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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM FIVE SITES IN ORANGE COUNTY, CALIFORNIA

by

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INTRODUCTION

The analysis here includes 50 artifacts from various period sites in Orange County, California. The dominance of obsidian from the Coso Volcanic Field in Inyo County, California argues for a strong Archaic presence in the sites.

LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION

ANALYSIS AND INSTRUMENTATION

This assemblage was analyzed on a Spectrace/Thermo *QuanX* energy-dispersive x-ray spectrometer at the Archaeological XRF Laboratory, Department of Earth and Planetary Sciences at the University of California, Berkeley.

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 spectrometer is equipped with an electronically cooled Cu x-ray target with a 125 micron Be window, an x-ray generator that operates from 4-50 kV/0.02-2.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTrace™ reduction software. The x-ray tube is operated at 30 kV, 0.14 mA, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity Kα-line data for elements titanium (Ti), manganese (Mn), iron (as Fe^T), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), and thorium (Th). Weight percent iron ($Fe_2O_3^T$) can be derived by multiplying ppm estimates by 1.4297(10-4). 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). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1992, 1995, 2005; also Mahood and Stimac 1991; and Hughes and Smith 1993). Specific standards used for the best fit regression calibration for elements Ti through Nb include G-2 (basalt), AGV-1 (andesite), GSP-1, SY-2 (syenite), BHVO-1 (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), all US Geological Survey standards, JR-1 and JR-2 (rhyolite) from the Geological Survey of Japan, and BR-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). In addition to the reported values here, Ni, Cu, Zn, and Ga were measured, but these are rarely useful in discriminating glass sources and are not generally reported.

The data from both systems 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. Multiple analyses of RGM-1 are included in Table 1. Source references come from Ericson and Glascock (2004), Haarklau et al. (2005), Hughes (1988), Jack (1976), and source data at Berkeley. Further information on the laboratory instrumentation can be found at: http://www.swxrflab.net/ and Shackley (1998). Trace element data exhibited in Table 1 are reported in parts per million (ppm), a quantitative measure by weight (see also Figures 1 and 2).

SUMMARY AND CONCLUSIONS

Recently, a number of scholars have argued over the utility of separating the various obsidian producing domes in the Coso Volcanic Field (Ericson and Glascock 2004; Gilreath and Hildebrandt 1997; Hughes 1988). While there appears to be some differential procurement of some of the domes through time, the small samples sizes in this collection make discrimination at Coso difficult. It was not attempted for that reason.

Although the assemblage is dominated by eastern Sierra sources (Coso and Casa Diablo), three samples were from Obsidian Butte in Imperial County, California. Obsidian Butte is most common in late period sites in Orange and San Diego Counties (Ericson and Glascock 2004; Hughes and True 1985).

REFERENCES CITED

Davis, M.K., T.L. Jackson, M.S. Shackley, T. Teague, and J.H. Hampel
1998 Factors Affecting the Energy-Dispersive X-Ray Fluorescence (EDXRF) Analysis of Archaeological Obsidian. In *Archaeological Obsidian Studies: Method and Theory*, edited by M.S. Shackley, pp. 159-180. Springer/Plenum Press, New York and Amsterdam.

Ericson, J.E., and M.D. Glascock
2004 Subsource Characterization: Obsidian Utilization of Subsources of the Coso Volcanic Field, Coso Junction, California, USA. *Geoarchaeology* 19:779-805.

Gilreath, A., and W.R. Hildebrandt
1997 *Prehistoric Use of the Coso Volcanic Field*. Contributions of the University of California Archaeological Research Facility 56. Berkeley

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

Haarklau, L., L. Johnson, and D.L. Wagner
2005 *Fingerprints in the Great Basin: The Nellis Air Force Base Regional Obsidian Sourcing Study*. U.S. Army Corps of Engineers, Fort Worth District.

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.

Hildreth, W.
1981 Gradients in Silicic Magma Chambers: Implications for Lithospheric Magmatism. *Journal of Geophysical Research* 86:10153-10192.

Hughes, R.E.
1988 The Coso Volcanic Field Reexamined: Implications for Obsidian Sourcing and Hydration Dating Research. *Geoarchaeology* 3:253-265.

Hughes, Richard E., and Robert L. Smith
1993 Archaeology, Geology, and Geochemistry in Obsidian Provenance Studies. *In Scale on Archaeological and Geoscientific Perspectives*, edited by J.K. Stein and A.R. Linse, pp. 79-91. Geological Society of America Special Paper 283.

Hughes, R.E., and D.L. True
1985 Perspectives on the Distribution of Obsidians in San Diego County, California. *North American Archaeologist* 6:325-339.

Jack, R.N.
1976 Prehistoric Obsidian in California: Geochemical Aspects. In *Advances in Obsidian Glass Studies: Archaeological and Geochemical Perspectives*, edited by R.E. Taylor, pp. 183-217. Noyes Press, Parkridge, New Jersey.

Mahood, Gail A., and James A. Stimac
1990 Trace-Element Partitioning in Pantellerites and Trachytes. *Geochemica et Cosmochimica Acta* 54:2257-2276.

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(4):315-326.

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

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

2005 *Obsidian: Geology and Archaeology in the North American Southwest*. University of Arizona Press, Tucson.

Table 1. Elemental concentrations and source assignments for the archaeological specimens.

Site/Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
1297-1033	1245	330	9206	243	13	46	137	42	Coso
1311-3103	995	282	8514	230	9	55	127	50	Coso
244-12618	1564	292	9047	255	7	46	132	36	Coso
244-17368	918	311	9681	276	12	58	147	44	Coso
244-32775	974	692	7660	141	103	4	106	22	unknown
244-33545	868	226	8326	223	14	50	134	47	Coso
244-35234	880	294	9580	269	13	49	127	58	Coso
244-35411	843	300	8333	223	16	49	111	44	Coso
244-37120	1782	313	6763	172	10	38	86	31	Coso*
244-37557	1923	257	7099	192	11	35	102	47	Coso
244-37720	872	273	8630	206	15	40	138	43	Coso
244-38238	1809	573	23628	163	37	121	331	29	Obsidian Butte, CA
244-39079	875	230	7300	213	11	45	120	40	Coso
244-39183	3580	293	10655	55	37	41	140	0	not obsidian
244-39183	1048	337	9975	269	13	45	135	43	Coso
244-39241	1035	587	6871	156	24	27	126	38	Coso?
244-39296	1682	245	6944	179	9	37	99	39	too small
244-40059	1056	325	9796	252	14	58	119	48	Coso
244-40533	1139	349	10863	258	16	45	128	44	Coso
244-40989	1230	521	7960	171	22	29	106	31	Coso
244-51366	1788	621	7510	147	43	17	136	30	Coso
244-51366-01	981	341	10136	268	11	52	146	46	Coso
244-51467	1363	209	8083	228	10	43	125	40	Coso
244-51762	1524	601	8504	187	45	29	177	27	Casa Diablo
244-51906	1776	394	17449	113	37	97	351	27	Obsidian Butte, CA
244-51935	1540	443	20032	120	40	107	369	26	Obsidian Butte, CA
244-52544	872	241	8880	235	14	45	134	54	Coso
244-59019	981	297	8965	246	14	45	133	52	Coso
244-59125	816	273	9369	234	12	46	145	43	Coso
244-64815	1517	348	10851	245	12	59	127	36	Coso
244-64851	1341	325	10191	269	9	45	116	45	Coso
244-65573	906	249	8312	204	14	58	142	38	Coso
244-65992	912	311	8539	242	13	44	127	51	Coso
244-66760	1012	373	10605	295	16	57	142	48	Coso
244-66899	1845	264	8195	191	15	49	109	26	Coso
244-67658	978	296	9564	265	12	54	140	50	Coso
244-73675	1766	316	8697	215	10	40	116	31	Coso
244-74549	1593	309	9325	183	18	39	139	38	Coso
244-78792	911	294	8591	225	9	51	144	51	Coso
244-79157	1296	248	7571	193	11	35	96	50	Coso
650-3868	815	329	9252	227	9	41	146	42	Coso
650-4037	1575	369	9178	227	15	40	110	41	Coso
650-4060	970	255	9176	256	11	54	136	45	Coso
650-4348	966	237	6172	159	10	42	90	38	Coso?
650-4555	833	296	9056	263	12	54	143	56	Coso
650-4706	952	258	8526	216	8	42	125	50	Coso
650-4982	1056	300	9441	187	18	32	137	55	Coso
762-5011	3825	14300	11598	7	195	21	299	15	not obsidian

762-5012	3759	10318	36335	14	192	10	206	0	not obsidian
762-5018	3184	10849	17014	15	157	12	133	9	not obsidian
RGM1S3	1628	302	13260	147	105	24	219	3	standard
Site/Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
RGM-1S3	1563	335	13398	153	114	22	217	13	standard
RGM1-S3	1599	307	13289	154	112	22	221	0	standard

* and ?: These samples are slightly outside the range of elemental concentrations, mainly due to small sample sizes (see Davis et al. 1998).

Table 2. Crosstabulation of obsidian source provenance by site.

			Site					
			1297	1311	244	650	762	Total
Source	Casa Diablo	Count	0	0	1	0	0	1
		% within Source	.0%	.0%	100.0%	.0%	.0%	100.0%
		% within Site/Sample	.0%	.0%	3.0%	.0%	.0%	2.2%
		% of Total	.0%	.0%	2.2%	.0%	.0%	2.2%
	Coso	Count	1	1	28	7	3	40
		% within Source	2.5%	2.5%	70.0%	17.5%	7.5%	100.0%
		% within Site/Sample	100.0%	100.0%	84.8%	100.0%	100.0%	88.9%
		% of Total	2.2%	2.2%	62.2%	15.6%	6.7%	88.9%
	Obsidian Butte, CA	Count	0	0	3	0	0	3
		% within Source	.0%	.0%	100.0%	.0%	.0%	100.0%
		% within Site/Sample	.0%	.0%	9.1%	.0%	.0%	6.7%
		% of Total	.0%	.0%	6.7%	.0%	.0%	6.7%
	unknown	Count	0	0	1	0	0	1
		% within Source	.0%	.0%	100.0%	.0%	.0%	100.0%
		% within Site/Sample	.0%	.0%	3.0%	.0%	.0%	2.2%
		% of Total	.0%	.0%	2.2%	.0%	.0%	2.2%
Total		Count	1	1	33	7	3	45
		% within Source	2.2%	2.2%	73.3%	15.6%	6.7%	100.0%
		% within Site/Sample	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	2.2%	2.2%	73.3%	15.6%	6.7%	100.0%

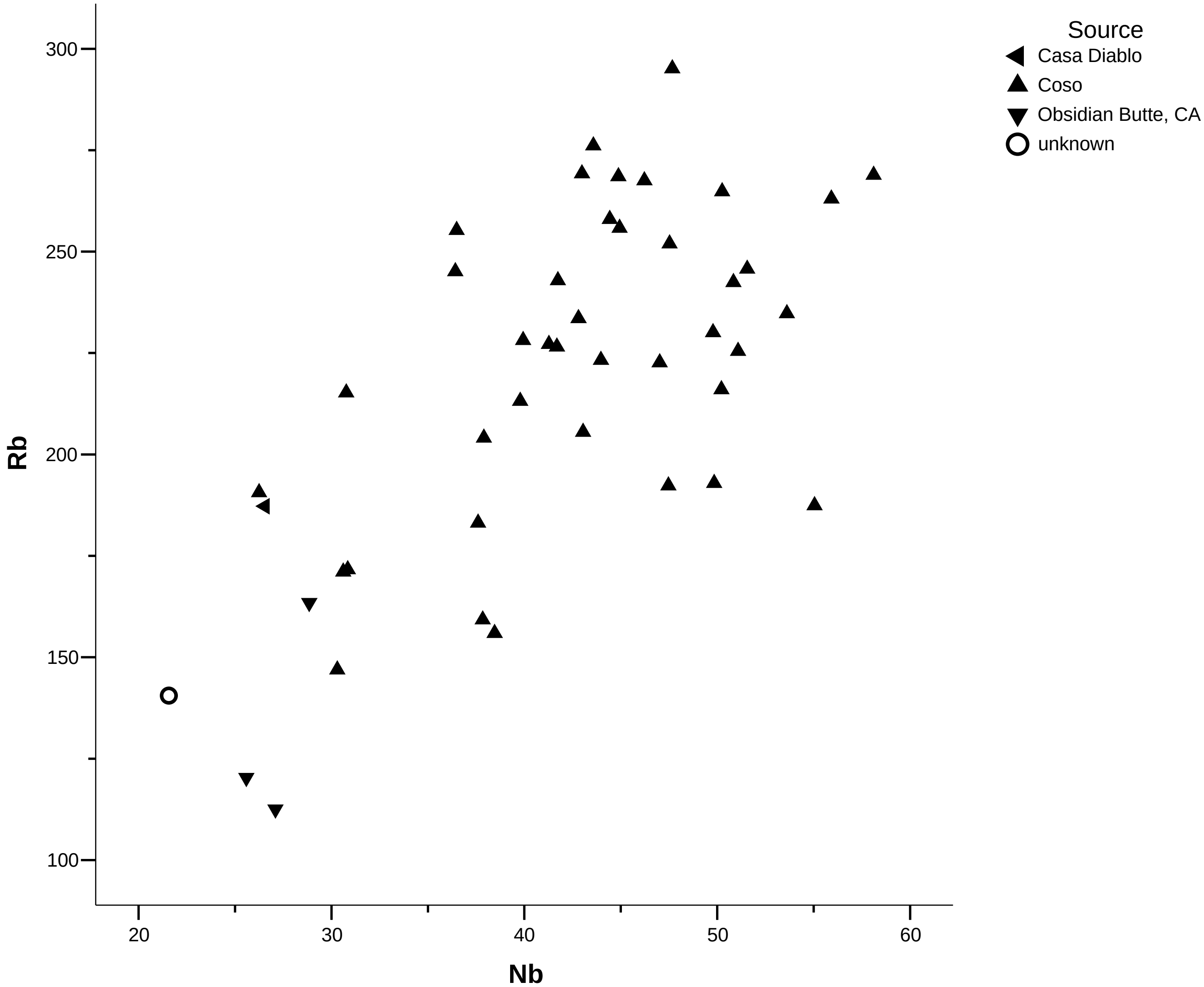

Figure 1. Rb versus Nb plot of the elemental concentrations for the archaeological specimens.

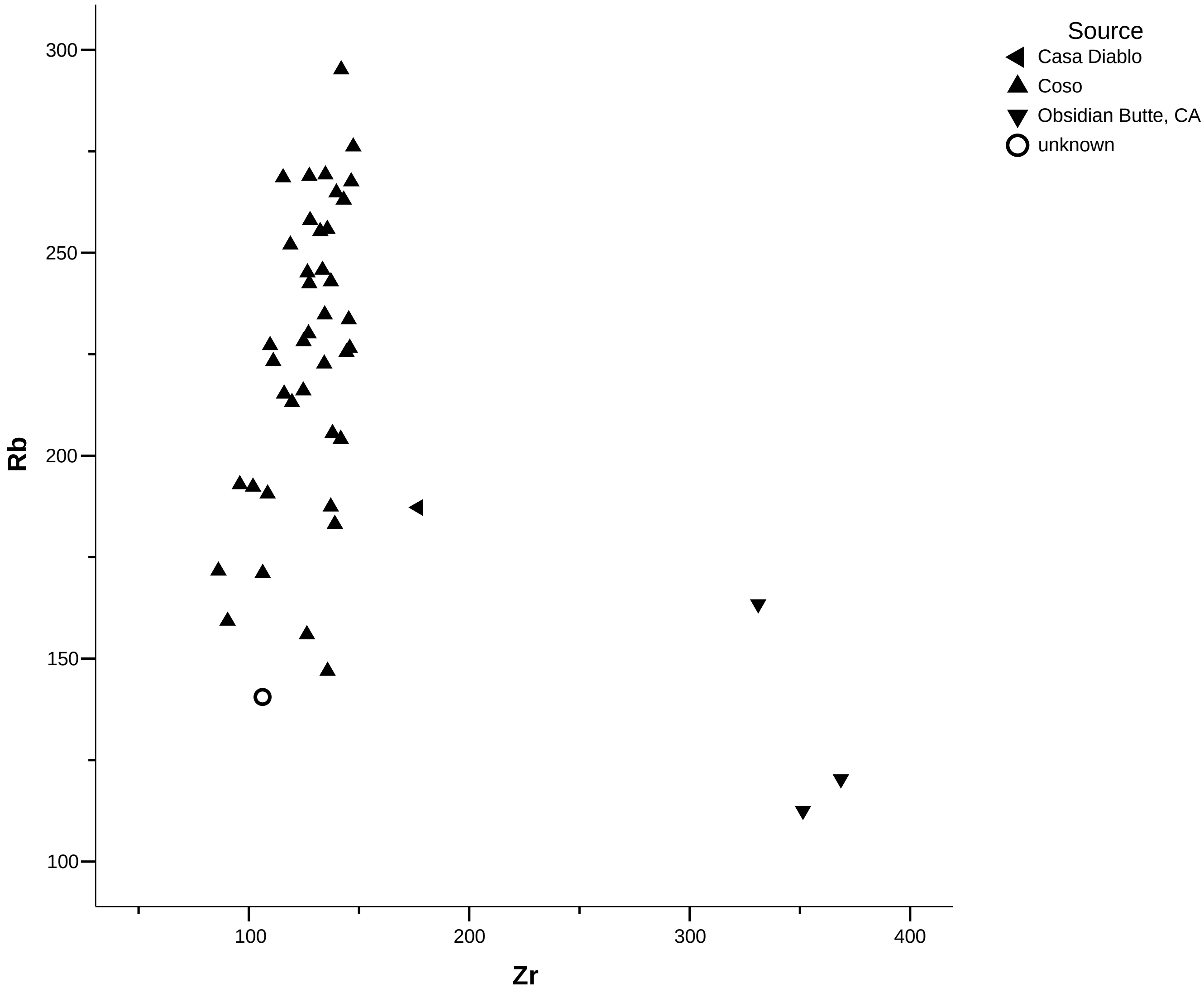

Figure 2. Rb versus Zr plot of archaeological specimens, more effectively separating Casa Diablo.