GEOARCHAEOLOGICAL XRF LAB

GEOARCHAEOLOGICAL X-RAY FLUORESCENCE SPECTROMETRY LABORATORY
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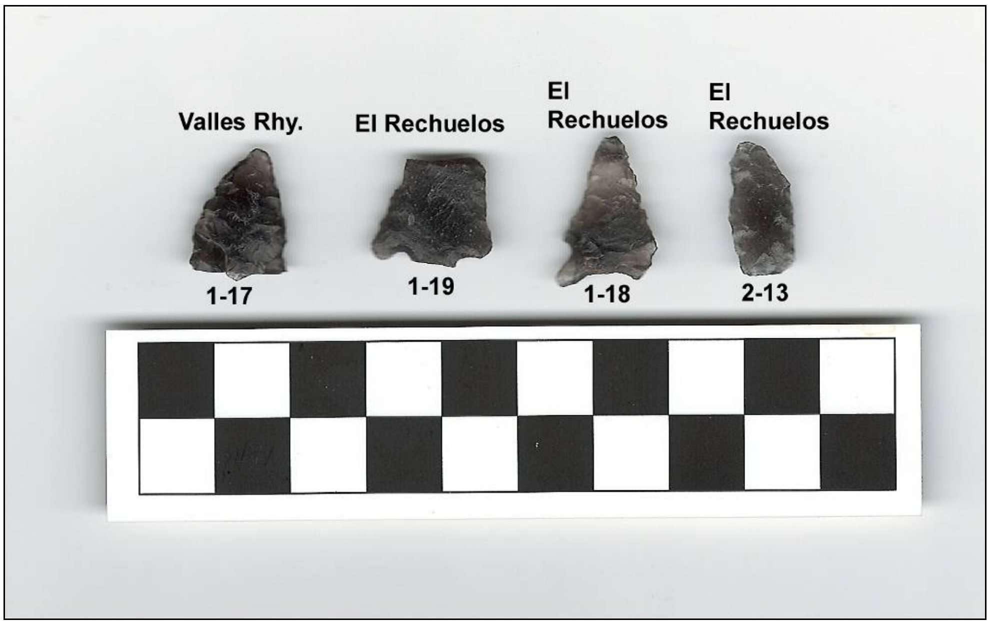
SOURCE PROVENANCE OF OBSIDIAN AND DACITE ARTIFACTS FROM THE PROTOHISTORIC APACHE PUNCHE LAKE TEPEE SITE (LA 64805) TAOS PLATEAU, NORTHERN NEW MEXICO



Projectile points and fragments from two areas at Punche Lake, northern New Mexico

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INTRODUCTION

The analysis here of obsidian and dacite artifacts from the Protohistoric Apache site at Punche Lake in northern New Mexico indicates procurement from obsidian sources in the Jemez Mountains to the south, and obsidian and dacite sources in the Taos Plateau Volcanic Field, the latter essentially local sources for the Punche Lake Apache.

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 at the University of California, Berkeley. 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 2010; 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 was analyzed during the analysis of the obsidian artifacts, and AGV-1 a USGS andesite standard during the analysis of the dacite samples to check machine calibration (Tables 1 and 2).

Source assignments were made by reference to the laboratory data base (see Shackley 1995, 2005, 2011). Further information on the laboratory instrumentation can be found at: http://www.swxrflab.net/. Trace element data exhibited in Tables 1 and 2 are reported in parts per million (ppm), a quantitative measure by weight (see also Figures 1 and 2).

DISCUSSION

The Jemez Sources of Archaeological Obsidian

Taken together, the pre-caldera and caldera sources of archaeological obsidian in the Jemez Mountains of northern New Mexico (approximately 120 km SW of this site) are volumetrically the largest sources in the Southwest (Shackley 2005). El Rechuelos obsidian derived from a rhyolite dome complex along Cañada del Ojitos north of the Valles Caldera is a pre-caldera event dated to about 2.09 mya (Kempter et al. 2007). El Rechuelos obsidian erodes into the Chama River and then into the Rio Grande, the Chama River could be the source for the raw material used for these artifacts (Shackley 2005, 2013a).

Cerro del Medio a resurgent dome from the Valles Rhyolite caldera collapse is dated to about 1.23 mya and is volumetrically the largest single archaeological obsidian source in the Southwest (Gardner et al. 2007; Phillips 2004; Shackley 2005). This eruptive event was relatively quiet compared to the previous Cerro Toledo eruption that carried ash well to the southeast of the caldera and created the Bandelier Tuff and high quality obsidian. Unlike Cerro

Toledo Rhyolite obsidian, Valles Rhyolite has not eroded outside the caldera in any quantity, and so had to be originally procured from Cerro del Medio proper (Shackley 2005, 2013). Given this, it is also possible that the artifacts produced from El Rechuelos were procured from the primary domes north of the caldera (see Figure 3).

Taos Plateau Volcanic Field Obsidian and Dacite Sources

Initially defined by Lipman and Mehnert in 1979, the Taos Plateau Volcanic Field is a 30 X 50 km cluster of over 35 central vent basalt, andesite and dacite volcanic shields and rhyolite dome complexes, most erupted between 4.5 and 2.0 Ma (1979, 289; Shackley 2011, see Figure 3 here). Tholietic shields occur in the center with dacite volcanoes like San Antonio Mountain and the Newman Dome on the edges, and rhyolite centers in the central part of the field like No Agua Peaks a high silica perlite and obsidian source (Glascock et al. 1999; Newman and Nielsen 1987; Shackley 2005; Figure 3 here).

San Antonio Mountain, the source of all the dacite for these artifacts is a late Pliocene dacite shield that dominates the western Taos Plateau, and would have been a prominent feature seen by the Apache at Punche Lake (Eppler 1976; Lipman and Mehnert 1979; Figure 3). Somewhat relevant here is the comment by Bryan and Butler in 1940 that: "Artifacts made from this rock may be confused with those made from the hypersthene andesite unless care is used in identifying the rock" (Bryan and Butler 1940). This is not an issue anymore with 21st century analytical chemistry. The dacite is present in very large nodules and the production of bifaces and Paleoindian and Early Archaic projectile points was frequent, as well as the other major dacite source in the field, Newman Dome (Shackley 2013b; Vierra et al. 2012).

The No Agua Peaks obsidian produces a generally vitrophyric glass that is not well suited for biface production as evident in this assemblage. The No Agua Peaks dome complex exhibits two chemical groups, one to the west seen here, and one to the eastern area (Shackley 2005).

The western chemical group appears to be more common archaeologically. It is generally only seen in sites on the Taos Plateau, and seemingly was only used for utilized cutting and scraping tools (Shackley 2005). Again, the San Antonio Mountain and No Agua Peaks sources are well within the foraging radius of the Apache at Punche Lake and it appears that they made use of these sources regularly.

Prehistoric Procurement

With respect to media for tool production, El Rechuelos and Valles Rhyolite can be considered equal. While Valles Rhyolite is available in larger nodule sizes and quantities, much of it contains spherulites, while the El Rechuelos glass generally does not (Shackley 2005). Both sources have been used throughout prehistory from Clovis periods onward, and Valles Rhyolite has been recovered from archaeological contexts continent wide (Hamilton et al. 2013; Steffen and LeTourneau personal communication). Parenthetically, I personally find El Rechuelos obsidian a better media for projectile point production than Valles Rhyolite, but I'm obviously not an Apache knapper.

Early Athabaskan archaeological contexts that have been analyzed on the Taos Plateau are rare. This assemblage indicates relatively high mobility in northern New Mexico, from the local Taos Plateau to the Jemez Mountains area over 100 km to the south, precisely what would be expected of hunter-gatherers during this time period.

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

Area/Sample	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Pb	Th	Source
1-5	555	363	10052	31	151	14	24	70	47	25	21	El Rechuelos
1-7	562	822	10209	92	293	11	55	80	89	42	32	No Agua West
1-16	717	405	12242	96	162	12	46	163	55	28	15	Valles Rhyolite
1-17	693	373	11792	74	155	13	42	159	54	23	23	Valles Rhyolite
1-18	819	404	10694	62	147	10	21	66	46	24	22	El Rechuelos
1-19	740	406	10382	54	151	13	20	69	44	24	17	El Rechuelos
1-21	715	364	10093	32	147	13	24	69	45	25	19	El Rechuelos
2-8	531	874	10370	109	302	11	54	86	88	44	23	No Agua West
2-9	651	387	10129	43	148	11	22	70	46	22	15	El Rechuelos
2-12	503	370	9940	51	148	12	23	69	45	21	14	El Rechuelos
2-13	665	392	10205	69	159	13	21	65	43	25	26	El Rechuelos
2-14	414	684	9808	66	261	9	49	77	84	35	27	No Agua West
RGM1-S4	1588	282	13331	39	147	108	22	212	10	23	14	standard

Table 2. Elemental concentrations and source assignments for the dacite archaeological specimens and USGS AGV-1 andesite standard. All measurements in parts per million (ppm).

Area/Sample	Ti	Mn	Fe	Zn	Rb	Sr	Y	Zr	Nb	Ba	Pb	Th	Source
1-1	3846	564	32741	83	59	568	23	250	15	1691	12	6	San Antonio Mtn
1-2	4485	626	37077	95	67	620	24	254	21	1685	14	3	San Antonio Mtn
1-3	3211	477	27471	91	54	528	19	233	16	1764	5	3	San Antonio Mtn
1-4	4087	563	32772	86	60	566	24	238	19	1498	13	6	San Antonio Mtn
1-6	3728	502	30093	77	59	556	24	237	15	1399	10	3	San Antonio Mtn
1-20	3930	590	33544	92	59	585	23	257	17	1679	14	6	San Antonio Mtn
2-10	403	606	3521	90	63	607	23	259	16	176	14	3	San Antonio Mtn

	8		4							7			
2-11	3712	507	29536	78	58	561	23	243	17	1421	10	5	San Antonio Mtn
2-15	3664	560	32532	86	58	585	23	245	16	1644	13	3	San Antonio Mtn
AGV-1	5577	703	42647	94	65	646	17	219	14	1020	28	3	standard

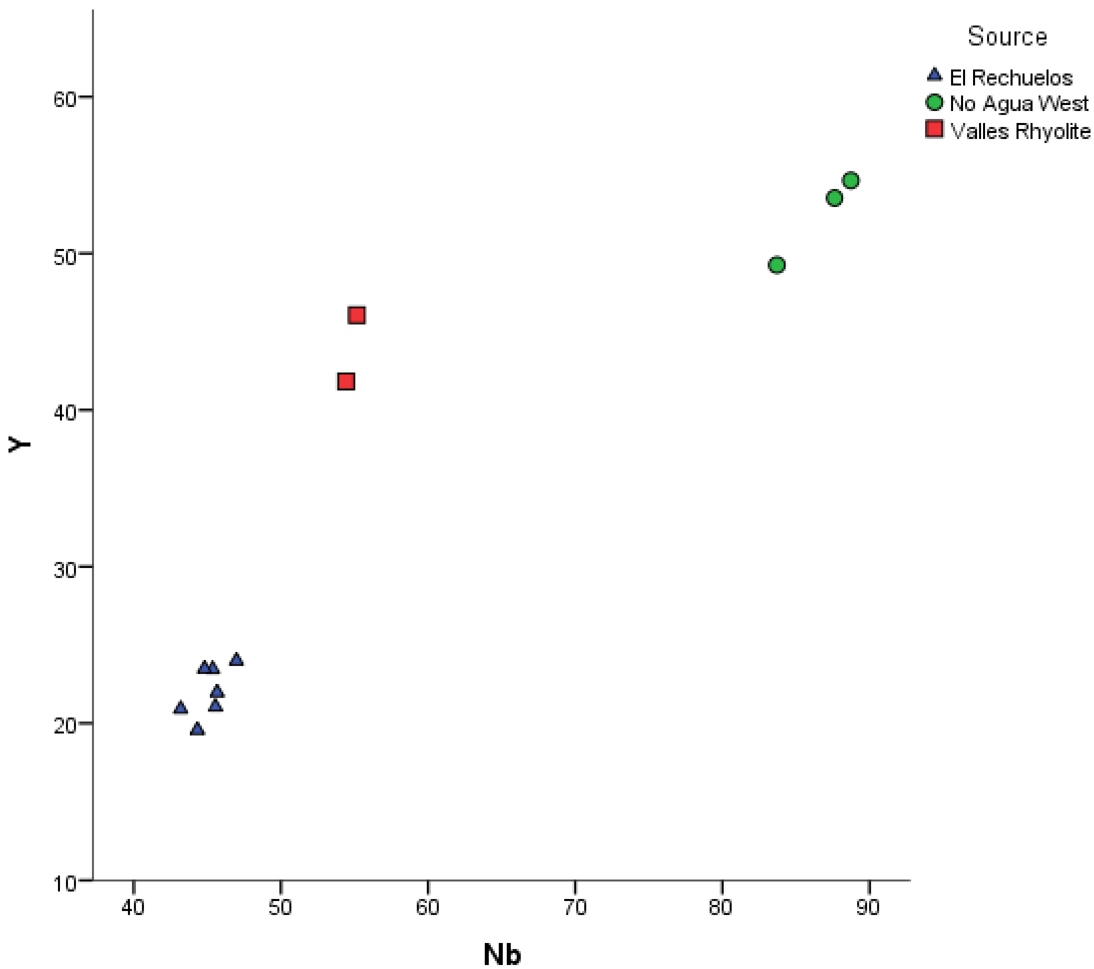

Figure 1. Nb versus Y bivariate plot of the elemental concentrations for the obsidian archaeological specimens.

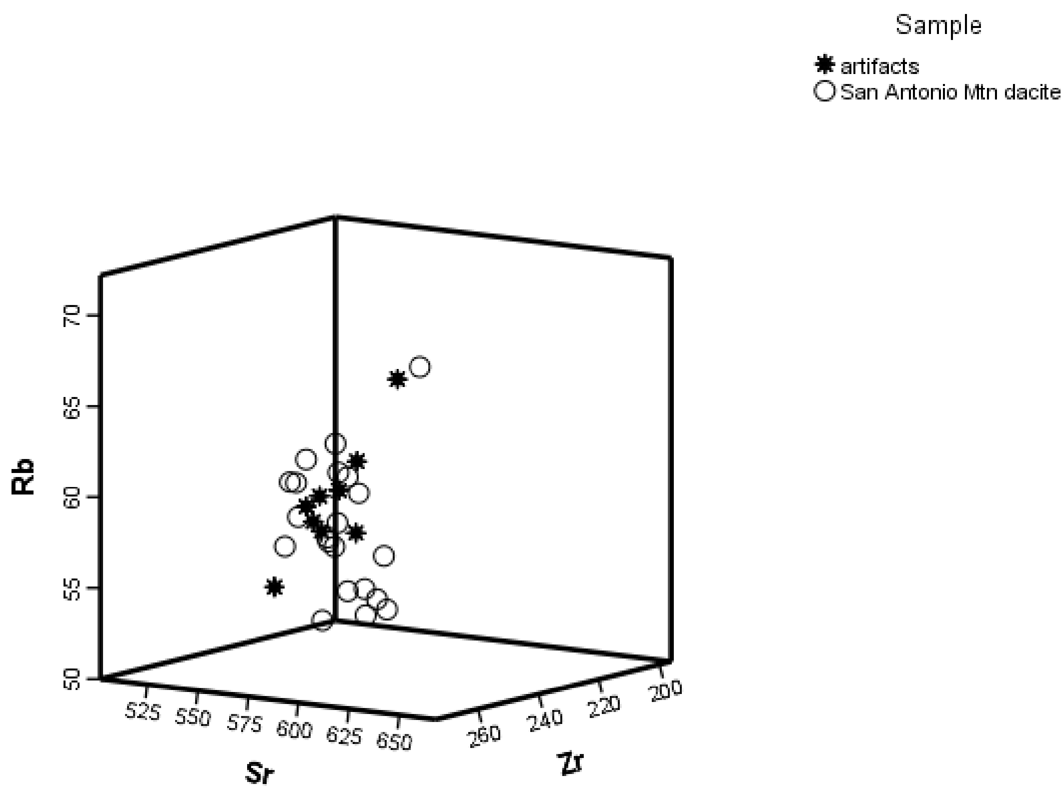

Figure 2. Sr, Rb, Zr three-dimensional plot of the dacite archaeological specimens and San Antonio Mountain source standards.

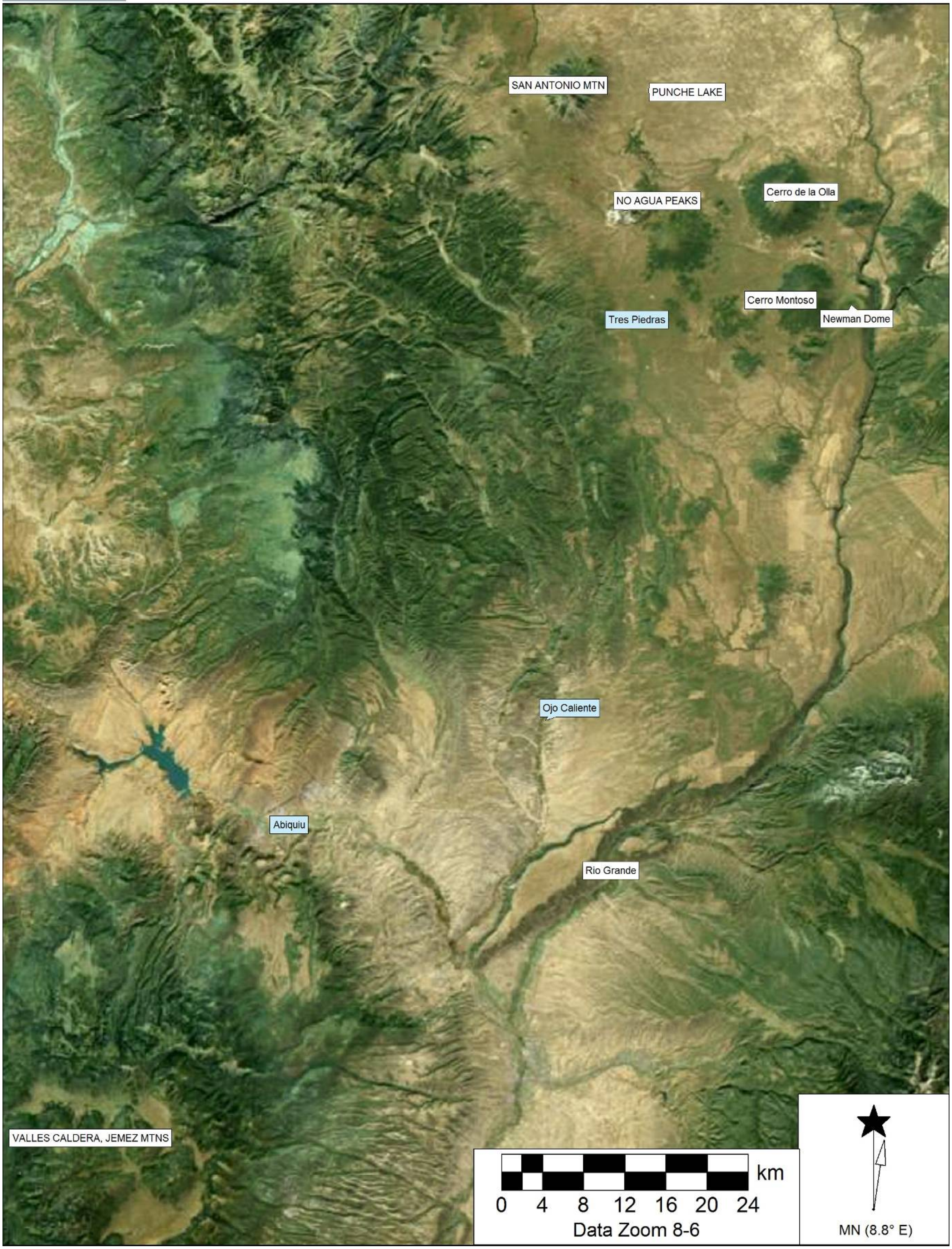

Figure 3. SPOT image of northern New Mexico showing relevant dacite and obsidian sources and appropriate features.