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Source Determination of Archaeological Obsidian from San Clemente Island

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Method

The trace element analysis of the obsidian specimens in table 6.1 was conducted at the Department of Geology, University of California, Davis. This work was performed on a Kevex 0700 energy dispersive x-ray fluorescence unit, using a rhodium (Rh) tube with a 0.05 rhodium filter at 30 kilovolts and 0.05 milliamps to analyze for rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), lead (Pb), and thorium (Th). Only Rb, Sr, and Zr are reported here because those are the critical three elements used to differentiate obsidian sources in this region of California. To generate an Fe/Mn ratio, a germanium (Ge) target was irradiated at 17 kilovolts and 1.7 milliamps. This unit has a Si(Li) detector and is used in conjunction with a Kevex 8000 multichannel analytical spectrometer.

Normally, in controlled geological studies, a rock is crushed into a powder and pressed into a pellet. That prepared sample has a homogeneous distribution of constituent elements and is perfectly flat, providing the appropriate geometry for consistent and systematic results. Archaeological materials cannot be treated in this manner, so their elemental distribution (glasses are assumed to possess homogeneous elemental distributions) and imperfect geometry (i.e., their lack of a perfectly flat surface) must be compensated through a form of "ratio" analysis.

In this procedure, samples are run for 200 live-seconds and the resulting spectra stripped of their backgrounds. Integrated intensities are calculated for each of the elements in each sample and those intensities are divided by the integral of the Compton peak. In conjunction with this work, geological rock standards with known quantities of constituent elements are analyzed similarly. Ratios from rock standards are used to calculate a regression formula and the sample ratios are used to derive parts per million values for each specimen. Those figures are matched with source patterns from parent obsidians. Due to the very small size of several archaeological specimens, the concentrations are not accurate with respect to source characterizations. Those figures, however, can be used to derive ratios reflecting the relative quantities of Rb, Sr, and Zr in each artifact and, in conjunction with an Fe/Mn ratio, those proportions can be matched with source patterns and assigned to parent obsidians.

The quantitative computation used in this analysis is an acceptable method, although it is not a replacement for more detailed and accurate techniques (see Andermann and Kemp 1958; Nelsen, 1979). Different machines and techniques also have been found to produce slightly varying numerical results, due in part to particle-size effects of the variously processed rock standards. Direct comparisons between laboratories are, therefore, problematic.

Data

The 46 specimens from various San Clemente Island sites present an interesting and somewhat unusual problem. Data from other regions of southern California are based on source profiles dominated by either *Coso* or *Obsidian Butte* glasses. This collection is not different in that respect with most items yielding trace element data (ppm and ratio) compatible with *Coso* patterns and three others with *Obsidian Butte.* The anomaly is a small assemblage of four specimens, all of which share quantitative and Fe/Mn characterizations, but are inconsistent with any known glass source in this region (including California, northern Baja California, and Arizona). In Table 6.1, this source is designated as “A”. It is likely that this material is derived from a small, nodule source area, similar to those found across many of the surrounding desert regions on the mainland. A final specimen (1215-1034) is an ‘unknown,’ although ratios are comparable to *Government Mountain* in Arizona. This archaeological sample has a notably lower Zr concentration than *Government Mountain* and, because this piece is so small and the UC Davis laboratory has so few *Government Mountain* source specimens, a conclusive determination is not possible.

Regarding the *Coso* material, the volcanic field in the eastern California desert has attracted considerable attention over the last several years, as a consequence of geological characterization of rhyolite flows according to trace element constituents (Bacon et al. 1981). Bacon et al. indicate that notable distinctions are found among some geographically discrete flows, a pattern taken by Hughes (1988) to define four different artifact-quality sub-sources: *West Cactus Peak, Joshua Ridge, Sugarloaf Mountain,* and *West Sugarloaf.* Enlisting those data further, Hughes also argues that associated major element chemical variation should result in separate obsidian hydration rates. While his propositions are provocative, two important aspects require attention: one is related to the nature of trace element clustering and the second is associated with empirical reality of proposed hydration differences. Analytical research conducted at three different California laboratories exhibits rather unique characteristics for the *West Cactus* and *Joshua Ridge* source areas, although only relatively small samples have been examined to date (see Basgall and McGuire 1988; Gilreath 1987, 1988; Gilreath and Hildebrandt 1987; Hildebrandt and Gilreath 1988). Recent research has also demonstrated that analytical conditions associated with specimen surface geometry generate less precise data than those necessary to distinguish between *West Sugarloaf* and *Sugarloaf Mountain* source areas (Bouey 1990).

The second *Coso* obsidian problem is associated with hydration processes. Efforts have been made to account for hydration source-specific variability on the basis of elemental constituents (Friedman and Long 1976), a strategy employed by Hughes (1988), but without scrutiny of archaeological data. No empirical indication exists to suggest that *Coso* subsources behave in a manner indicated by those calculations (see Basgall and McGuire 1988; Gilreath 1987, 1988; Gilreath and Hildebrandt 1987; Hildebrandt and Gilreath 1988 for hydration data which do not meet those formulaic expectations) and indicate that such differentiation should be employed with due caution.

Table 6.1. Trace Element Analyses for Obsidian Archaeological Specimens from San Clemente Island.

Site	Cat. No.	Rb (ppm)	Sr (ppm)	Zr (ppm)	SUM	Rb%	Sr%	Zr%	Fe/Mn	Source
43B	1453	208.81	6.64	93.67	309.12	67.55	2.15	30.3		Coso
43B	1870	173.25	29.04	10202	304.31	56.93	9.54	33.53	25.7	A
43C	237	278.08	4.25	148.98	431.31	64.47	0.99	34.54		Coso
43C	908	273.58	1.49	154.33	429.4	63.71	0.35	35.94		Coso
43C	910	225.68	3.86	115.4	345.08	65.4	1.12	33.48		Coso
43C	E149	308.64	5.44	149.75	463.83	66.54	1.17	32.29		Coso
43C	E150	312.75	4.42	175.05	492.22	63.54	0.9	35.56		Coso
43C	E151	292.59	1.49	150.89	444.97	65.75	0.33	33.91		Coso
43C	E152	245.84	7.57	149.55	402.96	61.01	1.88	37.11		Coso
43C	E153	289.73	3.38	132.32	425.43	68.1	0.79	31.1		Coso
43C	E154X	148.83	7.07	85.02	240.92	61.78	2.93	35.29	48.1	Coso
43C	E154XF	201.58	1.49	94.24	297.31	67.8	0.5	31.7	50.9	Coso
43C	E154XSC	174.46	1.49	68.49	244.44	71.37	0.61	28.02	56	Coso
43C	E1581	227.53	5.01	104.55	337.09	67.5	1.49	31.02		Coso
43C	E158S	261.27	1.49	154.79	417.55	62.57	0.36	37.07		Coso
43C	E202	216.41	1.49	110.86	328.76	65.83	0.45	33.72		Coso
43C	E596X	147.89	1.49	73.49	222.87	66.36	0.67	32.97	66.4	Coso
126	0342x	213.06	6.81	110.24	330.11	64.54	2.06	33.39	50.1	Coso
126	0602X	174.04	1.49	95.49	271.02	64.22	0.55	35.23	50.1	Coso
126	0839X	210.35	1.49	112.76	324.6	64.8	0.46	34.74	50.1	Coso
126	1756	119.08	24.21	314.52	457.81	26.01		5.29	68.7	Obsidian Butte
126	031X	190.46	1.49	94.97	286.92	66.38	0.52	33.1	49.6	Coso
1215	389	249.49	4.4	122.38	376.27	66.31	1.17	32.52		Coso
1215	409	264.99	8.5	123.08	396.57	66.82	2.14	31.04		Coso
1215	0438A	244.35	5.16	104.83	354.34	68.96	1.46	29.58		Coso
1215	0438B	186.81	1.49	90.32	278.62	67.05	0.53	32.42		Coso
1215	0445X	201.22	1.49	99.29	302	66.63	0.49	32.88	46.5	Coso
1215	455	223.5	4.09	103.89	331.48	67.42	1.23	31.34		Coso
1215	457	174.11	8.51	91.84	274.46	63.44	3.1	33.46		Coso
1215	0477X	221.39	1.49	107.47	330.35	67.02	0.45	32.53	48.6	Coso
1215	661	208.43	8.45	114.79	331.67	62.84	2.55	34.61		Coso
1215	1034X	93.6	64.69	49.13	207.42	45.13	31.19	23.69	16.1	?
1215	1082	195.54	1.49	96.08	293.11	66.71	0.51	32.78		Coso
1215	4080X	153.86	34.15	101.04	289.05	53.23	11.81	34.96	23.5	A

Table 6.1, cont. Trace Element Analyses for Obsidian Archaeological Specimens from San Clemente Island.

Site	Cat. No.	Rb (ppm)	Sr (ppm)	Zr (ppm)	SUM	Rb%	Sr%	Zr%	Fe/Mn	Source
1215	4519	0	6.07	4.69	10.76	0	56.41	43.59		[not obsidian]
1215	4682	168.56	28.89	92.02	289.47	58.23	9.98	31.79	23.8	A
1215	4860X	176.51	8.13	93.84	278.48	63.38	2.92	33.7	56.9	Coso
1215	5077	220.89	1.49	115.97	338.35	65.28	0.44	34.28		Coso
1215	5078	207.98	1.49	133.45	342.92	60.65	0.43	38.92		Coso
1487	0056X	104.25	14.91	245.28	364.44	28.61	4.09	67.3		Obsidian Butte
1487	0072X	171.36	1.49	112.34	285.19	60.09	0.52	39.39	44.5	Coso
1487	733	117.04	16.42	252.36	385.82	30.34	4.26	65.41		Obsidian Butte
1487	0740X	155.24	27.19	84.97	267.4	58.06	10.17	31.78	23.6	A
1524	0128X	222.99	1.49	122.38	346.86	64.29	0.43	35.28		Coso
1524	1575X	219.36	4.35	97.86	321.57	68.22	1.35	30.43	45.3	Coso
1524	2113X	154.93	4.71	74.99	234.63	66.03	2.01	31.96	52.6	Coso

In catalog numbers: X= specimen too small to generate quantitative concentrations
L= large S= small F= flake SC= small chunk

Site names:

43B	Eel Point B
43C	Eel Point C
126	Ledge
1215	Nursery
1487	Old Air Field
1524	???