SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM WHITE SANDS MISSILE RANGE, SOUTHERN NEW MEXICO

by

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INTRODUCTION

The analysis here of 24 obsidian artifacts from various contexts on the White Sands Missile Range in southern New Mexico exhibits a mix of obsidian source provenance typical of southern New Mexico. All but four of the artifacts were produced from the Cerro Toledo Rhyolite source, most likely collected as secondary deposits in the Rio Grande Quaternary alluvium. The two artifacts produced from Mount Taylor is a source also available in the Rio Grande alluvium south of Socorro. The one interior flake produced from Valles Rhyolite (Cerro del Medio) obsidian in the Jemez Mountains of northern New Mexico is not available in alluvial contexts south of Albuquerque and only in very small proportions and nodule sizes less than 16 mm (Shackley 2005, 2010).

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).

The trace element analyses were performed in the NSF Geoarchaeological XRF Laboratory, Department of Anthropology, University of California, Berkeley, using a Thermo Scientific Quant’X energy dispersive x-ray fluorescence spectrometer. The spectrometer is equipped with a ultra-high flux peltier air cooled Rh x-ray target with a 125 micron beryllium (Be) window, an x-ray generator that operates from 4-50 kV/0.02-1.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTrace™ 4.1 reduction software. The spectrometer is equipped with a 2001 min⁻¹ Edwards vacuum pump for the analysis of elements below titanium (Ti). Data is acquired through a pulse processor and analog to digital converter.
This is a significant improvement in analytical speed and efficiency beyond the former Spectrace 5000 and QuanX analog systems (see Davis et al. 1998; Shackley 2005).

For Ti-Nb, Pb, Th elements the mid-Zb condition is used operating the x-ray tube 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 Kα₁-line data for elements titanium (Ti), manganese (Mn), iron (as Fe⁴⁺), 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 is 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 acquired, the Rh tube is operated at 50 kV and 0.5 mA in an air path at 200 seconds livetime to generate x-ray intensity Kα₁-line data, through a 0.630 mm Cu (thick) filter ratioed to the bremsstrahlung region (see Davis et al. 1998). Further details concerning the petrological choice of these elements in North American obsidians is available in Shackley (1988, 1990, 1995, 2005; also Mahood and Stimac 1991; and Hughes and Smith 1993). A suite of 17 specific standards used for the best fit regression calibration for elements Ti- Nb, Pb, and Th, 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), BCR-2 (basalt), TLM-1 (tonalite), SCO-1 (shale), all US Geological Survey standards, NBS-278 (obsidian) from the National Institute of Standards and Technology, 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).

The data from the WinTrace software were translated directly into Excel for Windows and into SPSS for statistical manipulation (Table 1). In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run (Table 1). RGM-1 is analyzed during each sample run for obsidian artifacts to check machine calibration (Table 1). Source assignments made by reference to source data at Berkeley and Shackley (1995, 1998, 2005; Figure 1 here).

Figure 1. Rb versus Zr bivariate plot of all the archaeological specimens (left) and Y versus Nb bivariate plot of the artifacts assigned to the Tewa Formation sources Cerro Toledo Rhy. and Valles Rhy. yielding better discrimination.
DISCUSSION

Before a discussion of the source provenance of the samples, a short discussion of the Jemez Mountains sources is in order. Following this is a short discussion of the samples proper.

The Jemez Mountains and the Sierra de los Valles

A more complete discussion of the archaeological sources of obsidian in the Jemez Mountains is available in Shackley (2005:64-74). Distributed in archaeological contexts over as great a distance as Government Mountain in the San Francisco Volcanic Field in northern Arizona, the Quaternary sources in the Jemez Mountains, most associated with the collapse of the Valles Caldera, are distributed at least as far south as Chihuahua through secondary deposition in the Rio Grande, and east to the Oklahoma and Texas Panhandles through exchange. And like the sources in northern Arizona, the nodule sizes are up to 10 to 30 cm in diameter; El Rechuelos, Cerro Toledo Rhyolite, and Valles Rhyolite (Valles Rhyolite derived from the Cerro del Medio dome complex) glass sources are as good a media for tool production as anywhere. Until the recent land exchange of the Baca Ranch properties, the Valles Rhyolite primary domes (i.e., Cerro del Medio) have been off-limits to most research. The discussion of this source group here is based on collections by Dan Wolfman and others, facilitated by Los Alamos National Laboratory, and the Museum of New Mexico, and recent sampling of all the major sources courtesy of the Valles Caldera National Preserve (VCNP; Shackley 2005; Wolfman 1994).

There are at least four eruptive events in the last 8.7 million years that have produced the four chemical groups in the Jemez Mountains (Figure 2).
The earliest is the Bear Springs Peak source, part of Canovas Canyon Rhyolite that is dated to about 8.7 mya, firmly in the Tertiary (Kempter et al. 2004; Figure 2 here). This source is a typical Tertiary marekanite source with remnant nodules embedded in a perlitic matrix. It is located in a dome complex including Bear Springs Peak on Santa Fe National Forest and radiating to the northeast through Jemez Nation land (Shackley 2009). While the nodule sizes are small, the glass is an excellent media for tool production and has been found archaeologically at Zuni and in secondary deposits as far south as Las Cruces (Church 2000; Shackley 2009).

The second relevant eruptive event that produced artifact quality obsidian is the El Rechuelos Rhyolite. This source, present as one sample here, is what I consider the best media for tool production of the group. It dates to about 2.4 million years ago, and nodules at least 10
cm in diameter are present in a number of domes north of dacite Polvadera Peak, the incorrect vernacular name for this source. El Rechuelos has eroded through the Rio Chama into the Rio Grande and has also been found in alluvium into southern New Mexico (Church 2000; Shackley 2010).

About 1.4 mya, the first caldera collapse occurred in the Jemez Mountains, called Cerro Toledo Rhyolite. This very large event produced the Bandelier Tuffs and spread ash flows many kilometers into the area and horizontally southwest from what is now Rabbit Mountain and the Cerro Toledo domes to the east. These large ash flow sheets are responsible for the great quantity of Cerro Toledo obsidian that is present in the Quaternary Rio Grande alluvium all the way to Chihuahua (Church 2000; Shackley 2005, 2010). Cerro Toledo Rhyolite secondary deposit nodules are present relatively near to WSMR on Quaternary terraces at San Antonito west of the Rio Grande (Shackley 2010). Tim Church also reports these sources as well as Bear Springs Peak (Canovas Canyon Rhyolite) in the Rio Grande alluvium at Rincon Arroyo and areas south of Las Cruces (Church 2000).

The second caldera collapse, that produced the Valles Rhyolite member of the Tewa Formation, called Valles Rhyolite here, occurred around one million years ago and created most of the geography of the current Valles Caldera. A number of rhyolite ring domes were produced on the east side of the caldera, but only Cerro del Medio produced artifact quality obsidian. Indeed, the Cerro del Medio dome complex produced millions of tons of artifact quality glass, and is the volumetrically largest obsidian source in the North American Southwest challenged only by Government Mountain in the San Francisco Volcanic Field. This source was apparently preferred by Folsom knappers, as well as those in all periods since. While Cerro Toledo probably appears in archaeological contexts in New Mexico sites with greater frequency, it is likely because it is distributed in secondary contexts in very high proportions. Valles Rhyolite (Cerro del Medio), present as one sample here importantly does not erode outside the caldera in any appreciable numbers, and had to be originally procured in the caldera proper, as discussed
above (Shackley 2005, 2010). No Valles Rhyolite obsidian was recovered in the Church study to the south (Church 2000). Extensive collections at Placitas and Tijeras Arroyo have recovered less than .01% of Valles Rhyolite nodules and nothing larger than 16 mm in diameter, as opposed to Cerro Toledo nodules up to 150 mm (Shackley 2010). While the interior flake that was produced from Valles Rhyolite (Sample 51) could have come from a secondary context upstream somewhere, it’s dimension over 23 mm suggests otherwise.

**Source Provenance Discussion**

Most of the artifacts analyzed produced from Cerro Toledo Rhyolite are bipolar core or flake fragments and most appear to have waterworn cortex. This suggests that these raw materials were procured along the river somewhere. The Mount Taylor obsidian are available in the Rio Puerco which enters the Rio Grande just north of Socorro is also present in this assemblage (Shackley 2005, 2010; Table 1 here). The other artifact produced from Valles Rhyolite (Cerro del Medio) obsidian most likely had to be originally procured in the caldera and isn’t available in Rio Grande alluvium in any quantity based on research so far, again as discussed above (Shackley 2005, 2010).

Finally, the one projectile point that appears to be an Archaic form and possibly radically rejuvenated (Sample 52), was produced from Red Hill obsidian, a source located north of Luna, New Mexico and south of Zuni could have been produced nearer the source given the lack of Red Hill debitage here, and the rather high density of Archaic sites in that region.

The dominance of Cerro Toledo obsidian in Paleoindian through late period sites in southern New Mexico is rather typical (Church 2000; LeTourneau and Shackley 2009; Shackley 2005, 2009). Whether the distribution of source provenance at WSMR is typical of the region overall is difficult to determine with a relatively small sample. What is suggested is a reflection of the dominance of procurement from the Rio Grande Quaternary alluvium with high proportions of Cerro Toledo Rhyolite obsidian from Espanola to Chihuahua (Church 2000; Shackley 2005, 2010).
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McCarthy, J.J., and F.H. Schamber

Schamber, F.H.

Shackley, M. Steven


Wolfman, Daniel
Table 1. Elemental concentrations for the archaeological specimens and the USGS RGM-1 standard. All measurements in parts per million (ppm).

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