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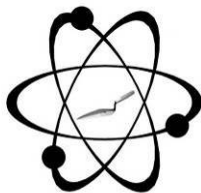
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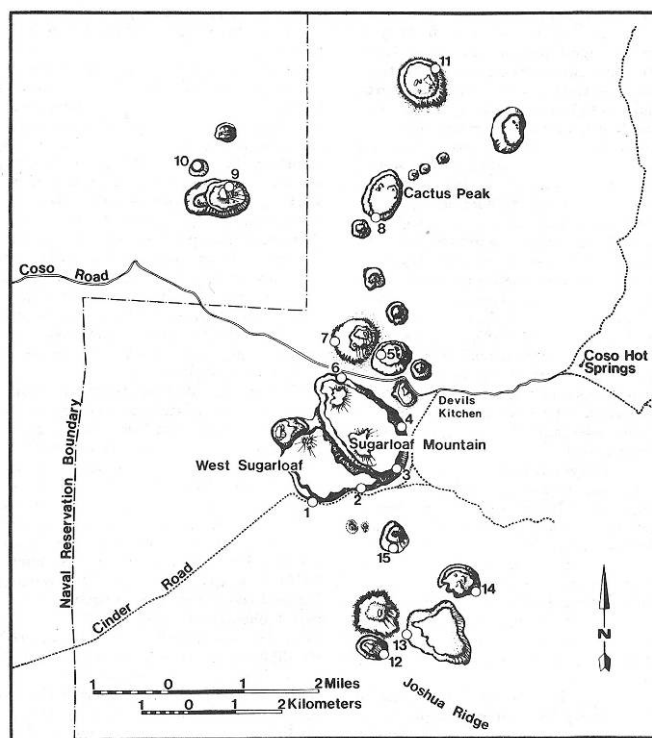
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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM TWO SITES ON THE NAVAL WEAPONS STATION CHINA LAKE, INYO, KERN, AND SAN BERNARDINO COUNTIES, CALIFORNIA



A portion of the Coso Volcanic Field with relevant rhyolite domes (from Bacon et al. 1981; Hughes 1988)

by

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Ridgecrest, California

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INTRODUCTION

The analysis here of 30 obsidian artifacts from two sites in Inyo, Kern, and San Bernardino Counties within the China Lake Naval Weapons Station indicates a relatively diverse provenance assemblage dominated by the West Sugarloaf dome obsidian as in previous studies (Shackley 2014, 2015). One Sugarloaf and a number of Joshua Ridge sources are also evident, the latter not common in the previous studies, and Joshua Ridge only at INY-9749.

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 at the University of California, Berkeley. 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.

For the analysis of 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 linear 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 2011; Shackley 2011). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (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). RGM-1 a USGS obsidian standard from Glass Mountain, Medicine Lake Highlands is analyzed during each sample run of 20 to check stability of machine calibration (Table 1). Source assignments were made by comparison to Ericson and Glascock (2004) and Hughes (1988; see Table 1 and Figure 1 here).

DISCUSSION

While the dominance of West Sugarloaf dome obsidian is typical in archaeological contexts in all time periods in the region, Sugarloaf and Joshua Ridge obsidian does occur in smaller proportions (Ericson and Glascock 2004; Gilreath and Hildebrandt 1997; Hughes 1988; Shackley 2014, 2015; see Tables 1 and 2 here). In Figure 1 it is apparent that the distribution of the West Sugarloaf rubidium composition is somewhat greater than Hughes (1988) early analysis, but similar in other elements to the Ericson and Glascock (2004) study. Since Coso obsidian standards were not available to this lab analysis, it is assumed that this is, in part, inter-instrument interpretation. Given the general dominance of West Sugarloaf obsidian in regional archaeological contexts, the source assignments are considered accurate.

Joshua Ridge obsidian was not common in the previous studies, and was present only at INY-9749, while the other sources were not common. It is possible that all the Joshua Ridge debitage could have been produced from a single core procured at Joshua Ridge, but this is not discernable with EDXRF compositional analysis (Shackley 2011).

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

Sample	Site	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
2a	INY-9749	513	28	1180	80	27	17	55	14	45	33	40	West Sugarloaf
			2	7		1			2				
2b	INY-9749	630	31	1235	11	26	15	56	14	42	36	35	West Sugarloaf
			3	7	1	9			5				
3	INY-9749	701	30	1258	12	21	18	42	15	35	25	25	Joshua Ridge
			0	7	4	4			5				
4	INY-9749	797	32	1376	16	24	18	48	16	35	33	36	West Sugarloaf
			4	3	3	7			4				
5	INY-9749	592	29	1253	74	21	18	44	16	35	26	33	Joshua Ridge
			4	3		3			4				
6	INY-9749	597	28	1220	65	20	18	42	16	37	28	37	Joshua Ridge
			6	5		8			1				
7	INY-9749	544	27	1190	71	25	15	50	14	43	31	36	West Sugarloaf
			8	7		2			5				
8	INY-9749	626	30	1278	69	21	18	45	16	38	28	35	Joshua Ridge
			6	4		7			9				
9	INY-9749	705	29	1205	65	19	18	42	16	39	25	27	Joshua Ridge
			6	6		8			7				
10a	INY-9749	567	28	1208	11	20	17	43	15	35	25	31	Joshua Ridge
			8	8	0	7			3				
10b	INY-9749	545	27	1212	83	20	17	45	15	40	28	34	Joshua Ridge
			6	5		6			6				
10c	INY-9749	549	27	1217	62	20	16	47	15	39	25	31	Joshua Ridge
			8	1		3			8				
11	INY-9749	660	27	1244	11	20	18	44	15	34	26	26	Joshua Ridge
			8	8	9	7			9				
5	INY-9757	431	31	1143	85	24	13	44	11	42	30	37	Sugarloaf
			1	0		3			4				
7a	INY-9757	624	34	1280	83	29	17	56	15	49	38	43	West Sugarloaf
			6	4		5			1				
7b	INY-9757	735	31	1277	15	26	20	51	15	42	33	36	West Sugarloaf
			5	3	6	0			3				
7c	INY-9757	470	29	1220	80	27	18	55	14	49	34	43	West Sugarloaf
			8	7		0			7				
8a	INY-9757	739	33	1270	93	30	19	56	14	44	37	43	West Sugarloaf
			5	5		5			8				
8b	INY-9757	419	27	1152	61	25	17	55	14	45	29	35	West Sugarloaf
			9	2		1			0				
8.5a	INY-9757	552	32	1254	89	28	17	57	15	46	34	35	West Sugarloaf
			0	1		2			5				
8.5b	INY-9757	444	31	1261	77	24	22	50	16	43	27	33	West Sugarloaf
			3	5		7			3				
8.5c	INY-9757	439	31	1219	87	27	17	58	14	46	37	38	West Sugarloaf
			0	0		2			2				
8.5d	INY-9757	508	29	1215	91	27	17	55	15	51	31	42	West Sugarloaf
			5	4		4			4				
8.5e	INY-9757	739	29	1199	11	24	16	49	14	44	29	38	West Sugarloaf
			3	4	8	7			0				
9a	INY-9757	563	30	1214	10	25	20	54	15	51	34	33	West Sugarloaf
			3	7	8	3			0				
9b	INY-9757	560	31	1236	73	27	16	55	14	47	34	44	West Sugarloaf
			0	9		0			6				

11	INY-9757	584	30 2	1230 6	99	26 7	18	52	14 7	43	30	34	West Sugarloaf
12a	INY-9757	554	32 7	1306 6	12 6	30 1	20	58	15 0	46	35	41	West Sugarloaf
12b	INY-9757	504	31 8	1245 5	99	29 2	17	56	14 9	47	35	42	West Sugarloaf
13	INY-9757	608	33 3	1286 2	11 7	28 8	23	52	15 1	44	36	39	West Sugarloaf
RGM1-S4		140 9	30 8	1360 0	41	14 7	10 3	27	22 1	9	21	18	standard
RGM1-S4		143 0	28 8	1365 6	39	14 6	10 6	26	21 8	12	21	16	standard

Table 2. Frequency distribution of source by archaeological site.

		Source			Total
		Joshua Ridge	Sugarloaf	West Sugarloaf	
Site	INY-9749	Count	9	0	4
		% within Site	69.2%	0.0%	30.8%
		% within Source	100.0%	0.0%	20.0%
		% of Total	30.0%	0.0%	13.3%
	INY-9757	Count	0	1	16
		% within Site	0.0%	5.9%	94.1%
		% within Source	0.0%	100.0%	80.0%
		% of Total	0.0%	3.3%	53.3%
Total		Count	9	1	20
		% within Site	30.0%	3.3%	66.7%
		% within Source	100.0%	100.0%	100.0%
		% of Total	30.0%	3.3%	66.7%

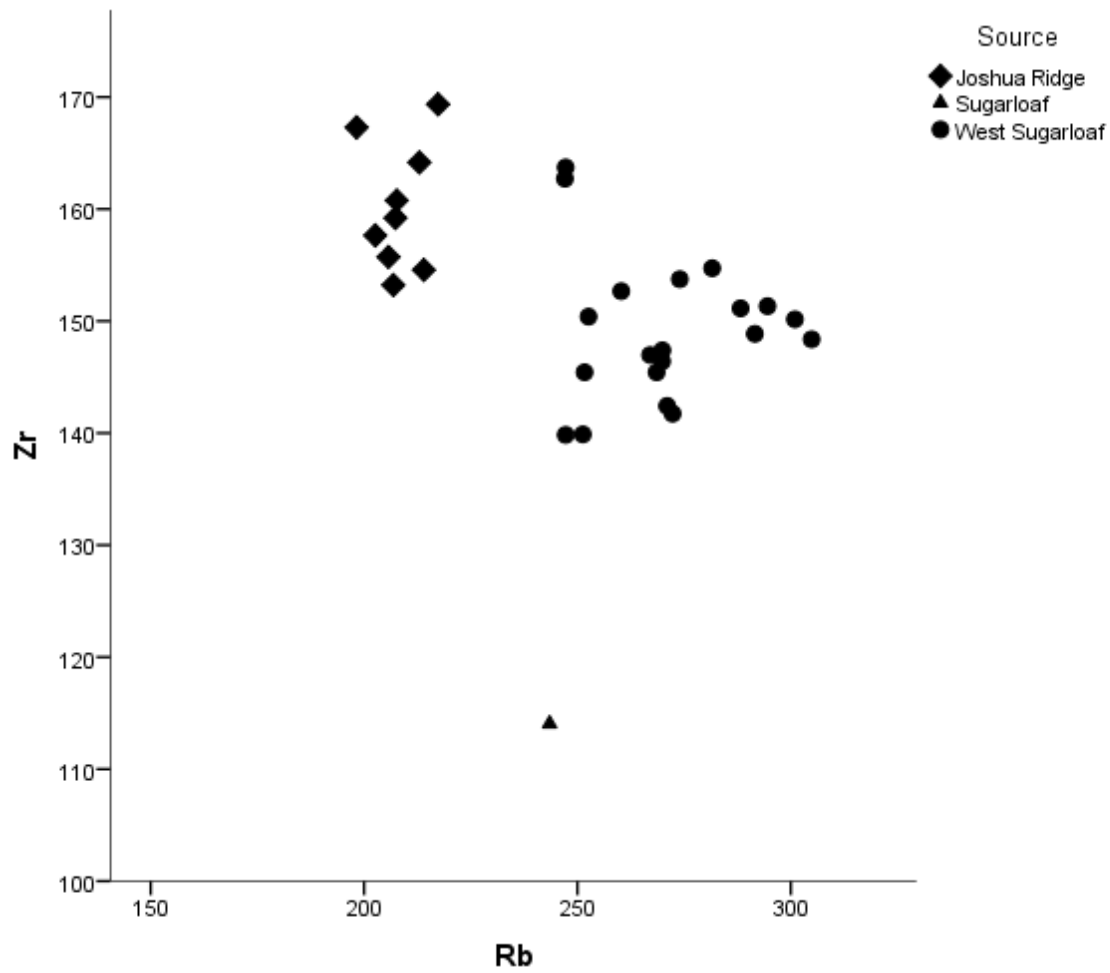


Figure 1. Bivariate plot of Rb/Zr concentrations for archaeological specimens from all sites (after Hughes 1988).