

APPENDIX B

**GEOCHEMICAL ANALYSIS OF THE LOST
VALLEY FLUTED POINT**

GEOCHEMICAL ANALYSIS

Geochemical Research Laboratory Letter Report 2006-42

April 20, 2006

Mr. George E. Kline
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Dear Geo:

On page two of this letter you will find a table presenting energy dispersive x-ray fluorescence (edxf) data generated from the analysis of a fluted obsidian projectile point from archaeological site CA-SDi-2506 in Lost Valley, San Diego County, California. This analysis was conducted pursuant to your email request of April 12, 2006.

Analyses of obsidian are performed at my laboratory on a QuanX-ECTM (Thermo Electron Corporation) edxf spectrometer equipped with a silver (Ag) x-ray tube, a 50 kV x-ray generator, digital pulse processor with automated energy calibration, and a Peltier cooled solid state detector with 145 eV resolution (FWHM) at 5.9 keV. The x-ray tube was operated at differing voltage and current settings to optimize excitation of the elements selected for analysis. In this case analyses were conducted for the elements rubidium (Rb K α), strontium (Sr K α), yttrium (Y K α), zirconium (Zr K α), niobium (Nb K α), barium (Ba K α), titanium (Ti K α), manganese (Mn K α), and total iron (Fe₂O₃^T). An iron vs. manganese (Fe K α /Mn K α) ratio also was computed, with x-ray tube current scaled to the physical size of the specimen.

After x-ray spectra are acquired and elemental intensities extracted for each peak region of interest, matrix correction algorithms are applied to specific regions of the x-ray energy spectrum to compensate for inter-element absorption and enhancement effects. Following these corrections intensities are converted to concentration estimates by employing a least-squares calibration line established for each element from analysis of up to 30 international rock standards certified by the U.S. Geological Survey, the U.S. National Institute of Standards and Technology, the Geological Survey of Japan, the Centre de Recherches Petrographiques et Geochimiques (France), and the South African Bureau of Standards. Further details pertaining to x-ray tube operating conditions and calibration appear in Hughes (1988, 1994).

All trace element values (except Fe/Mn ratios) for the artifact in the accompanying table are expressed in quantitative units (i.e. parts per million [ppm] by weight), and these were compared directly to values for known obsidian sources that appear in Bowman et al. (1973), Hughes (1983, 1985, 1988, 1989, 1994, 2001, 2005), Jack (1976), and Jackson (1989) and unpublished data in my possession on certain interior southern California and Great Basin obsidians (e.g. Hughes n.d.). An artifact is assigned to a parent obsidian

chemical type if diagnostic trace element concentration values (i.e., ppm values for Rb, Sr, Y, Zr and, when necessary Ba, Ti, Mn and Fe_2O_3^T) corresponded at the 2-sigma level. Stated differently, artifact-to-obsidian source (geochemical type, *sensu* Hughes 1998) matches are considered reliable if diagnostic mean measurements for artifacts fall within 2 standard deviations of mean values for source standards. The term "diagnostic" is used here to specify those trace elements that are well-measured by x-ray fluorescence, and whose concentrations show low intra-source variability and marked variability across sources (see Hughes 1990, 1993). Zn and Ga ppm concentrations are not considered "diagnostic" because they don't usually vary significantly across obsidian sources (see Hughes 1982, 1984).

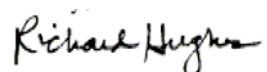
The trace element composition measurements presented in the accompanying table are reported to the nearest ppm to reflect the resolution capabilities of non-destructive edxrf spectrometry for quantitative analysis. The resolution limits of the present x-ray fluorescence instrument for the determination of Rb is about 4 ppm; for Sr about 3 ppm; Y about 3 ppm; Zr about 4 ppm; and Nb about 2 ppm (see Hughes [1994] for other elements). When counting and fitting error uncertainty estimates (the "+/-" value in the table) for a sample are greater than calibration-imposed limits of resolution, the larger number is a more conservative reflection of composition variation and measurement error arising from differences in sample size, surface and x-ray reflection geometry.

Cat. Number	Trace Element Concentrations											Ratio	Obsidian Source (Chemical Type)
	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba	Ti	Mn	Fe_2O_3^T	Fe/Mn	
4408	nm	nm	142 ±4	91 ±3	16 ±3	172 ±4	12 ±3	946 ±12	1203* ±21	344 ±10	1.38 ±.02	39	Lookout Mountain Casa Diablo area
U.S. Geological Survey Reference Standard													
RGM-1 (measured)	nm	nm	148 ±4	109 ±3	26 ±3	225 ±4	8 ±3	808 ±15	nm	nm	nm	65	
RGM-1 (recommended)	32	15	149	108	25	219	9	807	1600	279	1.86	nr	
Values in parts per million (ppm) except total iron [in weight %] and Fe/Mn intensity ratios; ± = expression of x-ray counting uncertainty and regression fitting error at 120-360 seconds livetime. nm= not measured. * = surface adherent inflated measurement.													

Edxrf data in Table I indicate that this specimen from SDi-2506 matches the trace and selected minor element composition of obsidian of the Lookout Mountain chemical type, Casa Diablo area, California. All measured elements are in excellent agreement with geologic source standards from Lookout Mountain (Hughes 1994: Tables 1 and 2) with the exception of Ti. The computed Ti composition was inflated by enrichment contribution from an accretion of material of unknown origin on the surface of the artifact. Given this, I employed Ba to achieve the same intrasource distinction I usually make using Ti (cf. Hughes 1994: Figure 3).

I hope this information will help in your analysis and interpretation of the significance of this specimen. Please contact me at my laboratory (phone: [950] 851-1410; e-mail: rehughes@silcon.com) if I can provide any further assistance or information. As you requested I have forwarded the specimen to Tom Origer for obsidian hydration analysis.

Sincerely,

A handwritten signature in cursive script that reads "Richard Hughes". The signature is written in black ink and is positioned to the left of a vertical line.

Richard E. Hughes, Ph.D., RPA
Director, Geochemical Research
Laboratory

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