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**ELEMENTAL AND MAJOR OXIDE ANALYSIS OF A HIGH SILICA  
GEOLOGICAL OBSIDIAN FROM EAST OF SUMMIT LAKE, NEVADA**

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## INTRODUCTION

The analysis here of 20 obsidian source standards from geological contexts east of Summit Lake, Nevada indicates a source that has not yet been reported, at least not in the published literature. The study includes a trace and major elemental analysis of 12 elements, and a major oxide analysis of nine oxides.

## 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).

All analyses for this study were conducted on a Thermo Scientific *Quant'X* EDXRF spectrometer, located in the Department of Anthropology, 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  $\mu\text{m}$  (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  $\text{l min}^{-1}$  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 trace element analyses were performed in the Archaeological XRF Laboratory, El Cerrito, California, using a ThermoScientific *Quant'X* energy dispersive x-ray fluorescence spectrometer. 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  $\text{Fe}_2\text{O}_3^T$  reported elementally), 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 0.5 mA, ratioed to the bremsstrahlung region (see Davis et al. 2010). Further details concerning the petrological choice of these elements in North American obsidians is available in Shackley (1988, 1995, 2005; also Mahood and Stimac 1991; and Hughes and Smith 1993). Specific standards used for the best fit regression calibration for elements Ti- Nb, Pb, Th, and Ba, include G-2 (basalt), AGV-2 (andesite), GSP-1 (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), all US Geological Survey standards, BR-1 (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). Table 1 exhibits the trace element results.

The major oxide analyses were performed using a fundamental parameters (theoretical) method using four separate conditions based on the atomic weight of the elements of interest all at 100 seconds livetime, and automatically determined amperage based on mass: Low Za (6 kV, no filter); Low Zb (8 kV, cellulose filter); Mid Zb (32 kV, Pd medium filter); High Zb (50 kV, Cu thick filter; Table 2 here). See Davis et al. (2010) and Shackley (2010) for a discussion of EDXRF analytical theory. This method assumes that the substance analyzed is a homogeneous flat glass, so the results here are approximate, but the analysis of the RGM-1 pressed powder standard suggests that the results are within a few percent of actual.

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 when necessary. 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 (Tables 1 and 2).

## **DISCUSSION**

As noted above, all published data on obsidian sources in Nevada do not indicate a source near Summit Lake, nor elemental concentrations like the 20 samples analyzed here (Dames and Moore 1994; Hughes 1983; Haarklau et al. 2005). Although the relatively high strontium is generally unique in Great Basin rhyolites, many of the elements here overlap the Bristol Mounatins source in eastern California (Shackley 1994, and Table 3 here). It appears that zirconium and barium will be necessary to separate these two sources at opposite ends of the Great Basin.

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Table 1. Elemental concentrations for source standards and USGS RGM-1. All measurements in parts per million (ppm).

Sample	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Ba <sup>1</sup>	Pb	Th
1	1590	436	13529	61	169	151	22	158	15		28	26
2	1240	413	11209	59	157	146	21	151	13	1411	26	23
3	1356	438	12155	61	160	145	20	142	14		26	28
4	1307	406	11515	54	157	144	22	151	10		25	18
5	1362	434	12432	71	156	144	21	147	12		27	25
6	1255	416	11750	59	158	149	21	158	13		25	23
7	1294	409	12016	61	158	148	20	156	16		28	19
8	1365	387	12186	66	158	146	17	153	11		26	18
9	1492	494	13002	67	173	157	22	157	11		28	21
10	1265	384	11071	60	151	135	16	145	11		28	17
11	1184	384	11455	65	148	142	19	140	11		24	19
12	1279	429	11245	61	159	146	19	148	11		25	21
13	1130	396	10678	65	149	140	18	146	9		25	16
14	1235	432	11632	69	159	146	20	148	12		29	20
15	1282	429	11986	69	159	144	21	154	11		26	22
16	1231	393	11254	60	153	143	19	149	13		24	20
17	1153	396	10723	55	151	141	17	144	12		26	22
18	1176	394	10787	55	148	140	19	157	17	1490	22	16
19	1246	408	11131	59	154	145	22	149	12		27	18
20	1621	438	12653	61	156	148	22	152	13		28	28
RGM1-S4	1492	315	12806	37	146	105	24	225	10	784	27	21

<sup>1</sup> Barium only run for two samples and RGM-1.

Table 2. Mean and central tendency for the elemental data from Table 1.

Summit Lake, NV					
	N	Minimum	Maximum	Mean	Std. Deviation
Ti	20	1130	1621	1303	133
Mn	20	384	494	416	26
Fe	20	10678	13529	11720	775
Zn	20	54	71	62	5
Rb	20	148	173	157	6
Sr	20	135	157	145	5
Y	20	16	22	20	2
Zr	20	140	158	150	5
Nb	20	9	17	12	2
Ba	2	1411	1490	1450	56
Pb	20	22	29	26	2
Th	20	16	28	21	4

Table 3. Major oxide values for Sample # 2 and RGM-1. All measurements in percent by weight.

Sample	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	Fe <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	MgO	MnO	Na <sub>2</sub> O	TiO <sub>2</sub>
2	75.651	12.891	1.19	1.538	5.106	0	0.065	3.272	0.068
RGM1-S4	74.548	12.352	1.487	2.216	5.195	0	0.05	3.669	0.275