Phoebe Hearst Museum of Anthropology
103 Kroeber Hall
University of California
Berkeley, CA 94720-3712
http://obsidian.pahma.berkeley.edu

# SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM PREHISTORIC SITES IN CIMARRON COUNTY, OKLAHOMA, AND DALLAM COUNTY, TEXAS

by

M. Steven Shackley, Ph.D.
Director

Report Prepared for
Jason LaBelle
Department of Anthropology
Southern Methodist University
Dallas, Texas

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## INTRODUCTION

The 32 artifacts comprising the obsidian assemblage from the Panhandle region is one of the most diverse yet seen from that region. While this diversity may be partly due to the varying temporal contexts, it includes artifacts produced from obsidian procured from both the Jemez Mountains, and Mount Taylor in New Mexico, eastern Idaho, and western Wyoming. Additionally, two samples could not be assigned to source with available source standard data.

## 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 K$\alpha$-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 L$\alpha$-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 one included in the run is provided 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 Tables 1 and 2 are reported in parts per million (ppm), a quantitative measure by weight (see also Figures 1 and 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 3 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). Similar to the Mount Taylor field to the west, 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 (Shackley 1998a; 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 1998a, 1998b; see Figure 1 here). 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.

The presence of Idaho and Wyoming sources in Panhandle sites has generally been associated with Archaic period occupations, with the New Mexico sources associated with later occupations. This assemblage could shed more light on the issue.

**Secondary Depositional Effects**

Recent research by this lab investigating the secondary depositional regime from both the Jemez Mountains (Sierra del Valle), and the Mount Taylor Volcanic Field to the west, indicates that: 1) Valle Grande Member rhyolite and obsidian in the Jemez Mountains, the result of the most recent eruptive event that produced glass in the caldera, does not erode out of the caldera; 2) Cerro Toledo Rhyolite and glass, mainly the result of the Rabbit Mountain ash flow eruption deposited vast quantities of ash and quenched rhyolite in the Rio Grande River basin; and the Grant's Ridge glass of the Mount Taylor Volcanic Field has been eroding through the Rio Puerco and Rio Grande systems since the Plio-Pleistocene (Shackley 1998a, 2000). Both the Cerro Toledo Rhyolite glass and Mount Taylor glass is common in Quaternary alluvium of the Rio Grande as far south as Chihuahua, and was frequently used as a toolstone source in prehistory (Shackley 1997). It is impossible to determine in a finished artifact whether the raw material was procured from the primary or secondary sources, unless the artifact is very large (>5-10 cm), when it can be assumed that the artifact was procured from nearer the source. In this assemblage given the presence of Valle Grande glass, one can assume more confidently that some of the other sources may have been procured from the caldera proper (see Table 3 and Figure 4).

## GEOCHEMICAL RESULTS AND SUMMARY

The presence of northern New Mexico obsidian in western Texas and Oklahoma sites is not unusual. What is most unusual here is the presence of Mount Taylor obsidian in these sites. Located in northwestern New Mexico, these sources have been eroding into the Rio Puerco and

Rio Grande river systems since the Plio-Pleistocene (Shackley 1998a). It is probable that the raw material was procured from the Rio Grande alluvium, although the Rio Puerco intersects the Rio Grande south of Albuquerque.

The diversity of source procurement in this assemblage will certainly raise as many questions as it addresses. It appears that a relatively large number of sources were exploited in northern New Mexico, and at least the Valle Grande Member glass had to have originally come from the Valles Caldera proper rather than secondary deposits of the Rio Grande River.

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Table 1. X-ray fluorescence concentrations for selected trace elements RGM-1 (n=5 runs, this analysis). ± values represent first standard deviation computations for the group of measurements. All values are in parts per million (ppm) as reported in Govindaraju (1994) and this study. RGM-1 is a U.S. Geological Survey rhyolite standard.

| SAMPLE | Rb | Sr | Y | Zr | Nb | Ba |
|---|---|---|---|---|---|---|
| RGM-1 (Govindaraju 1994) | 149 | 108 | 25 | 219 | 8.9 | 807 |
| RGM-1 (Glascock and Anderson 1993) | 145±3 | 120±10 | n.r.[a] | 150±7 | n.r. | 826±31 |
| RGM-1 (this study) | 144.6±0.55 | 102.2±0.45 | 24±0 | 216.4±0.55 | 8.8±0.45 | 806.4±5 |

[a] n.r. = no report; n.m.=not measured

Table 2. Elemental concentrations for archaeological samples. All measurements in parts per million (ppm).

| Sample | Rb | Sr | Y | Zr | Nb | Ba | Source |
|---|---|---|---|---|---|---|---|
| CIMARRON-1 | 198 | 6 | 61 | 179 | 95 | 12 | Cerro Toledo Rhyolite, NM |
| CIMARRON-2 | 187 | 7 | 60 | 177 | 94 | 48 | Cerro Toledo Rhyolite, NM |
| CIMARRON-3 | 197 | 6 | 61 | 175 | 96 | 9 | Cerro Toledo Rhyolite, NM |
| CIMARRON-4 | 195 | 8 | 59 | 174 | 94 | 82 | Cerro Toledo Rhyolite, NM |
| CIMARRON-5 | 102 | 9 | 21 | 71 | 34 | 31 | El Rechuelos, NM* |
| CIMARRON-6 | 121 | 73 | 32 | 94 | 15 | 1480 | Malad, ID |
| CIMARRON-7 | 503 | 9 | 89 | 144 | 232 | 79 | Mount Taylor |
| CIMARRON-8 | 201 | 7 | 63 | 178 | 95 | 52 | Cerro Toledo Rhyolite, NM |
| CIMARRON-9 | 161 | 11 | 44 | 170 | 55 | 100 | Valle Grande, NM |
| CIMARRON-10 | 150 | 11 | 24 | 78 | 46 | 112 | El Rechuelos, NM |
| CIMARRON-11 | 198 | 6 | 62 | 177 | 96 | 10 | Cerro Toledo Rhyolite, NM |
| CIMARRON-12 | 203 | 7 | 63 | 187 | 98 | 59 | Cerro Toledo Rhyolite, NM |
| CIMARRON-13 | 193 | 7 | 59 | 173 | 94 | 35 | Cerro Toledo Rhyolite, NM |
| CIMARRON-14 | 204 | 7 | 64 | 181 | 99 | 74 | Cerro Toledo Rhyolite, NM |
| CIMARRON-15 | 156 | 10 | 43 | 172 | 55 | 89 | Valle Grande, NM |
| CIMARRON-16 | 149 | 11 | 23 | 78 | 46 | 70 | El Rechuelos, NM |
| CIMARRON-17 | 144 | 10 | 23 | 76 | 45 | 51 | El Rechuelos, NM |
| CIMARRON-18 | 158 | 10 | 43 | 166 | 55 | 70 | Valle Grande, NM |
| CIMARRON-19 | 167 | 68 | 19 | 102 | 14 | 393 | unknown |
| CIMARRON-20 | 200 | 11 | 62 | 180 | 98 | 49 | Cerro Toledo Rhyolite, NM |
| CIMARRON-21 | 200 | 7 | 62 | 181 | 97 | 38 | Cerro Toledo Rhyolite, NM |
| CIMARRON-22 | 151 | 10 | 42 | 160 | 52 | 89 | Valle Grande, NM |
| CIMARRON-23 | 245 | 9 | 77 | 177 | 47 | 60 | Obsidian Cliff, WY |
| CIMARRON-24 | 481 | 10 | 83 | 138 | 215 | 40 | Mount Taylor |
| CIMARRON-25 | 122 | 74 | 33 | 99 | 15 | 1507 | Malad, ID |
| CIMARRON-27 | 194 | 8 | 86 | 491 | 28 | 43 | unknown |
| CIMARRON-29 | 153 | 10 | 42 | 168 | 54 | 47 | Valle Grande, NM |
| CIMARRON-30 | 156 | 11 | 43 | 169 | 54 | 93 | Valle Grande, NM |
| CIMARRON-31 | 204 | 7 | 63 | 178 | 95 | 38 | Cerro Toledo Rhyolite, NM |
| CIMARRON-32 | 150 | 10 | 42 | 161 | 51 | 102 | Valle Grande, NM |
| DALLAM-26 | 159 | 10 | 44 | 173 | 56 | 150 | Valle Grande, NM |
| DALLAM-28 | 198 | 7 | 61 | 178 | 97 | 110 | Cerro Toledo Rhyolite, NM |
| RGM-1-H-1 | 143 | 101 | 24 | 214 | 8 | 805 | standard |
| RGM-1-H-1 | 146 | 103 | 24 | 217 | 9 | 802 | standard |

* This sample is relatively small and while the elemental concentrations fall outside the source standard data is likely from this source (see Davis et al. 1998).

Table 3. Frequency distribution of obsidian source provenance.

| | | Frequency | Percent |
|---|---|---|---|
| SOURCE | Cerro Toledo Rhyolite, NM | 13 | 40.6 |
| | El Rechuelos, NM | 3 | 9.4 |
| | El Rechuelos, NM? | 1 | 3.1 |
| | Malad, ID | 2 | 6.3 |
| | Mount Taylor, NM | 2 | 6.3 |
| | Obsidian Cliff, WY | 1 | 3.1 |
| | unknown | 2 | 6.3 |
| | Valle Grande, NM | 8 | 25.0 |
| | Total | 32 | 100.0 |

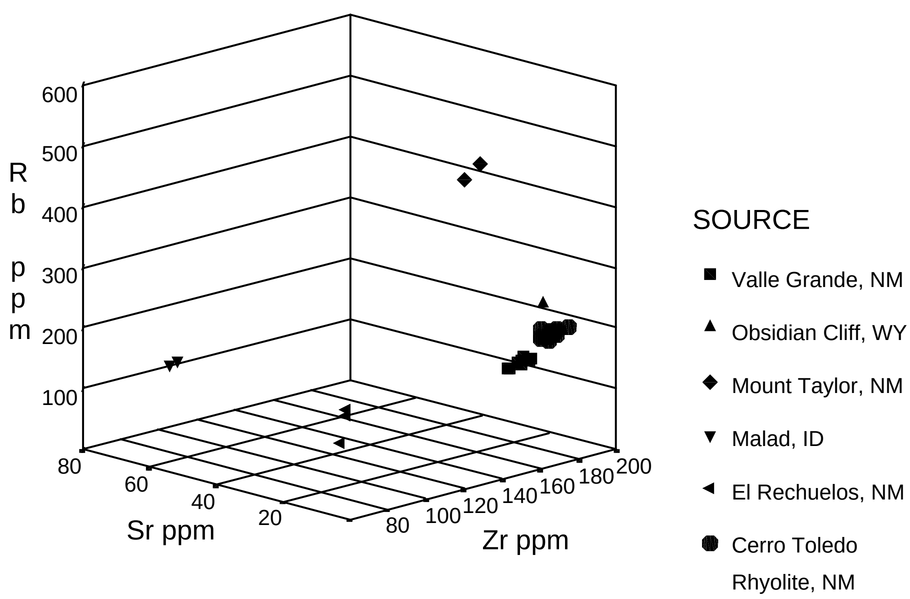


Figure 1. Rb, Sr, Zr three-dimensional plot of artifact elemental concentrations.

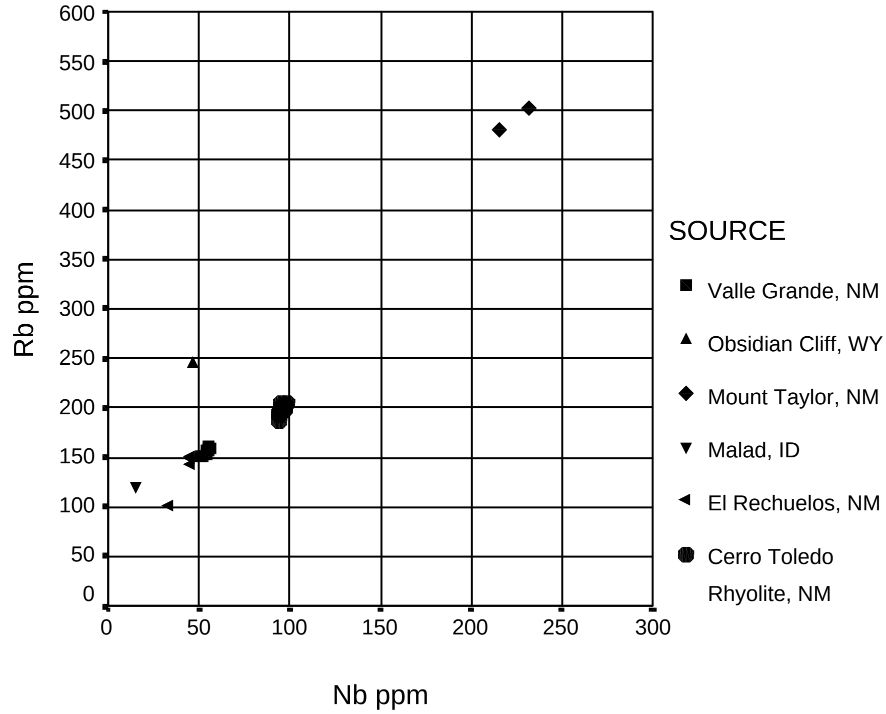


Figure 2. Rb versus Nb plot of artifact elemental concentrations more effectively separating Obsidian Cliff from the Jemez Mountain sources.

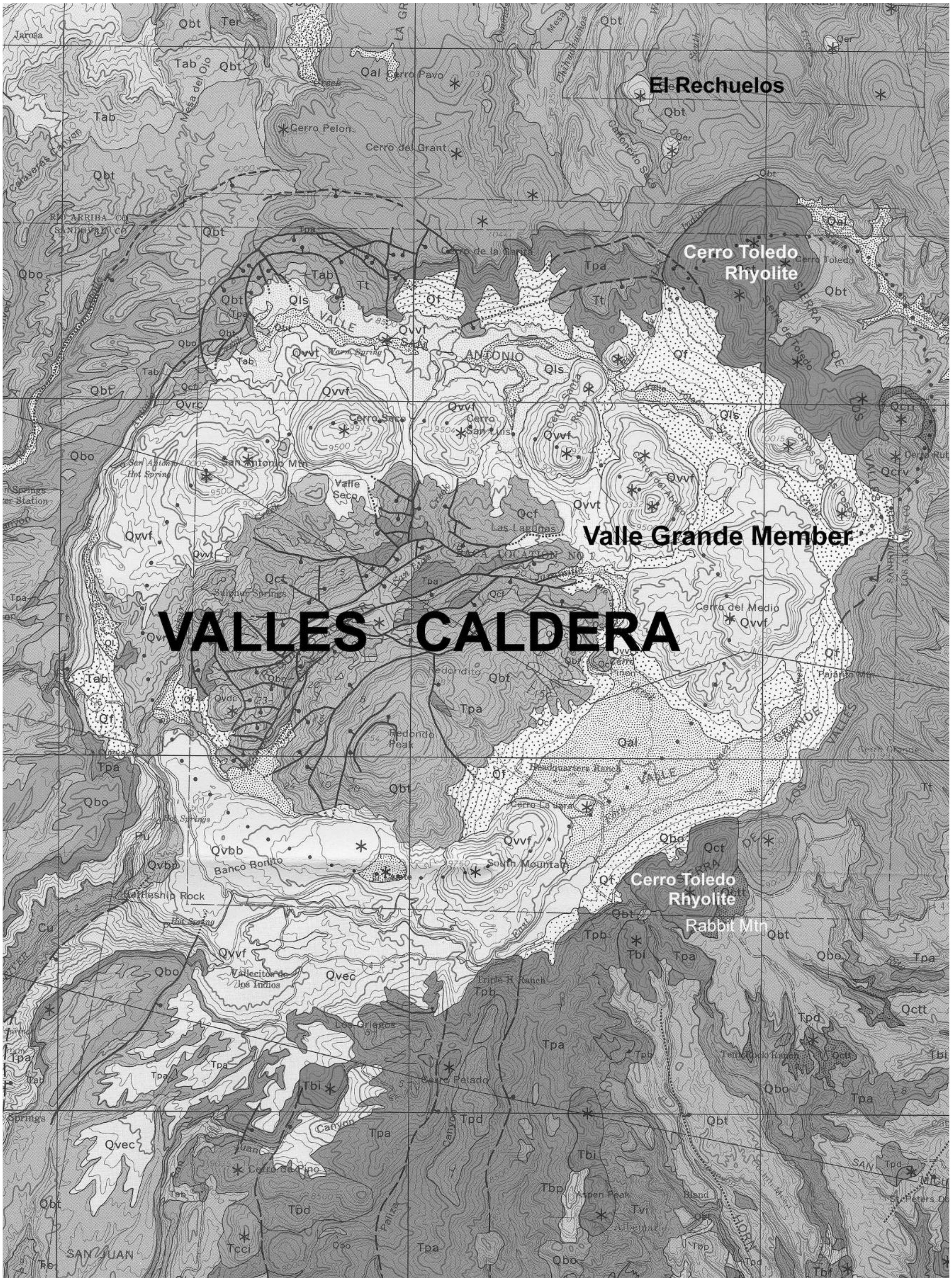


Figure 3. Topographical rendering of a portion of the Jemez Mountains, Valles Caldera, and relevant features.

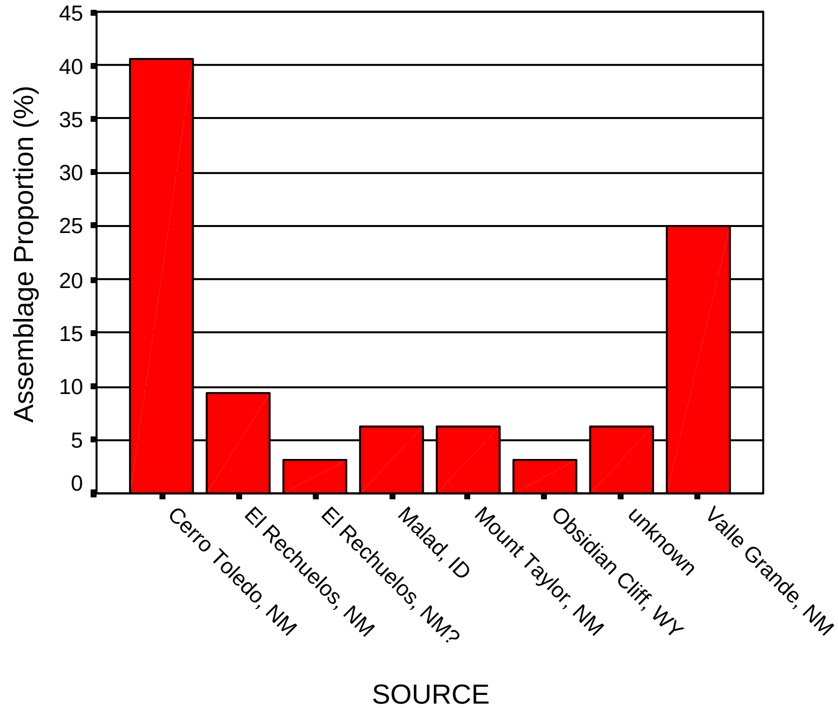


Figure 4. Histogram/bar chart of the distribution of obsidian source provenance in the entire assemblage.