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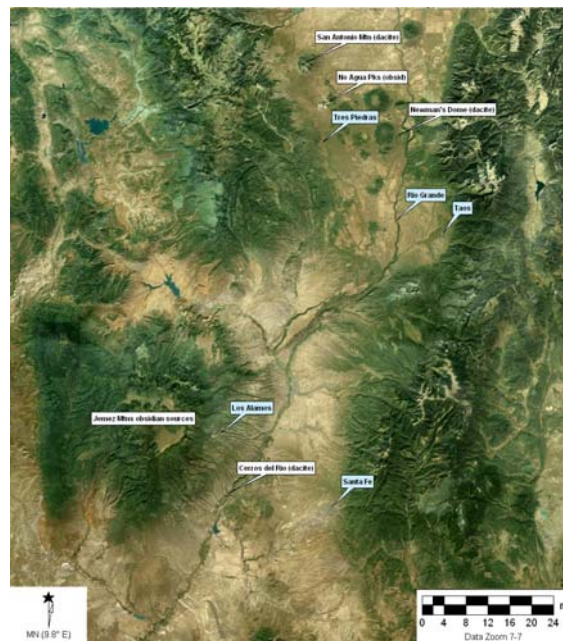
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SOURCE PROVENANCE OF OBSIDIAN AND DACITE PALEOINDIAN AND PUEBLOAN PERIOD ARTIFACTS FROM NORTHERN NEW MEXICO



by

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Report Prepared for

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INTRODUCTION

The analysis here of obsidian and dacite artifacts from northern New Mexico yields results similar to a larger study with the Smithsonian Institution and Los Alamos National Laboratory (Shackley 2005a). All the obsidian artifacts were produced from one of the sources in northern New Mexico, dominated by El Rechuelos located on the northern end of the Jemez Mountains (Table 1). All the dacite artifacts can be assigned to one of three sources in northern New Mexico.

LABORATORY SAMPLING, ANALYSIS AND INSTRUMENTATION ANALYSIS AND INSTRUMENTATION

All archaeological obsidian and dacite 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 Archaeological XRF Laboratory, Department of Earth and Planetary Sciences, University of California, Berkeley, using a Spectrace/ThermoNoran™ QuanX energy dispersive x-ray fluorescence spectrometer. 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™ reduction 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 $K\alpha$ -line data for elements titanium (Ti), manganese (Mn), iron (as FeT), zinc (Zn), gallium (Ga), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). Zinc and gallium are only reported for the dacite artifacts, since they are generally in low quantities in western North American obsidian. 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). Line fitting is linear (XML) for all elements but Fe where a derivative fitting is used to improve the fit for the high concentrations of iron and thus for all the other elements. Further details concerning the petrological choice of these elements in obsidian is available in Shackley (1995, 1998 and 2005b; 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, BR-N (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). In addition to the reported values here, Ni, and Cu, were measured, but these are rarely useful in discriminating glass sources, are poorly measured with the Cu target, and are not generally reported.

The data from the WinTrace 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. RGM-1 is analyzed during each sample run for obsidian artifacts to check machine calibration (see Table 1). Compilation and discussion of RGM-1 analyses are available at <http://www.swxrflab.net/analysis.htm>. Source assignments were made with reference to the source standard library at Berkeley, and the Cerros de Rio and San Antonio Mountain dacite source samples supplied by Vierra, and dacite and obsidian data in (Boyer and Moore 2001; Lipman and Mehnert 1979; Newman and Nielson 1984; Shackley 1995, 1998, 2005b).

DISCUSSION

Obsidian Artifacts

The provenance of the obsidian artifacts dominated by Jemez Mountains sources is not surprising (Table 1, and Figure 1). El Rechuelos on the north side of the Jemez Mountains may certainly explain its dominance, but the obsidian proper is less likely to have the devitrified spherulites so common in Cerro Toledo and Valle Grande (Cerro del Medio) obsidian, and therefore may have been preferred for large bifaces during the Paleoindian and Archaic periods. These three major sources are only about 15 km apart at the maximum. Valle Grande (Cerro del Medio) obsidian has not yet eroded outside the caldera and had to have been originally procured in the caldera proper, rather than secondary deposits as with Cerro Toledo and El Rechuelos material (Shackley 2005b).

Dacite Artifacts

Previous to the recent study (Shackley 2005a; Shackley and Vierra 2005), Paleoindian and Archaic dacite bifaces were difficult to assign to source, mainly due to the lack of source standards from regional dacite sources, but also due to the vagaries of heterogeneous rock analysis by mass analytical methods (c.f. Dello-Russo 2004; Figures 2-5 here). In this case with the elemental analysis of the Cerros de Rio and San Antonio Mountain dacite, and the “Newman

Dome” discussed below, some of the provenance problem may be solved (Shackley 2005a; Table 2 and Figures 4-5 here). Unlike homogeneous obsidian, dacite does not necessarily display the inter-source variability that obsidian does, and the intra-source variability is often quite large. So, the source assignments here are less “compact”, but just as compelling. Referring to Table 2 and Figures 2-5, it is readily apparent that these two sources that are quite an elemental distance apart, vary only in three elements – Rb, Sr, Zr.

The “Newman Dome” Chemical Group. After both field and literature research, and discussions with both USGS geologists working in the region, and Jay Newman (U.S. Army Corps of Engineers, San Antonio) who worked in the region in the 1980s, it has become apparent that the previously surmised “San Antonio B” artifacts are produced from dacite from what I’m calling “Newman’s Dome” directly east of Cerro Montoso, and southeast of San Antonio Mountain, and a member of the Taos Plateau Volcanic Field (see Boyer and Moore 2001; Lipman and Mehnert 1979; Newman and Neilson 1987; Table 2 and Figures 3-4 here). Newman located a relatively small dome complex to the east of Cerro Montoso, that produced very fine grained dacite quite similar in hand sample to the San Antonio and Cerros del Rio dacite. His analysis of 20 source samples from this dome fits the previously “unknown” group relatively well, at least for Rb and Sr. One sample sent by Newman is plotted on Figures 4 and 5. I’ll sample this dome in the fall and analyze the samples on the Berkeley EDXRF and WXRF.

While the source provenance of the dacite artifacts should be seen as preliminary, it is certainly compelling. I have never seen as close a grouping between a source(s) and dacite artifacts in the Southwest before. Given the high quality of these two sources and the morphological similarity between the source rock and the artifacts, I think we can say with some confidence that most of these artifacts as in the earlier study were produced from sources in the northern New Mexico region, rather than some “exotic” source.

Comparing the dacite and obsidian source provenance results, it is surprising that none of the obsidian artifacts from sites nearer the San Antonio Mountain dacite source were produced from the No Agua Peaks obsidian that is in the same volcanic field. Again, as I've said elsewhere, the No Agua Peaks obsidian with the large sanidine phenocrysts is not a viable raw material, and in this case could not compete with El Rechuelos to the south even when San Antonio Mountain dacite was a preferred biface raw material (Shackley 2005a, 2005b).

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

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
06-01	1033	432	8621	149	14	42	150	57	Valle Grande (CDM)
03-01	896	500	6055	150	7	24	69	39	El Rechuelos
03-05	988	458	5873	143	8	21	68	49	El Rechuelos
HQ-3	943	430	8641	156	7	42	162	68	Valle Grande (CDM)
HQ-2	855	378	8311	147	12	37	163	56	Valle Grande (CDM)
HQ-5	984	479	6064	144	8	16	72	41	El Rechuelos
HQ-1	976	539	9304	193	11	69	169	100	Cerro Toledo Rhy
HQ-4	843	464	5708	145	11	17	66	54	El Rechuelos
IO-9	982	480	6059	150	11	23	75	45	El Rechuelos
RGM1-S1	1572	319	13205	149	111	22	221	9	standard

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

Sample	Ti	Mn	Fe	Zn	Ga	Rb	Sr	Y	Zr	Nb	Source
HQ-6	3580	650	3296 9	88	21	42	840	18	212	26	Cerros del Rio
01-01	3758	586	3382 0	86	23	62	599	17	255	19	San Antonio Mtn
02-03	4479	724	4008 8	60	25	63	211	18	86	11	Newman Dome
03-04	3662	667	3471 5	76	23	63	588	25	258	15	San Antonio Mtn
IO-11	3825	633	3654 7	80	22	60	654	25	240	22	San Antonio Mtn

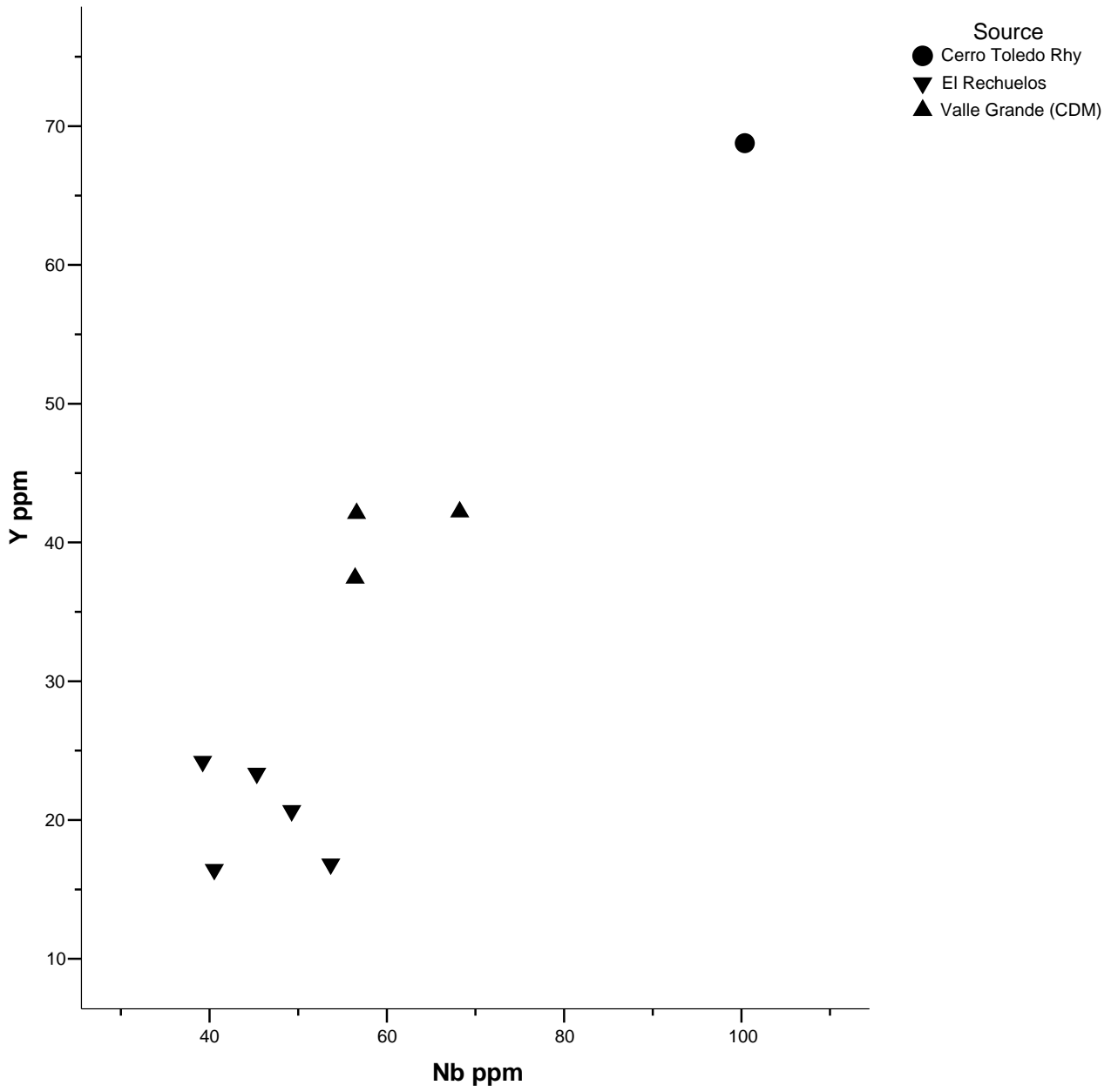


Figure 1. Y versus Nb biplot of obsidian archaeological samples from all sites.

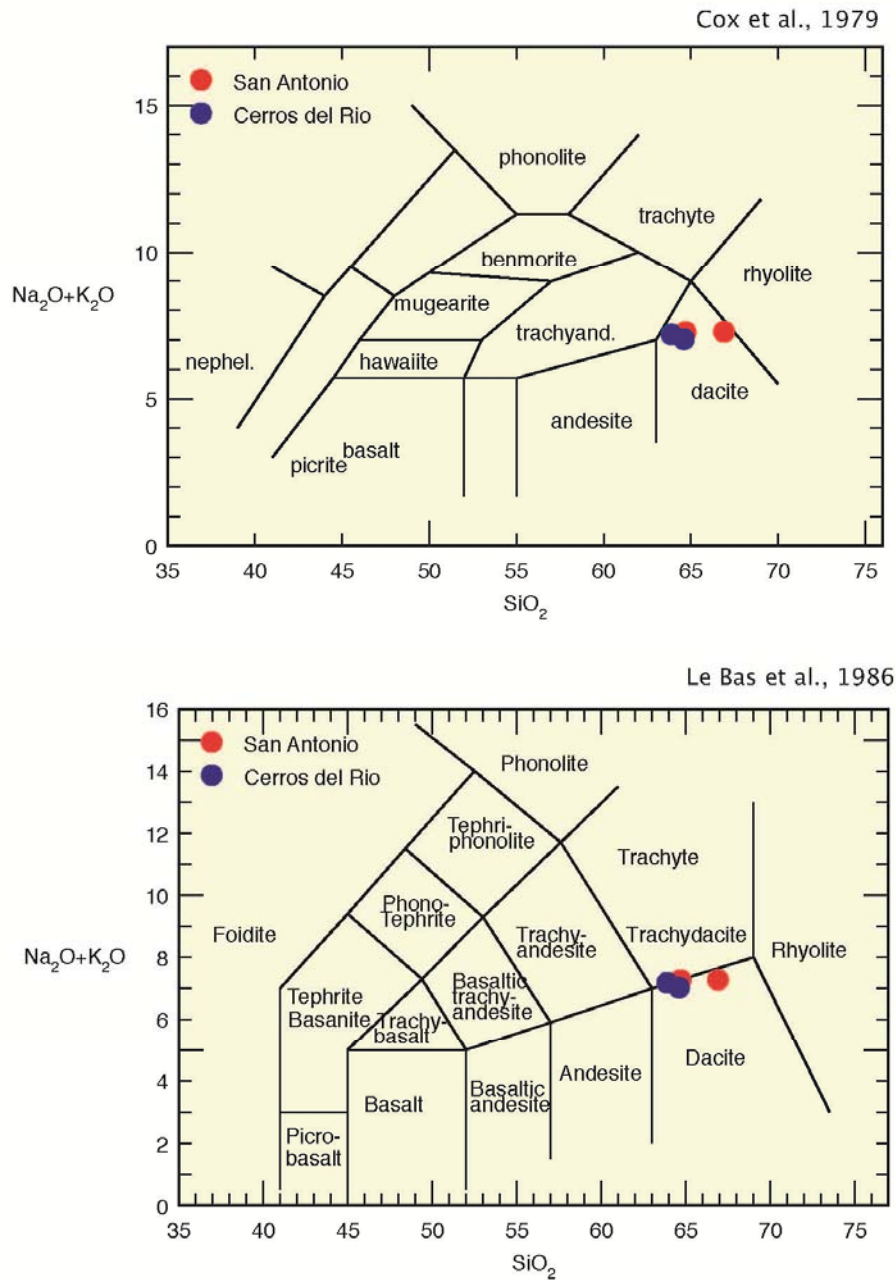


Figure 2. Cox et al. (1979) and Le Bas et al. (1986) classifications for fused and powdered disk samples from San Antonio Mountain and Cerros del Rio. Instrumental settings discussed in Shackley 1998, 2005).

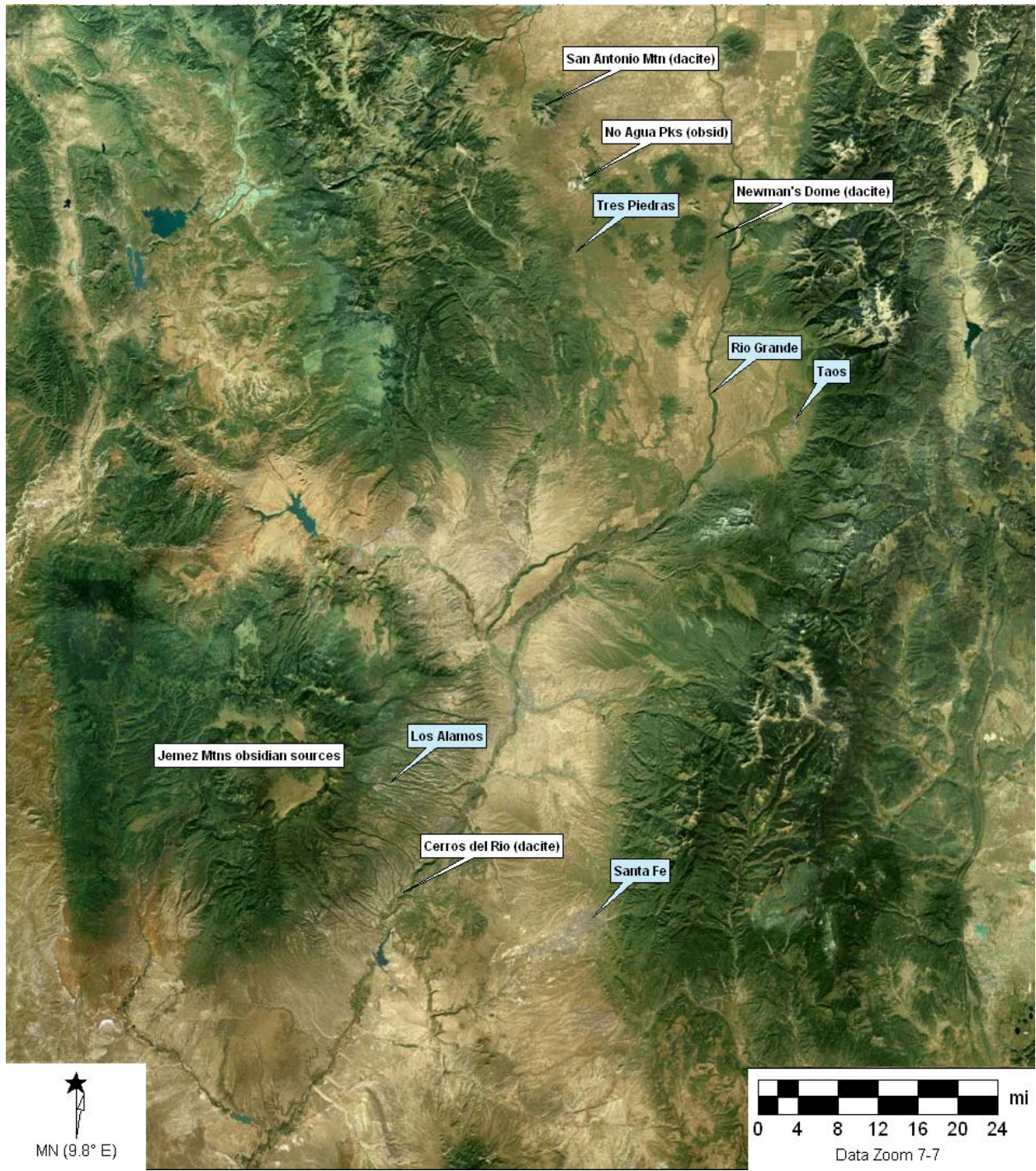


Figure 3. Distribution of the major obsidian and dacite sources in the assemblage (Landsat 7 image).

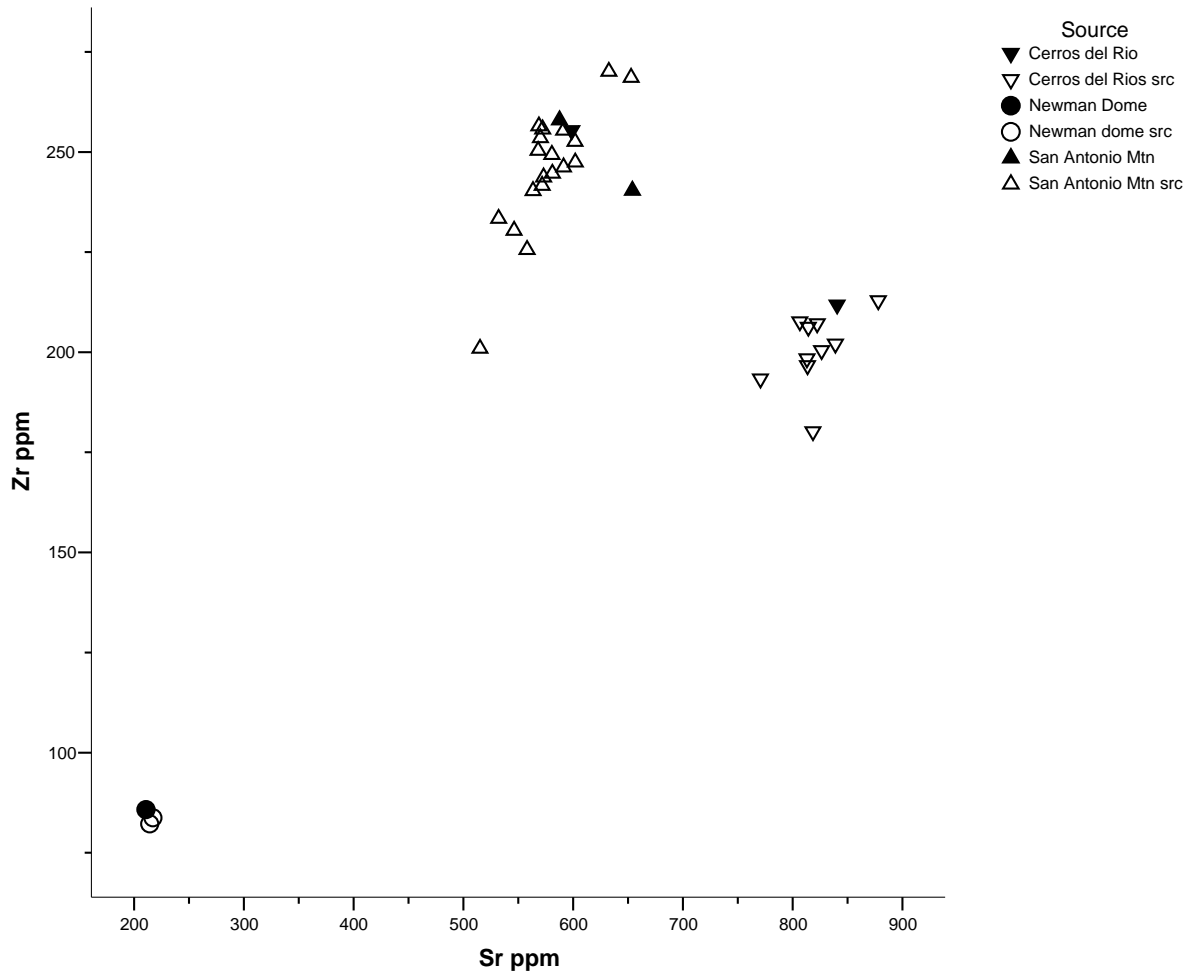


Figure 4. Zr versus Sr plot of the two dacite sources and the dacite artifacts.

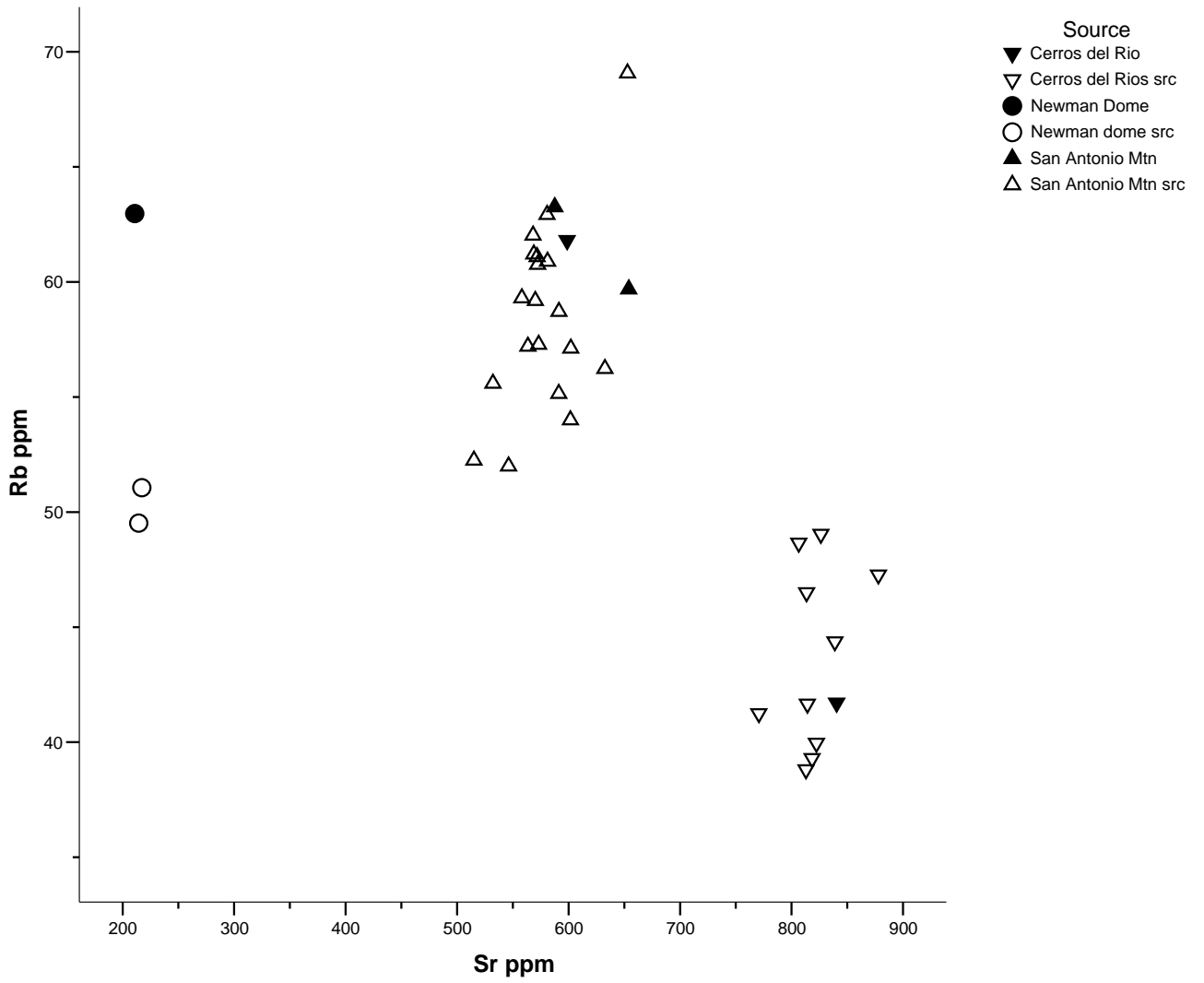


Figure 5. Rb versus Sr plot of the two dacite sources and the dacite artifacts.