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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM LA 4624, PAJARITO PLATEAU, NORTHERN NEW MEXICO

by

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INTRODUCTION

The following report documents a geochemical analysis of 14 obsidian artifacts from LA 4624, Mesita del Buey, northern New Mexico. All of the obsidian artifacts were produced from obsidian procured from one of the domes and chemical groups in the Toledo and Valles Caldera collapse phases of the Jemez Mountain Volcanic Field, as well as one specimen from the earlier El Rechuelos member of the Polvadera Group. In addition to a discussion of the results, a short summary of the silicic petrology in the Jemez Mountains is included relevant to archaeological obsidian and attendant recent field studies.

LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION

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 trace element analyses were performed in the Department of Geology and Geophysics, University of California, Berkeley, using a Philips PW 2400 wavelength x-ray fluorescence spectrometer using a LiF 200 crystal for all measurements. This crystal spectrometer uses specific software written by Philips (SuperQ/quantitative) and modifies the instrument settings between elements of interest. Practical detection limits have not been calculated for this new instrument, but but the variance from established standards is shown in Table 1. Sample selection is automated and controlled by the Philips software. X-ray intensity

Kα-line data with the scintillation counter were measured for elements rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). X-ray intensities for barium (Ba) were measured with the flow counter from the Lα-line. 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). Specific standards used for the best fit regression calibration for elements Ti through Nb include G-2 (basalt), AGV-1 (andesite), GSP-1 and SY-2 (syenite), BHVO-1 (hawaiite), STM-1 (syenite), QLM-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).

The data from the SuperQ software 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 RGM-1 is included in Table 1. Source nomenclature follows Baugh and Nelson (1987), Glascock et al. (1999), and Shackley (1988, 1995, 1998a). Further information on the laboratory instrumentation can be found at: http://obsidian.pahma.berkeley.edu/ and Shackley (1998a). Trace element data exhibited in Table 1 are reported in parts per million (ppm), a quantitative measure by weight.

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 volcanisim 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 1 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.

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 in local alluvium (i.e. the Puye Formation).

SUMMARY AND CONCLUSION

LA 1624 exhibits artifacts produced from obsidian procured from both Cerro Toledo and Valle Grande members of the Valles Caldera (Table 1, Figures 2 and 3). Marekanites exhibiting the identical signature as Cerro Toledo Rhyolite are incorporated into the upper member of the Bandelier Tuff, and the obsidian at LA 4624 could have been procured from this context. These nodules however, are generally small, so larger artifacts would have to be produced from more primary sources. One projectile point was produced from El Rechuelos glass, and could have entered archaeological context as a finished artifact rather than ram material.

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Table 1. Elemental concentrations for the archaeological specimens. All measurements in parts per million (ppm).

Sample	Rb	Sr	Y	Zr	Nb	Ba	Source
LA 4624-90	199	8	62	177	95	15	Cerro Toledo Rhy
LA 4624-117A	160	11	44	173	56	51	Valle Grande
LA 4624-117B	200	6	61	177	96	2	Cerro Toledo Rhy
LA 4624-131	192	7	60	176	95	6	Cerro Toledo Rhy
LA 4624-136	198	7	62	178	96	6	Cerro Toledo Rhy
LA 4624-154A	201	7	62	181	98	15	Cerro Toledo Rhy
LA 4624-154B	202	7	62	180	98	2	Cerro Toledo Rhy
LA 4624-154C	201	6	62	182	97	11	Cerro Toledo Rhy
LA 4624-154D	202	7	62	181	97	2	Cerro Toledo Rhy
LA 4624-157A	198	6	61	178	96	1	Cerro Toledo Rhy
LA 4624-157B	198	7	60	173	95	1	Cerro Toledo Rhy
LA 4624-171	149	10	23	78	45	21	El Rechuelos
LA 4624-181	199	7	62	186	97	0	Cerro Toledo Rhy
LA 4624-187	152	11	43	171	54	52	Valle Grande
RGM H-1	144	103	25	218	9	812	standard

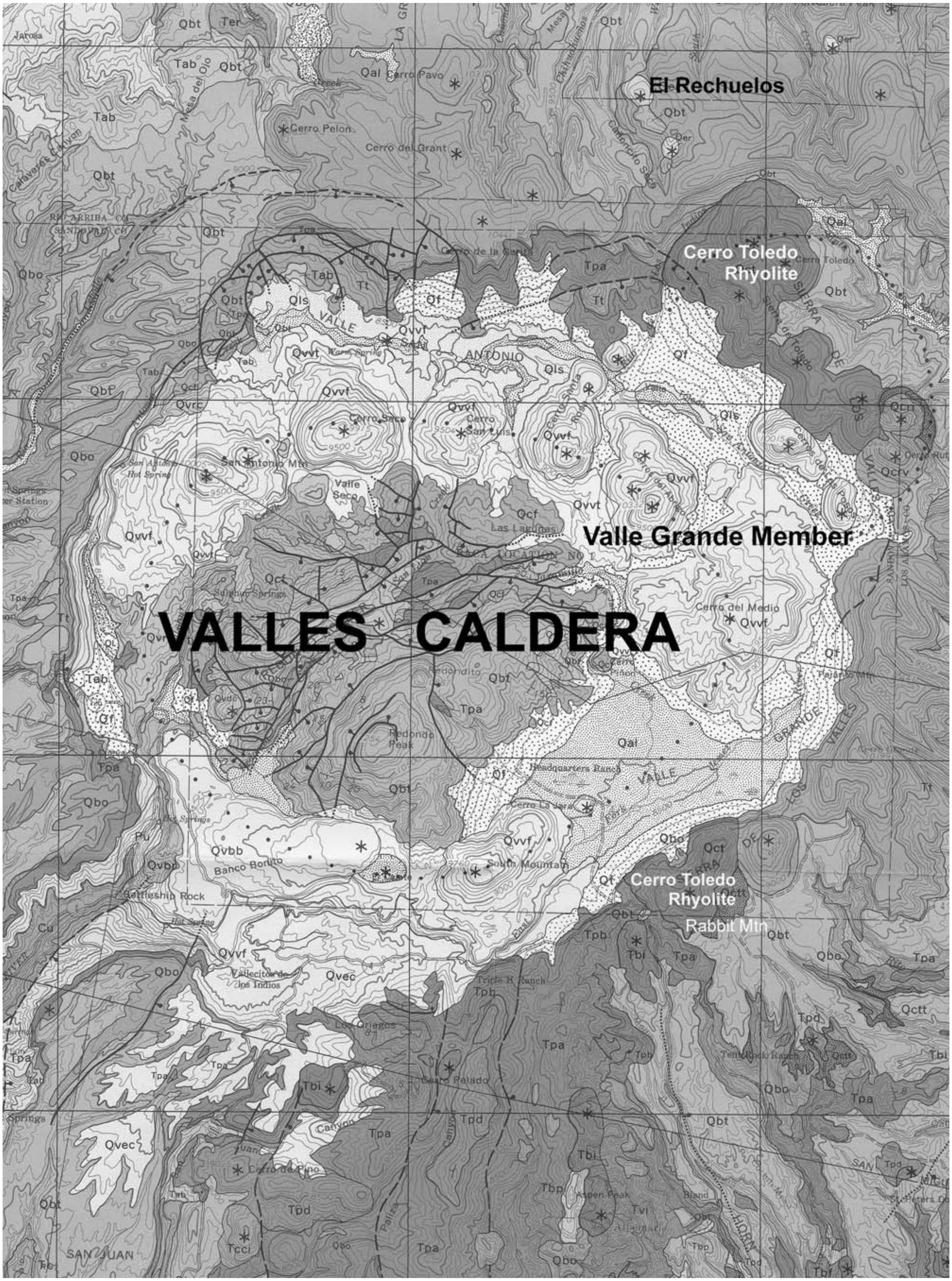

Figure 1. Topographical rendering of a portion of the Jemez Mountains, Valles Caldera, and relevant features. (from Baugh and Nelson 1987; Smith et al. 1970).

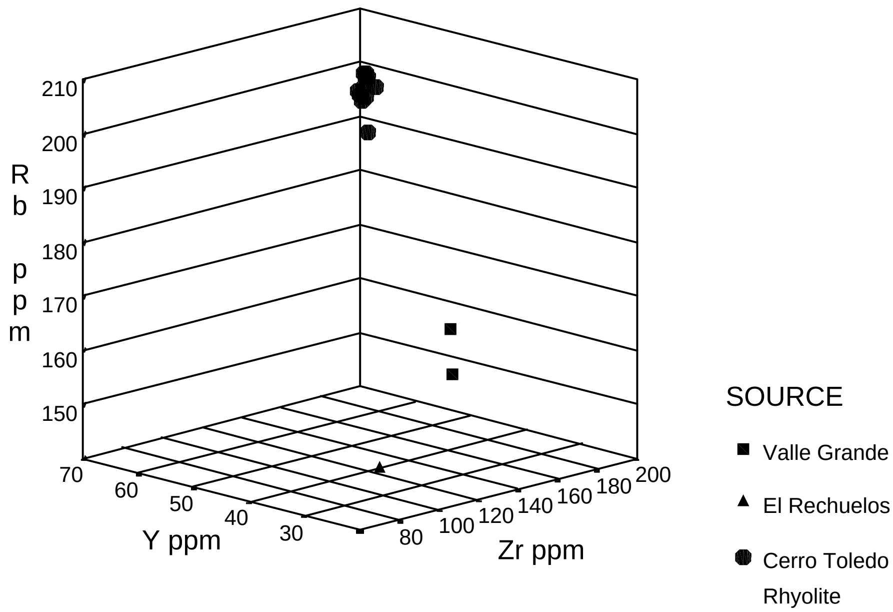

Figure 2. Rb, Y, Zr plot of archaeological samples from all sites.

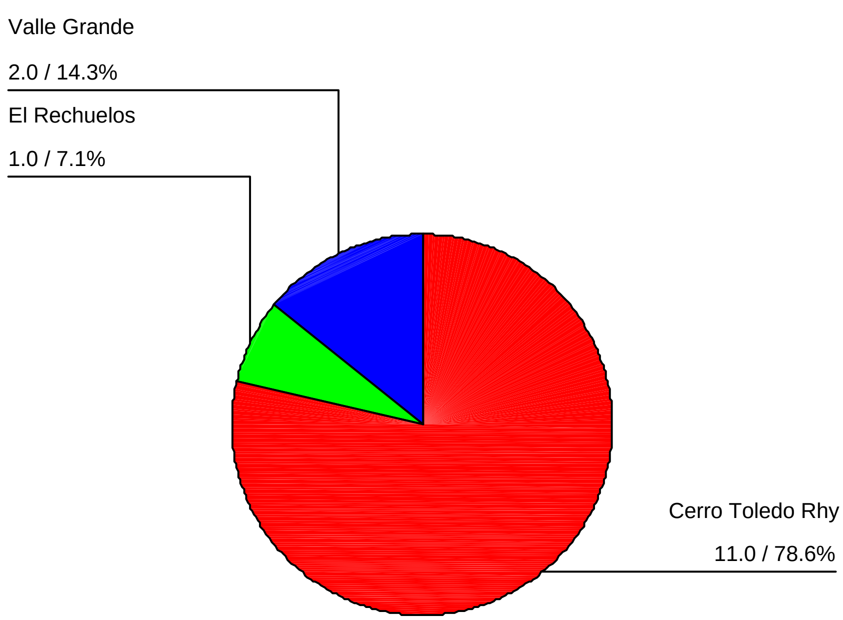

Figure 3. Frequency distribution of obsidian source provenance in LA 4624.