Title
SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM LAS CAPAS(AZ AA:12:111 ASM), SANTA CRUZ RIVER BASIN, TUCSON, ARIZONA

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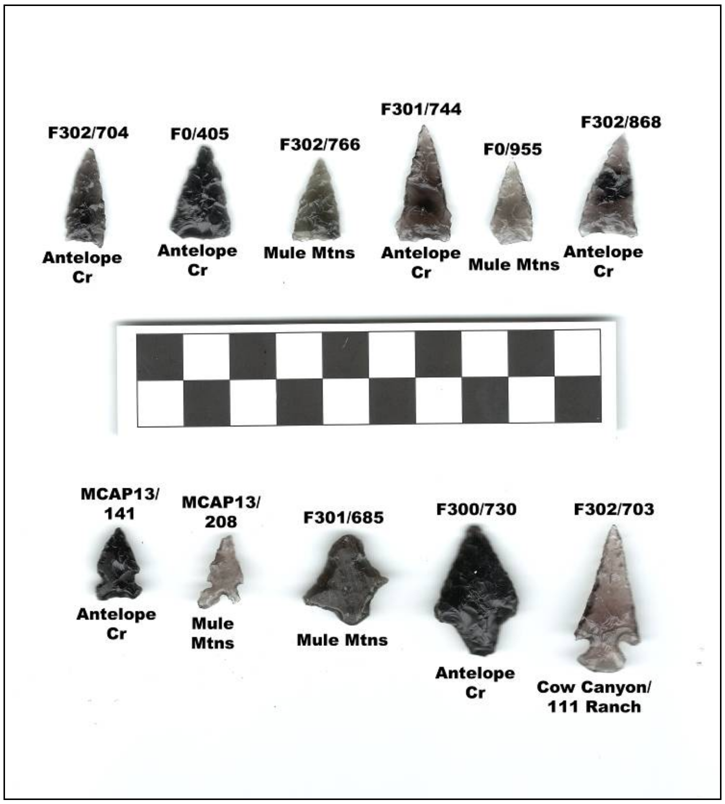
SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THE DINWIDDIE SITE (LA 106003), CLIFF, WESTERN NEW MEXICO



Sample of projectile points and source provenance from Dinwiddie (see text)

by

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INTRODUCTION

The analysis here of more than 358 obsidian artifacts from the late period Dinwiddie Site (LA 106003) near Cliff, New Mexico indicates a dominance of procurement from Mule Creek sources (98.6%) evenly split between Mule Mountains, the nearest locality, and Antelope Creek farther northwest. This report combines the 2014 and 2016 analyses, but essentially yields the same results as the earlier project. Even given the contemporaneity between Dinwiddie and the sites in the Mule Creek Valley proper, the procurement of obsidian for tool production is quite different, here split between Antelope Creek and Mule Mountains (Shackley 2010). This is certainly due to the proximity of the Mule Mountains locality to Dinwiddie. Five artifacts were produced from two other regional sources, Cow Canyon/111 Ranch in eastern Arizona (n=2), Superior (Picketpost Mountain) in central Arizona (n=1), Gwynn/Ewe Canyon in the Mogollon Highlands to the north (n=1), and one that could not be assigned to source (see discussion). One water-eroded nodule is a terphri-phonlite based on an analysis of the major oxides (not provided here).

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 100 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. When barium (Ba) is acquired 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 with reference to Shackley (1995, 2005; Shackley et al. 2016) and source standard data at this lab (Tables 2 and 3 and Figures 1 and 2; see also http://swxrflab.net/swobsrcs.htm).

DISCUSSION

The Mogollon-Datil Volcanic Province

The Mogollon-Datil volcanic field is part of a discontinuous belt of middle Cenozoic volcanism that runs from the Sierra Madre Oriental in central Mexico, through the Trans-Pecos volcanic field in west Texas, and northward to the San Juan volcanic field in southwestern Colorado. Geological studies of this very large volcanic province began in the 1930s, but in the last decade have essentially ceased as interest grew in other theoretical areas away from studies of crustal extension, particularly for the high-silica fluid depleted rhyolites that produced obsidian (Elston 2008; c.f. Shackley et al. 2016).

Lavas and tuffs erupted from andesitic to silicic volcanoes, domes, and calderas coalesced to form the Mogollon-Datil Volcanic Province in southwestern New Mexico between ~20 to 40 Ma (Chapin et al. 2004; Elston 2008; McIntosh et al. 1991; Ratté et al. 1984; Shackley et al. 2016). This feature, which includes the mountainous terrain of the Gila Wilderness, covers about 40,000 km^2. Initially, andesite volcanism occurred across this region 40 to 36 Ma. Later, both basaltic and andesitic events and silicic calderas formed between 36 and ~20 Ma. Many of these eruptive events were very large ignimbrite (tuff) events, many silicic and responsible for the production of obsidian through rapid quenching at the margins and pyroclastic cooling (Elston 2008). During the latter part of the sequence, silicic rhyolite dome complexes were formed as well, sometimes as ring events at the margins of calderas such as at Mule Creek and Gwynn/Ewe Canyons creating the very old artifact quality obsidian dated by $^{40}Ar/^{39}Ar$ between 17.67 Ma at North Sawmill Creek/Mule Creek to 31.74 Ma at Nutt Mountain in Sierra County, New Mexico in this important archaeological region (Elston 2008; Ratté 2004; Shackley 2005; Shackley et al. 2016; see Figure 3 here). The province is composed of two caldera complexes that were active at about the same time. The oldest eruptions of the southern complex occurred in the Organ Mountains near Las Cruces about 36 Ma. The Nutt Mountain obsidian source in Sierra County was created shortly after this and is dated by $^{40}Ar/^{39}Ar$ to 31.74 ± 0.13 Ma, the oldest dated artifact quality obsidian source in the Southwest, and probably on earth (Shackley et al. 2016). Volcanic activity migrated from the Organ Mountains toward the northwest 220 km, ending with the eruption of the 28 million year old Bursum caldera located northwest of Silver City, New Mexico responsible for the Gwynn/Ewe Canyons obsidian dated to 28.13 ± 0.02 Ma by $^{40}Ar/^{39}Ar$ (Shackley et al. 2016). Caldera formation in the northern complex started near Socorro about 32 Ma and migrated toward the southwest, including the Mule Creek caldera complex, one of the most important sources of archaeological obsidian from Paleoindian to the historic period (ca. 14,000 Ka to AD 1540; Hamilton et al. 2013; Mills et al. 2013a, 2013b; Ratté 2004; Shackley 2005; Shackley et al. 2016). The elemental and isotopic similarity between these obsidian sources is likely the result of near contemporaneous events over the very large area during the latter stages of volcanism in the province sampling similar crustal magma in this case very large granite plutons (Elston 2008; Shackley et al. 2016).

The Mule Creek Caldera and Ash Flow Sheet Obsidian

Counting secondary deposition, the Mule Creek sources are some of the geographically largest obsidian sources in the Southwest. The obsidian is found in a very extensive late Tertiary (Neogene) ash-flow sheet that covers portions of Greenlee County, Arizona, Catron and Grants Counties, New Mexico (Ratté 2004; Shackley et al. 2016). The 100+ mm nodule density at the Antelope Creek West locality reaches 100s per $5m^2$, especially on the top of the ash hills. Erosion into the San Francisco and Gila River systems has been occurring for over 19 Ma ($^{40}Ar/^{39}Ar$ date of 19.433 ± 0.013 Ma from Antelope Creek West and 21.98 ± 0.02 Ma from Mule Mountains; Shackley et al. 2016).

At least four distinct chemical groups are evident, distinguished by Rb, Y, Nb, Zr, and Ba concentration values, and are named after the localities where marekanites have been found in perlitic lava and ignimbrites: Antelope Creek (East and West localities); Mule Mountains; and North Sawmill Creek all in New Mexico (from Ratté 2004, and personal communication; Shackley 2005; Shackley et al. 2016). 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 eastern Arizona north of Clifton (Shackley 2005). This 'low zirconium' sub-group was discovered in alluvium upstream from the juncture of the Blue and San Francisco Rivers, but the primary source has not be discovered.

The Antelope Creek locality after Government Mountain, Arizona, and the Jemez Mountains sources in northern New Mexico was the most significant source of obsidian in prehistory from Paleoindian through historic times, recovered in sites in the region in much greater frequency than any other of the Mogollon-Datil obsidians. Indeed, it has been recovered as artifacts from western Arizona into Texas, Oklahoma, Kansas, and south into northwest Mexico (Hamilton et al. 2013; Mills et al. 2013a, 2013b; Taliafero et al. 2010). The Late Classic inhabitants of the Mule Creek area as well as Classic Mimbres appear to have seen this obsidian as a commodity. Clovis knappers in New Mexico often used the obsidian for point production, pointing to the Late Pleistocene value of the area.

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 mahogany-brown and black banded similar to Slate Mountain (Wallace Tank) material in northern Arizona. 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 the Antelope Creek East locality obsidian is very brittle much like Los Vidrios. The pressure reduction potential is, however, very good as seen in the sites in this study. The recently discovered Antelope Creek West locality is some of the best obsidian raw material in the Southwest and exhibits nodules ≥100 mm. The Mule Mountain glass, the locality closest to Dinwiddie, is an equally good raw material as can be seen in the archaeological assemblage.

Dinwiddie Obsidian Projectile Points

The vast majority of projectile points during the late periods in the Southwest are dominated by triangular concave or straight based forms, called Cottonwood Triangular in much of the West (Heizer and Baumhoff 1961; Justice 2002; see also Franklin 1980 for Salado contexts). At least some of these forms could be late stage preforms for the production of side-notched points, but since side-notched obsidian points seem to be relatively uncommon at Dinwiddie, this is likely rarely the case. Most of the obsidian projectile points are typical of late period styles including the concave and straight-base, triangular forms common throughout the West, as well as what have been called Pueblo side-notched by Justice (2002) also common throughout the West, indeed most of western North America during the late periods (Turner and Hester 1985; Whittaker 1984; Figure 4 here). There appears to be an active assemblage of arrowpoint production but little impact damage and rejuvenation evident in the obsidian points. This is likely because of abundant raw material (Mule Mountains obsidian) nearby so that rejuvenation of points was less of a requirement - new projectile points could be easily produced from abundant and easily procured raw material.

There were a number of circular obsidian (discoid) forms in the collection (not illustrated), perhaps ornaments, and flaked unifacially. The function of these rare artifacts is unknown to me.

The corner-notched expanding stemmed point produced from Cow Canyon is also a common form in the Southwest part of what Justice (2002: 240-246) calls the Dolores Cluster, and would also include the stemmed points shown in Figure 4 here. The Cow Canyon specimen could very likely have been procured in exchange from eastern Arizona especially since this form is uncommon in the obsidian assemblage.

The analysis of artifacts in the second batch in 2016 essentially mirrored the 2014 project. The projectile points were all of similar morphology and not illustrated here. The number of obsidian discoids increased considerably and should be investigated. Considerable effort went into production of these artifacts, and I have not seen them in any other archaeological contexts.

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Table 1. Recommended values for USGS RGM-1 obsidian standard and mean and central tendency values from this study (both years combined). ± = 1st standard deviation.

SAMPLE	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th
RGM-1 (Govindaraju 1994)	1600	279	12998	149	108	25	219	8.9	24	15.1
RGM-1 (USGS recommended)[1]	1619±120	279±50	13010±210	150±8	110±10	25[2]	220±20	8.9±0.6	24±3	15±1.3
RGM-1, pressed powder standard (this study, n=9)	1509±54	296±16	13701±32	148±3	107±2	24±2	218±4	8±3	21±2.1	16±4.5

[1] Ti, Mn, Fe calculated to ppm from wt. percent from USGS data.
[2] information value

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

Sample	Context/Fea.	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
400	Fea 0	666	356	11557	237	20	38	110	25	27	22	Antelope Cr/Mule Creek
410	Fea 0	567	356	11487	238	23	40	110	28	27	30	Antelope Cr/Mule Creek
423	Fea 0	614	386	11600	241	24	43	113	26	29	34	Antelope Cr/Mule Creek
452	Fea 0	635	390	11707	252	21	43	111	24	31	32	Antelope Cr/Mule Creek
487	Fea 0	804	350	11854	237	26	40	110	26	30	38	Antelope Cr/Mule Creek
516	Fea 0	612	367	11719	249	21	44	112	28	29	32	Antelope Cr/Mule Creek
530	Fea 0	512	341	11423	243	22	42	112	25	31	37	Antelope Cr/Mule Creek
536	Fea 0	586	398	10249	171	16	23	105	29	20	32	Mule Mtns/Mule Creek
405	Fea 0	631	343	11492	242	22	39	112	24	27	29	Antelope Cr/Mule Creek
409-1	Fea 0	651	416	10508	174	19	25	114	31	21	23	Mule Mtns/Mule Creek
409-2	Fea 0	658	434	10540	177	16	25	115	35	22	28	Mule Mtns/Mule Creek
415-1	Fea 0	836	442	10699	183	14	25	116	31	24	29	Mule Mtns/Mule Creek
415-2	Fea 0	519	327	11071	227	20	40	107	26	27	31	Antelope Cr/Mule Creek
434-1	Fea 0	550	357	11384	244	19	43	106	29	27	32	Antelope Cr/Mule Creek
434-2	Fea 0	754	510	11035	200	14	22	117	35	28	31	Mule Mtns/Mule Creek
439	Fea 0	625	364	11361	233	21	44	106	27	27	38	Antelope Cr/Mule Creek
475-1	Fea 0	767	441	10628	185	16	23	109	33	19	23	Mule Mtns/Mule Creek
475-2	Fea 0	586	376	11694	245	21	45	108	29	28	36	Antelope Cr/Mule Creek
515-1	Fea 0	785	476	10930	184	16	21	110	27	26	25	Mule Mtns/Mule Creek
515-2	Fea 0	1132	436	11747	179	17	23	114	28	26	28	Mule Mtns/Mule Creek
515-3	Fea 0	717	411	10522	173	16	25	113	33	18	25	Mule Mtns/Mule Creek
955	Fea 0	824	516	10990	192	15	25	116	33	21	29	Mule Mtns/Mule Creek
1113-1	Fea 0	787	464	10805	181	15	26	116	29	26	28	Mule Mtns/Mule Creek
1113-2	Fea 0	757	457	10791	190	14	21	119	32	24	37	Mule Mtns/Mule Creek
1117	Fea 0	811	446	11055	186	18	23	117	32	22	25	Mule Mtns/Mule Creek
Sample	Context/Fea.	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
1119-1	Fea 0	886	472	11063	185	17	25	118	30	24	32	Mule Mtns/Mule Creek
1119-2	Fea 0	703	432	10646	183	18	23	121	35	21	29	Mule Mtns/Mule Creek
1119-3	Fea 0	805	402	12150	247	29	39	117	28	33	37	Antelope Cr/Mule Creek
1421	Fea 0	455	350	11238	228	21	42	110	27	27	37	Antelope Cr/Mule Creek

1425	Fea 0	680	394	11971	250	21	40	115	28	28	37	Antelope Cr/Mule Creek
1442	Fea 0	778	436	10595	179	18	21	113	30	22	29	Mule Mtns/Mule Creek
1450	Fea 0	819	363	11422	229	21	41	110	23	23	33	Antelope Cr/Mule Creek
1480	Fea 0	917	453	11157	179	20	24	119	29	21	32	Mule Mtns/Mule Creek
1519	Fea 0	454	360	11083	221	22	35	116	23	25	27	Antelope Cr/Mule Creek
440-1	Fea 300	721	470	10719	196	15	23	109	31	21	23	Mule Mtns/Mule Creek
440-2	Fea 300	753	479	10557	174	15	27	114	34	25	22	Mule Mtns/Mule Creek
440-3	Fea 300	915	480	11058	195	17	26	117	31	30	30	Mule Mtns/Mule Creek
473-1	Fea 300	543	334	9807	134	14	23	96	23	12	22	Superior
473-2	Fea 300	1071	669	12126	234	21	26	123	31	35	36	Mule Mtns/Mule Creek?
493	Fea 300	623	376	10134	165	16	21	107	28	17	18	Mule Mtns/Mule Creek
496	Fea 300	772	460	10765	189	16	24	115	35	23	25	Mule Mtns/Mule Creek
550	Fea 300	626	399	11770	255	22	47	114	27	30	37	Antelope Cr/Mule Creek
554-1	Fea 300	821	497	11069	192	15	24	120	32	23	24	Mule Mtns/Mule Creek
554-2	Fea 300	1527	478	12851	186	23	25	122	36	31	28	Mule Mtns/Mule Creek
554-3	Fea 300	876	460	10749	186	17	21	109	33	20	26	Mule Mtns/Mule Creek
621-1	Fea 300	584	330	11489	240	19	42	112	28	25	27	Antelope Cr/Mule Creek
628	Fea 300	550	391	11616	249	20	42	106	25	29	31	Antelope Cr/Mule Creek
632	Fea 300	693	390	11694	243	21	40	104	22	28	37	Antelope Cr/Mule Creek
674-1	Fea 300	720	462	10663	190	16	27	118	32	22	26	Mule Mtns/Mule Creek
674-2	Fea 300	667	384	10151	170	15	27	117	36	17	27	Mule Mtns/Mule Creek
674-3	Fea 300	479	122	9736	-1	25	5	94	6	132	13	not obsidian
677-1	Fea 300	541	352	11087	223	19	37	104	21	25	32	Antelope Cr/Mule Creek
677-2	Fea 300	712	446	10588	184	16	26	112	30	19	29	Mule Mtns/Mule Creek
721-1	Fea 300	641	439	10499	178	15	24	114	31	19	27	Mule Mtns/Mule Creek
727-1	Fea 300	653	422	10467	176	19	23	110	36	23	31	Mule Mtns/Mule Creek
727-2	Fea 300	873	474	11071	194	17	27	116	29	24	25	Mule Mtns/Mule Creek
727-3	Fea 300	833	474	10904	195	14	28	121	34	25	30	Mule Mtns/Mule Creek
730	Fea 300	607	393	11932	257	21	47	118	31	30	38	Antelope Cr/Mule Creek
756	Fea 300	635	381	11804	248	21	42	107	24	27	46	Antelope Cr/Mule Creek
790-1	Fea 300	976	473	11332	217	17	23	115	30	22	28	Mule Mtns/Mule Creek
790-2	Fea 300	613	398	10330	169	16	21	108	31	19	30	Mule Mtns/Mule Creek
797-1	Fea 300	620	424	10381	172	16	24	111	29	22	23	Mule Mtns/Mule Creek
797-2	Fea 300	762	459	10820	194	17	25	122	31	24	29	Mule Mtns/Mule Creek
860	Fea 300	689	426	10533	187	16	19	115	26	20	20	Mule Mtns/Mule Creek

883	Fea 300	844	433	10813	180	15	23	113	33	25	30	Mule Mtns/Mule Creek
908	Fea 300	524	339	11143	235	19	39	108	30	24	33	Antelope Cr/Mule Creek
929	Fea 300	927	480	11178	181	16	23	115	31	25	26	Mule Mtns/Mule Creek
937	Fea 300	521	371	11394	238	21	40	110	24	26	33	Antelope Cr/Mule Creek
969	Fea 300	716	343	11541	225	26	37	115	24	25	33	Antelope Cr/Mule Creek
970	Fea 300	608	391	10240	166	15	25	111	31	20	26	Mule Mtns/Mule Creek
426-1	Fea 301	655	371	10211	165	15	22	106	28	18	25	Mule Mtns/Mule Creek
426-2	Fea 301	676	457	10544	179	14	24	113	31	23	27	Mule Mtns/Mule Creek
426-3	Fea 301	838	514	11204	194	16	28	123	34	24	24	Mule Mtns/Mule Creek
Sample	Context/Fea.	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
481	Fea 301	771	451	10645	178	16	23	111	28	23	24	Mule Mtns/Mule Creek
567	Fea 301	732	432	10619	178	14	25	113	31	20	23	Mule Mtns/Mule Creek
577	Fea 301	516	362	11282	236	20	37	108	26	27	36	Antelope Cr/Mule Creek
660-1	Fea 301	610	363	11500	250	22	44	118	28	29	34	Antelope Cr/Mule Creek
660-2	Fea 301	733	446	10656	185	16	25	115	36	20	26	Mule Mtns/Mule Creek
683-1	Fea 301	662	378	11719	243	21	41	111	26	27	40	Antelope Cr/Mule Creek
683-2	Fea 301	612	381	11561	249	20	39	110	27	31	32	Antelope Cr/Mule Creek
683-3	Fea 301	571	382	11793	249	20	40	109	23	33	39	Antelope Cr/Mule Creek
685	Fea 301	833	460	10835	191	16	28	117	30	23	23	Mule Mtns/Mule Creek
688	Fea 301	679	419	12195	272	23	46	119	30	32	38	Antelope Cr/Mule Creek
744	Fea 301	743	430	12284	268	22	44	113	30	34	35	Antelope Cr/Mule Creek
748-1	Fea 301	586	380	11824	255	19	41	118	27	26	32	Antelope Cr/Mule Creek
748-2	Fea 301	571	320	11015	229	20	44	104	27	27	29	Antelope Cr/Mule Creek
748-3	Fea 301	875	405	12311	248	22	48	114	32	32	31	Antelope Cr/Mule Creek
748-4	Fea 301	698	419	10585	178	15	25	110	32	22	33	Mule Mtns/Mule Creek
748-5	Fea 301	509	339	11268	237	18	42	107	24	25	30	Antelope Cr/Mule Creek
748-6	Fea 301	681	435	10655	181	16	24	113	34	19	24	Mule Mtns/Mule Creek
750	Fea 301	492	342	11095	229	22	43	106	26	26	24	Antelope Cr/Mule Creek
793	Fea 301	583	391	11722	250	22	42	113	22	30	38	Antelope Cr/Mule Creek
833	Fea 301	527	363	11369	236	22	40	108	25	28	33	Antelope Cr/Mule Creek
845	Fea 301	513	377	11386	238	23	43	106	25	26	33	Antelope Cr/Mule Creek
973-1	Fea 301	616	365	11612	243	22	40	114	27	29	38	Antelope Cr/Mule Creek
976	Fea 301	648	364	11622	251	21	44	108	29	33	40	Antelope Cr/Mule Creek
637	Fea 302	456	311	10766	212	19	38	105	27	24	29	Antelope Cr/Mule Creek
637-1	Fea 302	1253	436	12032	180	19	25	119	32	20	26	Mule Mtns/Mule Creek

637-2	Fea 302	531	393	11854	248	17	44	111	27	31	34	Antelope Cr/Mule Creek
700-1	Fea 302	752	451	10691	182	16	23	114	31	23	23	Mule Mtns/Mule Creek
700-10	Fea 302	917	561	11461	217	17	26	124	32	27	26	Mule Mtns/Mule Creek
700-11	Fea 302	598	400	10372	170	14	25	110	35	19	25	Mule Mtns/Mule Creek
700-2	Fea 302	629	519	11090	388	11	73	99	110	32	37	N Sawmill Cr/Mule Creek
700-3	Fea 302	873	475	10959	196	18	26	121	32	25	26	Mule Mtns/Mule Creek
700-4	Fea 302	668	422	10438	175	13	27	111	30	18	26	Mule Mtns/Mule Creek
700-5	Fea 302	579	382	11721	251	19	43	113	31	28	29	Antelope Cr/Mule Creek
700-6	Fea 302	587	398	11999	259	22	46	114	29	32	34	Antelope Cr/Mule Creek
700-7	Fea 302	989	456	11257	186	18	26	114	30	24	30	Mule Mtns/Mule Creek
700-8	Fea 302	668	414	10409	174	14	22	109	28	19	28	Mule Mtns/Mule Creek
700-9	Fea 302	691	437	10590	178	13	22	110	27	21	30	Mule Mtns/Mule Creek
703	Fea 302	806	420	10538	142	88	21	79	18	19	14	Cow Canyon/111 Ranch
704	Fea 302	547	351	11526	248	23	41	108	26	33	33	Antelope Cr/Mule Creek
766	Fea 302	727	450	10656	183	16	23	116	30	22	31	Mule Mtns/Mule Creek
772	Fea 302	553	413	11731	254	21	41	112	24	30	36	Antelope Cr/Mule Creek
828	Fea 302	678	418	10541	178	17	26	112	31	23	27	Mule Mtns/Mule Creek
830	Fea 302	625	386	11632	243	23	40	111	26	32	33	Antelope Cr/Mule Creek
868	Fea 302	492	362	11434	247	20	38	108	28	29	35	Antelope Cr/Mule Creek
905	Fea 302	707	362	11731	251	21	44	115	26	26	25	Antelope Cr/Mule Creek
933	Fea 302	572	325	11161	235	22	44	110	25	25	26	Antelope Cr/Mule Creek
957	Fea 303	616	373	11732	255	23	42	115	26	32	40	Antelope Cr/Mule Creek
1006-1	Fea 400	671	437	10740	178	16	25	116	30	25	22	Mule Mtns/Mule Creek
Sample	Context/Fea.	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
1006-2	Fea 400	635	438	10652	183	15	24	114	30	23	34	Mule Mtns/Mule Creek
1034-1	Fea 400	659	400	11758	240	19	43	114	22	33	37	Antelope Cr/Mule Creek
1034-10	Fea 400	839	429	12091	246	25	44	115	19	27	26	Antelope Cr/Mule Creek
1034-11	Fea 400	573	389	11689	244	22	44	114	31	28	37	Antelope Cr/Mule Creek
1034-12	Fea 400	868	393	10318	159	24	22	111	29	21	24	Mule Mtns/Mule Creek
1034-13	Fea 400	692	467	12227	271	22	48	124	30	36	40	Antelope Cr/Mule Creek
1034-14	Fea 400	765	476	10931	192	15	25	131	29	22	24	Mule Mtns/Mule Creek
1034-15	Fea 400	536	289	11167	222	24	44	112	27	30	33	Antelope Cr/Mule Creek
1034-16	Fea 400	695	450	10642	174	19	26	111	34	25	38	Mule Mtns/Mule Creek
1034-17	Fea 400	464	513	10563	397	17	69	107	109	32	49	N Sawmill Cr/Mule Creek
1034-18	Fea 400	644	425	10474	174	15	23	118	26	22	28	Mule Mtns/Mule Creek

1034-19	Fea 400	721	502	10884	184	16	27	119	30	25	29	Mule Mtns/Mule Creek
1034-2	Fea 400	771	475	10766	183	13	25	119	29	21	29	Mule Mtns/Mule Creek
1034-20	Fea 400	756	445	10733	187	18	34	115	31	27	30	Mule Mtns/Mule Creek
1034-21	Fea 400	705	377	11619	235	23	44	106	23	29	36	Antelope Cr/Mule Creek
1034-22	Fea 400	667	420	10534	176	15	30	120	27	20	32	Mule Mtns/Mule Creek
1034-3	Fea 400	716	373	11771	231	23	38	115	25	24	38	Antelope Cr/Mule Creek
1034-4	Fea 400	633	416	10430	169	18	23	119	33	20	24	Mule Mtns/Mule Creek
1034-5	Fea 400	515	569	10732	413	9	73	112	118	31	42	N Sawmill Cr/Mule Creek
1034-6	Fea 400	618	366	11495	239	24	42	111	28	26	27	Antelope Cr/Mule Creek
1034-7	Fea 400	611	458	10621	177	19	23	122	34	26	29	Mule Mtns/Mule Creek
1034-8	Fea 400	755	419	10581	179	19	30	112	29	22	30	Mule Mtns/Mule Creek
1034-9	Fea 400	723	394	11717	242	22	44	116	35	29	40	Antelope Cr/Mule Creek
1038	Fea 400	876	463	10829	182	21	24	122	33	21	27	Mule Mtns/Mule Creek
1044	Fea 400	583	379	11638	245	23	45	116	23	32	49	Antelope Cr/Mule Creek
1045	Fea 400	613	394	11833	258	19	43	117	29	32	32	Antelope Cr/Mule Creek
1046	Fea 400	760	467	10939	189	15	23	119	40	24	23	Mule Mtns/Mule Creek
1047	Fea 400	844	481	11009	189	16	28	121	32	24	32	Mule Mtns/Mule Creek
1123	Fea 400	644	406	11675	245	24	43	111	27	31	32	Antelope Cr/Mule Creek
1131	Fea 400	719	432	10528	173	13	29	118	28	20	26	Mule Mtns/Mule Creek
1132-1	Fea 400	731	481	10789	185	15	24	119	29	25	33	Mule Mtns/Mule Creek
1132-10	Fea 400	619	413	11736	247	26	43	116	30	30	37	Antelope Cr/Mule Creek
1132-11	Fea 400	521	332	11004	216	22	42	103	32	25	34	Antelope Cr/Mule Creek
1132-12	Fea 400	761	494	11080	207	17	28	128	36	23	33	Mule Mtns/Mule Creek
1132-13	Fea 400	685	515	10995	199	17	28	123	35	23	37	Mule Mtns/Mule Creek
1132-14	Fea 400	812	494	10962	185	15	30	125	34	26	30	Mule Mtns/Mule Creek
1132-15	Fea 400	590	407	11813	250	24	47	113	25	30	27	Antelope Cr/Mule Creek
1132-16	Fea 400	604	349	11391	225	25	41	110	22	23	32	Antelope Cr/Mule Creek
1132-17	Fea 400	659	422	10452	174	15	24	114	28	27	27	Mule Mtns/Mule Creek
1132-2	Fea 400	745	370	11817	237	20	43	116	30	30	34	Antelope Cr/Mule Creek
1132-3	Fea 400	688	387	11609	254	23	47	115	25	25	44	Antelope Cr/Mule Creek
1132-4	Fea 400	734	376	11356	235	20	44	108	25	29	32	Antelope Cr/Mule Creek
1132-5	Fea 400	724	433	10552	175	14	23	118	27	23	25	Mule Mtns/Mule Creek
1132-6	Fea 400	821	526	11148	193	16	30	122	29	23	35	Mule Mtns/Mule Creek
1132-7	Fea 400	497	322	10807	205	24	38	103	24	20	34	Antelope Cr/Mule Creek
1132-8	Fea 400	559	381	11530	248	24	42	119	27	30	32	Antelope Cr/Mule Creek

1132-9	Fea 400	730	447	10849	177	16	26	118	32	26	30	Mule Mtns/Mule Creek
1158-1	Fea 400	1639	436	13081	164	28	22	126	32	21	38	Mule Mtns/Mule Creek
Sample	Context/Fea.	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
1158-10	Fea 400	710	437	10720	185	14	27	116	28	23	24	Mule Mtns/Mule Creek
1158-11	Fea 400	716	457	10681	183	17	25	117	30	24	35	Mule Mtns/Mule Creek
1158-12	Fea 400	637	453	10699	182	15	25	123	36	24	37	Mule Mtns/Mule Creek
1158-13	Fea 400	650	378	11384	238	24	41	113	24	32	43	Antelope Cr/Mule Creek
1158-14	Fea 400	798	499	10972	191	14	28	116	31	24	31	Mule Mtns/Mule Creek
1158-15	Fea 400	531	370	11331	225	23	43	111	30	26	31	Antelope Cr/Mule Creek
1158-16	Fea 400	596	404	10516	172	16	21	120	30	20	27	Mule Mtns/Mule Creek
1158-17	Fea 400	685	424	10538	176	16	28	116	34	20	20	Mule Mtns/Mule Creek
1158-2	Fea 400	826	434	10849	180	19	27	118	34	22	32	Mule Mtns/Mule Creek
1158-3	Fea 400	554	403	11873	257	26	41	122	19	27	28	Antelope Cr/Mule Creek
1158-4	Fea 400	794	459	10827	186	20	22	117	26	27	34	Mule Mtns/Mule Creek
1158-5	Fea 400	832	483	11156	194	15	26	121	33	27	35	Mule Mtns/Mule Creek
1158-6	Fea 400	667	300	10708	203	20	35	103	21	22	29	Antelope Cr/Mule Creek
1158-7	Fea 400	606	389	11699	246	23	42	110	26	25	25	Antelope Cr/Mule Creek
1158-8	Fea 400	535	546	11039	421	15	73	109	118	35	46	N Sawmill Cr/Mule Creek
1158-9	Fea 400	820	456	10842	186	17	28	120	33	24	32	Mule Mtns/Mule Creek
1165	Fea 400	602	426	11631	247	24	42	112	26	30	31	Antelope Cr/Mule Creek
1167	Fea 400	659	396	11865	263	22	36	117	33	30	41	Antelope Cr/Mule Creek
1168	Fea 400	601	397	11644	255	19	41	118	28	28	37	Antelope Cr/Mule Creek
1173-1	Fea 400	579	361	11412	235	24	42	107	30	26	43	Antelope Cr/Mule Creek
1173-2	Fea 400	711	424	10528	173	15	21	111	30	22	31	Mule Mtns/Mule Creek
1173-3	Fea 400	744	372	11683	241	22	45	109	26	34	29	Antelope Cr/Mule Creek
1173-4	Fea 400	680	362	11476	231	25	37	116	22	29	36	Antelope Cr/Mule Creek
1173-5	Fea 400	697	450	10614	178	14	24	120	30	20	27	Mule Mtns/Mule Creek
1200-1	Fea 400	971	520	11302	204	19	18	128	31	28	37	Mule Mtns/Mule Creek
1200-2	Fea 400	537	412	11799	246	23	39	119	26	32	39	Antelope Cr/Mule Creek
1200-3	Fea 400	727	426	10613	168	18	24	120	28	21	24	Mule Mtns/Mule Creek
1200-4	Fea 400	639	409	12063	258	24	51	121	28	32	38	Antelope Cr/Mule Creek
1200-5	Fea 400	470	362	11439	237	23	40	111	30	23	23	Antelope Cr/Mule Creek
1200-6	Fea 400	613	430	10633	179	16	24	116	35	20	35	Mule Mtns/Mule Creek
1200-7	Fea 400	713	459	10679	188	18	28	128	30	24	32	Mule Mtns/Mule Creek
1200-8	Fea 400	528	354	11228	227	21	42	111	31	28	32	Antelope Cr/Mule Creek

1246-1	Fea 400	757	461	10768	186	15	26	134	34	22	34	Mule Mtns/Mule Creek
1246-2	Fea 400	3256	499	17172	230	100	82	294	26	14	29	tephri-phonolite
1246-3	Fea 400	776	455	10625	179	17	29	117	35	21	31	Mule Mtns/Mule Creek
1246-4	Fea 400	537	401	11719	249	22	44	117	28	23	40	Antelope Cr/Mule Creek
1246-5	Fea 400	792	457	12353	271	19	47	125	30	32	38	Antelope Cr/Mule Creek
1252	Fea 400	650	376	10295	168	15	25	117	32	19	34	Mule Mtns/Mule Creek
1307	Fea 400	836	502	11118	196	13	22	118	30	29	31	Mule Mtns/Mule Creek
1314	Fea 400	816	488	11027	216	18	28	115	33	21	35	Mule Mtns/Mule Creek
1353	Fea 400	531	398	11638	237	28	44	119	23	26	36	Antelope Cr/Mule Creek
1373-1	Fea 400	1354	454	12138	185	18	25	118	35	24	33	Mule Mtns/Mule Creek
1373-2	Fea 400	654	375	11807	243	23	36	115	28	32	34	Antelope Cr/Mule Creek
1384	Fea 400	634	404	11889	259	26	48	115	29	31	33	Antelope Cr/Mule Creek
1521-1	Fea 400	733	454	10794	183	18	25	118	31	26	31	Mule Mtns/Mule Creek
1521-2	Fea 400	719	456	10602	177	15	24	120	33	23	29	Mule Mtns/Mule Creek
1521-3	Fea 400	460	405	11671	245	24	40	110	25	27	37	Antelope Cr/Mule Creek
1072	Fea 401	756	468	10937	202	15	27	122	35	23	29	Mule Mtns/Mule Creek
Sample	Context/Fea.	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
1140	Fea 401	699	444	10588	178	19	26	120	36	21	28	Mule Mtns/Mule Creek
1141	Fea 401	577	403	11838	257	20	43	124	28	31	45	Antelope Cr/Mule Creek
1303	Fea 401	742	498	10766	187	18	23	122	39	23	29	Mule Mtns/Mule Creek
1001-1	Fea 401	727	451	10786	181	16	26	120	35	22	33	Mule Mtns/Mule Creek
1001-2	Fea 401	730	436	10684	174	16	21	120	32	16	28	Mule Mtns/Mule Creek
1001-3	Fea 401	738	460	10884	183	16	25	124	31	26	33	Mule Mtns/Mule Creek
1001-4	Fea 401	847	441	10949	185	20	28	116	32	25	39	Mule Mtns/Mule Creek
1001-5	Fea 401	717	444	10613	177	16	25	117	34	22	28	Mule Mtns/Mule Creek
1022-1	Fea 401	624	353	11368	235	16	43	112	23	31	38	Antelope Cr/Mule Creek
1022-2	Fea 401	660	382	10275	168	18	24	109	26	16	28	Mule Mtns/Mule Creek
1137-1	Fea 401	985	661	12121	228	20	28	138	38	29	27	Mule Mtns/Mule Creek
1137-2	Fea 401	896	442	11343	184	18	25	123	34	21	31	Mule Mtns/Mule Creek
1137-3	Fea 401	623	379	11588	251	21	46	115	27	27	31	Antelope Cr/Mule Creek
1137-4	Fea 401	751	434	10495	172	14	24	112	35	17	32	Mule Mtns/Mule Creek
1137-5	Fea 401	725	459	10587	174	19	22	120	32	17	27	Mule Mtns/Mule Creek
1137-6	Fea 401	896	431	10669	182	17	27	113	35	22	30	Mule Mtns/Mule Creek
1137-7	Fea 401	951	535	11194	198	19	23	123	34	22	30	Mule Mtns/Mule Creek
1137-8	Fea 401	535	393	11627	247	21	42	115	30	28	33	Antelope Cr/Mule Creek

1214-1	Fea 401	621	403	11727	253	21	40	117	29	32	34	Antelope Cr/Mule Creek
1214-2	Fea 401	696	441	10673	185	16	29	120	33	21	35	Mule Mtns/Mule Creek
1214-3	Fea 401	634	377	11235	240	24	45	119	25	25	40	Antelope Cr/Mule Creek
1214-4	Fea 401	739	429	10629	182	15	24	112	36	22	31	Mule Mtns/Mule Creek
1214-5	Fea 401	728	411	10466	172	12	24	116	25	18	22	Mule Mtns/Mule Creek
1214-6	Fea 401	889	542	11259	207	18	22	126	28	28	30	Mule Mtns/Mule Creek
1259-1	Fea 401	835	477	10901	190	20	27	122	39	25	41	Mule Mtns/Mule Creek
1259-2	Fea 401	722	455	10760	183	18	28	127	29	25	34	Mule Mtns/Mule Creek
1090-1	Fea 402	613	361	11420	238	22	42	116	31	29	26	Antelope Cr/Mule Creek
1090-2	Fea 402	759	454	10794	188	17	29	120	32	24	36	Mule Mtns/Mule Creek
1090-3	Fea 402	647	337	11062	224	23	39	114	23	18	33	Antelope Cr/Mule Creek
1121-1	Fea 402	769	455	10646	180	15	28	122	31	22	26	Mule Mtns/Mule Creek
1121-2	Fea 402	618	402	11498	227	27	37	112	26	29	27	Antelope Cr/Mule Creek
1149	Fea 402	706	385	11786	246	23	41	111	27	32	41	Antelope Cr/Mule Creek
1150	Fea 402	668	412	11791	245	23	43	117	25	29	36	Antelope Cr/Mule Creek
1153	Fea 402	792	494	11002	184	14	26	124	29	21	18	Mule Mtns/Mule Creek
1179	Fea 402	704	385	11855	254	24	43	118	26	32	50	Antelope Cr/Mule Creek
1186-1	Fea 402	592	374	10236	156	15	24	102	30	19	34	Mule Mtns/Mule Creek
1186-10	Fea 402	630	414	11598	239	20	40	112	32	32	39	Antelope Cr/Mule Creek
1186-11	Fea 402	724	427	10507	171	16	29	119	31	16	27	Mule Mtns/Mule Creek
1186-12	Fea 402	686	474	10703	177	18	27	121	32	25	37	Mule Mtns/Mule Creek
1186-13	Fea 402	1222	388	12423	245	26	43	117	30	31	35	Antelope Cr/Mule Creek
1186-14	Fea 402	828	389	11915	235	22	40	120	30	25	35	Antelope Cr/Mule Creek
1186-15	Fea 402	622	428	10456	172	16	24	114	31	18	37	Mule Mtns/Mule Creek
1186-2	Fea 402	632	590	10911	410	14	81	113	124	33	48	N Sawmill Cr/Mule Creek
1186-2	Fea 402	648	406	11689	246	25	37	117	25	28	36	Antelope Cr/Mule Creek
1186-3	Fea 402	715	398	11775	245	24	47	117	27	28	31	Antelope Cr/Mule Creek
1186-4	Fea 402	710	454	12308	266	25	50	125	29	32	47	Antelope Cr/Mule Creek
1186-5	Fea 402	663	394	11572	241	22	43	118	31	30	40	Antelope Cr/Mule Creek
1186-6	Fea 402	740	449	10759	183	16	24	115	22	21	24	Mule Mtns/Mule Creek
Sample	Context/Fea.	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
1186-7	Fea 402	670	437	10695	182	17	28	117	29	26	30	Mule Mtns/Mule Creek
1186-8	Fea 402	986	455	11245	227	25	32	149	22	30	39	Gwynn/Ewe Canyon
1186-9	Fea 402	779	390	11948	244	23	40	112	23	32	26	Antelope Cr/Mule Creek
1231-1	Fea 402	550	401	11430	235	20	37	112	31	22	40	Antelope Cr/Mule Creek

1231-2	Fea 402	638	440	10477	170	17	23	117	34	21	33	Mule Mtns/Mule Creek
1231-3	Fea 402	504	368	11430	245	24	40	113	29	29	42	Antelope Cr/Mule Creek
1231-4	Fea 402	658	411	11927	261	25	46	114	27	32	37	Antelope Cr/Mule Creek
1296-1	Fea 402	789	388	11785	250	26	43	117	20	30	37	Antelope Cr/Mule Creek
1296-2	Fea 402	770	487	10819	186	15	27	116	32	20	26	Mule Mtns/Mule Creek
1296-3	Fea 402	562	392	11533	237	23	38	115	26	23	39	Antelope Cr/Mule Creek
1296-4	Fea 402	1001	527	11029	189	18	25	112	30	28	22	Mule Mtns/Mule Creek
1296-5	Fea 402	866	484	10906	194	17	26	125	30	25	33	Mule Mtns/Mule Creek
1296-6	Fea 402	512	363	11190	228	19	41	115	23	30	39	Antelope Cr/Mule Creek
1296-7	Fea 402	655	412	10559	175	17	25	115	30	20	16	Mule Mtns/Mule Creek
1296-8	Fea 402	601	383	11575	246	24	43	113	26	27	34	Antelope Cr/Mule Creek
1298	Fea 402	625	403	11602	248	22	42	122	26	28	37	Antelope Cr/Mule Creek
1318	Fea 402	583	366	11499	231	18	45	109	23	31	37	Antelope Cr/Mule Creek
1320-1	Fea 402	825	458	10733	174	19	25	113	41	24	37	Mule Mtns/Mule Creek
1320-2	Fea 402	517	360	11496	243	23	44	113	23	29	40	Antelope Cr/Mule Creek
1330	Fea 402	699	394	11708	251	20	40	115	21	30	31	Antelope Cr/Mule Creek
1345-1	Fea 402	724	413	11892	245	19	41	113	22	33	40	Antelope Cr/Mule Creek
1345-10	Fea 402	555	360	11432	248	20	45	116	35	28	39	Antelope Cr/Mule Creek
1345-11	Fea 402	592	400	11493	244	21	39	114	27	28	36	Antelope Cr/Mule Creek
1345-2	Fea 402	611	400	11840	247	27	42	120	33	31	41	Antelope Cr/Mule Creek
1345-3	Fea 402	609	399	11720	245	23	45	117	27	30	34	Antelope Cr/Mule Creek
1345-4	Fea 402	610	355	11533	237	23	41	111	26	25	32	Antelope Cr/Mule Creek
1345-5	Fea 402	557	381	11736	248	20	42	115	29	26	27	Antelope Cr/Mule Creek
1345-6	Fea 402	598	362	11539	244	20	41	115	31	30	41	Antelope Cr/Mule Creek
1345-7	Fea 402	537	543	10923	427	15	80	110	125	34	47	N Sawmill Cr/Mule Creek
1345-8	Fea 402	510	348	11265	220	25	39	108	28	26	36	Antelope Cr/Mule Creek
1345-9	Fea 402	674	429	10758	176	16	27	119	31	23	32	Mule Mtns/Mule Creek
1347-1	Fea 402	540	363	11535	230	25	38	105	27	28	28	Antelope Cr/Mule Creek
1347-2	Fea 402	786	436	10716	189	15	30	121	34	24	27	Mule Mtns/Mule Creek
1386-1	Fea 402	895	411	12120	253	24	43	116	28	29	38	Antelope Cr/Mule Creek
1386-2	Fea 402	672	409	11833	258	27	45	121	26	29	32	Antelope Cr/Mule Creek
1406	Fea 402	621	373	11610	256	20	43	116	25	29	47	Antelope Cr/Mule Creek
1416	Fea 402	759	474	10857	185	20	26	117	26	16	27	Mule Mtns/Mule Creek
1429	Fea 402	697	377	11508	236	24	42	115	30	26	41	Antelope Cr/Mule Creek
1437	Fea 402	568	602	11163	428	10	74	119	113	41	30	N Sawmill Cr/Mule Creek

1474-1	Fea 402	695	393	11687	257	20	41	122	24	29	38	Antelope Cr/Mule Creek
1474-2	Fea 402	554	396	11573	242	18	41	113	24	29	36	Antelope Cr/Mule Creek
1509	Fea 402	687	447	10728	181	16	24	115	33	16	28	Mule Mtns/Mule Creek
1513	Fea 402	582	397	11676	234	22	37	117	25	26	40	Antelope Cr/Mule Creek
104	MCAP13	670	411	10398	171	14	24	110	30	23	27	Mule Mtns/Mule Creek
141	MCAP13	610	374	11778	251	23	45	110	29	30	41	Antelope Cr/Mule Creek
168	MCAP13	645	414	10370	170	13	27	115	35	21	28	Mule Mtns/Mule Creek
175	MCAP13	572	361	11474	240	19	41	108	28	27	35	Antelope Cr/Mule Creek
179	MCAP13	543	377	11679	244	19	40	114	24	29	30	Antelope Cr/Mule Creek
Sample	Context/Fea.	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
195	MCAP13	816	465	12625	272	23	42	117	32	33	40	Antelope Cr/Mule Creek
208	MCAP13	1004	470	11081	184	15	29	112	31	24	23	Mule Mtns/Mule Creek
213	MCAP13	679	432	10552	185	16	25	115	27	23	25	Mule Mtns/Mule Creek
214	MCAP13	573	396	11615	244	22	41	109	25	27	40	Antelope Cr/Mule Creek
214-2	MCAP13	892	447	12717	270	21	42	122	24	33	38	Antelope Cr/Mule Creek
22	MCAP13	645	453	10704	183	16	21	118	31	25	24	Mule Mtns/Mule Creek
221-1	MCAP13	560	393	11708	252	21	41	113	30	31	38	Antelope Cr/Mule Creek
221-2	MCAP13	662	405	10597	179	15	27	112	26	20	28	Mule Mtns/Mule Creek
233	MCAP13	1017	485	11475	194	16	24	115	31	22	26	Mule Mtns/Mule Creek
237	MCAP13	514	336	11227	233	21	39	110	27	29	30	Antelope Cr/Mule Creek
247	MCAP13	522	359	11675	246	21	44	110	25	31	35	Antelope Cr/Mule Creek
253	MCAP13	773	532	11272	204	15	26	121	33	22	34	Mule Mtns/Mule Creek
260	MCAP13	841	488	10915	194	15	27	113	31	26	24	Mule Mtns/Mule Creek
27	MCAP13	604	373	11651	251	20	45	115	28	30	34	Antelope Cr/Mule Creek
275-1	MCAP13	543	343	11527	241	24	47	111	29	32	35	Antelope Cr/Mule Creek
275-2	MCAP13	648	379	11659	248	21	43	110	28	29	38	Antelope Cr/Mule Creek
288	MCAP13	738	362	11426	229	21	42	106	26	30	34	Antelope Cr/Mule Creek
297-1	MCAP13	613	396	12039	257	22	44	113	28	32	43	Antelope Cr/Mule Creek
297-2	MCAP13	854	450	10875	183	14	28	118	29	24	25	Mule Mtns/Mule Creek
330	MCAP13	589	333	11406	232	23	42	109	25	26	30	Antelope Cr/Mule Creek
332	MCAP13	577	333	11178	227	20	40	108	27	27	34	Antelope Cr/Mule Creek
344-1	MCAP13	557	362	11404	236	19	37	108	28	28	30	Antelope Cr/Mule Creek
344-2	MCAP13	659	397	12089	261	23	46	120	29	31	39	Antelope Cr/Mule Creek
344-3	MCAP13	633	463	10585	183	16	21	114	32	19	27	Mule Mtns/Mule Creek
344-4	MCAP13	775	455	10782	179	15	26	113	31	21	22	Mule Mtns/Mule Creek

355	MCAP13	483	307	10879	217	19	39	103	24	22	33	Antelope Cr/Mule Creek
366-1	MCAP13	677	353	11534	238	21	39	113	28	26	35	Antelope Cr/Mule Creek
366-2	MCAP13	849	459	11247	194	17	25	118	33	29	32	Mule Mtns/Mule Creek
366-3	MCAP13	651	387	10505	166	17	24	111	33	18	31	Mule Mtns/Mule Creek
372-1	MCAP13	510	345	11511	248	21	44	110	25	30	34	Antelope Cr/Mule Creek
372-2	MCAP13	883	454	10967	187	17	20	118	35	25	31	Mule Mtns/Mule Creek
382	MCAP13	563	377	11694	248	23	42	110	27	31	30	Antelope Cr/Mule Creek
388	MCAP13	579	336	11367	232	20	44	109	27	26	31	Antelope Cr/Mule Creek
50	MCAP13	712	458	10740	186	14	29	120	36	23	27	Mule Mtns/Mule Creek
52-1	MCAP13	1050	366	12281	224	24	40	112	26	27	30	Antelope Cr/Mule Creek
52-2	MCAP13	1840	411	13053	217	74	30	141	24	22	28	unknown
52-3	MCAP13	903	449	10482	147	89	20	83	14	20	17	Cow Canyon/111 Ranch
52-4	MCAP13	817	443	10802	182	16	26	112	33	20	31	Mule Mtns/Mule Creek
64	MCAP13	763	457	10737	183	15	24	115	32	23	31	Mule Mtns/Mule Creek
66	MCAP13	696	473	10643	182	15	24	116	30	20	27	Mule Mtns/Mule Creek
82	MCAP13	789	412	10488	165	16	24	109	33	17	27	Mule Mtns/Mule Creek
86	MCAP13	699	411	10578	177	16	21	113	29	18	24	Mule Mtns/Mule Creek
89	MCAP13	1392	473	14061	241	27	41	113	28	32	31	Antelope Cr/Mule Creek
91-1	MCAP13	538	341	11445	233	23	43	107	28	27	35	Antelope Cr/Mule Creek
91-2	MCAP13	491	327	10837	212	20	38	105	25	21	30	Antelope Cr/Mule Creek
91-3	MCAP13	717	462	10682	185	16	23	114	28	21	23	Mule Mtns/Mule Creek
91-4	MCAP13	556	354	11511	237	23	40	106	28	27	28	Antelope Cr/Mule Creek

Table 2. Crosstabulation of source by locality site provenience. Non-obsidian samples not included.

			Context/Fea.									
			Fea 0	Fea 300	Fea 301	Fea 302	Fea 303	Fea 400	Fea 401	Fea 402	MCAP13	Total
Source	Antelope Cr/Mule Creek	Count	17	10	17	10	1	42	6	42	28	173
		% within Source	9.8%	5.8%	9.8%	5.8%	0.6%	24.3%	3.5%	24.3%	16.2%	100.0%
		% within Context/Fea.	50.0%	28.6%	65.4%	43.5%	100.0%	44.2%	22.2%	64.6%	53.8%	48.3%
		% of Total	4.7%	2.8%	4.7%	2.8%	0.3%	11.7%	1.7%	11.7%	7.8%	48.3%
	Mule Mtns/Mule Creek	Count	17	24	9	11	0	50	21	19	22	173
		% within Source	9.8%	13.9%	5.2%	6.4%	0.0%	28.9%	12.1%	11.0%	12.7%	100.0%
		% within Context/Fea.	50.0%	68.6%	34.6%	47.8%	0.0%	52.6%	77.8%	29.2%	42.3%	48.3%
		% of Total	4.7%	6.7%	2.5%	3.1%	0.0%	14.0%	5.9%	5.3%	6.1%	48.3%
	N Sawmill Cr/Mule Creek	Count	0	0	0	1	0	3	0	3	0	7
		% within Source	0.0%	0.0%	0.0%	14.3%	0.0%	42.9%	0.0%	42.9%	0.0%	100.0%
		% within Context/Fea.	0.0%	0.0%	0.0%	4.3%	0.0%	3.2%	0.0%	4.6%	0.0%	2.0%
		% of Total	0.0%	0.0%	0.0%	0.3%	0.0%	0.8%	0.0%	0.8%	0.0%	2.0%
	Cow Canyon/111 Ranch	Count	0	0	0	1	0	0	0	0	1	2
		% within Source	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%	50.0%	100.0%
		% within Context/Fea.	0.0%	0.0%	0.0%	4.3%	0.0%	0.0%	0.0%	0.0%	1.9%	0.6%
		% of Total	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.3%	0.6%
	Gwynn/Ewe Canyon	Count	0	0	0	0	0	0	0	1	0	1
		% within Source	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	100.0%
		% within Context/Fea.	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.5%	0.0%	0.3%
		% of Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.3%
	Superior	Count	0	1	0	0	0	0	0	0	0	1
		% within Source	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
		% within Context/Fea.	0.0%	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
		% of Total	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
	unknown	Count	0	0	0	0	0	0	0	0	1	1
		% within Source	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
		% within Context/Fea.	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.9%	0.3%
		% of Total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%
Total		Count	34	35	26	23	1	95	27	65	52	358
		% within Source	9.5%	9.8%	7.3%	6.4%	0.3%	26.5%	7.5%	18.2%	14.5%	100.0%
		% within Context/Fea.	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	9.5%	9.8%	7.3%	6.4%	0.3%	26.5%	7.5%	18.2%	14.5%	100.0%

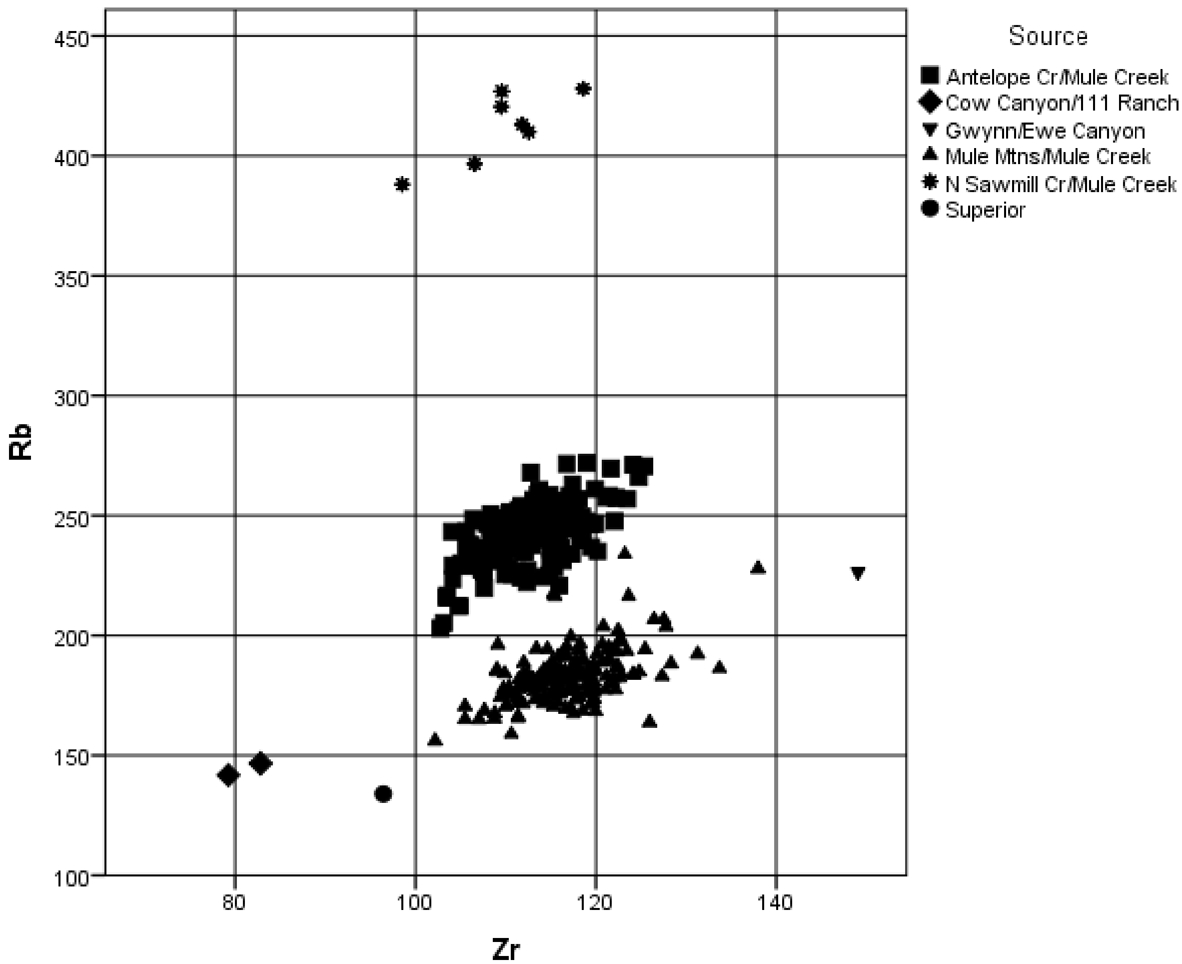

Figure 1. Zr versus Rb bivariate plot of all artifacts. Following plot aids in discrimination between the Mogollon-Datil Volcanic Province localities Antelope Creek, Mule Mountains, and Gwynn/Ewe Canyon.

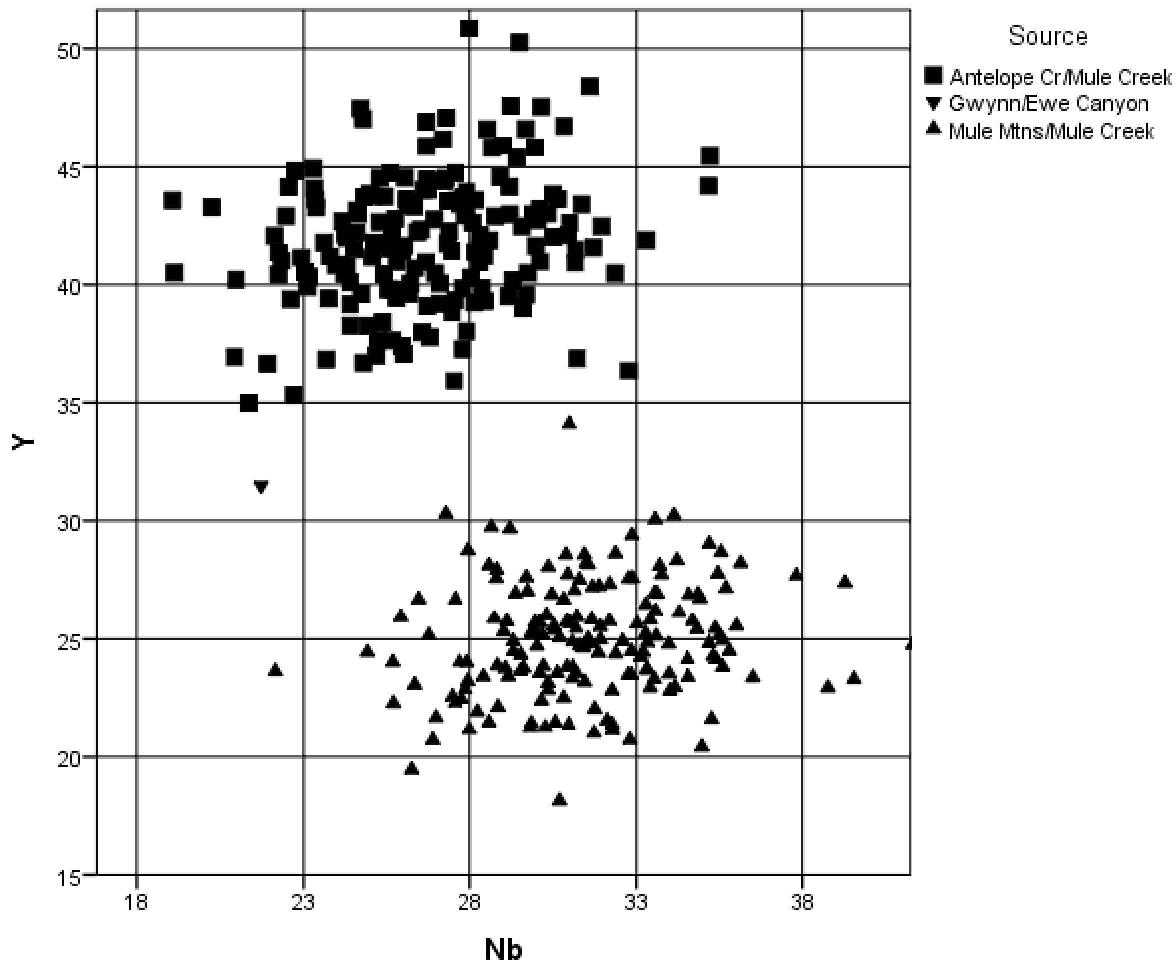

Figure 2. Nb versus Y bivariate plot of the Mule Creek locality artifacts providing greater discrimination. Gwynn/Ewe Canyon is discriminated better in Figure 1 above. Some of this variability (i.e. lower concentrations) is due to smaller samples and/or sediment matrix on the samples (see Davis et al. 2011; Shackley 2005, 2011).

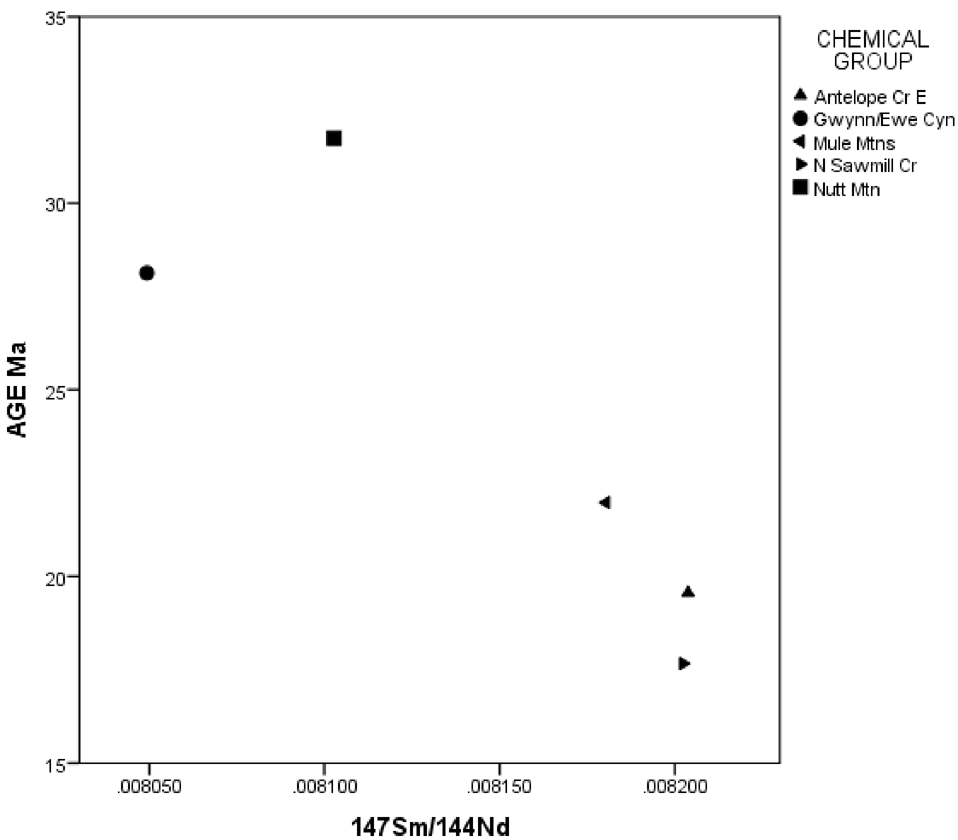

Figure 3. $^{40}Ar/^{39}Ar$ dates versus Nd and Sm isotopes plot of Mogollon-Datil Volcanic Province obsidian showing range of chronological and isotopic variability (adapted from Shackley et al. 2016). Note chronological and isotopic similarity of Mule Creek sources that can be discriminated on elemental concentrations. The event chronology from south to north is evident here from the Nutt Mountain in the south, through the Bursum event (Gwynn/Ewe Canyon) and on back to the Mule Creek event.

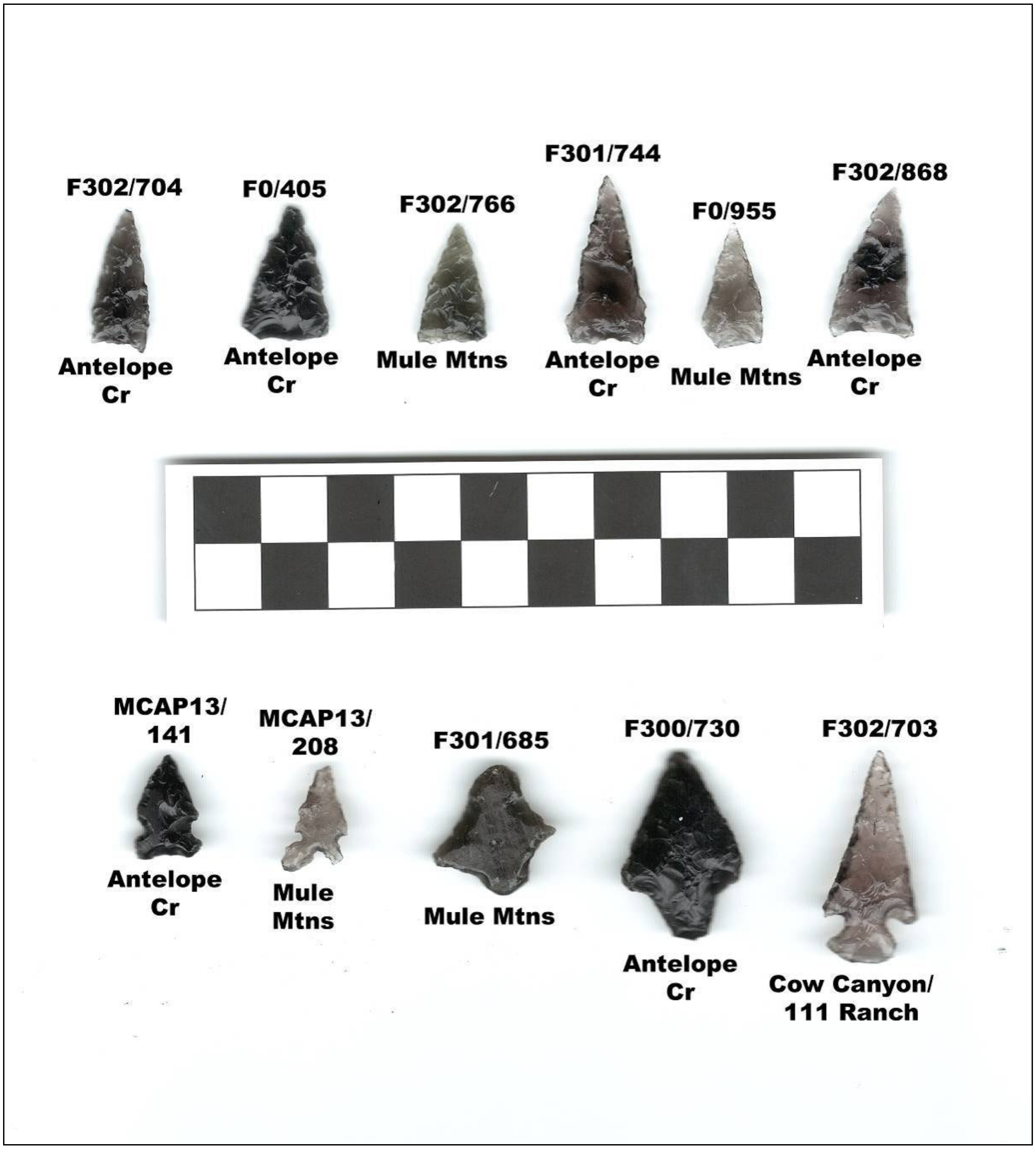

Figure 4. Selected projectile points and source assignments from the Dinwiddie site.