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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM CA-SMA-113, WEST-CENTRAL CALIFORNIA

CA-SMA-113 Arrowpoints produced from Napa Valley obsidian

by

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INTRODUCTION

The analysis here of 74 obsidian artifacts indicates a dominant source provenance from the Sonoma Volcanic Field, mainly one or more chemical groups of Napa Valley obsidian approximately 150 linear km north of SMA-113. Four samples were produced from the Annadel source in Napa Valley. One biface thinning flake was produced from the Sawmill Ridge chemical group at the Casa Diablo obsidian source, Long Valley Caldera in the eastern Sierra Nevada, and one sample possibly from the Dodge Reservoir source in the South Warner Mountains, northeastern California.

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 2010; Shackley 2010a). 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). Due to the generally small size of the artifacts, a 3.5 mm tube collimator was used for all analyses to concentrate x-ray energy into a smaller (≈4 mm) spot size (see Davis et al. 2011; Shackley 2011).

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 Hughes (1994) and Jackson (1986, 1989; see Table 2 and Figures 1 and 2 here), as well as source standard data at this lab.

RESULTS

Obsidian Sources in the Sonoma Volcanic Field

Before a discussion of the results, a brief outline of the major source group and geological context in the Sonoma Volcanic Field is helpful. The Sonoma Volcanic Field is a relatively complex and relatively recent field that produced mafic through silicic volcanics through a number of processes from phreatomagmatic ash flows to dome complex events (Fox 1983; Jackson 1986; Figure 3 here). Fox divides the field into two chronological units that grade from mafic to silicic, the latter including the obsidian relevant here (see Mankinen 1972). The lower member, in the southeastern portion of the field dates to 5.5 to 7.1 my, and the upper member exhibits dates as late as 1.4 my (Mankinen 1972; Figure 3 here). Both the early and later members produced rhyolite dome events that quenched rapidly enough to produce obsidian, and both are represented in the SMA-113 collection. Both Franz Valley and Annadel obsidian is contained in the upper member, and both are ably described by Jackson in his dissertation (1986) and subsequent paper (1989). Annadel is a large dome complex near Santa Rosa that produced large quantities of artifact quality obsidian, but mainly in small nodule sizes. Nodules up to 30 cm have been recovered in Santa Rosa Creek by Jackson, but these are difficult to locate today (Jackson 1989:82-83). The quality is as good as any obsidian, and was frequently used throughout northern California.

Franz Valley is a very small dome complex that exhibits relatively high Sr concentrations for Sonoma Volcanic rhyolites (see Table 2). It is a high quality obsidian, but is only available in nodule sizes generally less than 9 cm in diameter based on my reconnaissance.

The elemental composition of Annadel and Franz Valley is very similar (Jackson 1989: Table 1). Only the mean is listed in Jackson's tables, so it is difficult to know whether the composition actually overlaps. Jackson does state that "Franz Valley obsidian is chemically differentiated from Napa Valley obsidians by barium element concentrations in excess of 600 ppm", but analyses at this lab indicate overlapping Ba values between the two sources (Jackson 1989:86; Table 2 here). Rb values are a bit higher for Annadel, so given the values here are classified as Annadel for this study. The numeric superiority of Annadel at the source also argues for this assignment.

The Upper Member contains the Napa Glass Mountain chemical group, called Napa Valley by Jackson, a very large dome complex on the east side of the Napa Valley (Fox et al. 1973; Jackson 1986, 1989). While Jackson split the various quarries into four parts, they are chemically indistinguishable and only extend about 5 km north-south, some of which are likely secondary deposits. Napa Glass Mountain is the largest exposure, likely a vent emptying the magma chamber, with a large volume of artifact quality obsidian exhibiting nodules up to 35 cm in diameter. Prehistoric reduction of obsidian at this dome is at least 100,000 cubic feet, in some places nearly 2 meters deep (Heizer 1951; Jackson 1989). This is the densest concentration of the four exposures discussed by Jackson (1986, 1989).

It is important to mention that Napa Valley obsidian has been eroding into the Napa River all the way to the San Francisco Bay for more than 2 million years, and artifact quality obsidian is available in the Napa River delta at the bay. So, the Napa Valley obsidian is available throughout a large area in the eastern Napa Valley to the northern shores of San Francisco Bay. The route that prehistoric people transported the obsidian to SMA-113 is impossible to know, whether overland to the east, or by boat through the bay.

SOME THOUGHTS ON LITHIC TECHNOLOGY

Virtually all the artifacts here are debitage, most appear to be biface thinning flakes, likely from the production of projectile points. It is interesting that not more projectile points were recovered, but the thinning and probable rejuvenation flakes suggest a very active point production assemblage. It is also possible given the relatively tight elemental distribution of the Napa Valley obsidian, especially given the small debitage sizes, that all this obsidian could have come from just a few cores. The small debitage also suggests rather extreme conservation of this glass, probably in distinction to the Monterrey chert that is present in sediments in the region.

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Table 1. Recommended values for USGS RGM-1 obsidian standard and the mean and central tendency analyses from this study. ± = 1st standard deviation.

SAMPLE	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba
RGM-1 (Govindaraju 1994)	1600	279	12998	149	108	25	219	8.9	807
RGM-1 (USGS recommended)[1]	1619±120	279±50	13010±210	150±8	110±10	25[2]	220±20	8.9±0.6	810±46
RGM-1, pressed powder standard (this study, n=11)	1550±45	282±6	12922±194	146±3	106±2	25±3	216±3	9±2.6	818

[1] Ti, Mn, Fe calculated to ppm from wt. percent from USGS data.
[2] information value

Table 2. Elemental concentrations and source assignments for the archaeological specimens, and analyses of RGM-1 USGS obsidian standard. All measurements in parts per million (ppm).

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba	Source
Debitage										
6-009-A	985	228	11504	204	14	48	248	10		Napa Valley
9-007-A	1001	224	11145	200	13	44	245	6		Napa Valley
9-007-B	1088	232	12035	210	13	49	243	12		Napa Valley
20-007-A	1111	227	13414	226	13	50	257	9		Napa Valley
32-007-A	1361	368	17003	152	59	48	286	9	722	Annadel
36-007-A	918	203	10341	184	12	39	230	8		Napa Valley
42-007-A	894	194	9807	169	13	44	222	11		Napa Valley
74-007-A	1192	265	15024	239	14	51	253	13		Napa Valley
154-007-A	935	190	10172	181	14	40	219	10		Napa Valley
157-007-A	1919	314	18886	239	18	41	214	7		Napa Valley
175-007-A	1122	237	13755	227	14	49	256	13		Napa Valley
179-007-A	1110	217	12205	214	15	47	238	11		Napa Valley
183-007-A	1098	212	10370	189	12	47	219	14		Napa Valley
183-007-B	1058	214	12273	230	12	46	236	14		Napa Valley
190-007-A	1194	266	14167	231	14	46	242	11		Napa Valley
203-007-A	2000	262	13432	202	12	41	221	10		Napa Valley
206-007-A	1030	219	11160	194	15	48	238	11		Napa Valley
207-007-A	986	227	11286	203	12	49	240	13		Napa Valley
215-007-A	955	206	10412	190	11	46	233	10		Napa Valley
217-007-A	1071	240	12270	235	16	52	280	16		Napa Valley
217-007-B	1197	236	12428	217	12	50	239	12		Napa Valley
235-007-A	1286	280	16006	248	11	50	253	14		Napa Valley
241-007-A	1247	223	12244	204	15	47	244	14		Napa Valley
242-007-A	1110	234	12060	205	12	49	269	12		Napa Valley
242-007-B	1446	234	13000	211	16	44	225	10		Napa Valley

247-007-A	1728	422	19196	161	58	48	279	12	748	Annadel
255-007-A	1670	385	14276	179	106	19	191	12	1117	Sawmill Ridge (Casa Diablo)
255-007-B	1076	241	12081	213	15	44	260	10	544	Napa Valley
261-007-A	1233	236	13912	236	17	48	242	7	488	Napa Valley
262-007-A	1042	233	11211	192	11	41	236	11		Napa Valley
262-007-B	1011	231	12791	229	12	53	254	10	674	Napa Valley
264-007-A	949	218	11651	204	12	49	253	11		Napa Valley
270-007-A	971	220	10929	197	11	47	239	11		Napa Valley
271-007-A	1073	226	11747	194	12	49	238	9		Napa Valley
277-007-A	1159	235	12315	219	13	44	238	5	483	Napa Valley
295-007-A	1731	364	20064	255	13	47	242	14	399	Napa Valley
304-007-A	1417	307	17285	243	12	49	236	11		Napa Valley
324-007-A	991	189	10416	192	12	43	230	12		Napa Valley
343-007-A	1027	249	13041	229	13	48	270	16		Napa Valley
350-007-A	972	212	11454	209	17	48	244	13		Napa Valley
350-007-B	1035	233	12574	228	14	48	255	16		Napa Valley
352-007-A	1197	295	16629	263	16	52	261	10		Napa Valley
355-007-A	1087	260	13200	246	14	46	252	12		Napa Valley
361-007-A	1115	265	13916	237	14	48	248	6		Napa Valley
386-007-A	1087	244	14049	242	11	49	276	8		Napa Valley
389-007-A	1282	291	15162	230	12	45	282	4		Napa Valley
393-007-A	890	214	10884	214	16	47	242	10		Napa Valley
393-007-B	1207	252	13327	227	15	49	269	16		Napa Valley
399-007-A	1032	217	11590	204	12	44	230	10		Napa Valley
< 8 mm samples[1]										
0058-107	2437	566	25410	172	61	48	268	10		Annadel
0065-107	1361	265	14464	236	12	46	243	11		Napa Valley
0085-107	2200	320	16462	192	14	28	168	3		Napa Valley?
0377-107	289	48	9322	15	82	7	65	7		Dodge Reservoir, S Warner

	9	1		3					Mts,CA?
0090-107	1621	263	14009	194	14	37	195	6	Napa Valley
0072-107	1317	270	14061	211	12	43	223	12	Napa Valley
Projectile Points									
0002-013A	1004	229	11890	201	13	50	247	10	Napa Valley
0034-013A	958	209	11386	189	15	45	234	11	Napa Valley
0220-013A	959	221	10878	194	13	44	227	9	Napa Valley
0226-013A	1454	364	17013	145	60	51	294	10	Annadel
0235-013A	990	219	11161	189	13	44	230	12	Napa Valley
P1332-0-1	1004	228	11636	192	13	45	238	11	Napa Valley
P1332-0-2	1270	276	14341	222	15	49	248	12	Napa Valley
P1332-1-4	947	205	11138	189	14	47	238	13	Napa Valley
P1332-5-2	1294	228	11886	192	15	41	199	8	Napa Valley
P1332-6-2	1242	235	12796	199	13	42	229	8	Napa Valley
P1332-6-25	952	229	11329	191	14	45	233	7	Napa Valley
P1332-7-6	943	219	11252	191	13	41	237	12	Napa Valley
P1332-10-12	1236	242	12633	208	13	45	237	9	Napa Valley
P1332-10-24	1007	213	11253	194	14	45	247	8	Napa Valley
P1332-12-30	1022	228	11033	182	12	48	221	12	Napa Valley
P1332-13-4	1260	233	11887	193	14	44	226	11	Napa Valley
P1332-32-28	1016	214	11805	203	15	46	253	9	Napa Valley
P1332-35-1	1117	222	11360	181	14	45	221	6	Napa Valley
P1332-36-5	981	194	10686	176	13	45	213	11	Napa Valley

[1] Barium acquired for those samples where source assignment was difficult.

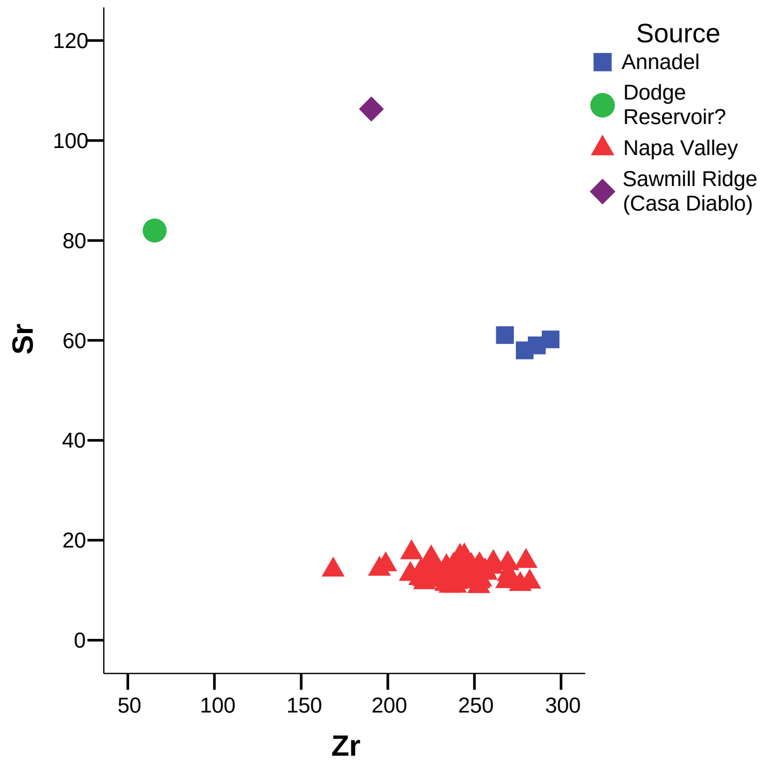

Figure 1. Zr versus Sr bivariate plot of the elemental concentrations for all the archaeological specimens.

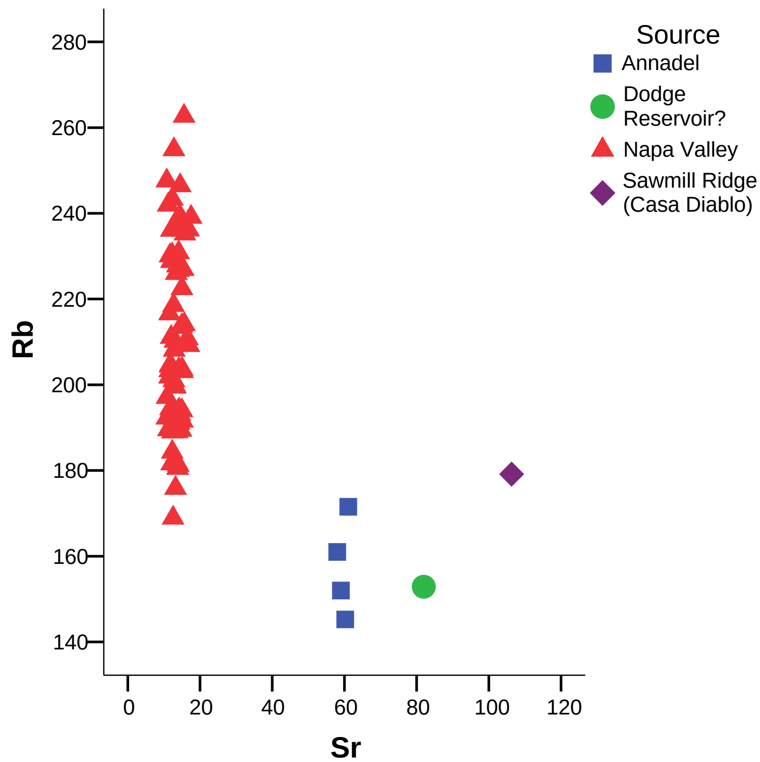

Figure 2. Sr versus Rb bivariate plot of the elemental concentrations for the artifacts. Variability in Rb due to variable sample sizes (see Davis et al. 2011).

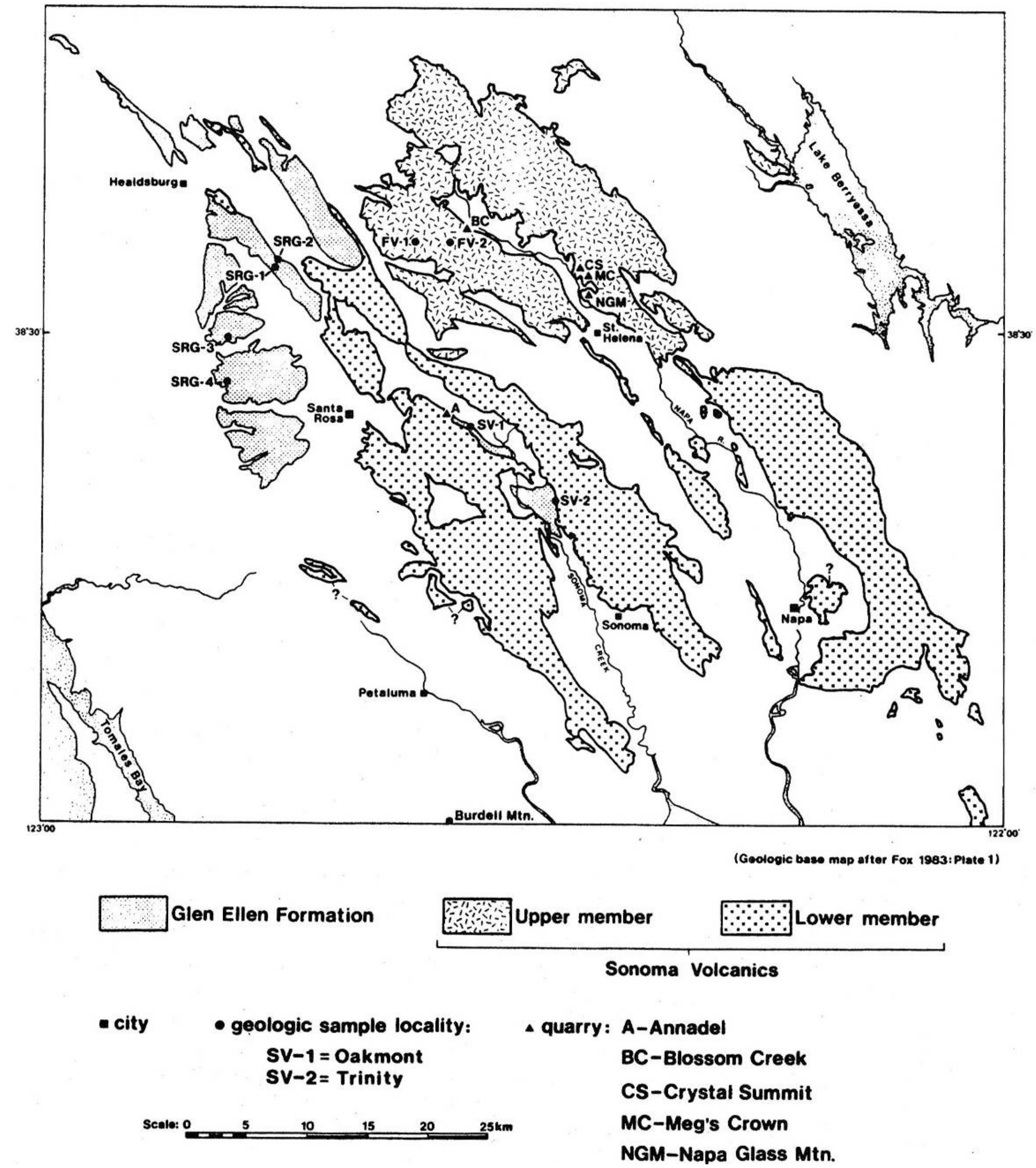

Figure 3. The Sonoma Volcanics and location of relevant rhyolite glass sources (from Jackson 1989:80). FV-1 and 2 indicate Franz Valley locations.