GEOARCHAEOLOGICAL XRF LAB
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GEOARCHAEOLOGICAL X-RAY FLUORESCENCE SPECTROMETRY LABORATORY
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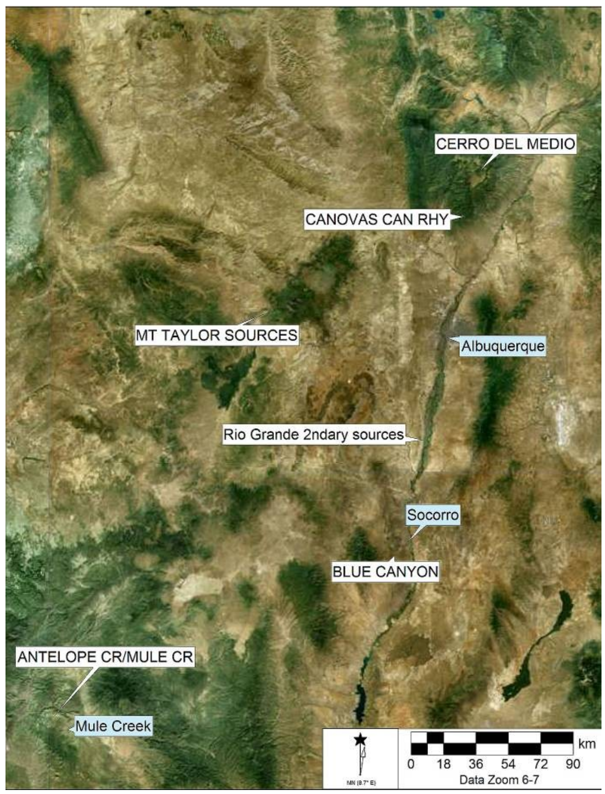
SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THE BLUE CANYON CLOVIS SITE, SOCORRO COUNTY, NEW MEXICO



Satellite orthophoto of Blue Canyon, obsidian sources in the assemblage, and selected features and locations

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INTRODUCTION

The analysis here of eight obsidian artifacts so far recovered from the newly discovered Blue Canyon Clovis archaeological site southwest of Socorro, New Mexico indicates a diverse provenance assemblage including sources from the Mule Creek Source Complex in western New Mexico that must have been originally procured at the source, and Jemez Lineament sources from northern and northwest New Mexico, some probably procured from Rio Grande Quaternary gravels nearby, although the cortex on Samples 27 and 66 appears to be angular and not water eroded (see discussion below; Church 2000; Shackley 2005, 2009, 2012; Shackley et al. 2018)

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 Geoarchaeological XRF Laboratory, Albuquerque, New Mexico. 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 from 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.

Trace Element Analysis

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 100 seconds livetime to generate x-ray intensity $K\alpha_1$-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. 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 using a 0.630 mm Cu (thick) filter (see Davis 2011; Shackley 2011). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1988, 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, and 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).

Statistical and Graphical Source Assignment.

The data from the WinTrace™ software were translated directly into Excel for Windows software for manipulation and on into JMP ver. 12.0.1 for Windows for statistical analyses. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. RGM-1 a USGS rhyolite standard is analyzed during each sample run of ≤ 20 samples for volcanic rock artifacts to check machine calibration (Table 1).

Source assignments were made by reference to the laboratory data base (see Shackley 1995, 1998, 2005, 2009; Shackley et al. 2018). Further information on the laboratory instrumentation and source data can be found at: http://www.swxrflab.net. Trace element data exhibited in Table 1 are reported in parts per million (ppm), a quantitative measure by weight (see also Figure 1).

DISCUSSION

The presence of secondarily deposited obsidian in Rio Grande Quaternary sediments from primary sources of the Jemez Lineament (Mount Taylor and Jemez Mountains) is well documented (Church 2000; Hamilton et al. 2013; Shackley 2012). The character of these well eroded obsidian nodules displays a typically well rounded and sub-rounded character, and as the distance from the source increases, the angular character of the nodules distinctive to samples from the primary sources disappears completely (Church 2000; Shackley 1998, 2012). If corticle material is still present on the artifacts in site contexts (i.e. primary and secondary flakes), angular cortex suggests that the raw material was originally procured at the source rather than, in the case of the Blue Canyon site, Rio Grande Quaternary alluvium. Two of the Horace/ La Jara Mesa assigned samples from Blue Canyon (Samples 27 and 66) exhibit angular or "rough" cortex typical of source samples from the primary source at Mount Taylor (Shackley 1998a, 2005; see Figure 2 here). It is beginning to look like there might be some preference for the Horace/La Jara Mesa raw material or that the group may have arrived at this site from the Mount Taylor area. With the presence of Antelope Creek obsidian from the Mule Creek Obsidian Complex in the assemblage and the inference that at least two of the Mount Taylor assigned artifacts were procured from the primary source, a procurement range with a radius of at least 200 km, both north and west of Blue Canyon is present within the obsidian assemblage (see cover image). Furthermore, the presence of Valles Rhyolite (Cerro del Medio) that has not eroded outside Valles Caldera in any meaningful size or quantity, that procurement range extends at least 220 km to the north as well (Antelope Creek and Cerro del Medio are approximately the same distance from Blue Canyon; see cover image; Shackley 2012). A procurement range of over 200 km indicated by obsidian as a raw material is not unusual for Paleoindian hunter-gatherers in the Southwest (Hamilton et al. 2009, 2013; Huckell 2007; Shackley 1990, 1996). Other raw materials, particularly chert recovered from the site, as at Mockingbird Gap to the south, would likely indicate a much larger procurement range (see Amick 1996; Buchanan and Collard 2007; Hamilton et al. 2013).

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Table 2. Elemental concentrations for the archaeological samples, and USGS RGM-1 rhyolite standard. All measurements in parts per million (ppm).

Sample	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Ba	Source
4	1024	376	10570	78	244	24	44	114	28	113	Antelope Cr/Mule Cr
16	856	748	9737	170	546	14	77	122	200	0	Grants Ridge/Mt Taylor
27	811	586	10876	224	529	16	92	141	232	0	Horace/La Jara Mesa/Mt Taylor
28	721	530	9634	188	495	15	92	137	230	0	Horace/La Jara Mesa/Mt Taylor
48	1026	400	8210	39	119	45	24	106	57	449	Canovas Can Rhy (Bear Springs Pk)
54	928	342	9907	73	146	14	43	164	59	0	Valles Rhy (Cerro del Medio)
66	762	517	9847	176	486	10	88	139	224	40	Horace/La Jara Mesa/Mt Taylor
78	826	552	10675	204	506	15	87	137	217	0	Horace/La Jara Mesa/Mt Taylor
RGM1-S4	1443	289	13163	40	152	106	26	224	11	831	standard

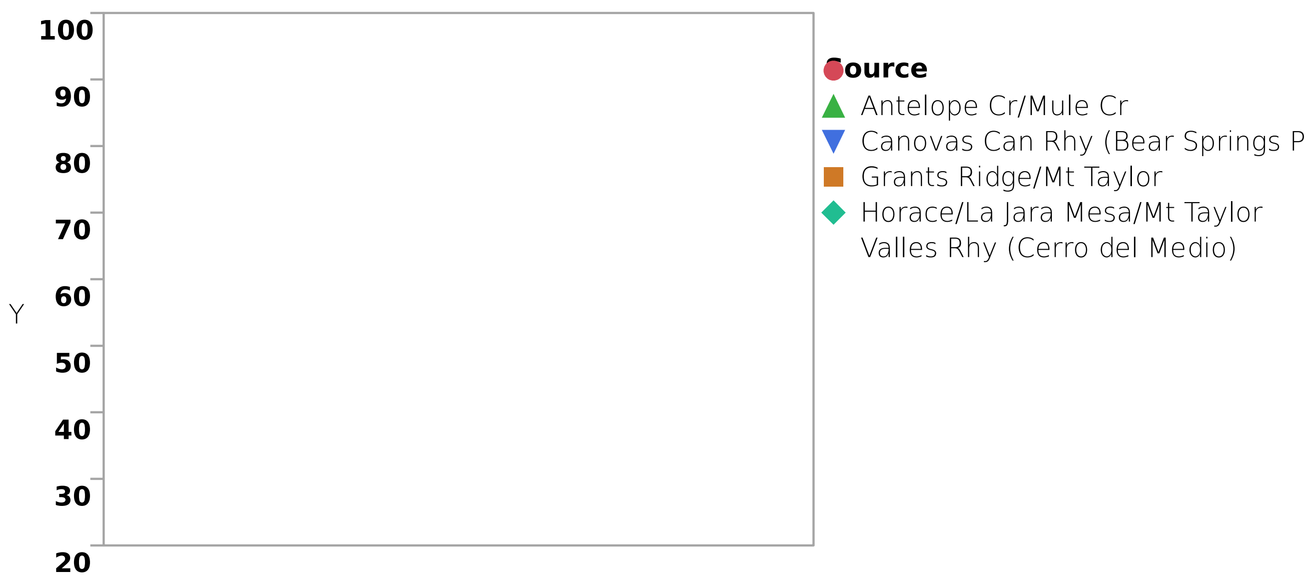

Figure 1. Sr/Y bivariate plot of the archaeological samples. Confidence ellipse at 95%.

Figure 2. Horace/La Jara Mesa, Mount Taylor, northwest New Mexico primary source samples, and debitage sample # 66 from the Blue Canyon site, central New Mexico showing the similarity in angular/rough cortex from the source samples and the artifact (see discussion).