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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THREE SITES WITHIN THE YELLOWHOUSE DRAINAGE, WEST TEXAS

by

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Report Prepared for
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INTRODUCTION

The analysis here of 10 artifacts from a three sites along the Yellowhouse system near Lubbock Lake, west Texas indicates that all the obsidian artifacts were produced from obsidian procured from the Jemez Mountains in northern New Mexico, although one of the sources is available as secondary deposits in the Rio Grande River Quaternary alluvium.

ANALYSIS AND INSTRUMENTATION

All samples were analyzed whole with little or no formal preparation. 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 EDXRF trace element analyses were performed in the Archaeological XRF Laboratory, Department of Earth and Planetary Sciences, University of California, Berkeley, using a Spectrace/ThermoNoran™ QuanX energy dispersive x-ray fluorescence spectrometer. All samples were analyzed whole with little or no formal preparation. 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 spectrometer is equipped with an air cooled Cu x-ray target with a 125 micron Be window, an x-ray generator that operates from 4-50 kV/0.02-2.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTrace™ software. The x-ray tube is operated at 30 kV, 0.14 mA, using a 0.05 mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity Kα-line data for elements titanium (Ti), manganese (Mn), iron (as Fe^{T}), rubidium zinc (Zn), (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), and thorium (Th). Weight percent iron (Fe_{2}O_{3}^{T}) can be derived by multiplying ppm estimates by 1.4297(10^-4). Trace element intensities
were converted to concentration estimates by employing a least-squares calibration line 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). Further details concerning the petrological choice of these elements in Southwest obsidian is available in Shackley (1992, 1995, 2004; also Mahood and Stimac 1991; and Hughes and Smith 1993). Specific standards used for the best fit regression calibration for elements Ti through Nb include G-2 (basalt), AGV-1 (andesite), GSP-1, SY-2 (syenite), BHVO-1 (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, and BR-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). In addition to the reported values here, Ni, Cu, and Ga were measured, but these are rarely useful in discriminating glass sources and are not generally reported.

The data were translated directly into Excel™ for Windows software for manipulation and on into SPSS™ for Windows for statistical analyses. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. An analysis of the specific run of source standard RGM-1 is included in Table 1. Source nomenclature follows Baugh and Nelson (1987), Glascock et al. (1999), and Shackley (1988, 1995, 1998a, 1998b, 2004). Further information on the laboratory instrumentation can be found at: http://www.swxrflab.net/ and Shackley (1998a). Trace element data exhibited in Table 1 are reported in parts per million (ppm), a quantitative measure by weight (see also Figure 2).

**SILICIC VOLCANISM IN THE JEMEZ MOUNTAINS**

Due to its proximity and relationship to the Rio Grande Rift System, potential uranium ore, geothermal possibilities, an active magma chamber, and a number of other geological issues, the Jemez Mountains and the Toledo and Valles Calderas particularly have been the subject of intensive structural and petrological study particularly since the 1970s (Bailey et al. 1969; Gardner et al. 1986; Heiken et al. 1986; Ross et al. 1961; Self et al. 1986; Smith et al. 1970; Figure 1 here). Half of the 1986 *Journal of Geophysical Research*, volume 91, was devoted to the then current research on the Jemez Mountains. More accessible for archaeologists, the geology
of which is mainly derived from the above, is Baugh and Nelson’s (1987) article on the relationship between northern New Mexico archaeological obsidian sources and procurement on the southern Plains.

Due to continuing tectonic stress along the Rio Grande, a lineament down into the mantle has produced a great amount of mafic volcanism during the last 13 million years (Self et al. 1986). Earlier eruptive events during the Tertiary more likely related to the complex interaction of the Basin and Range and Colorado Plateau provinces produced bimodal andesite-rhyolite fields, of which the Paliza Canyon (Keres Group) and probably the Polvadera Group is a part (Smith et al. 1970). While both these appear to have produced artifact quality obsidian, the nodule sizes are relatively small due to hydration and devitrification over time (see Hughes and Smith 1993; Shackley 1990, 1998b). Later, during rifting along the lineament and other processes not well understood, first the Toledo Caldera (ca. 1.45 Ma) and then the Valles Caldera (1.12 Ma) collapsed causing the ring eruptive events that were dominated by crustally derived silicic volcanism and dome formation (Self et al. 1986). The Cerro Toledo Rhyolite and Valles Grande Member obsidians are grouped within the Tewa Group due to their similar magmatic origins. The slight difference in trace element chemistry is probably due to evolution of the magma through time from the Cerro Toledo event to the Valle Grande events (see Hildreth 1981; Mahood and Stimac 1990; Shackley 1998c; see Figure 2 here). This evolutionary process has recently been documented in the Mount Taylor field (Shackley 1998c). Given the relatively recent events in the Tewa Group, nodule size is large and hydration and devitrification minimal, yielding the best natural glass media for tool production in the Jemez Mountains.

Recent study of the secondary depositional context of these sources and their relationship to the Rio Grande Rift have indicated that only two of the major sources enter that stream system (Shackley 2000). Cerro Toledo Rhyolite erodes from the domes in the Sierra de Toledo along the northeast scarp of the caldera, and in much greater quantity due to the ash flow tuff eruptive event associated with the Rabbit Mountain dome on the southeast margin of the caldera. This latter eruption created large quantities of glass that have continually eroded into the Rio Grande system (see Figure 1). Most likely the Cerro Toledo obsidian present in these sites was procured directly from the Rio Grande alluvium, or in the Puye Formation to the northeast of Santa Fe. El Rechuelos obsidian present on a number of minor domes northeast of the caldera, and slightly earlier than the
caldera event, erodes north into the Rio Chama and ultimately into the Rio Grande. This one artifact from LA 108902 could be produced from raw material procured in the Rio Grande system.

Obsidian from the Valle Grande member, however, does not leave the caldera floor, although some small nodules have been recovered from the East Jemez River, but does not erode outside the caldera area (Shackley 2000). This is likely due to the recent event that occurred as a resurgence on the caldera floor. Importantly, this would indicate that Valle Grande obsidian must be procured from the caldera floor proper (i.e. at Cerro del Medio) either directly or through exchange with groups with direct access. The Cerro Toledo Rhyolite and El Rechuelos obsidian could also be procured in this way, but they are also available, albeit in smaller nodule sizes, from the Santa Fe area in the Rio Grande alluvium.

**SUMMARY AND CONCLUSION**

All four sites exhibit artifacts produced from obsidian procured from the Cerro Toledo, Valle Grande, and Canovas Canyon members of the Valles Caldera and earlier eruptive events (Table 2). As discussed above, only Cerro Toledo Rhyolite obsidian is available in the Rio Grande River alluvium west in eastern New Mexico (Church 2000; Shackley 2004). Valle Grande, a Quaternary event has not eroded outside the caldera floor. The other two late Tertiary sources El Rechuelos and Bear Springs Peak also do not enter the Rio Grande system in any quantity. So, much of the obsidian used to produce these artifacts was originally procured in northern New Mexico.
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Schamber, F.H.

Self, S., F. Goff, J.N. Gardner, J.V. Wright, and W.M. Kite

Shackley, M. Steven


Smith, R.L., R.A. Bailey, and C.S. Ross
Table 1. Elemental concentrations and source assignments for archaeological samples. All measurements in parts per million.

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<th>Fe</th>
<th>Zn</th>
<th>Rb</th>
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<th>Zr</th>
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Figure 1. Topographical rendering of a portion of the Jemez Mountains, Valles Caldera, and relevant features. (from Baugh and Nelson 1987; Smith et al. 1970).
Figure 1. Rb, Y, Zr three dimensional plot of archaeological data. Note the genetic similarity between the Jemez obsidian sources, particularly the Valle Grande Member and Cerro Toledo Rhyolites. These can be discriminated using Y as below.
Figure 2. Y versus Nb biplot of archaeological data effectively separating the Jemez Mountain sources, Valle Grande, Cerro Toledo Rhyolite, El Rechuelos, and Bear Springs Peak.