

UC Berkeley

Archaeological X-ray Fluorescence Reports

Title

Source Provenance of Obsidian Artifacts from the Caja Del Rio Plateau, Northern New Mexico

Permalink

<https://escholarship.org/uc/item/05f9m7sv>

Author

Shackley, M. Steven

Publication Date

2011-03-05

Supplemental Material

<https://escholarship.org/uc/item/05f9m7sv#supplemental>

Copyright Information

This work is made available under the terms of a Creative Commons Attribution-NonCommercial License, available at <https://creativecommons.org/licenses/by-nc/4.0/>



Department of Anthropology
232 Kroeber Hall
University of California
Berkeley, CA 94720-3710

SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THE CAJA DEL RIO PLATEAU, NORTHERN NEW MEXICO

by

M. Steven Shackley
Professor and Director
Geoarchaeological XRF Laboratory
University of California, Berkeley

Report Prepared for

F. Scott Worman
Office of Contract Archaeology
University of New Mexico, Albuquerque

5 March 2011

INTRODUCTION

The analysis here of 33 obsidian artifacts from various temporal contexts at eleven sites in northern and central New Mexico exhibits artifacts produced from one of three obsidian sources in the Jemez Mountains. The proximity to the Rio Grande and the dominance of Cerro Toledo Rhyolite suggests procurement in the Rio Grande Quaternary alluvium (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 WinTraceTM 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 $K\alpha_1$ -line data for elements titanium (Ti), manganese (Mn), iron (as Fe^T),

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. A few of the samples were less than 10 mm in optimal minimum diameter or were very angular debris and a 3.5 mm tube collimator was used to concentrate x-rays on these small samples (see Davis et al. 2011). These are noted by asterisks in Table 1.

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 as discussed in Shackley (2005).

DISCUSSION

Before a discussion of the source provenance of the samples, a short discussion of the Jemez Mountains sources and secondary deposition in the Rio Grande Quaternary alluvium is in order.

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 by my lab courtesy of the Valles Caldera National Preserve (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 1).

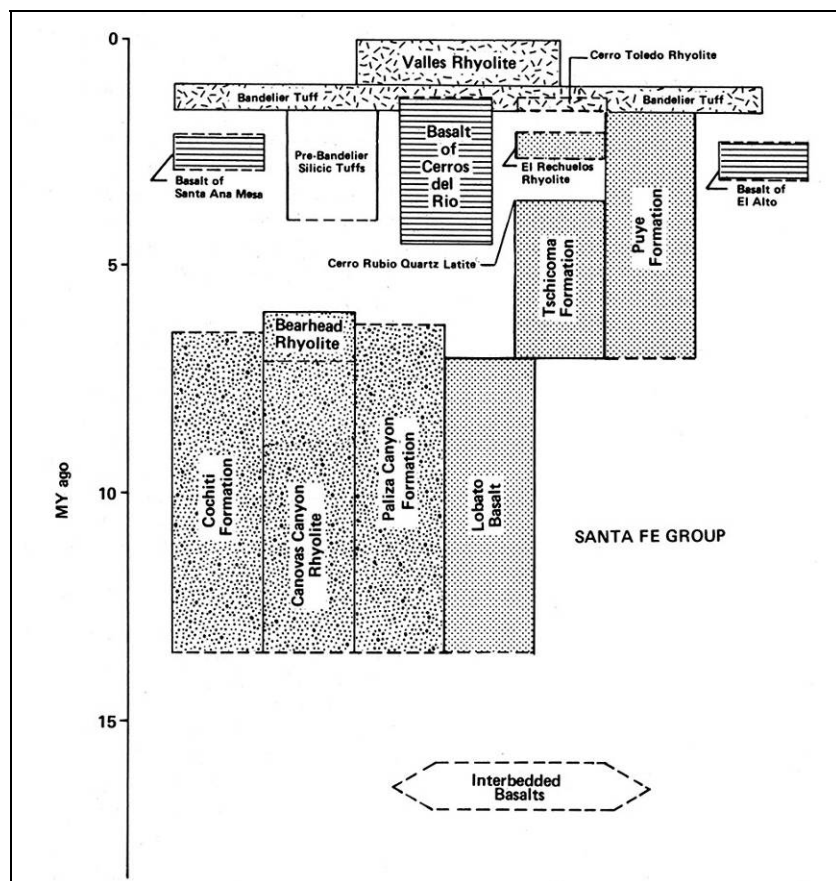


Figure 1. Generalized stratigraphic relations of the major volcanic and alluvial units in the Jemez Mountains (from Gardner et al. 1986). Note the near overlapping events at this scale for the Cerro Toledo and Valles Rhyolite members, and the position of Cerro Toledo Rhyolite at the upper termination of the Puye Formation.

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 1 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 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 is present throughout the Rio Grande and samples recovered from the Cochiti Dam area are up to 15 cm in diameter (Shackley 2010).

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 and dominates secondary contexts. Valles Rhyolite (Cerro del Medio), is present as secondary contexts as far south as Tijeras Wash south of Albuquerque, but in very small proportions and very small nodule sizes (< 20mm; Shackley 2009b, in preparation). See Figure 2 for a plot of the archaeological data and revealing the compositional relationship between these sources.

REFERENCES CITED

- Church, T.
2000 Distribution and Sources of Obsidian in the Rio Grande Gravels of New Mexico. *Geoarchaeology* 15:649-678.
- Davis, M.K., T.L. Jackson, M.S. Shackley, T. Teague, and J. Hampel
2011 Factors Affecting the Energy-Dispersive X-Ray Fluorescence (EDXRF) Analysis of Archaeological Obsidian. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, pp. 65-80. Springer, New York.
- Gardner, J. N., F. Goff, S. Garcia, R. Hagan
1986 Stratigraphic Relations and Lithologic Variations in the Jemez Volcanic Field, New Mexico. *Journal of Geophysical Research* 91B2:1763-1778.
- Govindaraju, K.
1994 1994 Compilation of Working Values and Sample Description for 383 Geostandards. *Geostandards Newsletter* 18 (special issue).
- Hampel, Joachim H.
1984 Technical Considerations in X-ray Fluorescence Analysis of Obsidian. In *Obsidian Studies in the Great Basin*, edited by R.E. Hughes, pp. 21-25. Contributions of the University of California Archaeological Research Facility 45. Berkeley.
- Hildreth, W.
1981 Gradients in Silicic Magma Chambers: Implications for Lithospheric Magmatism. *Journal of Geophysical Research* 86:10153-10192.
- Hughes, Richard E., and Robert L. Smith
1993 Archaeology, Geology, and Geochemistry in Obsidian Provenance Studies. In *Scale on Archaeological and Geoscientific Perspectives*, edited by J.K. Stein and A.R. Linse, pp. 79-91. Geological Society of America Special Paper 283.
- Kempton, K., G.R. Osburn, S. Kelley, M. Rampey, C. Ferguson, and J. Gardner
2004 Geology of the Bear Springs Peak 7.5' Quadrangle, Sandoval County, New Mexico. Open File Geologic Map OF-GM 74 (Draft), New Mexico Bureau of Mineral Resources, Socorro.
- Mahood, Gail A., and James A. Stimac
1990 Trace-Element Partitioning in Pantellerites and Trachytes. *Geochemica et Cosmochimica Acta* 54:2257-2276.
- McCarthy, J.J., and F.H. Schamber
1981 Least-Squares Fit with Digital Filter: A Status Report. In *Energy Dispersive X-ray Spectrometry*, edited by K.F.J. Heinrich, D.E. Newbury, R.L. Myklebust, and C.E. Fiori, pp. 273-296. National Bureau of Standards Special Publication 604, Washington, D.C.

Schamber, F.H.

- 1977 A Modification of the Linear Least-Squares Fitting Method which Provides Continuum Suppression. In *X-ray Fluorescence Analysis of Environmental Samples*, edited by T.G. Dzubay, pp. 241-257. Ann Arbor Science Publishers.

Shackley, M. Steven

- 1988 Sources of Archaeological Obsidian in the Southwest: An Archaeological, Petrological, and Geochemical Study. *American Antiquity* 53(4):752-772.
- 1990 *Early Hunter-Gatherer Procurement Ranges in the Southwest: Evidence from Obsidian Geochemistry and Lithic Technology*. Ph.D. dissertation, Arizona State University, Tempe.
- 1995 Sources of Archaeological Obsidian in the Greater American Southwest: An Update and Quantitative Analysis. *American Antiquity* 60(3):531-551.
- 2005 *Obsidian: Geology and Archaeology in the North American Southwest*. University of Arizona Press, Tucson.
- 2009 Two Newly Discovered Sources of Archaeological Obsidian in the Southwest. *Kiva* 76:269-280.
- 2010 The Secondary Distribution of Archaeological Obsidian in the Rio Grande Quaternary Sediments, Jemez Mountains to San Antonito, New Mexico: Inferences for Prehistoric Procurement and the Age of Sediments. Poster presentation, 38th International Symposium on Archaeometry, Tampa, Florida.

Wolfman, Daniel

- 1994 Jemez Mountains Chronology Study. Report prepared by the Office of Archaeological Studies, Museum of New Mexico for the USDA Forest Service, Contract No. 53-8379-9-14.

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

Site/FS#	Site	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
112841-4	LA 11284	927	41	7680	15	12	23	73	46	26	20	El Rechuelos
			9		8							
112841-11	LA 11284	924	51	1083	20	10	63	16	94	39	17	Cerro Toledo Rhy
			0	7	4			9				
112877-9	LA 112877	846	42	9531	18	9	62	16	93	29	24	Cerro Toledo Rhy
			8		4			9				
131767-82	LA 131767	908	52	1056	21	9	64	18	99	40	25	Cerro Toledo Rhy
			7	2	2			2				
131767-93	LA 131767	964	44	1002	19	8	67	17	94	34	22	Cerro Toledo Rhy
			6	2	5			3				
131768-35	LA 131768	932	60	1167	22	8	69	19	10	34	29	Cerro Toledo Rhy*
			2	4	9			0	6			
131768-43	LA 131768	914	48	1022	20	8	60	16	92	36	25	Cerro Toledo Rhy
			0	9	5			2				
131771-82	LA 131771	865	45	9729	19	10	61	17	99	33	29	Cerro Toledo Rhy
			3		7			2				
131771-99	LA 131771	863	50	1022	20	11	61	17	10	38	30	Cerro Toledo Rhy
			5	2	6			3	2			
131771-105	LA 131771	927	40	1040	16	12	44	15	49	25	12	Valles Rhy (Cerro del Medio)
			9	2	5			9				
131771-117	LA 131771	900	49	1069	21	8	65	18	10	41	30	Cerro Toledo Rhy
			3	9	2			2	4			
131772-4	LA 131772	947	49	1071	20	8	65	17	97	36	26	Cerro Toledo Rhy
			7	3	2			6				
131772-29	LA 131772	876	44	1003	20	11	66	17	97	31	17	Cerro Toledo Rhy
			6	6	1			0				
131772-73	LA 131772	879	46	1022	20	8	65	17	99	36	27	Cerro Toledo Rhy
			4	8	5			5				
131775-20	LA 131775	919	50	1024	20	10	64	17	96	36	26	Cerro Toledo Rhy
			1	2	4			2				
131793-67	LA 131793	896	52	1072	21	10	68	18	10	40	25	Cerro Toledo Rhy
			8	8	7			2	0			
131793-88	LA 131793	906	56	1117	22	10	62	18	10	40	27	Cerro Toledo Rhy
			7	0	1			2	0			
131793-321	LA 131793	976	47	1038	20	8	61	17	95	28	21	Cerro Toledo Rhy
			6	5	0			3				
131793-344	LA 131793	885	36	7200	13	15	23	68	44	24	25	El Rechuelos
			1		9							
131793-378	LA 131793	136	59	1308	22	9	65	17	97	42	29	Cerro Toledo Rhy
		3	7	6	0			1				
131810-67	LA 131810	931	50	1033	19	10	59	16	91	33	22	Cerro Toledo Rhy
			7	4	6			4				
131810-69	LA 131810	943	50	1038	20	8	65	17	10	37	22	Cerro Toledo Rhy
			0	0	4			2	2			
131810-89	LA 131810	981	55	1140	22	8	63	17	94	39	22	Cerro Toledo Rhy
			4	4	3			5				
131810-102	LA 131810	911	42	7866	15	11	23	71	48	25	26	El Rechuelos
			5		7							
131810-127	LA 131810	862	49	1051	21	8	63	17	10	38	25	Cerro Toledo Rhy
			8	0	0			5	2			
131810-139	LA 131810	976	36	9356	15	12	45	16	57	24	22	Valles Rhy (Cerro del Medio)*
			2		9			0				
131810-143-2	LA 131810	120	67	1369	24	8	66	18	10	46	36	Cerro Toledo Rhy*
		5	7	7	8			3	3			
131810-143-1	LA 131810	918	56	1114	22	9	67	17	10	40	32	Cerro Toledo Rhy
			1	9	4			9	0			
131810-164-	LA	841	48	1026	20	8	62	17	92	37	26	Cerro Toledo Rhy

1	131812		9	2	6			3				
131810-164-	LA	111	74	1391	25	9	78	18	10	47	33	Cerro Toledo Rhy*
2	131810	2	6	1	8			5	5			
131812-160	LA	892	47	1018	20	8	64	17	99	35	28	Cerro Toledo Rhy
	131812		8	5	1			6				
131812-198	LA	850	50	1004	20	8	66	17	10	34	29	Cerro Toledo Rhy
	131812		0	6	4			4	0			
131821-45	LA	853	49	1024	20	8	65	17	97	33	19	Cerro Toledo Rhy
	131821		8	8	2			6				
RGM1-S4		157	29	1318	14	10	26	22	11	22	18	standard
		8	2	2	9	8		2				
RGM1-S4		155	28	1314	14	10	22	22	10	21	8	standard
		8	0	0	9	7		0				

* These samples were smaller than 10 mm in minimum diameter or very angular. A 3.5 mm tube collimator was used to re-analyze these samples concentrating energy on a smaller area and yielding greater accuracy (see Davis et al. 2011).

Table 2. Crosstabulation of site by obsidian source.

Site		Source			Total
		Cerro Toledo Rhy	El Rechuelos	Valles Rhy (Cerro del Medio)	
LA 11284	Count	1	1	0	2
	% within Site	50.0%	50.0%	.0%	100.0%
	% within Source	3.6%	33.3%	.0%	6.1%
	% of Total	3.0%	3.0%	.0%	6.1%
LA 112877	Count	1	0	0	1
	% within Site	100.0%	.0%	.0%	100.0%
	% within Source	3.6%	.0%	.0%	3.0%
	% of Total	3.0%	.0%	.0%	3.0%
LA 131767	Count	2	0	0	2
	% within Site	100.0%	.0%	.0%	100.0%
	% within Source	7.1%	.0%	.0%	6.1%
	% of Total	6.1%	.0%	.0%	6.1%
LA 131768	Count	2	0	0	2
	% within Site	100.0%	.0%	.0%	100.0%
	% within Source	7.1%	.0%	.0%	6.1%
	% of Total	6.1%	.0%	.0%	6.1%
LA 131771	Count	3	0	1	4
	% within Site	75.0%	.0%	25.0%	100.0%
	% within Source	10.7%	.0%	50.0%	12.1%
	% of Total	9.1%	.0%	3.0%	12.1%
LA 131772	Count	3	0	0	3
	% within Site	100.0%	.0%	.0%	100.0%
	% within Source	10.7%	.0%	.0%	9.1%
	% of Total	9.1%	.0%	.0%	9.1%
LA 131775	Count	1	0	0	1
	% within Site	100.0%	.0%	.0%	100.0%
	% within Source	3.6%	.0%	.0%	3.0%
	% of Total	3.0%	.0%	.0%	3.0%
LA 131793	Count	4	1	0	5
	% within Site	80.0%	20.0%	.0%	100.0%
	% within Source	14.3%	33.3%	.0%	15.2%
	% of Total	12.1%	3.0%	.0%	15.2%
LA 131810	Count	7	1	1	9
	% within Site	77.8%	11.1%	11.1%	100.0%
	% within Source	25.0%	33.3%	50.0%	27.3%
	% of Total	21.2%	3.0%	3.0%	27.3%
LA 131812	Count	3	0	0	3
	% within Site	100.0%	.0%	.0%	100.0%
	% within Source	10.7%	.0%	.0%	9.1%
	% of Total	9.1%	.0%	.0%	9.1%
LA 131821	Count	1	0	0	1
	% within Site	100.0%	.0%	.0%	100.0%
	% within Source	3.6%	.0%	.0%	3.0%
	% of Total	3.0%	.0%	.0%	3.0%
Total	Count	28	3	2	33
	% within Site	84.8%	9.1%	6.1%	100.0%
	% within Source	100.0%	100.0%	100.0%	100.0%
	% of Total	84.8%	9.1%	6.1%	100.0%

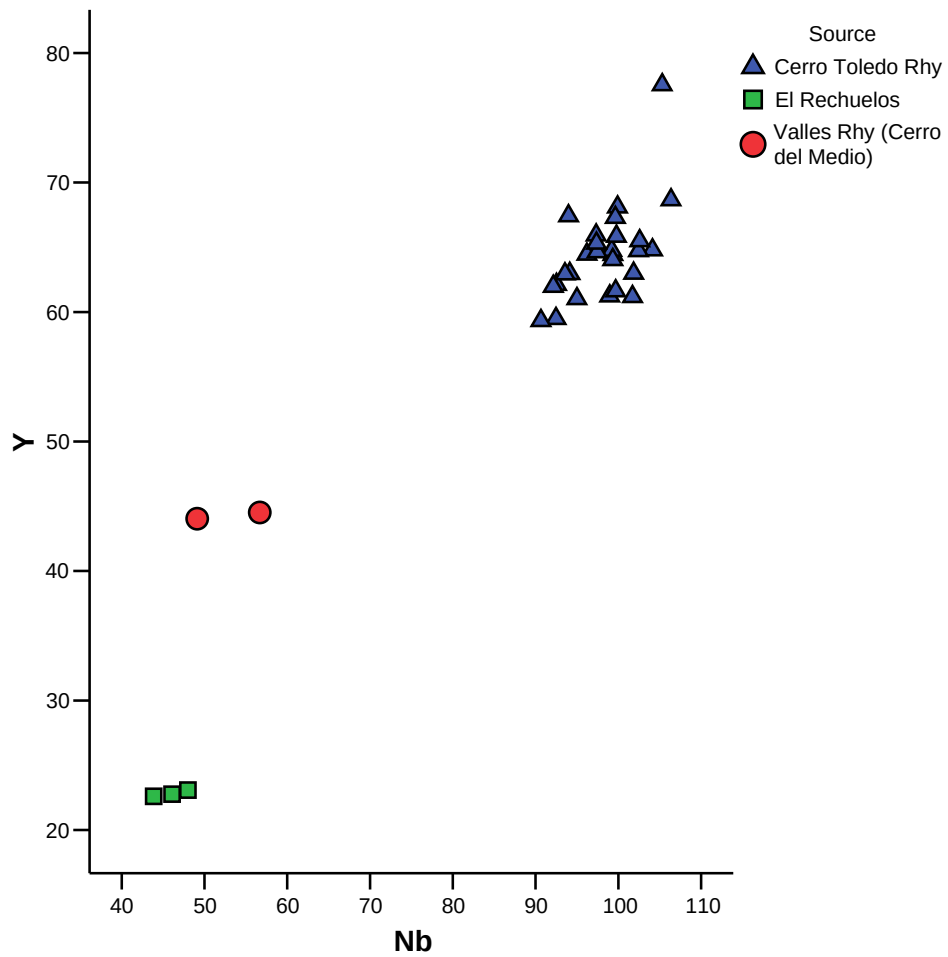


Figure 2. Y versus Nb biplot of the archaeological specimens.