	104.6	24.1	Mule Cr
12	1095.5	262.9	8840.0	132.3	62.0	27.5	170.0	24.3	Sauceda Mts*
13	1418.4	348.9	10263.4	160.1	69.9	33.5	187.9	22.0	Sauceda Mts
14	1668.2	302.0	12478.1	176.4	114.1	33.5	195.9	19.7	Sauceda Mts
15	1078.2	199.4	9308.9	134.3	92.7	20.5	140.9	15.0	Sauceda Mts*
16	1471.9	297.8	11087.5	161.7	107.1	24.0	179.6	17.8	Sauceda Mts
17	1630.1	313.6	12274.8	170.3	115.1	19.8	171.3	16.4	Sauceda Mts
18	1433.1	244.7	10299.1	152.2	93.0	28.2	173.7	13.2	Sauceda Mts
19	1337.7	260.7	9002.3	141.1	61.6	30.5	173.4	22.2	Sauceda Mts*
20	1633.0	303.3	11115.8	173.2	103.8	27.9	180.2	18.5	Sauceda Mts
21	2071.5	429.2	13028.6	190.8	86.5	32.6	205.6	22.4	Sauceda Mts
22	1392.2	219.3	10043.1	147.4	98.4	27.9	163.5	13.3	Sauceda Mts
23	1312.6	301.1	9498.6	153.7	69.8	30.7	179.6	18.2	Sauceda Mts
24	1569.9	234.1	10010.1	149.1	94.3	28.0	152.8	19.9	Sauceda Mts*
25	1518.9	371.8	11171.5	158.5	74.6	33.7	196.2	25.1	Sauceda Mts
26	1693.6	267.3	11258.0	167.9	107.7	24.3	179.4	14.8	Sauceda Mts
27	1530.8	329.5	10563.1	167.0	75.0	28.2	186.7	22.3	Sauceda Mts
28	1456.2	292.4	10104.8	141.2	75.1	25.5	176.0	18.2	Sauceda Mts*
29	1661.9	281.2	10712.9	154.8	100.3	24.8	161.9	17.8	Sauceda Mts*
30	1065.5	356.6	21451.0	127.9	4.0	76.7	636.7	49.5	Unknown A
31	1580.3	214.8	10077.0	143.1	97.1	28.9	157.5	9.7	Sauceda Mts*
32	1537.2	239.0	10303.3	152.4	96.3	23.6	172.4	12.0	Sauceda Mts*
33	835.9	337.2	7693.6	137.3	36.8	21.7	121.9	23.4	Vulture
34	1290.5	340.2	9925.1	155.8	73.2	31.7	197.9	19.8	Sauceda Mts
35	1644.2	273.2	11564.2	161.0	95.6	26.0	175.0	14.0	Sauceda Mts
36	1281.1	266.2	9693.7	155.2	71.6	31.8	190.3	26.4	Sauceda Mts
37	849.3	332.5	7633.1	133.6	41.0	21.3	124.8	18.4	Vulture
38	700.7	484.7	6662.2	117.8	12.9	24.8	89.3	24.9	Superior
40	613.8	491.7	6811.3	116.8	12.4	28.5	85.9	24.5	Superior
42	1542.6	282.5	10880.4	161.9	110.8	26.8	178.6	19.2	Sauceda Mts
43	1782.5	296.8	12044.0	178.6	116.8	25.1	183.0	18.9	Sauceda Mts
45	1699.9	349.7	12132.1	168.1	114.3	24.1	177.2	11.6	Sauceda Mts
46	1439.8	250.2	10267.8	154.3	99.0	27.2	172.4	20.1	Sauceda Mts
47	1787.9	239.7	10765.0	152.1	99.5	19.2	161.2	15.0	Sauceda Mts
48	1534.3	239.3	10413.1	152.8	105.4	27.4	166.5	19.9	Sauceda Mts
50	1385.3	240.5	10464.2	156.3	101.0	26.2	173.1	16.8	Sauceda Mts
51	1957.5	374.6	12890.1	178.4	119.8	26.8	177.2	21.2	Sauceda Mts
52	1337.9	232.9	10291.4	147.2	100.7	23.9	170.8	24.5	Sauceda Mts*

SAMPLE	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	SOURCE
53	1371.8	193.1	9923.4	143.3	96.4	19.5	156.0	17.7	Sauceda Mts*
54	1434.5	273.5	10690.9	149.1	100.4	25.8	170.8	15.9	Sauceda Mts*
55	1326.7	260.0	10378.1	155.6	102.6	24.7	176.8	24.5	Sauceda Mts
56	1395.9	237.2	10792.6	151.9	104.1	23.1	176.0	13.1	Sauceda Mts
57	1342.5	257.9	10321.4	155.6	100.2	24.7	175.1	19.0	Sauceda Mts
58	1385.5	232.5	10389.6	157.7	102.9	26.3	183.2	18.0	Sauceda Mts
61	1406.4	355.7	10398.8	156.7	69.9	30.7	195.0	26.2	Sauceda Mts
62	1397.7	223.5	10094.7	150.9	90.9	21.9	154.8	17.5	Sauceda Mts
63	1358.9	240.1	9984.0	148.7	96.6	24.4	165.8	23.0	Sauceda Mts
64	1313.2	271.7	9830.2	142.2	92.2	24.9	159.3	19.7	Sauceda Mts
65	1456.7	316.7	8937.7	137.3	63.8	33.2	174.2	23.8	Sauceda Mts
66	576.3	438.1	6411.9	108.2	16.2	22.1	88.11	28.9	Superior
67	1511.3	292.2	11086.2	164.7	105.0	24.9	184.1	22.4	Sauceda Mts
68	1505.4	268.0	10956.2	164.9	109.0	26.2	184.0	17.5	Sauceda Mts
69	1464.8	254.5	10369.2	160.9	105.6	23.4	179.1	15.0	Sauceda Mts
70	1359.1	313.2	9985.2	156.0	80.1	30.2	190.6	20.4	Sauceda Mts
71	900.8	383.3	8147.3	145.0	37.8	21.9	127.1	22.2	Vulture
72	1967.6	354.1	13151.9	170.1	117.6	24.0	174.2	16.4	Sauceda Mts
73	1596.6	247.6	10881.9	165.2	106.5	27.5	176.9	21.9	Sauceda Mts
74	1276.6	274.4	9276.2	143.6	63.8	27.9	170.9	15.4	Sauceda Mts*
75	1255.8	236.0	9822.3	152.7	101.7	27.0	174.5	18.1	Sauceda Mts
76	1602.8	333.0	11042.7	164.1	79.3	31.9	202.4	27.5	Sauceda Mts
77	1507.3	238.2	10538.0	157.2	101.4	22.4	179.9	11.9	Sauceda Mts
78	1561.8	271.2	11517.1	165.6	109.7	28.3	190.5	22.1	Sauceda Mts
79	1461.4	283.0	10774.4	160.9	104.4	28.2	179.2	19.7	Sauceda Mts
80	1015.6	389.2	8047.7	138.2	37.6	18.2	122.9	19.7	Vulture
81	1658.2	269.9	10504.2	150.1	98.6	25.2	161.7	13.4	Sauceda Mts
82	1494.5	290.1	11261.3	163.2	107.0	27.6	195.6	20.3	Sauceda Mts
83	1323.3	233.3	10259.0	147.9	94.8	28.0	166.4	18.4	Sauceda Mts
84	1494.3	207.6	10066.5	146.7	106.9	23.3	165.3	17.1	Sauceda Mts*
85	1206.3	249.0	9955.8	145.8	110.2	22.9	166.0	15.2	Sauceda Mts
86	1203.5	239.7	9565.7	140.9	91.5	24.1	163.3	14.0	Sauceda Mts
87	898.8	298.4	8121.6	124.1	46.5	21.2	122.7	20.2	Vulture
88	1826.7	268.1	11070.8	153.3	105.7	25.3	168.1	15.3	Sauceda Mts
89	1557.7	197.3	9949.1	146.4	95.5	30.6	163.7	19.3	Sauceda Mts
90	1606.4	352.5	10093.5	154.1	72.2	29.4	185.3	19.1	Sauceda Mts
91	1524.7	246.1	10105.5	143.9	101.6	23.4	164.2	16.3	Sauceda Mts
92	1590.2	255.4	10349.6	144.5	97.7	22.8	171.4	12.1	Sauceda Mts
93	1501.5	278.4	11340.0	167.5	105.3	27.6	183.1	21.9	Sauceda Mts
94	1386.5	240.8	10821.2	156.1	102.0	23.0	174.5	21.7	Sauceda Mts
95	1529.8	245.6	9948.4	149.7	91.9	25.1	154.8	8.9	Sauceda Mts
96	1413.7	489.2	9702.1	150.6	139.7	21.1	122.6	13.2	Cow Canyon
97	554.0	330.4	8845.8	231.7	13.4	37.0	109.1	18.3	Mule Cr
98	873.9	352.0	7780.7	130.9	36.8	21.4	119.7	23.2	Vulture
99	929.9	318.6	7498.3	190.8	20.9	30.4	124.4	15.9	Mule Cr
100	1469.5	289.5	9483.2	133.7	63.2	29.5	171.1	17.8	Sauceda Mts*
101	808.5	534.0	7033.3	124.4	30.5	24.3	89.6	28.3	Superior
102	642.0	386.6	9593.8	247.4	19.0	37.8	111.6	29.4	Mule Cr
103	764.0	387.6	6606.0	130.5	74.2	15.0	80.1	13.7	Cow Canyon
104	407.6	396.3	8165.9	238.7	6.3	40.0	84.9	51.7	Mule Cr
105	1471.8	231.5	10378.3	154.6	101.9	23.3	168.2	22.3	Sauceda Mts
106	1472.7	337.9	10503.8	152.3	70.3	26.6	176.7	16.7	Sauceda Mts*

SAMPLE	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	SOURCE
107	1440.7	238.4	11003.1	152.1	92.8	22.8	166.2	23.2	Sauceda Mts
108	1294.8	305.3	9731.6	152.9	63.0	29.3	179.7	19.9	Sauceda Mts
109	1302.2	275.0	10556.4	161.0	105.3	26.6	180.3	20.6	Sauceda Mts
110	1348.9	337.5	10070.7	158.1	69.7	26.8	188.7	22.6	Sauceda Mts
111	1285.3	253.5	9271.6	130.6	91.5	24.7	166.6	19.5	Sauceda Mts*
113	1132.7	487.0	26305.4	142.1	8.17	85.2	732.2	47.6	Unknown A
114	1555.5	279.9	11116.8	168.3	112.9	28.3	185.4	16.7	Sauceda Mts
115	1466.7	341.3	10279.5	167.2	77.4	32.4	195.1	19.1	Sauceda Mts

* These samples were very thin, small in diameter, and/or exhibited extremely irregular surfaces such that the concentrations may be skewed toward smaller concentrations and larger errors (see Jackson and Hampel 1992).

Figure 1. Concentration plot for Y versus Sr for the obsidian assemblage (C=Cow Canyon; M=Mule Creek; S=Sauceda Mountains; Su=Superior/Picketpost Mountain; V=Vulture; \$=multiple occurrence).

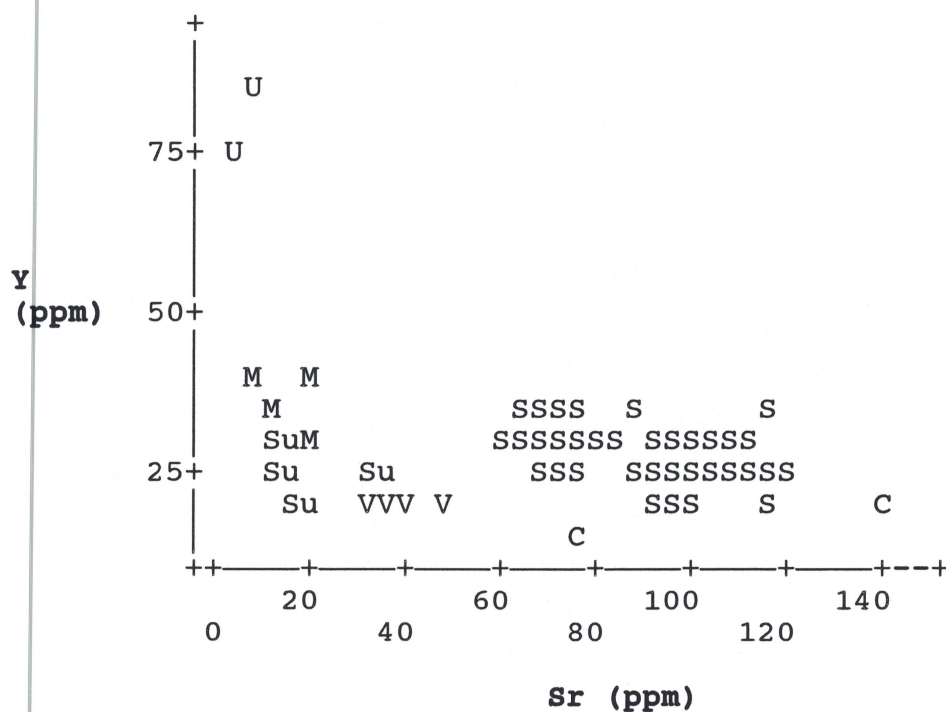


Figure 5. Concentration plot for Mn versus Sr for the obsidian assemblage (C=Cow Canyon; M=Mule Creek; S=Sauceda Mountains; Su=Superior/Picketpost Mountain; V=Vulture; \$=multiple occurrence).

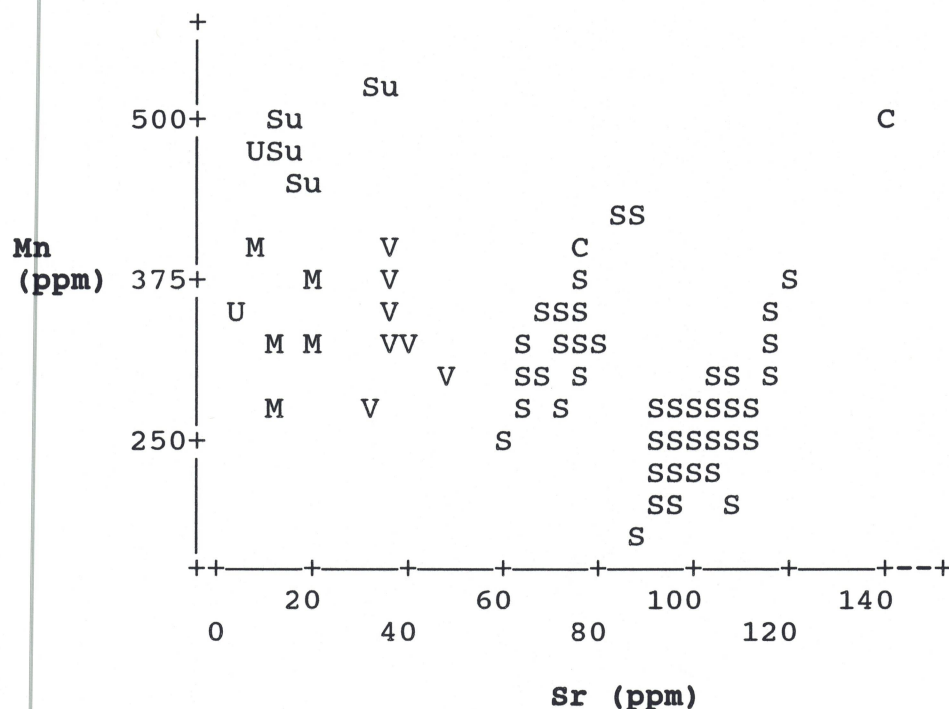


Table 3. Frequency distribution of obsidian source provenience.

Element	Frequency	Percent	Distance ¹ to Source (km)	Direction
Cow Canyon ^a	2	1.9	200	NE
Unknown A	2	1.9	n/a	n/a
Mule Creek ^a	5	4.6	210-250	NE
Superior ^b	5	4.6	90	N
Vulture	10	9.3	220	NW
Sauceda Mts	84	77.8	130	W
TOTAL	108	100.0		

¹ Straight-line distance; a Cow Canyon and Mule Creek material has been recovered from primary deposits on the western edge of the Mogollon Highlands to secondary contexts near Safford, Arizona (Shackley 1992a); b similarly Superior material is available in primary context at Picketpost Mountain and in the Queen Creek system to the west (Shackley 1988, 1990).

Figure 6. Frequency Histogram for the distribution of obsidian source provenience.

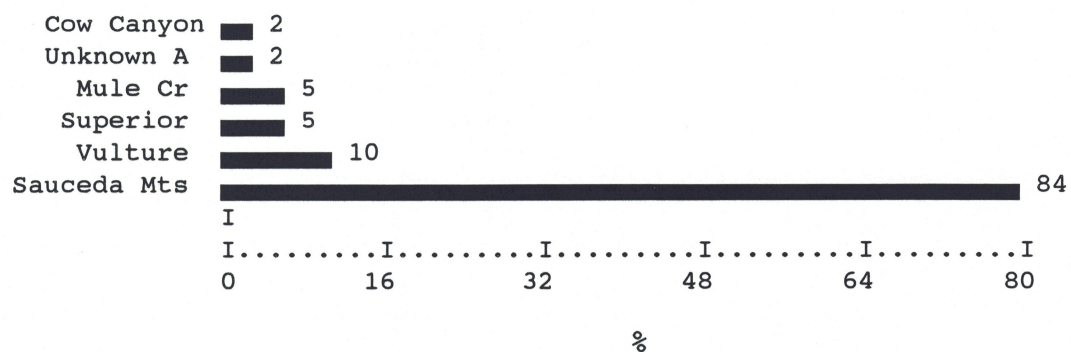


Figure 7. Regression Scatterplot for Distance to Source versus Assemblage Proportion.

