Title
SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM PIEDRAS MARCADAS PUEBLO RUIN (LA 290), MIDDLE RIO GRANDE VALLEY, NEW MEXICO

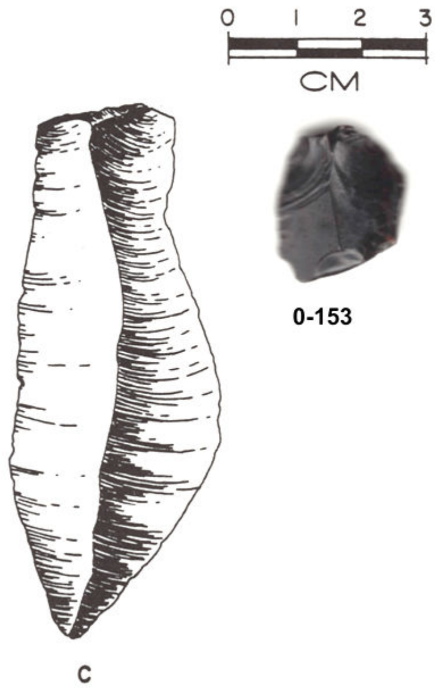
Author
Shackley, M. Steven

Publication Date
2021-08-17

GEOARCHAEOLOGICAL XRF LAB

GEOARCHAEOLOGICAL X-RAY FLUORESCENCE SPECTROMETRY LABORATORY
8100 WYOMING BLVD., SUITE M4-158 ALBUQUERQUE, NM 87113
USA

SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM PIEDRAS MARCADAS PUEBLO RUIN (LA 290), MIDDLE RIO GRANDE VALLEY, NEW MEXICO



One of the obsidian blade fragments (0-153) from Piedras Marcadas and an illustrated Late Classic chert blade from Colha, Belize (Roemer 1991) See text and Figure 5.

M. Steven Shackley, Ph.D., Director
Geoarchaeological XRF Laboratory
Albuquerque, New Mexico

Report Prepared for

Dr. Matthew Schmader
Albuquerque, New Mexico

17 August 2021

INTRODUCTION

The analysis here of 195 obsidian artifacts from the surface and subsurface of Piedras Marcadas Pueblo ruin (LA 290) in the middle Rio Grande River valley indicates a source provenance similar to previous analyses of surface and subsurface contexts dominated by sources from the Jemez Mountains, both pre-and-post caldera, (Shackley 2009, 2013a, 2014a, 2014b). All these sources are present in the Rio Grande alluvium as far south as Albuquerque, although the Valles Rhyolite (Cerro del Medio) nodules are very small, probably too small to produce the one projectile point made from this source (Sample 1911; Shackley 2021). Mount Taylor is not available in Rio Grande Quaternary sediments this far north (Shackley 2021). Refer to Shackley (2021) for a thorough discussion of the sources and secondary distribution.

Most unique and important for the history of the site, and indeed the Coronado presence in the Middle Rio Grande valley is the occurrence of two polyhedral blade fragments produced from the Zinapecuaro obsidian source near the town of the same name in northeastern Michoacan state of west central Mexico (see discussion below). This blade fragments from a source thousands of kilometers south into Mexico was most likely transported to the site during the siege of Piedras Marcadas by Coronado in 1540 by one or more of the West Mexican Indians traveling with Coronado. This source has never been recovered in the U.S. portion of the Southwest to my knowledge, and blade production after the Paleoindian period in North America was not practiced by native artisans (Bradley et al. 2010; Collins 1999). The only other obsidian Mexican artifacts recovered from Arizona and New Mexico are blades and blade fragments produced from one of the Sierra de Pachuca sources from Hidalgo state, Mexico, and no documented obsidian has been recovered in the Southwest from central Mexican or sources south of central Mexico other than these here and the four blades produced from Pachuca sources (Dolan and Shackley 2021).

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 Geoarchaeological XRF Laboratory, Albuquerque, New Mexico, 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 WinTrace™ 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. 2011; Shackley 2011).

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 100 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. When barium (Ba) is acquired, the Rh tube is operated at 50 kV and 0.5 mA in an air path at 200 seconds livetime to generate x-ray intensity $K\alpha_1$-line data, through a 0.630 mm Cu (thick) filter ratioed to the bremsstrahlung region (see Davis et al. 2011). Further details concerning the petrological choice of these elements in North American obsidians is available in Shackley (1988, 1990, 1995, 2005; Shackley et al. 2018; 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, and on into SPSS ver. 27 and JMP 12.0.1 for statistical anlayses (Tables 1 and 2). In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run (Table 2). RGM-1, a USGS rhyolite standard is analyzed during each sample run of ≤20 for obsidian artifacts to check machine calibration (Table 1). Source assignments made by reference to source data at the lab and (Glascock 2011; Healan 1997; Shackley 1995, 2005, 2021; Shackley et al. 2016).

DISCUSSION

The distribution of obsidian source provenance dominated by Jemez Lineament sources from the Jemez and Mount Taylor volcanic fields of northern New Mexico is perfectly reasonable (Shackley 2021:Supplement 1). The distribution of sources from the Jemez Mountains closely mirrors that recovered in secondary deposits just south of Albuquerque in Rio Grande Quaternary sediments at the mouth of Tijera Wash (see Shackley 2021). It is perfectly reasonable to expect that most of the obsidian recovered at Piedras Marcadas was procured in Rio Grande Quaternary alluvium. The Grants Ridge and Horace/La Jara Mesa obsidian from the Mount Taylor volcanic field of northwestern New Mexico however, was either procured from the primary sources at Mount Taylor or as secondary deposits from the Rio Puerco south toward Socorro, New Mexico, or points south, more likely from the primary sources either directly or through exchange. This procurement pattern is typical of archaeological contexts throughout the Middle Rio Grande valley in all time periods (Shackley 2021).

The presence of two blade fragments produced from the Zinapecuaro obsidian source in northeast Michoacan state, central Mexico thousands of kilometers south of Piedras Marcadas requires some explanation (see Figures 1 through 6). As noted above, this is the first recovery of central Mexican obsidian in U.S. Southwestern sites other than four blades produced from one of the Sierra de Pachuca sources in Hidalgo state, Mexico (Dolan and Shackley 2021). All these artifacts are likely from some facet of the Coronado expedition in the middle 16th century, and are directly associated with the well over 1000 Mexican Indians traveling with Coronado into what is now North America. The two blades recovered from Piedras Marcadas are unique in that while Pachuca has been recovered, although rare, throughout archaeological contexts in the southern portion of North America, this is the first evidence of obsidian artifacts from a west Mexican source. Parenthetically, Zinapecuaro is part of a volcanic field with multiple sources, including the Ucareo source, one of the most commonly recovered obsidian sources in central Mexican archaeological contexts (Healan 1997; Michael Glascock, personal communication, August 2021; Glascock 2011). It is quite possible that the two blades were simply carried north among the materials of someone from that region of Mexico, and deposited at Piedras Marcadas during the long-term siege of that Pueblo by Coronado's "army" including the Mexican Indians. So what could they have been used for?

Blade fragment 0-153 does indicate some marginal and platform usewear, possibly from long term cutting or scraping hard substances. Another use of obsidian blades from Mexico are blades inserted in *macuahuitl*, a Nauatl word for a large wooden club used in warfare (see Figure 6). To my knowledge there is no evidence that these types of weapons were used during the Coronado campaign, but it is possible. Nevertheless, this is direct evidence of the presence of Mexican Indians, probably West Mexican Indians at Piedras Marcadas Pueblo during the siege of that pueblo.

Finally, does the presence of artifacts produced from non-Pachuca Mexican obsidian suggest that we have simply missed some of these other sources in Southwestern archaeological contexts? Many North American archaeologists do not have much if any experience recognizing blade production versus biface production - that's the way we're trained. Unless an archaeologist has experience in the Old World or one of the other Americas where blade production is much more common in prehistory, they could very well go unnoticed. And without source provenance, blade fragments may never be discovered. Then again, the case at Piedras Marcadas could be an isolated incident.

REFERENCES CITED

Bradley, B.A., M.B. Collins, A. Hemmings
2010 *Clovis Technology*. Archaeological Series 17, International Monographs in Prehistory, Ann Arbor, Michigan.

Collins, M.B.
1999 *Clovis Blade Technology*. University of Texas Press, Austin.

Davis, K.D., T.L. Jackson, M.S. Shackley, T. Teague, and J.H. Hampel
2011 Factors Affecting the Energy-Dispersive X-Ray Fluorescence (EDXRF) Analysis of Archaeological Obsidian. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M.S. Shackley, pp. 45-64. Springer, New York.

Dolan, S.G., and M.S. Shackley
2021 Pachuca Obsidian Blades from the U.S. Southwest: Implications for Mesoamerican Connections and Coronado's Mexican Indian Allies. *American Antiquity*, in press. DOI:10.1017/aaq.2021.65

Glascock, M.D.
2011 Comparison and Contrast Between XRF and NAA: Used for Characterization of Obsidian Sources in Central Mexico. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M.S. Shackley, pp. 161-192. Springer, New York.

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.

Healan, D.M.
1997 Pre-Hispanic Quarrying in the Ucareo-Zinapecuaro Obsidian Source Area. *Ancient Mesoamerica* 8:77-100.

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.

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 Source Provenance of Obsidian Artifacts from Piedras Marcadas (LA 290), Middle Rio Grande Valley, New Mexico. Report prepared for Matt Schmader, Albuquerque Open Space, City of Albuquerque, New Mexico.

2011b An Introduction to X-Ray Fluorescence (XRF) Analysis in Archaeology. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M.S. Shackley, pp. 7-44. Springer, New York.

2013a Source Provenance of Obsidian Artifacts from Three Subsurface Test Units at Piedras Marcadas (LA 290), Middle Rio Grande Valley, New Mexico. Report prepared for Albuquerque Open Space, City of Albuquerque, New Mexico.

2013b The Secondary Distribution of Archaeological Obsidian in Rio Grande Quaternary Sediments, Jemez Mountains to San Antonito, New Mexico: Inferences for Paleoamerican Procurement and the Age of Sediments. Poster presented at the Paleoamerican Odyssey Conference, Santa Fe, New Mexico, October, 2013.

2014a Source Provenance of Obsidian Artifacts from a Selected Surface Sample at Piedras Marcadas (LA 290), Middle Rio Grande Valley, New Mexico. Report prepared for Matt Schmader, Albuquerque Open Space, City of Albuquerque, New Mexico.

2014b Source Provenance of Obsidian and Dacite Bifaces from Piedras Marcadas (LA 290) and City Of Albuquerque Open Space Property, Middle Rio Grande Valley, New Mexico. Report prepared for Matt Schmader, Albuquerque Open Space, City of Albuquerque, New Mexico.

2021 Distribution and Sources of Secondary Deposit Archaeological Obsidian in Rio Grande Alluvium New Mexico, USA. *Geoarchaeology* 36:808-825.

Shackley, M.S., F. Goff, and S.G. Dolan
2016 Geologic Origin of the Source of Bearhead Rhyolite (Paliza Canyon) Obsidian, Jemez Mountains, Northern New Mexico. *New Mexico Geology* 28:52-65.

Shackley, M.S., L.E. Morgan, and D. Pyle
2018 Elemenal, Isotopic, and Geochronological Variability in Mogollon-Datil Volcanic Province Archaeological Obsidian, Southwestern USA. *Geoarchaeology* 33:486-497.

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

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba[1]	Source
0-1	583	490	11957	211	9	71	183	101		Cerro Toledo Rhy
0-2	567	502	12082	206	9	63	180	92		Cerro Toledo Rhy
0-3	500	508	11747	197	12	61	168	95		Cerro Toledo Rhy
0-4	851	430	12386	164	11	43	163	50		Valles Rhy (Cerro del Medio)
0-5	850	445	10612	114	42	23	111	53	391	Canovas Canyon Rhy
0-6	564	465	11546	189	10	62	163	88		Cerro Toledo Rhy
0-7	608	436	10287	162	11	22	81	51		El Rechuelos Rhy
0-9	608	496	12141	207	11	64	175	98		Cerro Toledo Rhy
0-10	609	514	12013	208	13	67	171	94		Cerro Toledo Rhy
0-11	738	512	9574	208	4	64	170	101		Cerro Toledo Rhy
0-12	811	577	10339	221	5	62	172	96		Cerro Toledo Rhy
0-13	759	502	9210	201	3	64	172	96		Cerro Toledo Rhy
0-14	703	548	9854	219	5	65	172	105		Cerro Toledo Rhy
0-15	745	508	9651	209	3	61	171	100		Cerro Toledo Rhy
0-16	681	509	9410	205	4	63	173	97		Cerro Toledo Rhy
0-17	776	410	8993	163	8	41	160	59		Valles Rhy (Cerro del Medio)
0-18	781	478	9132	193	3	60	163	89		Cerro Toledo Rhy
0-19	749	491	9643	211	3	65	168	100		Cerro Toledo Rhy
0-20	693	530	9557	210	5	58	164	98		Cerro Toledo Rhy
0-21	662	466	8916	198	5	60	167	99		Cerro Toledo Rhy
0-22	621	499	9410	209	3	61	164	98		Cerro Toledo Rhy
0-23	736	505	9650	212	3	63	167	99		Cerro Toledo Rhy
0-24	788	680	11771	240	5	67	178	94		Cerro Toledo Rhy
0-25	488	780	7462	537	6	78	110	197		Grants Ridge, Mt Taylor
0-26	733	526	9648	208	4	64	170	98		Cerro Toledo Rhy
0-27	769	524	10252	222	4	66	176	105		Cerro Toledo Rhy
0-28	727	562	10180	218	4	64	173	102		Cerro Toledo Rhy

0-29	733	531	9752	214	6	65	167	96		Cerro Toledo Rhy
0-30	657	498	9358	210	3	64	172	95		Cerro Toledo Rhy
0-31	781	445	6748	160	7	25	72	46		El Rechuelos Rhy
0-32	699	473	9072	202	4	60	165	99		Cerro Toledo Rhy
0-33	716	562	9927	217	6	61	173	101		Cerro Toledo Rhy
0-34	681	529	9709	210	3	61	168	98		Cerro Toledo Rhy
0-35	738	501	9632	210	5	67	172	97		Cerro Toledo Rhy
100	689	469	12093	203	9	67	170	100		Cerro Toledo Rhy
101	354	572	11633	513	12	88	131	233		Horace/La Jara Mesa, Mt Taylor
103	514	465	11743	205	8	68	172	98		Cerro Toledo Rhy
104	417	583	11700	529	13	84	132	223		Horace/La Jara Mesa, Mt Taylor
105	537	483	11835	205	8	68	180	102		Cerro Toledo Rhy
106	548	469	11837	199	10	62	173	98		Cerro Toledo Rhy
107	634	489	12350	206	8	63	170	99		Cerro Toledo Rhy
108	646	564	12647	232	9	68	188	104		Cerro Toledo Rhy
110	601	540	12623	224	11	68	185	104		Cerro Toledo Rhy
111	551	500	12192	210	8	67	178	101		Cerro Toledo Rhy
112	678	478	12236	203	11	59	174	98		Cerro Toledo Rhy
113	581	456	11803	201	8	65	170	94		Cerro Toledo Rhy
114	605	480	11942	199	9	61	169	99		Cerro Toledo Rhy
115	708	404	12145	166	11	46	167	54		Valles Rhy (Cerro del Medio)
116	524	466	11643	197	11	65	172	100		Cerro Toledo Rhy
Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba[1]	Source
117	660	577	12835	227	9	68	183	104		Cerro Toledo Rhy
118	548	441	11544	199	8	66	171	97		Cerro Toledo Rhy
119	473	449	11614	204	9	65	174	96		Cerro Toledo Rhy
120	1121	496	10999	105	88	23	126	33		Bearhead Rhy
121-1	620	419	11470	185	9	59	157	96		Cerro Toledo Rhy
121-2	526	512	12119	215	9	64	177	96		Cerro Toledo Rhy
122-1	599	401	10239	154	11	23	71	46		El Rechuelos Rhy

122-2	524	475	11730	199	10	61	173	94		Cerro Toledo Rhy
123-1	501	498	11865	207	10	66	168	98		Cerro Toledo Rhy
123-2	535	538	12242	215	8	67	177	96		Cerro Toledo Rhy
124	571	457	11661	207	16	61	163	97		Cerro Toledo Rhy
125	461	366	10961	179	8	59	161	92		Cerro Toledo Rhy
128	668	529	12219	198	10	61	171	97		Cerro Toledo Rhy
129	553	472	11901	202	10	65	174	99		Cerro Toledo Rhy
130	497	481	11828	201	8	67	169	99		Cerro Toledo Rhy
131	579	490	11885	207	8	65	177	101		Cerro Toledo Rhy
132	494	456	11648	200	10	61	167	100		Cerro Toledo Rhy
135	310	720	10845	544	12	78	118	194		Grants Ridge, Mt Taylor
137-1	594	479	11727	206	10	65	172	98		Cerro Toledo Rhy
137-2	483	459	11638	206	10	66	169	98		Cerro Toledo Rhy
138-1	493	465	11818	208	11	63	179	99		Cerro Toledo Rhy
138-2	522	495	12005	211	8	63	179	103		Cerro Toledo Rhy
139-1	502	475	11728	202	8	61	173	97		Cerro Toledo Rhy
139-2	535	515	12313	220	11	70	177	100		Cerro Toledo Rhy
140	456	482	11851	206	9	63	172	98		Cerro Toledo Rhy
141	574	457	11945	210	8	65	176	96		Cerro Toledo Rhy
142	559	472	11800	207	9	62	174	100		Cerro Toledo Rhy
143	508	463	11736	202	8	64	173	92		Cerro Toledo Rhy
144	545	524	12067	209	10	62	174	93		Cerro Toledo Rhy
145	569	465	11827	206	9	61	172	91		Cerro Toledo Rhy
537	851	489	10794	209	8	63	176	98		Cerro Toledo Rhy
1081	769	568	10073	508	14	93	132	226		Horace/La Jara Mesa, Mt Taylor
1641	865	503	10835	202	8	67	172	98		Cerro Toledo Rhy
1911	956	381	10166	159	13	45	166	54		Valles Rhy (Cerro del Medio)
70-80-1		525	11525	222	8	65	170	98		Cerro Toledo Rhy
70-80-2		531	11194	202	11	54	147	81		Cerro Toledo Rhy
70-80-3		422	9841	194	10	62	171	95		Cerro Toledo Rhy

70-80-4		524	10974	207	11	65	173	98		Cerro Toledo Rhy
70-80-5		440	8717	122	43	26	106	49		Canovas Canyon Rhy
70-80-6		461	10196	195	9	59	159	89		Cerro Toledo Rhy
70-80-7		512	10757	212	8	65	178	98		Cerro Toledo Rhy
80-90-1		417	9836	187	10	62	171	93		Cerro Toledo Rhy
80-90-2		504	10618	208	10	64	168	90		Cerro Toledo Rhy
80-90-3		488	10521	203	12	64	171	94		Cerro Toledo Rhy
90-100-1		517	11311	215	9	63	174	93		Cerro Toledo Rhy
90-100-2		492	10817	205	8	68	170	96		Cerro Toledo Rhy
110-120-1		484	10358	204	9	64	170	100		Cerro Toledo Rhy
120-130S-1		523	10965	204	19	60	170	93		Cerro Toledo Rhy
120-130S-2		510	11315	213	11	62	170	92		Cerro Toledo Rhy
130-140-1		461	10285	195	9	63	167	92		Cerro Toledo Rhy
140-150-1		487	10685	204	10	59	168	99		Cerro Toledo Rhy
140-150-2		494	11044	211	11	67	173	95		Cerro Toledo Rhy
Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba[1]	Source
140-150-3		473	10596	191	10	54	153	83		Cerro Toledo Rhy
220-230-1		507	11341	210	8	62	171	101		Cerro Toledo Rhy
220-230-2		573	12195	228	12	60	170	90		Cerro Toledo Rhy
20-30-1		473	10444	202	9	62	174	93		Cerro Toledo Rhy
20-30-2		547	11564	207	10	61	172	96		Cerro Toledo Rhy
20-30-3		539	12110	219	10	64	170	92		Cerro Toledo Rhy
20-30-4		515	11295	209	8	59	170	89		Cerro Toledo Rhy
40-50-1		545	11511	214	11	61	166	90		Cerro Toledo Rhy
50-60-1		495	10644	203	11	61	167	87		Cerro Toledo Rhy
50-60-2		412	10699	155	14	43	159	52		Valles Rhy (Cerro del Medio)
60-70-1		558	11782	218	8	63	176	105		Cerro Toledo Rhy
70-80-1		503	10988	211	10	66	170	96		Cerro Toledo Rhy
70-80-2		462	10560	207	11	66	184	101		Cerro Toledo Rhy
70-80-4		407	11066	151	14	38	150	47		Valles Rhy (Cerro del Medio)

80-85-1		514	11161	218	8	62	175	96		Cerro Toledo Rhy
85-90-1		489	10599	201	10	65	176	99		Cerro Toledo Rhy
90-100-1		474	9089	123	51	26	103	54		Canovas Canyon Rhy
90-100-2		540	11375	220	8	64	169	93		Cerro Toledo Rhy
90-100-3		478	10478	201	9	61	170	97		Cerro Toledo Rhy
100-110-1		552	11810	208	9	64	174	97		Cerro Toledo Rhy
100-110-2		553	11634	223	10	65	176	105		Cerro Toledo Rhy
100-110-3		495	10932	206	8	66	176	96		Cerro Toledo Rhy
120-130-1		504	10497	188	11	57	168	90		Cerro Toledo Rhy
0-30-1		501	10671	196	10	58	158	86		Cerro Toledo Rhy
0-30-2		568	11890	214	11	61	164	92		Cerro Toledo Rhy
30-40-2		460	10141	184	9	55	152	86		Cerro Toledo Rhy
40-50-1		447	10760	182	13	52	141	84		Cerro Toledo Rhy
50-60-1		506	11010	210	8	60	173	94		Cerro Toledo Rhy
60-70		504	10707	206	8	62	178	93		Cerro Toledo Rhy
90-100-1		503	10759	209	8	68	174	98		Cerro Toledo Rhy
90-100-2		437	8781	121	45	23	99	50		Canovas Canyon Rhy
90-100-3-1		543	11367	214	8	62	174	97		Cerro Toledo Rhy
100-110-1-1		471	10231	196	10	64	172	90		Cerro Toledo Rhy
110-120-1		545	10215	113	93	27	128	34		Bearhead Rhy
120-130-1-1		450	7916	173	11	27	75	50		El Rechuelos Rhy
120-130-2		526	11145	217	10	60	172	102		Cerro Toledo Rhy
130-140-1		548	11327	209	10	66	172	94		Cerro Toledo Rhy
130-140-2		387	10188	159	12	42	153	53		Valles Rhy (Cerro del Medio)
140-150-1		494	10749	191	9	50	147	81		Cerro Toledo Rhy
140-150-2		487	10551	208	12	64	167	99		Cerro Toledo Rhy
140-150-3		411	9489	115	64	21	107	41		Canovas Canyon Rhy
140-150-4		507	10996	205	11	63	164	94		Cerro Toledo Rhy
0-150	460	446	11261	191	9	58	164	87		Cerro Toledo Rhy
150-160-1		498	10863	195	10	56	160	85		Cerro Toledo Rhy

0-151	509	484	11842	204	13	65	176	97		Cerro Toledo Rhy
0-152	593	409	11528	162	9	41	162	57		Valles Rhy (Cerro del Medio)
0-153	810	246	9430	180	16	32	103	16	52	Zinapecuaro, Michoacan, MX
0-154	600	490	11959	210	10	62	184	100		Cerro Toledo Rhy
0-155	650	425	10244	157	15	21	76	39		El Rechuelos Rhy
0-156	486	541	12288	222	9	65	185	101		Cerro Toledo Rhy
0-157	655	521	12319	217	10	62	182	104		Cerro Toledo Rhy
0-158	544	537	12638	224	10	63	185	103		Cerro Toledo Rhy
Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba[1]	Source
0-159	562	515	11991	203	12	69	171	97		Cerro Toledo Rhy
0-160	627	514	12281	212	10	68	172	95		Cerro Toledo Rhy
0-161	680	402	10186	154	12	26	89	41		El Rechuelos Rhy
0-162	662	545	12127	219	11	63	177	99		Cerro Toledo Rhy
0-163	587	494	11820	201	13	60	176	100		Cerro Toledo Rhy
0-164	664	563	12280	212	10	64	174	94		Cerro Toledo Rhy
0-165	722	393	10426	113	46	22	105	50	365	Canovas Canyon Rhy
0-166	451	451	11630	201	12	63	175	97		Cerro Toledo Rhy
0-167	569	516	12090	218	11	63	186	92		Cerro Toledo Rhy
0-168	546	487	11983	199	10	64	176	101		Cerro Toledo Rhy
0-169	526	475	11702	200	10	58	173	93		Cerro Toledo Rhy
0-170	506	508	12331	212	13	68	182	104		Cerro Toledo Rhy
0-171	597	546	12384	211	10	67	177	102		Cerro Toledo Rhy
0-172	520	527	12407	222	11	60	174	97		Cerro Toledo Rhy
0-173	658	512	12229	216	9	62	177	96		Cerro Toledo Rhy
0-174	1177	545	11434	106	95	23	130	35	1609	Bearhead Rhy
0-181	484	639	12082	525	14	91	138	240		Horace/La Jara Mesa, Mt Taylor
0-182	591	482	11996	211	14	61	175	94		Cerro Toledo Rhy
0-183	680	403	11733	158	14	46	168	58		Cerro Toledo Rhy
0-184	1088	461	11031	99	85	25	128	34	1620	Bearhead Rhy
0-185	690	399	11826	162	14	45	165	56		Valles Rhy (Cerro del Medio)

0-186	651	516	12194	212	14	64	175	91		Cerro Toledo Rhy
0-200	814	284	10515	193	18	29	110	14	56	Zinapecuaro, Michoacan, MX
0-201	519	460	11453	187	9	58	170	88		Cerro Toledo Rhy
0-202	575	456	11810	210	9	56	181	100		Cerro Toledo Rhy
0-203	565	458	11709	199	9	58	178	99		Cerro Toledo Rhy
0-205	652	384	11684	155	14	47	158	55		Valles Rhy (Cerro del Medio)
0-206	526	465	11776	195	11	61	169	101		Cerro Toledo Rhy
0-207	519	512	11864	205	13	60	178	96		Cerro Toledo Rhy
0-208	464	603	11536	511	13	85	137	214		Horace/La Jara Mesa, Mt Taylor
0-209	575	464	11862	212	13	56	177	109		Cerro Toledo Rhy
0-210	559	492	11775	209	11	65	174	103		Cerro Toledo Rhy
0-211	641	508	12562	219	12	63	183	103		Cerro Toledo Rhy
0-212	685	395	11980	161	14	44	173	59		Valles Rhy (Cerro del Medio)
0-213	540	474	11765	210	11	64	176	102		Cerro Toledo Rhy
0-214	622	500	12212	205	11	68	175	96		Cerro Toledo Rhy
0-215	618	524	12068	214	9	60	179	102		Cerro Toledo Rhy
0-217	733	420	12047	160	12	44	173	55		Valles Rhy (Cerro del Medio)
3541	592	369	10005	143	15	23	77	49		El Rechuelos Rhy
3242	592	504	12218	218	10	70	184	100		Cerro Toledo Rhy
3243	627	504	12211	207	11	63	178	101		Cerro Toledo Rhy
3244	368	537	11146	485	13	89	128	219		Horace/La Jara Mesa, Mt Taylor
RGM1-S4	1523	294	13187	149	107	24	219	6	787	standard
RGM1-S5	1464	304	13663	142	109	21	214	9		standard
RGM1-S5	1425	328	13709	149	109	24	215	8		standard
RGM1-S5	1616	333	13678	147	107	23	214	9		standard

[1] Barium acquired for clarity in discrimination when needed (Davis et al. 2011).

Table 2. Frequency distribution of obsidian source provenance.

Source	Frequency	Percent
Cerro Toledo Rhy	155	79.5
Valles Rhy (Cerro del Medio)	13	6.7
El Rechuelos Rhy	7	3.6
Canovas Canyon Rhy	6	3.1
Bearhead Rhy	4	2.1
Horace/La Jara Mesa, Mt Taylor	6	3.1
Grants Ridge, Mt Taylor	2	1.0
Zinapecuaro, Michoacan, MX	2	1.0
Total	**195**	**100.0**

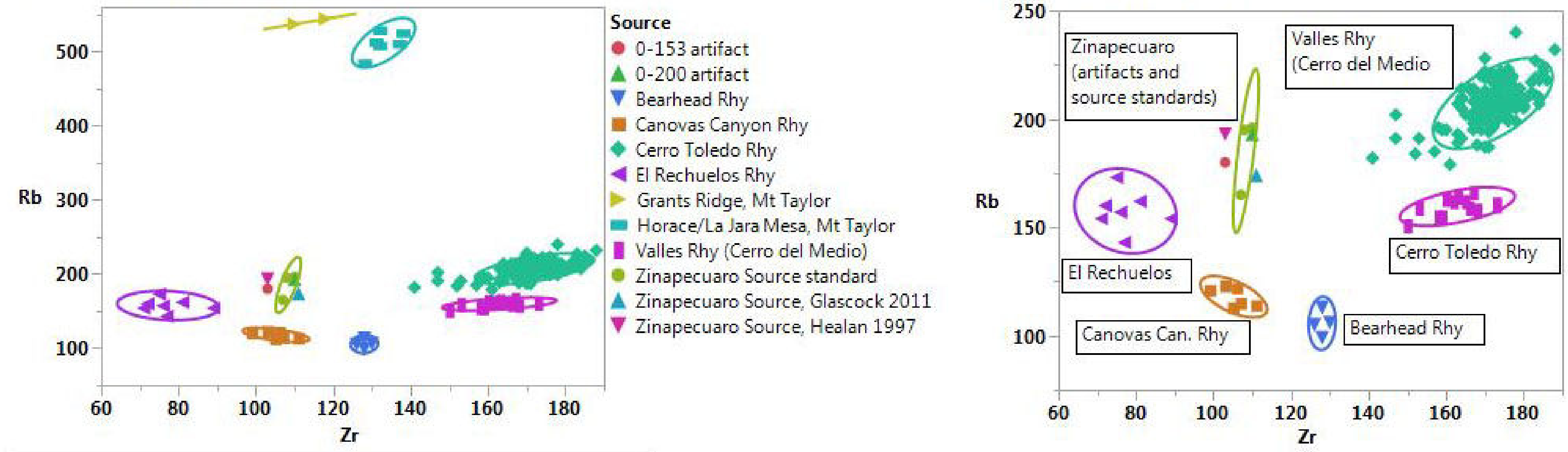


Figure 1. Zr/Rb bivariate plot of all artifacts (left), and Zr/Rb bivariate plot of lower Rb artifacts (right) providing greater discriminatory clarity. Confidence ellipses at 90%. Glascock and Healan source standard data for Zinapecuaro are mean values (Glascock 2011; Healan 1997). The "Zinapecuaro Source standard" are the results of three source standards in this laboratory.

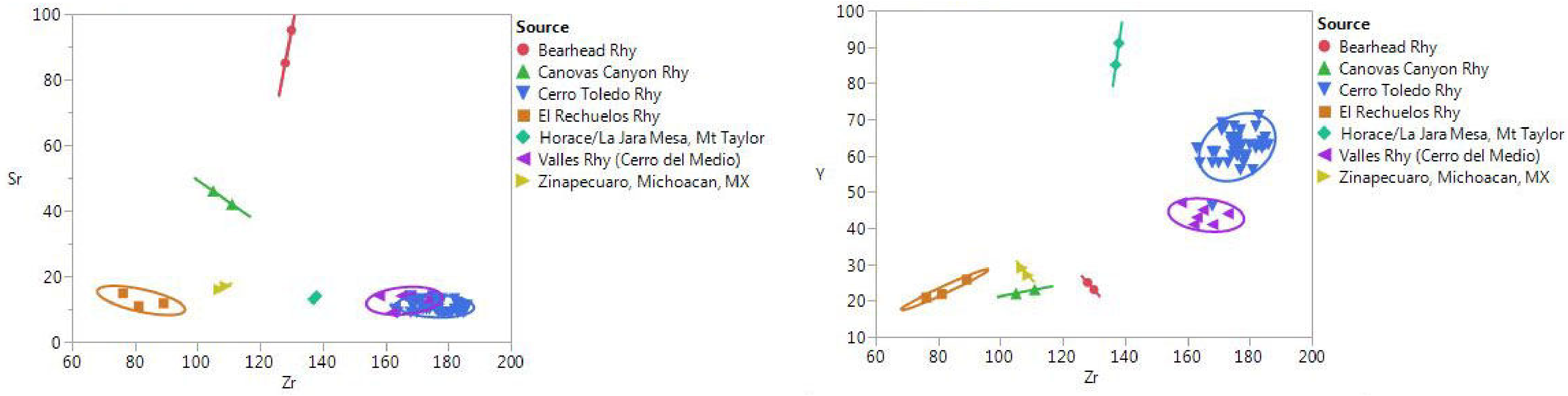


Figure 2. Zr/Sr bivariate plot of higher Sr artifacts, and Zr/Y bivariate plot providing discriminatory clarity for Jemez Lineament artifacts (see Shackley 2021). Confidence ellipses at 90%.

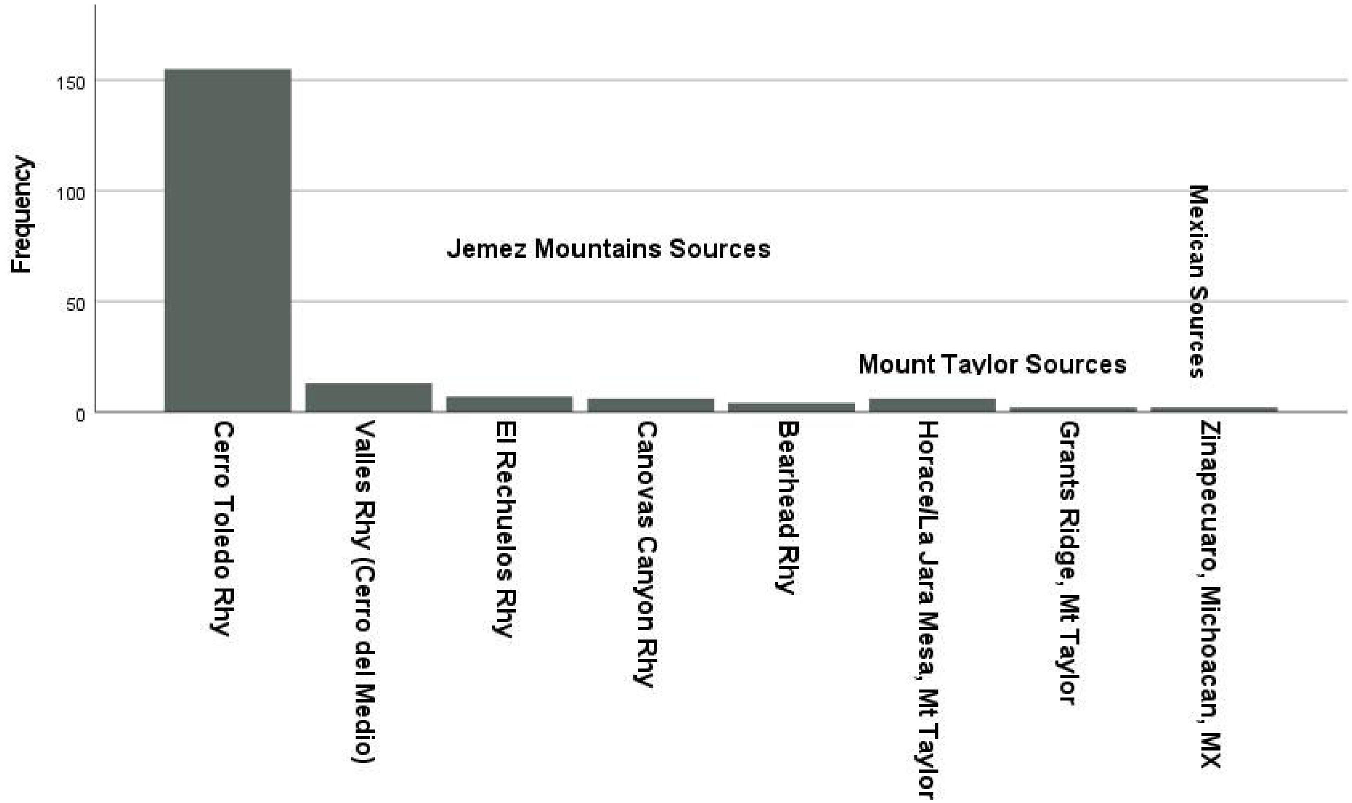


Figure 3. Frequency histogram of obsidian source provenance from Table 1 data.

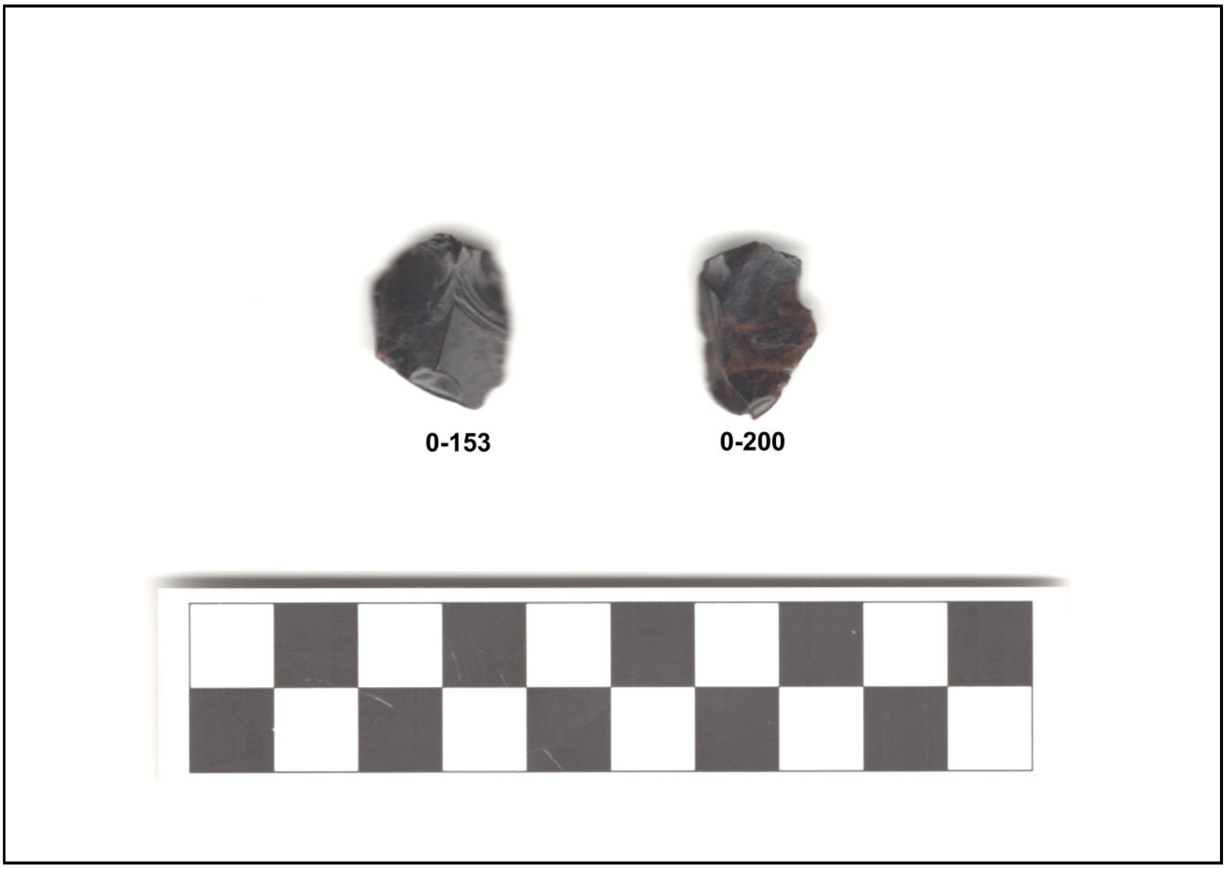


Figure 4. Polyhedral Zinapecuaro obsidian blade fragments (see Figure 5).

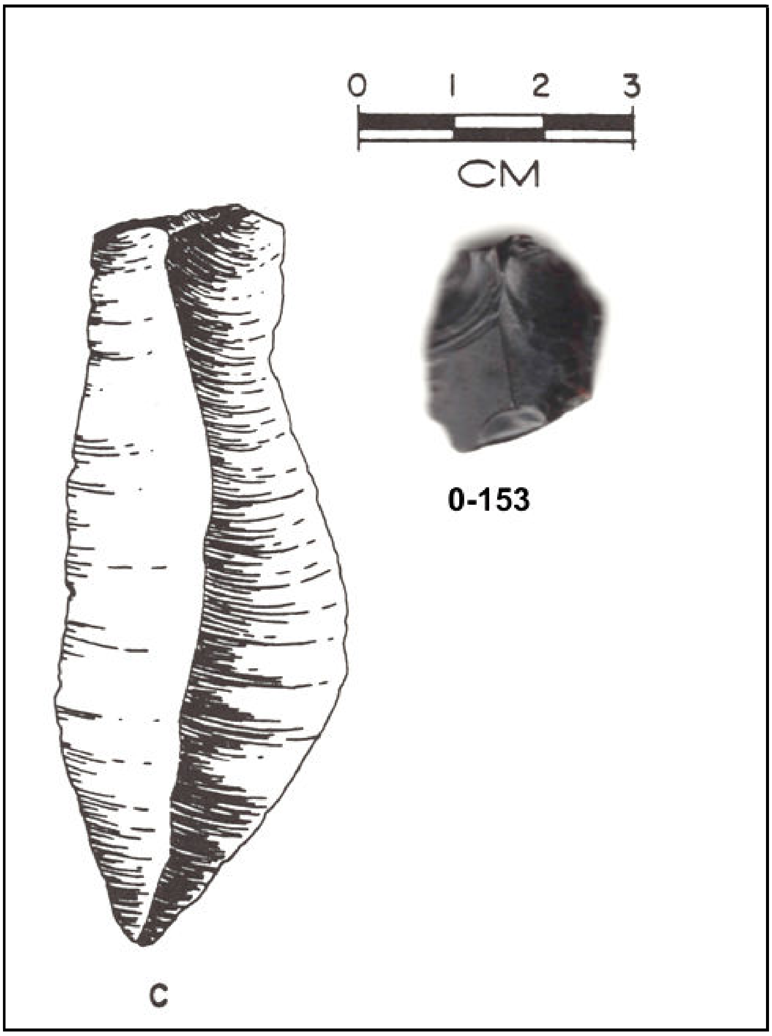


Figure 5. One of the obsidian blade fragments (0-153) from Piedras Marcadas and an illustrated Late Classic chert blade from Colha, Belize at the approximate same scale (Roemer 1991).

Figure 6. Aztec warriors brandishing *macuahuitl* a wooden club with inserted obsidian prismatic blades, from the 16th century Florentine Codex.