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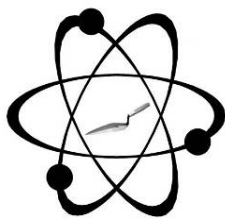
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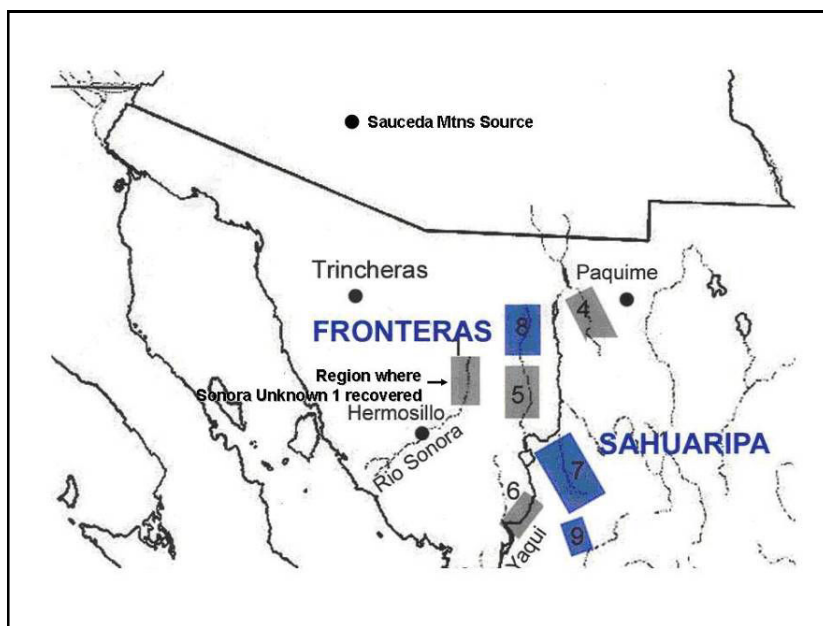
Location of Sauceda Mountains obsidian source and an artifact with similar composition recovered from the upper Rio Sonora, in Sonora, Mexico (map courtesy of Guadalupe Sanchez)

by

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Report Prepared for

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INTRODUCTION

The two artifacts from the Clovis site of Las Tortugas, Gran Desierto, northern Sonora are from one known and one as yet unlocated source: one piece of debitage from the Sauceda Mountains source in southwest Arizona, and one matching the composition of a single artifact recovered from the upper Rio Sonora in northern Sonora (Shackley 2005, 2019a). The biface, a possible Clovis fragment, produced from the source matching the one artifact from the Rio Sonora region is likely from a locality in northern Sonora, the location of which remains unknown. It does not match any known source in the Skinner/Shackley database of North American obsidian sources, including those in northwest Mexico (see Shackley 2005; Vidal-Solano et al. 2020; Table 1, Figures 1 and 2, see also cover image).

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 in 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 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.

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 below detection limits. 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 target 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 (1988, 1995, 2005, 2011, 2019a; Shackley et al. 2016, 2018; 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

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de Recherches Pétrographiques et Géochimiques in France, and JR-1 and JR-2 (obsidian) from the Geological Survey of Japan (Govindaraju 1994).

The data from the WinTrace software were translated directly into Excel for Windows software for manipulation and on into SPSS for Windows (ver. 27) and/or JMP 12.01 for statistical analyses as appropriate. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. G-2 a USGS granite standard was analyzed during the sample run for obsidian artifacts to check machine calibration (Table 2). Source assignments were made by reference to (Shackley 1995, 2005, 2019b; Shackley et al. 2018; Vidal-Solano et al. 2020) and updated at http://swxrflab.net/swobsrcs.htm; Table 1 and Figures 1 and 2 herein).

DISTRIBUTION OF OBSIDIAN SOURCE PROVENANCE IN SONORA

While there have been some obsidian provenance studies in Chihuahua, particularly recently, Sonora has remained essentially unknown in this regard (Dolan et al. 2017, 2019; Fralick et al. 1998; Hard and Roney 1999; Kibler et al. 2014; Shackley 2005; c.f. Vidal-Solano et al. 2020; Figure 1 herein). This small study does provide some more information for future obsidian provenance studies in Sonoran Paleoindian contexts.

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Table 1. USGS G-2 standard measurements and USGS recommended values. All measurements in part per million (ppm).

SAMPLE	Ti	Mn	Fe[1]	Rb	Sr	Y	Zr	Nb	Ba
G-2 (USGS recommended)	2878±180	232±77	18605±1189	170±3	478±2	11±2	309±35	12[2]	1880±23
G-2, pressed powder standard (this study, n=1)	2491	271	17137	168	477	13	275	14	1852

[1] Fe as total Fe_2O_3+

[2] USGS information value only

Table 2. Elemental concentrations for the two artifacts. All measurements in parts per million (ppm).

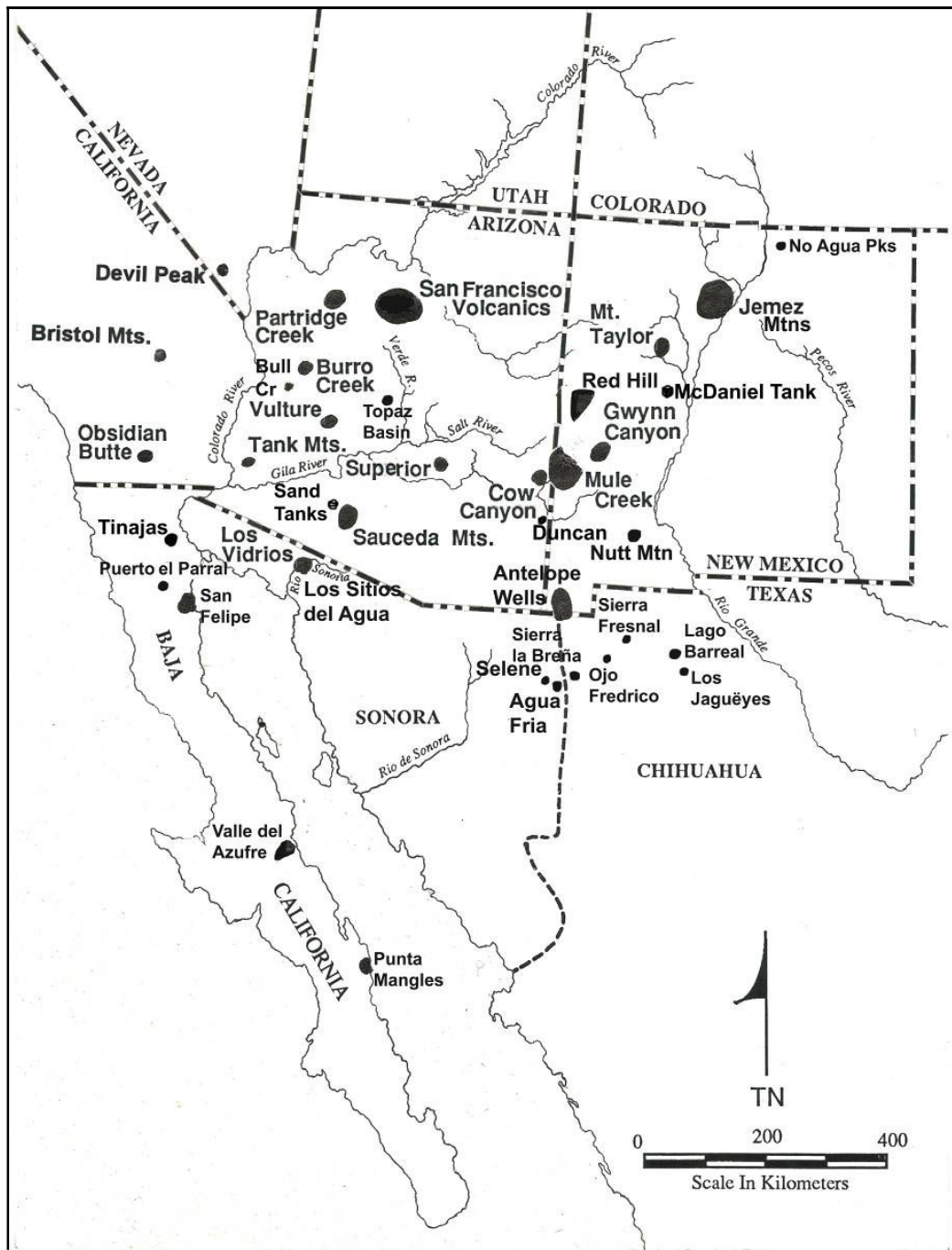| Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba	Ce	Source
94604A	1710	326	13032	146	146	24	160	7	2053	81	SON Unknown 1
94662A	1461	383	11047	155	78	34	206	20	1103	124	Sauceda Mtns, AZ

Figure 1. Approximate location of known sources of archaeological obsidian in the North American Southwest. Adapted from Panich et al. 2017; Shackley 1989, 2005; Shackley et al. 2018).
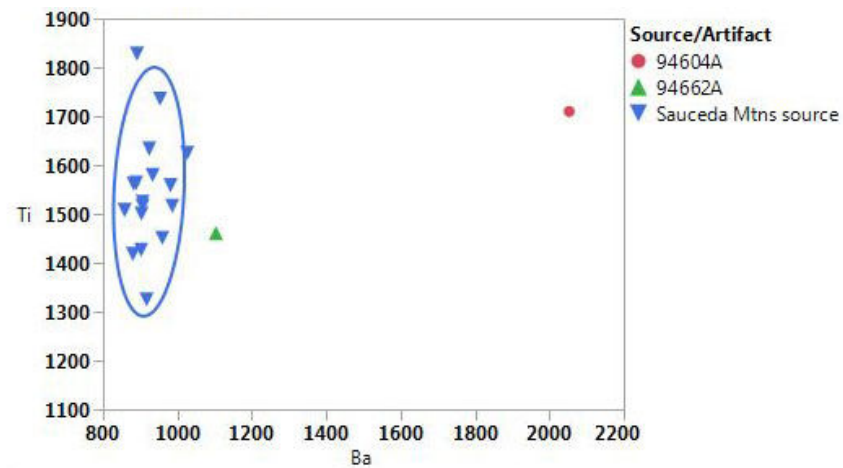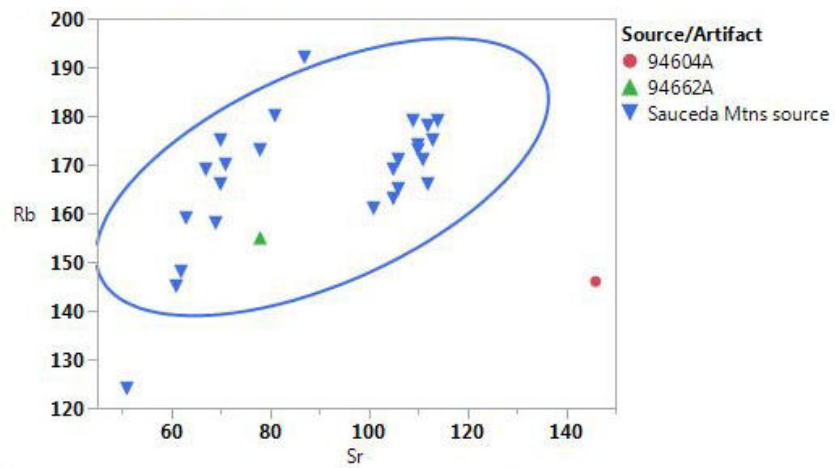
Figure 2. Sr/Rb and Ba/Ti bivariate plots of the two artifacts and Sauceda Mountain source standards. Confidence ellipses at 90%.