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SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM LA 5793 AND LA 34794 SOUTHERN NEW MEXICO

by

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Report Prepared for

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INTRODUCTION

The analysis here of 82 obsidian artifacts from LA 5793 and LA 34794, New Mexico, is dominated by artifacts produced from the Antelope Creek locality at Mule Creek in western New Mexico (72%), but a substantial number of artifacts produced from one of the other sources in the Mule Creek Source Area: Mule Mountains (15.9%) and North Sawmill Creek (8.5%), as well as one specimen produced from the Sierra County (Nutt Mountain) locality (Shackley 2010). Given the dominance of one source in these sites (Antelope Creek), little discussion is offered, however it appears that there is likely a social relationship between the Late Classic occupants at these sites and those that occupied the Mule Creek area, or at least consistent access to the sources at Mule Creek. Refer to Shackley (2005 and 2010) for a more detailed discussion of the Mogollon-Datil Volcanic Province sources and the importance of the Mule Creek sources in the Late Classic Southwest, and Taliafero et al. (2010) for a discussion of Mimbres obsidian provenance from Classic Mimbres sites in the region. The presence of Mule Mountains and North Sawmill Creek sources could be due to proximity (south of Mule Creek), but Antelope Creek still dominates for reasons that are both technological and social (Shackley 2005, 2010). One sample that could not be assigned to source looks similar to North Sawmill Creek elemental concentrations, but is outside the source standard data, and another with relatively high strontium values is unknown to me and does not match any in the known database.

LABORATORY SAMPLING, 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; Shackley 2011).

All analyses for this study were conducted on a ThermoScientific *Quant'X* EDXRF spectrometer, located in the Archaeological XRF Laboratory, Albuquerque, New Mexico. It is equipped with a thermoelectrically Peltier cooled solid-state Si(Li) X-ray detector, with a 50 kV, 50 W, ultra-high-flux end window bremsstrahlung, Rh target X-ray tube and a 76 µm (3 mil) beryllium (Be) window (air cooled), that runs on a power supply operating 4-50 kV/0.02-1.0 mA at 0.02 increments. The spectrometer is equipped with a 200 l min^{-1} Edwards vacuum pump, allowing for the analysis of lower-atomic-weight elements between sodium (Na) and titanium (Ti). Data acquisition is accomplished with a pulse processor and an analogue-to-digital converter. Elemental composition is identified with digital filter background removal, least squares empirical peak deconvolution, gross peak intensities and net peak intensities above background.

The analysis for mid Zb condition elements Ti-Nb, Pb, Th, the x-ray tube is operated 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 Ka-line data for elements titanium (Ti), manganese (Mn), iron (as $Fe_2O_3^T$), 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 are 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 analyzed in the High Zb condition, the Rh tube is operated at 50 kV and up to 1.0 mA, ratioed to the bremsstrahlung region (see Davis 2011; Shackley 2011). Further details concerning the petrological choice of these elements in Southwest obsidians is available in Shackley (1988, 1995, 2005; also Mahood and Stimac 1991; and Hughes and Smith 1993). Nineteen specific pressed powder standards are used for the best fit regression calibration for elements Ti-Nb, Pb, Th, and Ba, 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), TLM-1 (tonalite), SCO-1 (shale), NOD-A-1 and NOD-P-1 (manganese) all US Geological Survey standards, NIST-278 (obsidian), U.S. National Institute of Standards and Technology, BE-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).

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 a USGS obsidian standard is analyzed during each sample run for obsidian artifacts to check machine calibration (Table 1). Source assignments were made by reference to Shackley (1995, 1998a, 2005; see Tables 1 and 2, and Figures 1 and 2, as well as source standard data at this lab.

OBSIDIAN SOURCES IN THE MOGOLLON-DATIL VOLCANIC PROVINCE – MULE CREEK

One of the most startling discoveries in the 1990s was the chemical variability in Mule Creek obsidian (Shackley 1995, 1998b). In earlier studies, I noted two "outliers" collected at Mule Creek with significantly higher rubidium concentration values (Shackley 1988:767). These outliers have now been identified as a distinct chemical group, often mixed in the regional Gila Conglomerate with three other chemical groups. The geology in the area is complex and has been studied by Ratté, and others for some time (Brooks and Ratté 1985; Ratté 1982; Ratté and Brooks 1983, 1989; Ratté and Hedlund 1981; Rhodes and Smith 1972). Primary in situ perlite localities for three of the chemical groups have been located, but the secondary distribution of these source groups within the Mule Creek Basin is less well understood.

At least four distinct chemical groups are evident, distinguished by Rb, Y, Nb, and Ba, and a lesser extent Sr, and Zr elemental concentrations, and are named after the localities where marekanites have been found in perlitic lava: Antelope Creek; Mule Mountains; and Mule Creek/North Sawmill Creek all in New Mexico (see Shackley 1995, 1998b; Figure 2, and 4). It is quite evident that the obsidian at the Antelope Creek locality and adjacent secondary deposits constitute the volumetrically largest source of all the Mule Creek sources. The Tertiary Age dome complex at Antelope Creek covers hundreds of hectares and virtually all of it exhibits artifact quality marekanites. Parenthetically, surveys to the west in the Big Lue Mountains on the Arizona/New Mexico state line indicate a mix of North Sawmill Creek and Antelope Creek marekanites in secondary alluvium at a ratio of about six North Sawmill Creek to one Antelope Creek similar to the ratio reported in Shackley (1988). The Antelope Creek eruptive event about 17 mya was quite extensive.

Additionally, during the 1994 field season, a fourth sub-group was discovered in the San Francisco River alluvium near Clifton, Arizona and in older alluvium between Highway 191 and Eagle Creek in western Arizona north of Clifton called provisionally San Francisco River nodules. While in situ nodules have not yet been found they are certainly located somewhere west of Blue River and north and west of the San Francisco River since none of this 'low zirconium' sub-group was discovered in alluvium upstream from the juncture of the Blue and San Francisco Rivers. The genetic relationship between the Mule Creek localities is apparent in the bivariate plots of trace elements (Figures 1 and 2), and signifies the very complex nature of the Mule Creek silicic geology, with subsequent depositional mixing in the Gila Conglomerate. Glass at other Tertiary sources in the Southwest, such as Sauceda Mountains and Antelope Wells, also appear to exhibit more than one chemical mode, although not as distinct as Mule Creek or Mount Taylor, discussed below (Shackley 1988, 1990, 1998b). The Mule Creek case is unusual because the chemical groups are not always spatially discrete and occur together in the extensive Gila Conglomerate which is mainly composed of Mule Creek rhyolite and tuffs in the area where the marekanites do occur (see Ratté and Brooks 1989).

The Mogollon-Datil Province and the Mule Creek area. The Mule Creek Source Region is one of the most geologically explored archaeological sources of obsidian in the American Southwest (Brooks and Ratté 1985; Ratté 1982; Ratté and Brooks 1983, 1989; Ratté and Hedlund 1981; Rhodes and Smith 1972; Figure 3.5). Ratté has organized most of the research in the area focusing on mapping and establishing the origin of the volcanics during the Tertiary as originally described by Rhodes and Smith (1972). This region, which is on the boundary between the Basin and Range complex to the west and southwest, and the southeastern edge of the Colorado Plateau, exhibits a silicic geology that is somewhat distinctive; from the decidedly peraluminous glass of Cow Canyon with relatively high strontium values and the distinct chemical variability of the Mule Creek glasses (Elston et al. 1976; Ratté et al. 1984; Rhodes and Smith 1972; Shackley 2005). The province has been named Mogollon-Datil for its location and major floristic association (Elston et al. 1976). The region is, in part, characterized by precaldera andesites and later high-silica alkali rhyolites in association with caldera formation, subsequent collapse and post-caldera volcanism. Most recently, fieldwork and chemical analyses by Ratté and Brooks (1989) lead them to conclude that the Mule Creek Caldera is actually just a graben, although the typical succession from intermediate to silicic volcanism apparently holds.

The obsidian has been directly dated at the Antelope Creek locality (locality 1 in Figure 3.5 here) to 17.7±0.6 mya by K-Ar, and at the Mule Mountain locality at the same age (17.7±1 mya by K-Ar; Ratté and Brooks 1983, 1989). A single obsidian marekanite taken from the perlitic lava at the Antelope Creek locality was used in the analysis. Unusual in geological descriptions, the obsidian proper was discussed as an integral part of the regional geology.

> Rhyolite of Mule Creek (Miocene). Aphyric, high-silica, alkali-rhyolite domal flows from the Harden Cienega eruptive center along southwestern border of quadrangle [Wilson Mountain 1:24,000 Quad, New Mexico; Figure 4 here]. Unit **ob**, commonly at the base of the flows, consists of brown, pumiceous glass that grades upward into gray to black perlitic obsidian and obsidian breccia. Extensive ledges of partly hydrated, perlitic obsidian contain nonhydrated obsidian nodules (marekenites) which, when released by weathering, become the Apache tears that are widespread on the surface and within the Gila Conglomerate in this region. Age shown in Correlation is from locality about 1 km south of tank in Antelope Creek in Big Lue Mountains quadrangle adjacent to west edge of Wilson Mountain quadrangle. Thickness of flows is as much as 60 m and unit **ob** as much as 25 m (Ratté and Brooks 1989:map text, bold as in original).

This description adequately characterizes what is found at the other two primary localities (Mule Mountains, and Mule Creek/North Sawmill Creek; see Figure 4). Aphyric, artifact quality marekenites are remnant within perlitic glass and tuff lava units. Nodules at all localities are up to 15 cm in diameter although most are under 10 cm. The devitrified perlitic lava, quite friable, erodes easily into the local alluvium. As discussed elsewhere, this is relatively unique in Tertiary sources in the Southwest where most of the obsidian breccia and perlitic lava is often completely eroded away leaving only the rhyolite interior of the dome and a consequent inability to assign the surrounding marekanites to a specific dome structure (Shackley 2005; see also Hughes and Smith 1993).

The aphyric glass ranges from opaque black to translucent smoky gray with some gray banding. In over 1000 specimens collected from the Mule Creek/North Sawmill Creek group, three are some mahogany-brown and black banded similar to Slate Mountain (Wallace Tank) material. Some of the cortex exhibits a silver sheen, but most is a thin black-brown. The material is a fair medium for tool production, but is very brittle much like Los Vidrios. The pressure reduction potential is, however, very good as seen in the sites in this study. The Mule Mountain glass, however, is as good as any in the Southwest, but surprisingly relatively rare in sites in the region.

REFERENCES CITED

Brooks, W. E., and Ratté, J. C.
1985 Geologic map of Bear Mountain Quadrangle, Grant County, New Mexico. U.S. Geological Survey Miscellaneous Field Studies Map MF-1782.

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.

Elston, W., R. Rhodes, P. Coney, and E. Deal
1976 Progress Report on the Mogollon Plateau Volcanic Field Southwestern New Mexico. *New Mexico Geological Society Special Publication* 5:3-18.

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.

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.

McIntosh, W.C., C.E. Chapin, J.C. Ratté, and J.F. Sutter
1992 Time-Stratigraphic Framework for the Eocene-Oligocene Mogollon-Datil Volcanic Field, Southwest New Mexico. *Geological Society of America Bulletin* 104:851-871.

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.

Ratté, J. C.
1982 Geologic map of the Lower San Francisco Wilderness Study Area and contiguous roadless area, Greenlee County, Arizona, and Catron and Grant Counties, New Mexico. U.S. Geological Survey Miscellaneous Field Studies Map MF-1463-B.

Ratté, J. C., and Brooks, W. E.
1983 Geologic map of the Mule Creek Quadrangle, Grant County, New Mexico. U.S. Geological Survey Miscellaneous Studies Map MF-1666.

1989 Geologic map of the Wilson Mountain Quadrangle, Catron and Grant Counties, New Mexico. U.S. Geological Survey Geologic Quadrangle Map GQ-1611.

Ratté, J. C., and Hedlund, D.C.
1981 Geologic map of the Hells Hole Further Planning Area (RARE II), Greenlee County, Arizona and Grant County, New Mexico. U.S. Geological Survey Miscellaneous Field Studies Map MF-1344-A.

Ratté, J. C., Marvin, R.F., and Naeser, C.W.
1984 Calderas and ash flow tuffs of the Mogollon Mountains, southwestern New Mexico. *Journal of Geophysical Research* 89:8713-8732.

Rhodes, R. and E. Smith
1972 Geology and Tectonic Setting of the Mule Creek Caldera, New Mexico, USA. *Bulletin Volcanologíe* 36:401-411.

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, University Microfilms, Ann Arbor.

1995 Sources of Archaeological Obsidian in the Greater American Southwest: An Update and Quantitative Analysis. *American Antiquity* 60(3):531-551.

1998a Geochemical Differentiation and Prehistoric Procurement of Obsidian in the Mount Taylor Volcanic Field, Northwest New Mexico. *Journal of Archaeological Science* 25:1073-1082.

1998b Intrasource Chemical Variability and Secondary Depositional Processes in Sources of Archaeological Obsidian: Lessons from the American Southwest. In *Archaeological Obsidian Studies: Method and Theory*, edited by M.S. Shackley, pp. 83-102. Advances in Archaeological and Museum Studies 3. Springer, New York.

2005 *Obsidian: Geology and Archaeology in the North American Southwest*. University of Arizona Press, Tucson.

2010 Source Provenance of Obsidian Artifacts from Late Classic Contexts in Western and Southern New Mexico. Report prepared for Robert Jones, Center for Desert Archaeology, Tucson, Arizona.

2011 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.

2010 Taliafero, M.A., Schriever, B.A., and M.S. Shackley
Obsidian Procurement, Least Cost Path Analysis, and Social Interaction in the Mimbres Area of Southwestern New Mexico. *Journal of Archaeological Science* 37:536-548.

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

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
LA 5793									
8-7-2	833	588	8832	425	11	78	104	132	N. Sawmill Cr-Mule Creek
10-63-1	1354	388	10238	241	83	30	138	25	unknown
10-63-2	1148	406	10504	247	17	38	102	28	Antelope Cr-Mule Creek
15-21-1	899	355	9840	237	22	46	110	24	Antelope Cr-Mule Creek
15-21-3	930	329	9218	221	20	40	113	25	Antelope Cr-Mule Creek
17-5	1034	486	8562	179	16	25	115	29	Mule Mtns-Mule Creek
17-5-2	1001	520	8760	191	15	23	123	33	Mule Mtns-Mule Creek
17-5-3	1102	479	8963	181	17	24	115	31	Mule Mtns-Mule Creek
18-6-1	803	547	8415	399	11	71	101	116	N. Sawmill Cr-Mule Creek
18-6-2	1195	682	10696	460	14	74	108	125	N. Sawmill Cr-Mule Creek
18-6-4	1149	467	9278	178	16	26	118	32	Mule Mtns-Mule Creek
18-9	880	361	9826	243	22	41	113	25	Antelope Cr-Mule Creek
19-20	1027	455	8233	180	14	24	113	33	Mule Mtns-Mule Creek
19-20	916	370	9911	252	19	41	112	26	Antelope Cr-Mule Creek
19-3-1	942	369	9982	237	20	44	113	24	Antelope Cr-Mule Creek
19-3-2	907	355	9786	235	22	43	108	24	Antelope Cr-Mule Creek
19-37	955	393	10195	245	22	41	113	27	Antelope Cr-Mule Creek
20-2	1016	383	10231	248	20	40	111	28	Antelope Cr-Mule Creek
20-31	962	377	9373	238	23	38	107	23	Antelope Cr-Mule Creek
21-4-1	935	375	9621	236	21	45	109	24	Antelope Cr-Mule Creek
21-4-2	955	389	10125	245	20	41	114	25	Antelope Cr-Mule Creek
23-15-1	918	399	10447	257	19	44	119	26	Antelope Cr-Mule Creek
23-15-2	855	586	9060	424	11	74	102	119	N. Sawmill Cr-Mule Creek
23-6	941	370	10210	242	21	44	109	22	Antelope Cr-Mule Creek
27-1	1031	483	8735	189	15	28	116	34	Mule Mtns-Mule Creek
29-39	899	571	8788	417	13	73	106	118	N. Sawmill Cr-Mule Creek
30-9-1	1136	479	9228	184	17	26	112	31	Mule Mtns-Mule Creek
30-9-2	1027	459	8732	185	17	25	117	31	Mule Mtns-Mule Creek
32-106	1035	397	10314	244	22	41	112	24	Antelope Cr-Mule Creek
32-19	900	370	9871	234	27	38	111	25	Antelope Cr-Mule Creek
32-53	940	386	9913	247	22	39	109	27	Antelope Cr-Mule Creek
32-77	1001	371	9630	228	22	40	108	25	Antelope Cr-Mule Creek
33-1	1557	893	12625	245	18	30	141	38	Antelope Cr-Mule Creek
33-4-1	924	397	10052	248	22	42	114	25	Antelope Cr-Mule Creek
33-4-2	1068	396	10222	239	20	41	110	25	Antelope Cr-Mule Creek
33-4-3	1025	463	8515	190	17	22	115	37	Mule Mtns-Mule Creek
33-4-4	798	539	8421	407	10	73	102	119	N. Sawmill Cr-Mule Creek
33-4-5	1041	475	8413	183	14	26	114	29	Mule Mtns-Mule Creek
33-4-6	947	367	9964	244	22	38	108	25	Antelope Cr-Mule Creek
33-4-7	1021	384	10421	246	24	40	113	27	Antelope Cr-Mule Creek

34-15	891	342	9239	221	25	39	108	27	Antelope Cr-Mule Creek
34-15-1	908	368	9652	233	22	41	108	29	Antelope Cr-Mule Creek
35-19	907	376	9894	240	20	43	113	25	Antelope Cr-Mule Creek
36-6-1	921	359	10015	242	22	42	113	26	Antelope Cr-Mule Creek
36-6-2	882	365	9535	233	22	43	107	26	Antelope Cr-Mule Creek
Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
36-6-3	909	381	9957	244	21	38	110	25	Antelope Cr-Mule Creek
37-8-1	1029	405	10554	245	20	40	110	25	Antelope Cr-Mule Creek
37-8-2	902	379	10109	250	20	40	112	30	Antelope Cr-Mule Creek
38-1	1387	653	10673	201	19	27	127	41	Sierra County, NM
38-1-1	958	413	10302	256	22	43	113	26	Antelope Cr-Mule Creek
41-31-1	863	323	8630	218	22	40	106	26	Antelope Cr-Mule Creek
41-31-2	985	415	10465	248	24	42	116	27	Antelope Cr-Mule Creek
41-31-3	920	405	10256	259	21	45	120	29	Antelope Cr-Mule Creek
48-13	976	403	10510	251	20	45	110	26	Antelope Cr-Mule Creek
48-2	991	418	10760	257	24	42	118	29	Antelope Cr-Mule Creek
48-2-1	982	385	10014	238	17	38	109	30	Antelope Cr-Mule Creek
48-2-2	1093	404	10977	253	24	42	121	25	Antelope Cr-Mule Creek
50-11	975	387	10321	236	23	44	111	29	Antelope Cr-Mule Creek
57-16-1	1043	402	10872	253	23	44	115	28	Antelope Cr-Mule Creek
57-16-2	1125	367	10422	235	22	38	109	29	Antelope Cr-Mule Creek
57-20-1	980	393	10437	247	24	48	114	23	Antelope Cr-Mule Creek
57-20-2	1027	559	12938	302	23	47	134	34	unknown
57-20-2	980	425	7993	169	15	22	112	26	Mule Mtns-Mule Creek
57-20-4	912	355	9255	219	21	36	109	23	Antelope Cr-Mule Creek
57-21	876	355	9308	225	21	37	107	29	Antelope Cr-Mule Creek
63-27	904	365	9752	239	21	40	111	23	Antelope Cr-Mule Creek
63-34	931	396	9938	239	21	41	112	29	Antelope Cr-Mule Creek
78-27-1	939	411	10170	256	21	40	115	27	Antelope Cr-Mule Creek
79-27-2	1003	421	8337	174	14	26	116	32	Mule Mtns-Mule Creek
89-20	902	353	9592	242	20	40	111	26	Antelope Cr-Mule Creek
97-13	1529	393	12035	235	25	42	112	23	Antelope Cr-Mule Creek
LA 34794									
R3FLF-1	903	371	9809	237	22	44	115	28	Antelope Cr-Mule Creek
R3FLF-2	972	401	10330	249	21	43	108	28	Antelope Cr-Mule Creek
R4FLF-1	967	384	10243	248	20	41	112	22	Antelope Cr-Mule Creek
R4FLF-2	933	344	9646	231	21	43	107	21	Antelope Cr-Mule Creek
R5FLF-1	912	357	9683	239	20	39	107	34	Antelope Cr-Mule Creek
R5FLF-2	919	337	9374	227	20	38	105	24	Antelope Cr-Mule Creek
T32-1	919	430	10696	266	20	45	114	32	Antelope Cr-Mule Creek
T32-2	908	367	9784	238	21	44	109	29	Antelope Cr-Mule Creek
T47	924	373	9968	239	20	42	112	26	Antelope Cr-Mule Creek
T6	1266	413	9681	172	19	24	117	30	Mule Mtns-Mule Creek
T8	1015	705	10264	461	13	79	125	134	N. Sawmill Cr-Mule Creek
RGM1-S4	1606	287	13340	147	108	25	216	7	standard
RGM1-S4	1608	273	13305	148	108	24	217	10	standard
RGM1-S4	1658	302	13266	150	107	24	218	9	standard
RGM1-S4	1644	292	13327	147	106	25	217	7	standard
RGM1-S4	1610	270	13336	147	105	20	213	9	standard

Table 2. Frequency distribution of source provenance at the two sites.

		Frequency	Percent
Source	Antelope Cr-Mule Creek	59	72.0
	Mule Mtns-Mule Creek	13	15.9
	N. Sawmill Cr-Mule Creek	7	8.5
	Sierra County, NM	1	1.2
	unknown	2	2.4
	Total	82	100.0

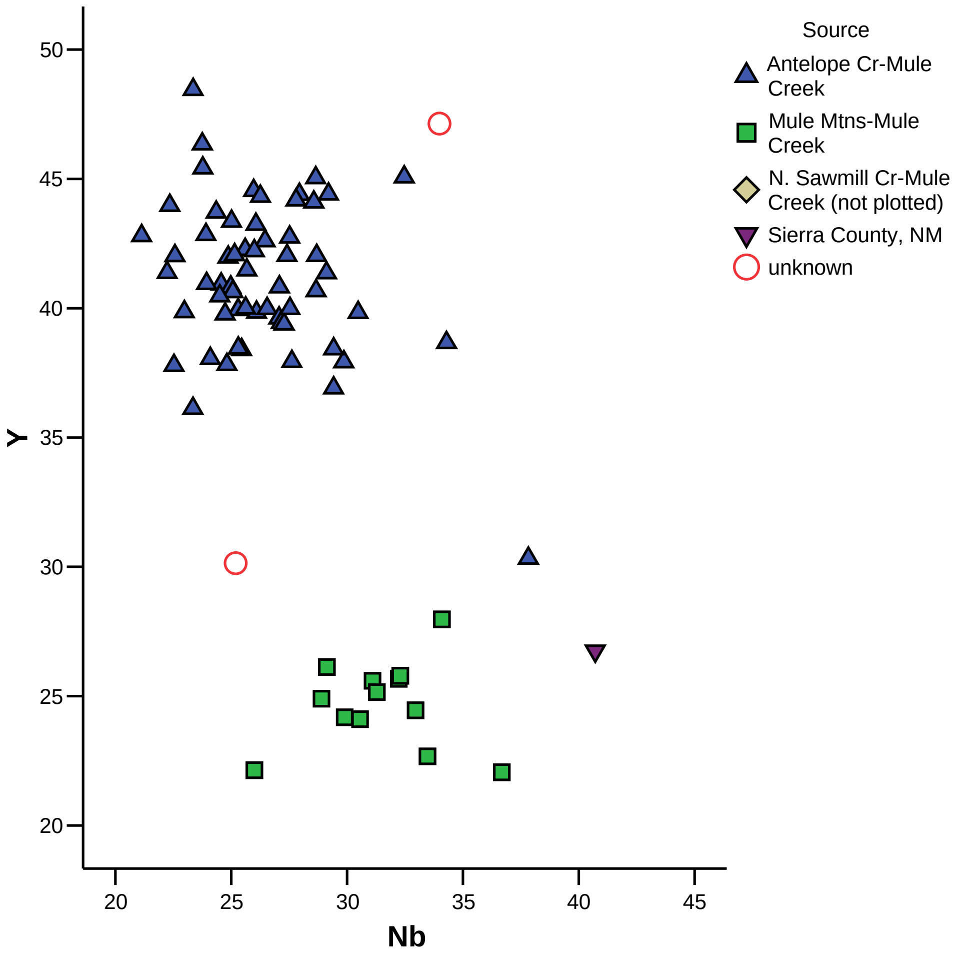

Figure 1. Nb versus Y bivariate plot of the elemental concentrations for the archaeological specimens. The distinctive North Sawmill Creek specimens removed for clarity.

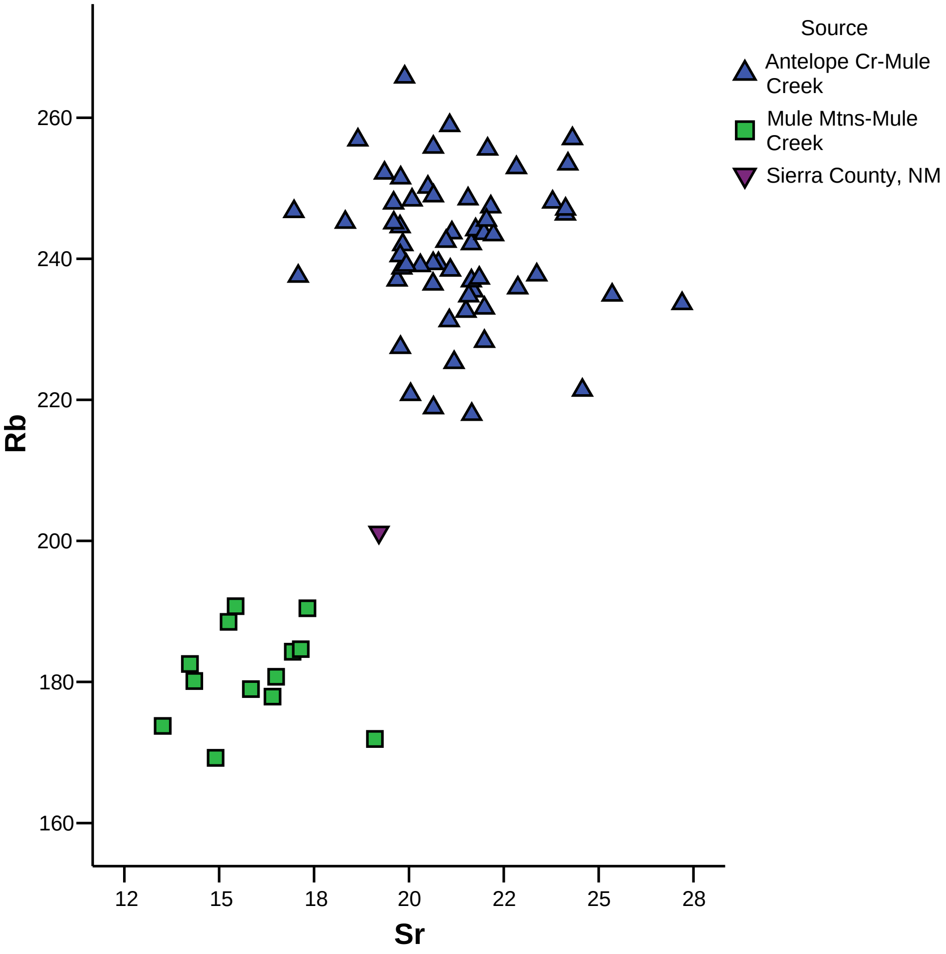

Figure 2. Sr versus Rb bivariate plot of the elemental concentrations for the artifacts produced from the Antelope Creek, Mule Mountains, and Sierra County chemical groups (see Shackley 2010). Note continuous distribution of these three sources in these incompatible elements (see Shackley 2010 for further discussion).