Title
Source Provenance Of Obsidian Artifacts from the Pojoaque Corridor Study, Northern New Mexico

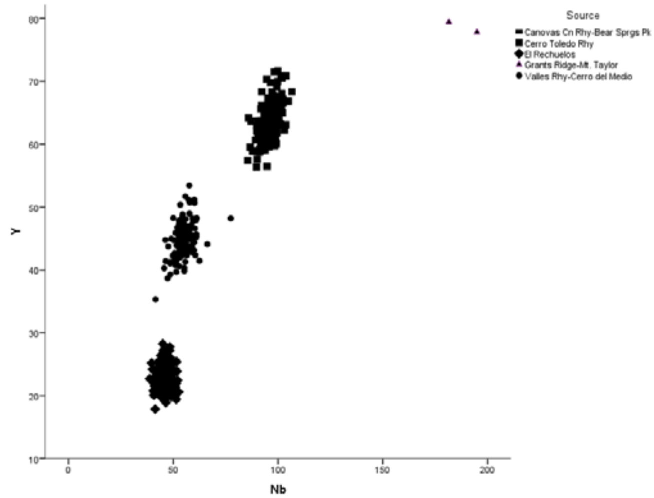
Author
Shackley, M. Steven

Publication Date
2015-08-10

GEOARCHAEOLOGICAL XRF LAB

GEOARCHAEOLOGICAL X-RAY FLUORESCENCE SPECTROMETRY LABORATORY
8100 Wyoming Blvd., Ste M4-158 Albuquerque, NM 87113 USA

SOURCE PROVENANCE OF OBSIDIAN ARTIFACTS FROM THE POJOAQUE CORRIDOR STUDY, NORTHERN NEW MEXICO



by

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

Report Prepared for

James Moore
Office of Archaeological Studies, Museum of New Mexico
Center for New Mexico Archaeology
Santa Fe, New Mexico

10 August 2015

INTRODUCTION

The analysis here of 454 artifacts (453 obsidian) from seven sites in the project area is dominated by obsidian sources along the Jemez Lineament, mainly pre-caldera and caldera event sources in the Jemez Mountains just to the west and northwest (99.6% of the total). The distribution of Cerro Toledo Rhyolite (35.3%), Valles Rhyolite-Cerro del Medio (34%), and El Rechuelos (30%) is nearly equal indicating that, taking all sites into consideration, the Jemez Mountains area was frequently visited in prehistory. At least some of the Cerro Toledo Rhyolite and El Rechuelos raw material could have been procured from secondary deposits on the west slope of the Jemez Mountains, and in Rio Grande Quaternary alluvium (Shackley 2005, 2012). The two artifacts produced from the Grants Ridge chemical group at the Mount Taylor Volcanic Field from LA 6579 are from the source at the greatest distance, but a source commonly recovered in all time periods from New Mexico (Shackley 2005).

After a discussion of the instrumental analysis, a discussion of these Jemez Lineament sources will be offered, followed by a general discussion of the results and a short discussion of source provenance. This is one of the largest single obsidian provenance projects in northern New Mexico (see also Duff et al. 2012).

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 Geoarchaeological 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 linear 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 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, and 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 of 20 for obsidian artifacts to check machine calibration (Table 1).

Source assignments were made by reference to the laboratory data base (see Shackley 1995, 2005). Further information on the laboratory instrumentation and source data can be found at: http://www.swxrflab.net/ (see Appendix Table for all data and Figure 1 in text). Trace element data exhibited in Tables 1 and Appendix are reported in parts per million (ppm), a quantitative measure by weight. Also refer to the preliminary reports for site by site analyses.

Table 1. Recommended values for USGS RGM-1 obsidian standard and mean and central tendency data from this study. ± = 1st standard deviation.

SAMPLE	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb
RGM-1 (Govindaraju 1994)	1600	279	12998	149	108	25	219	8.9
RGM-1 (USGS recommended)[1]	1619±120	279±50	13010±210	150±8	110±10	25[2]	220±20	8.9±0.6
RGM-1, pressed powder standard (this study, n=25)	1537±43	283±9	13657±47	146±3	107±2	24±2	212±4	8±2.7

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

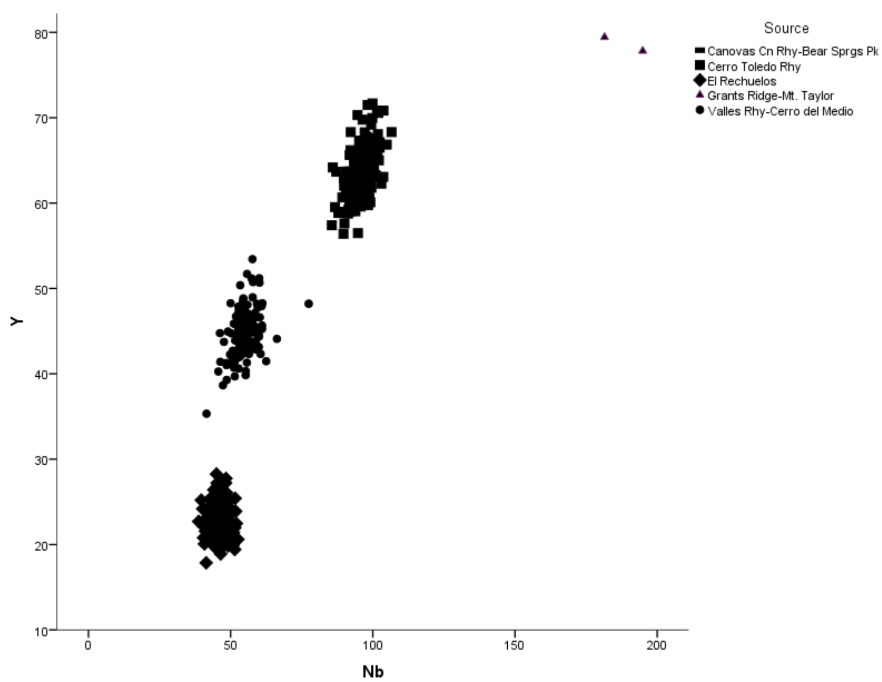


Figure 1. Nb versus Y bivariate plot of all the obsidian artifacts from all sites. See preliminary reports for increased discrimination.

THE JEMEZ LINEAMENT AND MOUNT TAYLOR AND JEMEZ MOUNTAINS SOURCES

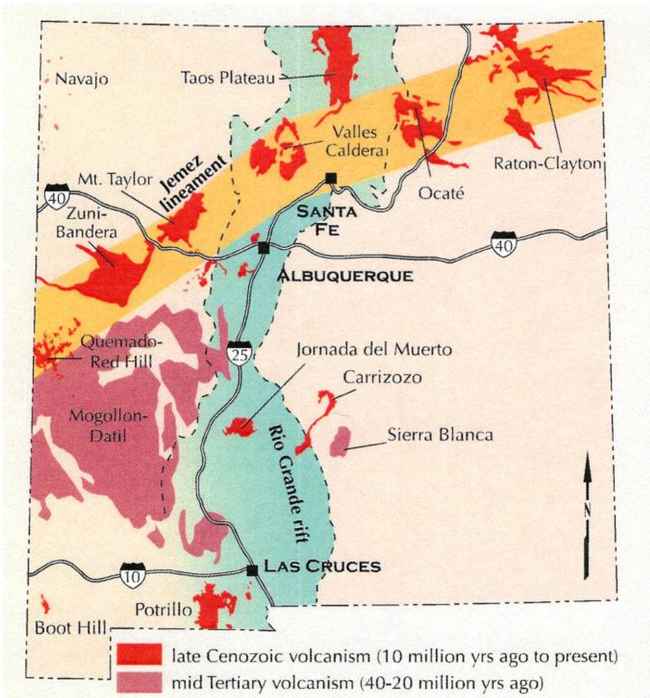


Figure 2. The Jemez Lineament in northern New Mexico (from *NM Earth Matters*, Winter 2006).

All of the obsidian used to produce artifacts from the sites in the Pojoaque Corridor were procured from one of two volcanic fields along the Jemez Lineament; the Mount Taylor Volcanic Field or the Jemez Mountains and Valles Caldera Volcanic Field (Figure 2). The Jemez lineament, first identified and named by Mayo (1958), is marked by a prominent alignment of Cenozoic volcanic centers (Figure 2). Several workers have postulated a Precambrian ancestry for the lineament (Aldrich et al. 1983, and references therein). U-Pb geochronologic data suggest that it marks the southward limit of pre-1.7 Ga crust (Wooden and Dewitt 1991). The idea that the Jemez lineament is an important crustal boundary is supported by a long history of reactivation. Strickland et al. (2003) suggest that the Jemez lineament may be a province boundary between the Yavapai (1.8-1.7 Ga) and Mazatzal (1.67-1.65 Ga) crustal provinces. It's location at the boundaries of the Rio Grande Rift, the Colorado Plateau, and the Basin and Range Complex appears to be reflected in the trace element chemistry with relatively high Y and Nb for North American rhyolites, a result of mantle sampling (Baker and Ridley 1970; Shackley 1998, 2005 and see discussions below). It appears to coincide with a region of low-velocity mantle and possible zone of partial melting, not unexpected in this environment (Karlstrom and Humphreys 1998; Dueker et al. 2001).

The Regional Sources of Archaeological Obsidian

Jemez Mountains and the Valles Caldera

A more complete discussion of the archaeological sources of obsidian in the Jemez Mountains is available in Shackley (2005:64-74). Distributed in archaeological contexts over as great a distance as Government Mountain in the San Francisco Volcanic Field in northern Arizona, some of the Tertiary and Quaternary sources in the Jemez Mountains, most associated with the collapse of the Valles Caldera, are distributed at least as far south as Chihuahua through secondary deposition in the Rio Grande, and east to the Oklahoma and Texas Panhandles through exchange. And like the sources in northern Arizona, the nodule sizes are from to 10 to 30 cm in diameter; El Rechuelos, Cerro Toledo Rhyolite, and Valles Rhyolite (Valles Rhyolite derived from the Cerro del Medio dome complex) glass sources are as good a media for tool production as anywhere. Until the recent land exchange of the Baca Ranch properties, the Valles Rhyolite primary domes (i.e., Cerro del Medio) had been off-limits to most research. The discussion of this source group here is based on collections by Dan Wolfman and others, facilitated by Los Alamos National Laboratory, and the Museum of New Mexico, and recent sampling of all the major sources by this laboratory courtesy of the Valles Caldera National Preserve (VCNP; Shackley 2005; Wolfman 1994).

Due to its proximity and relationship to the Rio Grande Rift System, potential uranium ore, geothermal possibilities, an active magma chamber, and a number of other geological issues, the Jemez Mountains and the Toledo and Valles Calderas particularly have been the subject of intensive structural and petrological study particularly since the late 1960s (Bailey et al. 1969; Gardner et al. 1986, 2007; Heiken et al. 1986; Self et al. 1986; Smith et al. 1970; Figure 3 below). Half of the 1986 *Journal of Geophysical Research*, volume 91, was devoted to the then current research on the Jemez Mountains. More accessible for archaeologists, the geology of which is mainly derived from the above, is Baugh and Nelson's (1987) article on the relationship between northern New Mexico archaeological obsidian sources and procurement on the southern Plains, and Glascock et al's (1999) more intensive analysis of these sources including the No Agua Peak source in the Mount San Antonio field on the Taos Plateau at the Colorado/New Mexico border, as well as Shackley (2005).

There are at least five eruptive events in the last 8.7 million years that have produced the five chemical groups in the Jemez Mountains (Figure 3).

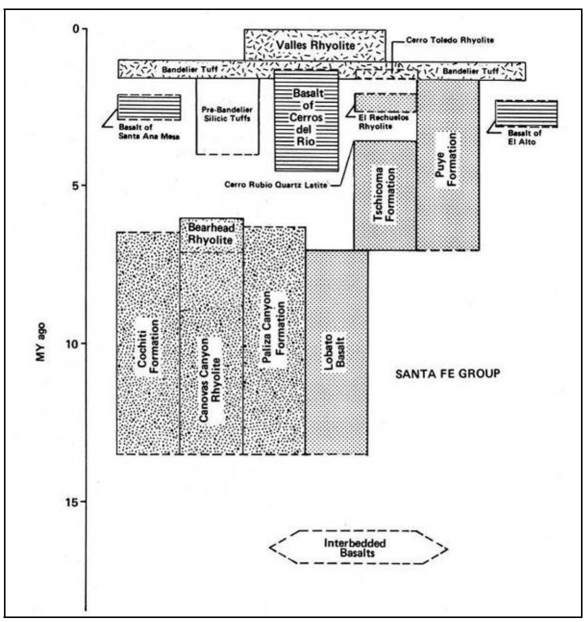


Figure 3. Generalized stratigraphic relations of the major volcanic and alluvial units in the Jemez Mountains (from Gardner et al. 1986). Note the near overlapping events at this scale for the Cerro Toledo and Valles Rhyolite of the Tewa Member, and the position of Cerro Toledo Rhyolite at the upper termination of the Puye Formation.

The earliest pre-caldera event is the Bear Springs Peak source, part of Canovas Canyon Rhyolite that is dated to about 8.7 Ma, firmly in the Tertiary (Kempter et al. 2004; Figure 3 here). This source is a typical Tertiary marekanite source with remnant nodules embedded in a perlitic matrix. It is located in a dome complex including Bear Springs Peak on Santa Fe National Forest and radiating to the northeast through Jemez Nation land (Shackley 2009). While the nodule sizes are small, the glass is an excellent media for tool production and has been found archaeologically at Zuni and in secondary deposits as far south as Las Cruces, as well as the sites here (Church 2000; Shackley 2012).

The second relevant pre-caldera eruptive event that produced artifact quality obsidian is El Rechuelos Rhyolite. This source, well represented in this assemblage, is what I consider one of the best media for tool production of the group. It dates to about 2.4 million years ago, and nodules at least 10 cm in diameter are present in a number of domes north of dacite Polvadera Peak, the incorrect vernacular name for this source.

About 1.4 Ma, the first caldera collapse occurred in the Jemez Mountains, called Cerro Toledo Rhyolite. This very large event produced the Bandelier Tuffs and spread ash flows many kilometers into the area and horizontally southeast from what is now Rabbit Mountain and the Cerro Toledo domes to the east. These large ash flow sheets are responsible for the great quantity of Cerro Toledo obsidian that is present in the Quaternary Rio Grande alluvium all the way to Chihuahua (Church 2000; Shackley 2012; Figure 3 here).

The second caldera collapse, that produced the Valles Rhyolite member of the Tewa Formation, called Valles Rhyolite here, occurred around one million years ago and created most of the geography of the current Valles Caldera (Gardner et al. 2007). A number or rhyolite ring domes were produced on the east side of the caldera, but only Cerro del Medio produced artifact quality obsidian. Indeed, the Cerro del Medio dome complex produced millions of tons of artifact quality glass, and is the volumetrically largest obsidian source in the North American Southwest challenged only by Government Mountain in the San Francisco Volcanic Field. This source was apparently preferred by Folsom knappers, as well as those in all periods since. While Cerro Toledo Rhyolite often appears in archaeological contexts in New Mexico sites with greater frequency, it is likely because it is distributed in secondary contexts. This was not the case in the sites at Pojoaque. Valles Rhyolite (Cerro del Medio) stone has not eroded outside the caldera to the extent as Cerro Toledo Rhyolite, and had to be originally procured in the caldera proper (Shackley 2005, 2012).

The Mount Taylor Volcanic Field

The "Grants Ridge" source of archaeological obsidian in the Mount Taylor Volcanic Field in northwestern New Mexico has been systematically sampled and analyzed nearly every year since 1997 (Shackley 1998, 2005). Previous chemical analyses by Baugh and Nelson (1987) and others have generally been based on grab samples from the East Grants Ridge area. My more recent analysis of archaeological obsidian from the Zuni and Hopi areas suggested that, unlike the somewhat vitrophyric glass from Grants Ridge, prehistoric knappers often preferred an aphyric glass that while chemically similar, does not elementally covary with samples from Grants Ridge. Systematic survey and sampling in 1997 resulted in the discovery of another source on Horace Mesa to the east of East Grants Ridge. These nodules up to 10 cm in diameter are aphyric and are generally a better medium for tool production. The chemistry differs in a number of incompatibles, but appears to be derived from the same magma source of high silica rhyolite, a late Tertiary and early eruptive phase in the Mount Floyd field (Goff et al. 2008). A complete major, minor, and trace analysis has been completed using the Philips PW2400 WXRF at Berkeley and published in Shackley (1998). The Mount Taylor obsidian appears to be yet another example of chemical gradients in silicic melts that have archaeological relevance (see Shackley, 1995, 2005).

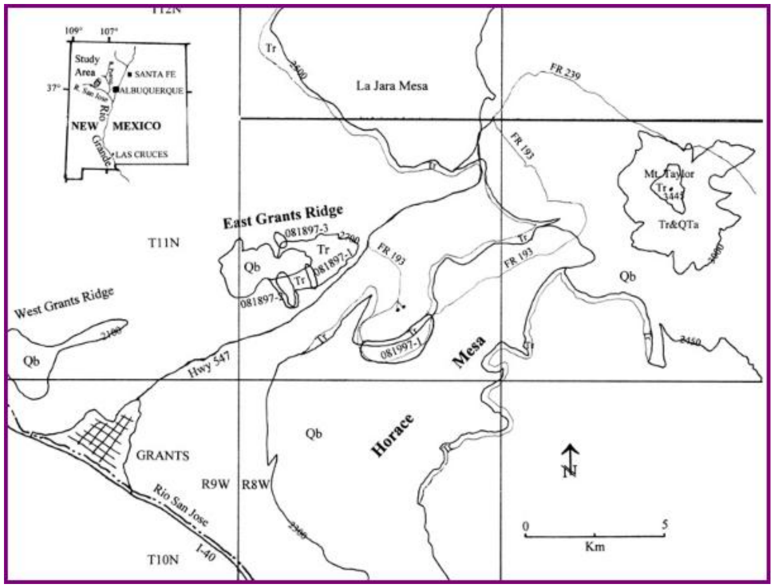


Figure 4. The Mount Taylor Volcanic Field and Grants Ridge and Horace/La Jara Mesa obsidian sources (from Shackley 1998).

In 2013 as part of the Keck Foundation Geoarchaeological Field School, La Jara Mesa was sampled on the mesa top and in the road cut and ash flow where Hwy 547 cuts through La Jara Mesa. The distinction between Horace and La Jara mesa structure is mainly due to a normal fault that separates the two, but this research and that of Goff et. al (2008) indicates that the ash flow on Horace and La Jara mesas are a single unit, now dated to 3.26 ± 0.04 Ma by $Ar^{40/39}$ (Goff et al. 2008). Lipman and Mehnert (1979) dated the East Grants Ridge glass at an unknown locality by K/Ar at 3.34 ± 0.16 Ma, potentially older, but statistically similar, given the vagaries of early K/Ar dating. The subsequent analysis and plot of Nb/Y/Rb indicates this relationship and the distinction between Horace/La Jara mesa and East Grants Ridge obsidian (Shackley 1998, see Figure 4 here). Again, the obsidian from both Horace and La Jara mesas is generally aphyric as opposed to the vitrophyric fabric at East Grants Ridge. The Grants Ridge obsidian, however, is an adequate media for tool production and formal tools including projectile points were produced from this obsidian in prehistory, as evident in this study.

RESULTS OF THE EDXRF ANALYSIS OF THE ARTIFACTS

As noted above, 453 obsidian artifacts were analyzed for source provenance from the 7 sites (Appendix; Figure 5 and Table 2 here). Also as noted above, the assemblages, taking all sites together, are dominated by Jemez Mountains sources with only two samples produced from the Grants Ridge-Mount Taylor source, shown graphically below, and the site by source tabulation in Table 2.

As mentioned above, while it is certainly possible that ALL the obsidian used to produce these artifacts was procured from the primary sources in the Jemez Mountains, Cerro Toledo Rhyolite is available in secondary contexts above the Puye Formation west of Española, and El Rechuelos is available in Rio Grande Quaternary alluvium as well (Shackley 2012). The general lack of cortical material on the debitage, and lack of real cores suggests that much of the raw material was initially reduced elsewhere.

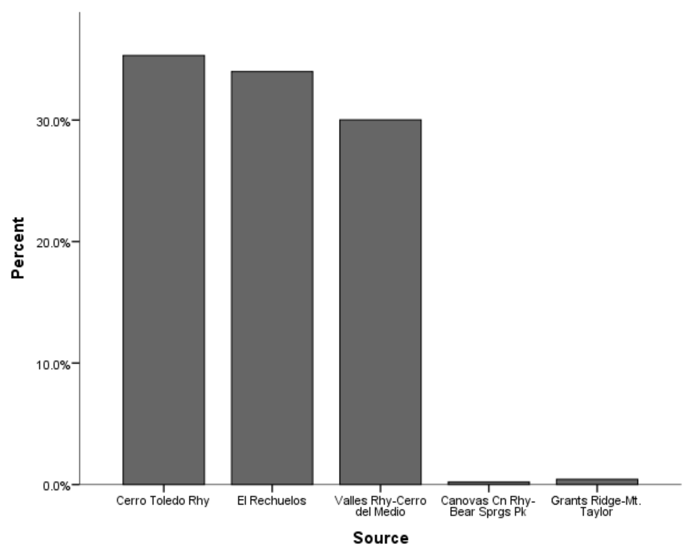


Figure 5. Frequency distribution of obsidian sources for all sites.

Table 2. Crosstabulation of site by source at the Pojoaque Corridor study. Non-obsidian artifacts not tabulated.

			Source					
			Cerro Toledo Rhy	El Rechuelos	Valles Rhy-Cerro del Medio	Canovas Cn Rhy-Bear Sprgs Pk	Grants Ridge-Mt. Taylor	Total
Site	LA 388	Count	22	19	9	0	0	50
		% within Site	44.0%	38.0%	18.0%	0.0%	0.0%	100.0%
		% within Source	13.8%	12.3%	6.6%	0.0%	0.0%	11.0%
		% of Total	4.9%	4.2%	2.0%	0.0%	0.0%	11.0%
	LA 391	Count	24	9	16	0	0	49
		% within Site	49.0%	18.4%	32.7%	0.0%	0.0%	100.0%
		% within Source	15.0%	5.8%	11.8%	0.0%	0.0%	10.8%
		% of Total	5.3%	2.0%	3.5%	0.0%	0.0%	10.8%
	LA 835	Count	29	15	5	1	0	50
		% within Site	58.0%	30.0%	10.0%	2.0%	0.0%	100.0%
		% within Source	18.1%	9.7%	3.7%	100.0%	0.0%	11.0%
		% of Total	6.4%	3.3%	1.1%	0.2%	0.0%	11.0%
	LA 3119	Count	27	20	5	0	0	52
		% within Site	51.9%	38.5%	9.6%	0.0%	0.0%	100.0%
		% within Source	16.9%	13.0%	3.7%	0.0%	0.0%	11.5%
		% of Total	6.0%	4.4%	1.1%	0.0%	0.0%	11.5%
	LA 6579	Count	31	10	7	0	2	50
		% within Site	62.0%	20.0%	14.0%	0.0%	4.0%	100.0%
		% within Source	19.4%	6.5%	5.1%	0.0%	100.0%	11.0%
		% of Total	6.8%	2.2%	1.5%	0.0%	0.4%	11.0%
	LA 84927	Count	9	36	5	0	0	50
		% within Site	18.0%	72.0%	10.0%	0.0%	0.0%	100.0%
		% within Source	5.6%	23.4%	3.7%	0.0%	0.0%	11.0%
		% of Total	2.0%	7.9%	1.1%	0.0%	0.0%	11.0%
	LA 111333	Count	18	45	89	0	0	152
		% within Site	11.8%	29.6%	58.6%	0.0%	0.0%	100.0%
		% within Source	11.3%	29.2%	65.4%	0.0%	0.0%	33.6%
		% of Total	4.0%	9.9%	19.6%	0.0%	0.0%	33.6%
Total		Count	160	154	136	1	2	453
		% within Site	35.3%	34.0%	30.0%	0.2%	0.4%	100.0%
		% within Source	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	35.3%	34.0%	30.0%	0.2%	0.4%	100.0%

REFERENCES CITED

Aldrich, M. J., Ander, M. E., and Laughlin, A. W., 1983, Geological and geophysical signatures of the Jemez Lineament; a reactivated Precambrian structure: *International Basement Tectonics Association Publication*, 4:77-85.

Bailey, R.A., R.L. Smith, and C.S. Ross, 1969 Stratigraphic Nomenclature of Volcanic Rocks in the Jemez Mountains, New Mexico. *U.S. Geological Survey Bulletin* 1274-P:1-19.

Baker, I. & Ridley, W. I., 1970, Field evidence and K, Rb, Sr data bearing on the origin of the Mt. Taylor volcanic field, New Mexico, U.S.A. *Earth and Planetary Science Letters* 10**:** 106–114.

Baugh, T.G., and F.W. Nelson, Jr.,1987, New Mexico Obsidian Sources and Exchange on the Southern Plains. *Journal of Field Archaeology* 14: 313-329.

Church, T.,2000, Distribution and Sources of Obsidian in the Rio Grande Gravels of New Mexico. *Geoarchaeology* 15:649-678.

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

Dueker, K., Yuan, H., Zurek, B., 2001, Thick-structured Proterozoic lithosphere of the Rocky Mountain region, *GSA Today*, 11:4-9.

Duff, A.I., J.M. Moss, T.C. Windes, J. Kantner, and M.S. Shackley, 2012, Patterning in Procurement of Obsidian in Chaco Canyon and in Chaco-era Communities in New Mexico as Revealed by X-Ray Fluorescence. *Journal of Archaeological Science*, 39:2995-3007.

Gardner, J. N., F. Goff, S. Garcia, R. Hagan, 1986, Stratigraphic Relations and Lithologic Variations in the Jemez Volcanic Field, New Mexico. *Journal of Geophysical Research* 91B2:1763-1778.

Gardner, J.N., M.M. Sandoval, F. Goff, E. Phillips, and A. Dickens, 2007, Geology of the Cerro del Medio moat rhyolite center, Valles Caldera, New Mexico. In Kues, B.S., Kelley, S.A., and V.W. Lueth (Eds.), *Geology of the Jemez Region II*, New Mexico Geological Society 58th Annual Field Conference. New Mexico Geological Society, Socorro.

Glascock, M.D., R. Kunselman, and D. Wolfman,1999, Intrasource chemical differentiation of obsidian in the Jemez Mountains and Taos Plateau, New Mexico. *Journal of Archaeological Science* 26:861-868.

Goff, F., S.A. Kelley, K. Zeigler, P. Drakos, and C.J. Goff, 2008, Preliminary geologic map of the Lobo Springs quadrangle, Cibola County, New Mexico. New Mexico Bureau of Geology and Mineral Resources Open File Geologic Map Series OF-GM-181.

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.

Heicken, G., F. Goff, J. Stix, S. Tamanyu, M. Shafiqullah, S. Garcia, and R. Hagan,1986, Intracaldera Volcanic Activity, Toledo Caldera and Embayment, Jemez Mountains, New Mexico. *Journal of Geophysical Research* 91:1799-1816.

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.

Karlstrom, K. E. and Humphreys, G., 1998, Influence of Proterozoic accretionary boundaries in the tectonic evolution of western North America: Interaction of cratonic grain and mantle modification events: *Rocky Mountain Geology*, 33:161-179.

Kempter, K., G.R. Osburn, S.Kelley, M. Rampey, C. Ferguson, and J.N. Gardner, 2003, Preliminary Geologic Map of the Bear Springs Peak Quadrangle, Sandoval County, New Mexico. New Mexico Bureau of Geology and Mineral Resources Open-file digital geologic map OF-GM 74. Socorro.

Kues, B.S., S.A. Kelley, and V.W. Lueth, (Eds.), 2007, *Geology of the Jemez Region II*. New Mexico Geological Society 58th Annual Field Conference, Socorro.

Lipman, P.W., and Mehnert, H.H.,1979, Potassium-argon ages from the Mount Taylor volcanic field, New Mexico. *U.S. Geological Survey Professional Paper* 1124-B, 8 pp.

Mahood, Gail A., and James A. Stimac, 1990, Trace-Element Partitioning in Pantellerites and Trachytes. *Geochemica et Cosmochimica Acta* 54:2257-2276.

Mayo, E. B., 1958, Lineament tectonics and some ore deposits of the southwest: *Mining Engineering*, 10:1169-1175.

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.

Self, S. F. Goff, J. N. Gardner, J.V. Wright, and W. M. Kite, 1986, Explosive Rhyolitic Volcanism in the Jemez Mountains: Vent Locations, Caldera Development and Relation to Regional Structure. *Journal of Geophysical Research* 91:1779-1798.

Shackley, M.S., 1988, Sources of Archaeological Obsidian in the Southwest: An Archaeological, Petrological, and Geochemical Study. *American Antiquity* 53:752-772.

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

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

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

Shackley, M.S., 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.

Shackley, M.S., 2012, The Secondary Distribution of Archaeological Obsidian in Rio Grande Quaternary Sediments, Jemez Mountains to San Antonito, New Mexico: Inferences for Prehistoric Procurement and the Age of Sediments. Poster presentation at the Society for American Archaeology, Annual Meeting, Memphis, Tennessee.

Smith, R.L., R.A. Bailey, and C.S. Ross, 1970, Geologic Map of the Jemez Mountains, New Mexico. Miscellaneous Investigations Series, Map I-571. U.S. Geological Survey, Denver.

Spell, T.L., and T.M. Harrison, 1993, $^{40}Ar/^{39}Ar$ Geochronology of post-Valles Caldera Rhyolites, Jemez Volcanic Field, New Mexico. *Journal of Geophysical Research* 98, B5: 8031-8051.

Strickland, D., Heizler, M.T., Selverstone, J., and Karlstrom, K.E, 2003, Proterozoic Evolution of the Zuni Mountains, Western New Mexico: Relationship to the Jemez Lineament and Implications For a Complex Cooling History. New Mexico Geological Society Guidebook, 54th Field Conference, *Geology of the Zuni Plateau*, p. 109-117.

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

Wooden, J. L., and DeWitt, E., 1991, Pb isotope evidence for a major Early Proterozoic crustal boundary in western Arizona, *in* Karlstrom, K. E., ed., *Proterozoic Geology and Ore Deposits of Arizona: Arizona Geological Society Digest*, 19:27-50.

APPENDIX

Elemental concentrations for the archaeological specimens from Pojoaque Corridor sites. All measurements in parts per million (ppm).

Sample	Site	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
1009-1	LA 388	576	494	12011	213	8	66	178	94	Cerro Toledo Rhy
1014-1	LA 388	593	494	12037	211	10	63	172	90	Cerro Toledo Rhy
1019-1	LA 388	657	399	11848	161	14	42	164	51	Valles Rhy-Cerro del Medio
1026-1	LA 388	586	408	10139	157	13	22	68	41	El Rechuelos
1028-1	LA 388	510	484	11816	207	8	63	173	95	Cerro Toledo Rhy
1038-1	LA 388	600	382	10101	150	14	25	66	45	El Rechuelos
1038-2	LA 388	564	359	9805	138	17	22	63	44	El Rechuelos
1051-1	LA 388	616	380	11950	161	12	47	165	56	Valles Rhy-Cerro del Medio
1051-1	LA 388	650	401	12019	163	12	42	165	53	Valles Rhy-Cerro del Medio
1055-1	LA 388	605	482	11911	204	8	63	171	97	Cerro Toledo Rhy
1062-1	LA 388	593	396	10079	155	12	23	70	45	El Rechuelos
1067-1	LA 388	676	419	10300	156	14	23	70	44	El Rechuelos
1070-1	LA 388	635	388	11930	160	12	42	152	53	Valles Rhy-Cerro del Medio
1072-1	LA 388	551	487	12023	214	8	64	171	100	Cerro Toledo Rhy
1076-1	LA 388	552	506	11983	208	8	61	173	94	Cerro Toledo Rhy
1105-1	LA 388	563	383	11681	155	9	45	152	56	Valles Rhy-Cerro del Medio
1131-1	LA 388	674	393	10020	146	14	22	71	47	El Rechuelos
1140-1	LA 388	528	387	10035	148	13	22	70	43	El Rechuelos
1141-1	LA 388	530	452	11698	195	8	64	170	100	Cerro Toledo Rhy
1153-1	LA 388	542	483	12023	204	10	65	171	96	Cerro Toledo Rhy
1194-1	LA 388	543	373	9902	143	12	23	66	42	El Rechuelos
1216-1	LA 388	684	481	11815	205	9	65	169	98	Cerro Toledo Rhy
1217-1	LA 388	519	460	11628	199	8	61	169	94	Cerro Toledo Rhy
1228-1	LA 388	531	439	11749	194	9	61	163	91	Cerro Toledo Rhy
1228-2	LA 388	663	463	10513	174	13	22	72	51	El Rechuelos
1228-3	LA 388	669	447	10496	165	12	24	68	45	El Rechuelos
1228-4	LA 388	969	669	13587	241	11	63	165	99	Cerro Toledo Rhy
1228-5	LA 388	610	574	12896	233	11	66	171	95	Cerro Toledo Rhy
1228-6	LA 388	913	435	12578	171	12	45	158	46	Valles Rhy-Cerro del Medio
1228-7	LA 388	812	475	10571	172	12	24	71	45	El Rechuelos
1228-8	LA 388	919	668	13755	242	13	64	173	96	Cerro Toledo Rhy
1228-9	LA 388	968	625	13216	225	8	61	166	89	Cerro Toledo Rhy
1228-10	LA 388	700	608	13191	241	8	66	170	92	Cerro Toledo Rhy
1228-11	LA 388	675	512	12223	217	9	59	177	91	Cerro Toledo Rhy

1231-1	LA 388	509	378	9976	151	11	21	65	47	El Rechuelos
1233-1	LA 388	1778	13395	8666	0	40	5	13	2	not obsidian
1233-2	LA 388	619	401	11920	159	13	40	159	46	Valles Rhy-Cerro del Medio
1234-1	LA 388	615	473	11647	207	15	60	168	92	Cerro Toledo Rhy
1236-1	LA 388	663	392	11935	166	11	42	160	54	Valles Rhy-Cerro del Medio
1236-2	LA 388	488	456	11650	206	8	63	168	101	Cerro Toledo Rhy
1311-1	LA 388	931	517	10888	178	14	22	69	44	El Rechuelos
1317-1	LA 388	749	369	9986	141	13	24	64	46	El Rechuelos
1317-1	LA 388	496	394	10008	150	12	23	69	49	El Rechuelos
1323-1	LA 388	549	542	12353	224	10	65	176	94	Cerro Toledo Rhy
1324-1	LA 388	1122	478	11730	186	10	59	158	88	Cerro Toledo Rhy
1324-2	LA 388	976	539	10852	175	12	21	70	46	El Rechuelos
1381-1	LA 388	780	426	12374	172	12	47	170	53	Valles Rhy-Cerro del Medio
1390-1	LA 388	569	374	9986	152	14	22	69	41	El Rechuelos
1390-2	LA 388	468	466	11675	199	9	64	165	91	Cerro Toledo Rhy
1390-3	LA 388	545	415	10218	155	12	24	70	52	El Rechuelos
1390-4	LA 388	727	435	10404	167	14	24	71	47	El Rechuelos
126-1	LA 391	607	517	12095	206	8	60	174	97	Cerro Toledo Rhy
126-2	LA 391	575	474	11815	205	8	62	175	91	Cerro Toledo Rhy
126-3	LA 391	518	448	11631	197	10	66	171	97	Cerro Toledo Rhy
142-1	LA 391	595	359	11757	158	13	47	160	53	Valles Rhy-Cerro del Medio
142-10	LA 391	641	391	11911	159	14	43	176	54	Valles Rhy-Cerro del Medio
142-11	LA 391	598	455	11764	193	13	56	162	95	Cerro Toledo Rhy
142-12	LA 391	385	198	8762	0	14	1	13	2	not obsidian
142-13	LA 391	680	544	12415	209	10	66	172	95	Cerro Toledo Rhy
142-14	LA 391	966	534	12464	213	10	62	165	91	Cerro Toledo Rhy
142-15	LA 391	778	373	11457	149	21	43	146	51	Valles Rhy-Cerro del Medio
142-16	LA 391	1174	421	11210	174	10	48	146	77	Valles Rhy-Cerro del Medio
142-2	LA 391	542	379	9935	146	13	22	66	52	El Rechuelos
142-3	LA 391	559	501	12109	211	10	64	172	99	Cerro Toledo Rhy
142-4	LA 391	628	486	12017	211	10	65	174	100	Cerro Toledo Rhy
142-5	LA 391	579	444	11873	200	12	62	164	93	Cerro Toledo Rhy
142-6	LA 391	582	473	11770	198	8	60	172	97	Cerro Toledo Rhy
142-7	LA 391	470	385	9903	147	11	24	67	43	El Rechuelos
142-8	LA 391	679	425	10301	154	12	23	70	48	El Rechuelos
142-9	LA 391	626	451	10325	165	14	20	66	46	El Rechuelos

149-1	LA 391	593	471	11742	195	8	59	163	92	Cerro Toledo Rhy
149-2	LA 391	682	406	10138	158	14	21	66	42	El Rechuelos
151-1	LA 391	818	626	13441	249	9	65	180	100	Cerro Toledo Rhy
151-2	LA 391	887	383	10299	141	14	21	62	43	El Rechuelos
170-1	LA 391	884	418	12625	160	17	44	167	52	Valles Rhy-Cerro del Medio
178-1	LA 391	614	366	11460	151	12	43	158	55	Valles Rhy-Cerro del Medio
178-2	LA 391	561	456	11688	200	9	65	167	93	Cerro Toledo Rhy
178-3	LA 391	642	388	12088	168	13	40	166	55	Valles Rhy-Cerro del Medio
802-1	LA 391	763	443	12560	176	12	44	175	55	Valles Rhy-Cerro del Medio
880-1	LA 391	803	415	12002	167	23	43	166	53	Valles Rhy-Cerro del Medio
885-1	LA 391	597	399	11725	157	12	44	161	55	Valles Rhy-Cerro del Medio
885-2	LA 391	624	388	11796	160	14	45	164	56	Valles Rhy-Cerro del Medio
915-1	LA 391	625	361	11839	164	15	45	166	57	Valles Rhy-Cerro del Medio
934-1	LA 391	478	473	11702	201	10	65	173	96	Cerro Toledo Rhy
937-1	LA 391	472	419	11217	179	9	62	161	90	Cerro Toledo Rhy
937-2	LA 391	610	380	10069	149	14	20	71	45	El Rechuelos
937-3	LA 391	525	486	11868	201	10	64	170	94	Cerro Toledo Rhy
997-1	LA 391	512	406	11405	186	9	59	161	89	Cerro Toledo Rhy
1003-1	LA 391	507	475	11891	205	9	67	170	95	Cerro Toledo Rhy
1012-1	LA 391	565	412	10104	153	11	21	69	51	El Rechuelos
1012-2	LA 391	439	474	11742	199	8	62	169	97	Cerro Toledo Rhy
1012-3	LA 391	594	373	9975	150	14	22	70	46	El Rechuelos
1012-4	LA 391	608	400	11953	163	13	45	166	60	Valles Rhy-Cerro del Medio
1012-5	LA 391	700	428	12496	179	13	43	174	59	Valles Rhy-Cerro del Medio
1012-6	LA 391	591	519	12176	217	10	64	174	96	Cerro Toledo Rhy
1076-1	LA 391	515	386	11748	159	13	41	165	51	Valles Rhy-Cerro del Medio
1076-2	LA 391	716	387	11784	158	13	46	166	54	Valles Rhy-Cerro del Medio
1076-3	LA 391	722	536	12409	219	9	62	171	94	Cerro Toledo Rhy
1076-4	LA 391	613	539	12284	214	8	70	169	95	Cerro Toledo Rhy
1250-1	LA 391	628	478	11886	201	8	65	168	93	Cerro Toledo Rhy
1250-2	LA 391	715	528	12475	217	14	66	181	92	Cerro Toledo Rhy
578-1	LA 835	579	513	12078	209	10	66	175	102	Cerro Toledo Rhy
704-1	LA 835	519	474	11708	205	8	61	171	99	Cerro Toledo Rhy
704-2	LA 835	833	419	10608	113	44	20	101	51	Canovas Cn Rhy-Bear Sprgs Pk
720-1	LA 835	551	397	10076	155	13	19	67	47	El Rechuelos

731-1	LA 835	614	377	10022	148	13	21	70	44	El Rechuelos
731-2	LA 835	528	384	10008	153	12	23	68	42	El Rechuelos
731-3	LA 835	581	559	12704	235	9	65	187	97	Cerro Toledo Rhy
762-1	LA 835	516	453	11682	200	8	62	171	98	Cerro Toledo Rhy
762-2	LA 835	486	454	11755	204	9	60	173	98	Cerro Toledo Rhy
762-3	LA 835	537	508	11997	209	8	67	168	99	Cerro Toledo Rhy
762-4	LA 835	509	479	11945	206	9	63	170	98	Cerro Toledo Rhy
762-5	LA 835	513	457	11681	200	9	62	167	95	Cerro Toledo Rhy
762-6	LA 835	498	455	11550	188	9	60	167	93	Cerro Toledo Rhy
762-7	LA 835	511	546	12310	216	8	67	184	100	Cerro Toledo Rhy
762-8	LA 835	632	512	12124	216	9	67	180	105	Cerro Toledo Rhy
762-9	LA 835	516	493	12010	205	9	62	175	93	Cerro Toledo Rhy
771-1	LA 835	465	439	11530	194	9	64	164	92	Cerro Toledo Rhy
771-2	LA 835	536	409	10057	150	14	19	67	46	El Rechuelos
771-3	LA 835	523	343	9756	133	12	21	67	43	El Rechuelos
786-1	LA 835	639	384	11849	163	13	45	171	56	Valles Rhy-Cerro del Medio
786-2	LA 835	541	495	12083	214	10	64	181	98	Cerro Toledo Rhy
873-1	LA 835	678	500	12109	209	10	66	171	95	Cerro Toledo Rhy
873-2	LA 835	527	443	11436	194	9	66	162	92	Cerro Toledo Rhy
873-3	LA 835	502	455	11699	200	9	65	172	97	Cerro Toledo Rhy
873-4	LA 835	537	468	11923	207	10	68	175	102	Cerro Toledo Rhy
877-1	LA 835	562	463	11799	199	12	64	178	87	Cerro Toledo Rhy
877-2	LA 835	439	468	11741	206	10	68	172	99	Cerro Toledo Rhy
877-3	LA 835	619	455	10339	160	11	26	74	49	El Rechuelos
877-4	LA 835	431	382	10935	172	11	57	154	86	Cerro Toledo Rhy
890-1	LA 835	529	495	12211	211	9	61	170	98	Cerro Toledo Rhy
894-1	LA 835	492	498	11976	210	9	67	179	99	Cerro Toledo Rhy
903-1	LA 835	709	403	12039	164	14	44	164	52	Valles Rhy-Cerro del Medio
908-1	LA 835	591	489	11977	205	9	63	181	104	Cerro Toledo Rhy
909-1	LA 835	515	396	10070	147	13	25	71	47	El Rechuelos
909-2	LA 835	658	434	10315	159	15	21	72	49	El Rechuelos
915-1	LA 835	572	381	9997	151	13	22	69	47	El Rechuelos
920-1	LA 835	683	545	12286	217	9	67	180	99	Cerro Toledo Rhy
920-2	LA 835	696	429	10257	162	11	25	71	46	El Rechuelos
920-3	LA 835	594	412	10170	158	11	24	68	46	El Rechuelos
923-1	LA 835	594	427	10204	155	13	24	67	42	El Rechuelos

943-1	LA 835	561	515	12204	213	10	64	174	100	Cerro Toledo Rhy
943-2	LA 835	791	381	12174	202	14	41	164	62	Valles Rhy-Cerro del Medio
947-1	LA 835	492	454	11562	194	8	59	169	94	Cerro Toledo Rhy
961-1	LA 835	613	398	10172	153	13	20	70	46	El Rechuelos
961-2	LA 835	539	377	10073	148	12	23	70	49	El Rechuelos
962-1	LA 835	627	407	10072	158	14	25	69	47	El Rechuelos
964-1	LA 835	580	374	11793	164	15	43	168	55	Valles Rhy-Cerro del Medio
964-2	LA 835	529	468	11727	199	9	62	171	100	Cerro Toledo Rhy
967-1	LA 835	633	345	11413	150	14	44	156	54	Valles Rhy-Cerro del Medio
999-1	LA 835	468	499	12105	205	8	62	180	103	Cerro Toledo Rhy
90-1	LA 3119	598	405	10116	151	10	21	70	43	El Rechuelos
582-1	LA 3119	455	482	11648	200	9	62	173	98	Cerro Toledo Rhy
582-2	LA 3119	597	387	10068	145	14	21	68	43	El Rechuelos
582-3	LA 3119	634	398	10172	163	15	22	70	42	El Rechuelos
582-4	LA 3119	730	561	12725	227	9	65	168	94	Cerro Toledo Rhy
583-1	LA 3119	545	371	9980	149	14	21	69	47	El Rechuelos
583-2	LA 3119	524	478	11808	211	11	66	176	99	Cerro Toledo Rhy
583-3	LA 3119	546	427	11538	194	10	65	164	95	Cerro Toledo Rhy
583-4	LA 3119	508	411	10234	157	13	28	70	45	El Rechuelos
583-5	LA 3119	693	544	12521	222	8	67	177	96	Cerro Toledo Rhy
583-6	LA 3119	749	419	12525	169	13	49	163	54	Valles Rhy-Cerro del Medio
586-1	LA 3119	496	470	11755	199	8	65	171	98	Cerro Toledo Rhy
586-2	LA 3119	743	499	10535	169	12	23	72	41	El Rechuelos
587-1	LA 3119	631	444	10306	158	13	23	71	41	El Rechuelos
587-2	LA 3119	530	523	12397	228	8	67	182	101	Cerro Toledo Rhy
587-3	LA 3119	707	448	10398	173	13	27	71	46	El Rechuelos
589-1	LA 3119	497	466	11693	204	8	63	167	97	Cerro Toledo Rhy
589-2	LA 3119	581	373	11938	159	14	43	164	58	Valles Rhy-Cerro del Medio
589-3	LA 3119	678	407	12214	172	13	47	170	52	Valles Rhy-Cerro del Medio
591-1	LA 3119	663	414	10213	159	12	27	71	45	El Rechuelos
612-1	LA 3119	588	513	12016	205	11	66	176	100	Cerro Toledo Rhy
612-2	LA 3119	638	421	10165	158	13	22	71	47	El Rechuelos
615-1	LA 3119	711	419	12148	169	10	43	163	60	Valles Rhy-Cerro del Medio
615-2	LA 3119	667	499	12265	218	8	65	179	98	Cerro Toledo Rhy
615-3	LA 3119	484	502	12026	214	9	65	174	102	Cerro Toledo Rhy
616-1	LA 3119	471	424	11380	175	8	56	161	90	Cerro Toledo Rhy

620-1	LA 3119	520	454	11589	202	8	63	169	96	Cerro Toledo Rhy
620-2	LA 3119	569	378	11745	163	8	45	166	55	Valles Rhy-Cerro del Medio
672-1	LA 3119	569	390	9967	150	11	22	66	44	El Rechuelos
674-1	LA 3119	674	564	12721	231	11	66	181	99	Cerro Toledo Rhy
676-1	LA 3119	634	506	12138	206	11	70	173	96	Cerro Toledo Rhy
757-1	LA 3119	541	419	10069	152	13	23	68	49	El Rechuelos
757-2	LA 3119	819	582	13012	230	9	63	187	96	Cerro Toledo Rhy
758-1	LA 3119	525	440	11676	206	9	65	167	94	Cerro Toledo Rhy
758-2	LA 3119	570	552	12484	225	10	63	176	101	Cerro Toledo Rhy
762-1	LA 3119	624	390	10091	158	12	24	70	45	El Rechuelos
762-2	LA 3119	679	481	12010	203	9	60	161	93	Cerro Toledo Rhy
765-1	LA 3119	467	413	11390	192	8	62	165	93	Cerro Toledo Rhy
765-2	LA 3119	550	543	12551	225	10	65	182	96	El Rechuelos
806-1	LA 3119	526	458	11743	204	8	67	175	101	El Rechuelos
806-2	LA 3119	593	521	12343	223	10	67	184	102	Cerro Toledo Rhy
807-1	LA 3119	1202	600	13338	226	11	64	184	86	Cerro Toledo Rhy
808-1	LA 3119	552	407	9989	150	16	24	65	48	El Rechuelos
808-2	LA 3119	531	373	9855	142	14	23	70	45	El Rechuelos
1050-1	LA 3119	725	490	10647	172	12	27	69	45	El Rechuelos
1050-2	LA 3119	565	566	12802	228	10	66	182	101	Cerro Toledo Rhy
1052-1	LA 3119	687	517	12282	213	12	63	174	99	Cerro Toledo Rhy
1059-1	LA 3119	543	477	11658	197	10	61	165	96	Cerro Toledo Rhy
1059-2	LA 3119	623	514	12229	221	8	71	181	102	Cerro Toledo Rhy
1060-1	LA 3119	544	494	12008	210	12	64	167	100	Cerro Toledo Rhy
1256-1	LA 3119	620	402	10099	149	12	23	68	47	El Rechuelos
1258-1	LA 3119	639	443	10336	160	13	20	85	49	El Rechuelos
142-1	LA 6579	675	504	12047	205	11	65	171	95	Cerro Toledo Rhy
162-1	LA 6579	844	579	13176	239	8	67	177	98	Cerro Toledo Rhy
216-1	LA 6579	588	409	10140	144	15	24	66	47	El Rechuelos
216-2	LA 6579	649	402	12082	166	11	45	163	57	Valles Rhy-Cerro del Medio
284-1	LA 6579	545	482	12060	214	9	63	172	97	Cerro Toledo Rhy
289-1	LA 6579	649	527	12247	217	9	64	179	95	Cerro Toledo Rhy
289-2	LA 6579	729	607	13110	244	9	68	175	97	Cerro Toledo Rhy
585-1	LA 6579	633	345	11658	160	13	40	162	55	Valles Rhy-Cerro del Medio
585-2	LA 6579	642	389	11998	162	13	41	164	53	Valles Rhy-Cerro del Medio
596-1	LA 6579	734	579	12867	226	9	68	175	99	Cerro Toledo Rhy

596-2	LA 6579	689	369	10320	146	13	22	69	50	El Rechuelos
597-1	LA 6579	548	452	11590	190	9	60	170	96	Cerro Toledo Rhy
616-1	LA 6579	360	755	11022	556	10	78	108	195	Grants Ridge-Mt. Taylor
616-2	LA 6579	994	488	12218	208	9	61	160	92	Cerro Toledo Rhy
616-3	LA 6579	697	442	10523	173	12	23	71	46	El Rechuelos
616-4	LA 6579	701	407	11896	163	12	43	173	53	Valles Rhy-Cerro del Medio
616-5	LA 6579	815	477	10634	169	14	22	74	48	El Rechuelos
622-1	LA 6579	584	531	12578	215	12	64	175	98	Cerro Toledo Rhy
624-1	LA 6579	510	435	11550	194	9	64	168	95	Cerro Toledo Rhy
624-2	LA 6579	678	511	12344	215	10	68	171	98	Cerro Toledo Rhy
628-1	LA 6579	605	473	11996	201	13	63	166	94	Cerro Toledo Rhy
690-1	LA 6579	536	488	11979	210	8	60	170	95	Cerro Toledo Rhy
690-2	LA 6579	725	547	12723	227	10	71	180	101	Cerro Toledo Rhy
690-3	LA 6579	624	413	10239	157	14	21	72	44	El Rechuelos
730-1	LA 6579	540	526	12306	232	10	67	182	100	Cerro Toledo Rhy
739-1	LA 6579	564	395	11989	166	13	52	164	56	Valles Rhy-Cerro del Medio
769-1	LA 6579	897	370	10049	144	13	21	62	42	El Rechuelos
790-1	LA 6579	703	500	12115	203	10	60	171	92	Cerro Toledo Rhy
792-1	LA 6579	742	511	12449	210	9	66	177	99	Cerro Toledo Rhy
792-2	LA 6579	828	545	12731	218	12	66	169	94	Cerro Toledo Rhy
792-3	LA 6579	714	486	11903	196	8	58	163	90	Cerro Toledo Rhy
807-1	LA 6579	616	553	12619	227	8	68	179	99	Cerro Toledo Rhy
807-2	LA 6579	417	742	10979	541	13	79	109	181	Grants Ridge-Mt. Taylor
808-1	LA 6579	639	373	11792	159	15	46	161	55	Valles Rhy-Cerro del Medio
808-2	LA 6579	734	545	12587	213	11	64	167	99	Cerro Toledo Rhy
815-1	LA 6579	654	534	12577	220	9	63	174	95	Cerro Toledo Rhy
815-2	LA 6579	610	474	11841	194	8	61	161	97	Cerro Toledo Rhy
835-1	LA 6579	815	645	13633	233	10	69	184	99	Cerro Toledo Rhy
835-2	LA 6579	757	414	10486	154	13	24	68	50	El Rechuelos
835-3	LA 6579	708	595	12869	229	13	71	174	98	Cerro Toledo Rhy
853-1	LA 6579	629	503	12138	213	10	62	175	98	Cerro Toledo Rhy
853-2	LA 6579	581	518	12010	209	10	68	173	92	Cerro Toledo Rhy
853-3	LA 6579	494	465	11911	210	9	60	174	99	Cerro Toledo Rhy
864-1	LA 6579	758	521	12314	211	13	66	172	99	Cerro Toledo Rhy
864-2	LA 6579	718	411	10325	157	12	20	70	46	El Rechuelos
864-3	LA 6579	709	442	10667	161	17	25	68	47	El Rechuelos

1025-1	LA 6579	558	513	12078	210	8	63	175	96	Cerro Toledo Rhy
1028-1	LA 6579	712	384	10094	152	13	22	70	43	El Rechuelos
1028-2	LA 6579	736	476	12790	185	14	43	164	55	Valles Rhy-Cerro del Medio
1028-3	LA 6579	551	503	12138	217	9	66	181	102	Cerro Toledo Rhy
157-1	LA 84927	515	385	9872	136	12	20	69	49	El Rechuelos
157-2	LA 84927	668	394	11922	170	13	44	162	53	Valles Rhy-Cerro del Medio
157-2	LA 84927	515	398	10016	146	13	25	70	48	El Rechuelos
157-3	LA 84927	811	380	10100	144	11	21	67	40	El Rechuelos
157-4	LA 84927	569	382	10048	149	13	25	69	44	El Rechuelos
157-5	LA 84927	628	517	12642	227	9	72	179	100	Cerro Toledo Rhy
157-6	LA 84927	664	389	10049	151	13	22	68	41	El Rechuelos
158-1	LA 84927	621	391	10174	154	15	22	67	46	El Rechuelos
158-2	LA 84927	480	376	10015	148	10	26	68	48	El Rechuelos
158-3	LA 84927	618	386	10129	150	12	22	70	46	El Rechuelos
158-4	LA 84927	481	352	9793	141	14	22	64	46	El Rechuelos
158-5	LA 84927	603	395	10081	152	13	22	70	44	El Rechuelos
158-6	LA 84927	664	440	10361	164	13	23	73	49	El Rechuelos
158-7	LA 84927	546	371	10004	153	12	19	66	51	El Rechuelos
158-8	LA 84927	599	416	10242	161	11	22	71	43	El Rechuelos
158-9	LA 84927	626	401	10204	155	11	23	69	45	El Rechuelos
163-1	LA 84927	595	379	9989	147	14	25	70	47	El Rechuelos
163-10	LA 84927	579	398	10083	154	14	21	68	49	El Rechuelos

163-11	LA 84927	595	395	10120	155	13	23	66	46	El Rechuelos
163-12	LA 84927	647	422	10389	166	12	24	71	49	El Rechuelos
163-13	LA 84927	681	445	10287	167	12	21	69	47	El Rechuelos
163-14	LA 84927	1069	475	10475	165	11	23	71	39	El Rechuelos
163-15	LA 84927	681	525	12505	220	8	64	175	95	Cerro Toledo Rhy
163-16	LA 84927	996	406	10655	147	15	24	68	48	El Rechuelos
163-2	LA 84927	537	366	10003	143	12	22	65	42	El Rechuelos
163-3	LA 84927	619	410	10305	156	14	24	69	46	El Rechuelos
163-4	LA 84927	544	448	11816	193	9	61	169	92	Cerro Toledo Rhy
163-5	LA 84927	651	466	10549	174	14	19	74	45	El Rechuelos
163-6	LA 84927	484	360	11493	149	15	41	159	49	Valles Rhy-Cerro del Medio
163-7	LA 84927	527	468	11880	202	8	63	167	93	Cerro Toledo Rhy
163-8	LA 84927	585	425	10237	158	13	25	69	49	El Rechuelos
163-9	LA 84927	745	396	10115	153	14	22	69	45	El Rechuelos
169-1	LA 84927	916	383	10148	144	13	21	69	45	El Rechuelos
169-10	LA 84927	746	503	10895	178	17	28	71	48	El Rechuelos
169-11	LA 84927	553	401	10076	145	13	24	70	46	El Rechuelos
169-12	LA 84927	628	434	10277	158	15	21	71	48	El Rechuelos
169-13	LA 84927	635	534	12565	215	9	64	174	95	Cerro Toledo Rhy
169-14	LA 84927	677	424	10445	157	14	23	69	44	El Rechuelos
169-15	LA	649	556	12419	217	10	63	174	97	Cerro Toledo Rhy

	84927									
169-16	LA 84927	749	446	10541	166	15	22	77	47	El Rechuelos
169-17	LA 84927	669	413	10334	156	13	25	70	46	El Rechuelos
169-18	LA 84927	670	371	10065	145	14	20	67	47	El Rechuelos
169-2	LA 84927	793	455	12652	169	12	48	170	61	Valles Rhy-Cerro del Medio
169-3	LA 84927	731	406	10351	154	13	24	68	46	El Rechuelos
169-4	LA 84927	555	492	11903	201	8	60	176	97	Cerro Toledo Rhy
169-5	LA 84927	558	554	12595	219	9	68	183	107	Cerro Toledo Rhy
169-6	LA 84927	512	428	11175	184	8	59	162	91	Cerro Toledo Rhy
169-7	LA 84927	797	359	11360	148	14	39	154	49	Valles Rhy-Cerro del Medio
169-8	LA 84927	463	370	9869	144	12	24	65	42	El Rechuelos
169-9	LA 84927	569	329	11241	133	11	41	150	51	Valles Rhy-Cerro del Medio
7-1	LA 111333	792	459	12873	188	14	48	179	54	Valles Rhy-Cerro del Medio
10-1	LA 111333	796	443	10387	163	13	25	74	40	El Rechuelos
14-1	LA 111333	470	453	11752	200	8	65	176	96	Cerro Toledo Rhy
14-2	LA 111333	516	490	12162	204	9	63	174	91	Cerro Toledo Rhy
20-1	LA 111333	612	443	10435	171	15	25	75	49	El Rechuelos
20-2	LA 111333	622	453	10281	163	10	24	71	48	El Rechuelos
24-1	LA 111333	722	472	10511	166	12	24	69	48	El Rechuelos
24-2	LA 111333	653	447	10328	169	13	23	73	50	El Rechuelos
24-3	LA 111333	592	412	10255	157	12	21	72	42	El Rechuelos

24-4	LA 111333	689	498	10673	177	13	26	68	44	El Rechuelos
24-5	LA 111333	738	510	10791	182	11	24	72	47	El Rechuelos
24-6-1	LA 111333	788	451	10786	169	15	20	76	41	El Rechuelos
24-6-2	LA 111333	748	465	10460	167	12	27	67	48	El Rechuelos
24-7	LA 111333	725	434	10365	164	13	24	69	45	El Rechuelos
24-8	LA 111333	988	552	11228	187	10	22	75	47	El Rechuelos
24-9	LA 111333	812	458	10469	170	12	22	69	43	El Rechuelos
150-1	LA 111333	594	376	11619	158	13	48	163	56	Valles Rhy-Cerro del Medio
150-2	LA 111333	983	407	12259	165	14	42	163	50	Valles Rhy-Cerro del Medio
182-1	LA 111333	699	407	12362	175	15	45	179	56	Valles Rhy-Cerro del Medio
182-2	LA 111333	801	469	12853	183	14	46	174	54	Valles Rhy-Cerro del Medio
182-3	LA 111333	1079	506	13464	195	12	47	182	56	Valles Rhy-Cerro del Medio
182-4	LA 111333	670	420	12140	174	12	45	176	55	Valles Rhy-Cerro del Medio
182-5	LA 111333	755	460	12989	192	11	48	182	59	Valles Rhy-Cerro del Medio
182-6	LA 111333	709	436	12420	186	13	51	182	60	Valles Rhy-Cerro del Medio
182-7	LA 111333	600	391	11865	164	12	46	166	56	Valles Rhy-Cerro del Medio
182-8	LA 111333	732	421	12396	178	10	48	168	60	Valles Rhy-Cerro del Medio
182-9	LA 111333	648	419	12143	172	12	45	169	61	Valles Rhy-Cerro del Medio
182-10	LA 111333	630	429	12286	171	14	45	174	54	Valles Rhy-Cerro del Medio
182-11	LA 111333	713	388	12124	168	12	45	168	59	Valles Rhy-Cerro del Medio
182-12	LA	698	404	12075	163	15	45	167	55	Valles Rhy-Cerro del Medio

	111333									
182-13	LA 111333	772	469	12656	185	14	44	179	57	Valles Rhy-Cerro del Medio
182-14	LA 111333	677	464	12465	185	13	46	172	55	Valles Rhy-Cerro del Medio
182-15	LA 111333	732	427	12483	176	13	51	175	60	Valles Rhy-Cerro del Medio
182-16	LA 111333	662	444	12420	175	15	44	165	60	Valles Rhy-Cerro del Medio
182-17	LA 111333	771	461	12854	184	11	51	172	57	Valles Rhy-Cerro del Medio
182-18	LA 111333	755	447	12485	175	14	48	176	60	Valles Rhy-Cerro del Medio
182-19	LA 111333	1029	447	12507	179	13	47	163	58	Valles Rhy-Cerro del Medio
182-20	LA 111333	730	444	12776	188	11	47	179	60	Valles Rhy-Cerro del Medio
182-21	LA 111333	756	443	12527	175	14	47	168	56	Valles Rhy-Cerro del Medio
182-22	LA 111333	645	413	12362	171	15	45	172	55	Valles Rhy-Cerro del Medio
182-23	LA 111333	708	384	12112	165	13	45	177	57	Valles Rhy-Cerro del Medio
182-24	LA 111333	839	444	12581	181	12	48	174	50	Valles Rhy-Cerro del Medio
182-25	LA 111333	728	431	12222	166	12	47	163	53	Valles Rhy-Cerro del Medio
362-1	LA 111333	903	536	13715	205	14	47	178	54	Valles Rhy-Cerro del Medio
362-2	LA 111333	653	434	12191	178	13	46	165	56	Valles Rhy-Cerro del Medio
362-3	LA 111333	869	459	12797	172	12	44	165	55	Valles Rhy-Cerro del Medio
362-4	LA 111333	835	452	12810	175	14	44	164	54	Valles Rhy-Cerro del Medio
362-5	LA 111333	717	426	12309	177	12	43	168	54	Valles Rhy-Cerro del Medio
362-6	LA 111333	748	399	12152	168	13	44	171	53	Valles Rhy-Cerro del Medio
362-7	LA 111333	805	449	12832	186	14	44	182	53	Valles Rhy-Cerro del Medio

362-8	LA 111333	846	452	13045	193	13	46	176	51	Valles Rhy-Cerro del Medio
362-9	LA 111333	1041	520	13765	190	13	46	167	57	Valles Rhy-Cerro del Medio
362-10	LA 111333	902	513	13488	199	16	47	169	54	Valles Rhy-Cerro del Medio
362-11	LA 111333	1162	519	13629	188	14	45	167	57	Valles Rhy-Cerro del Medio
362-12	LA 111333	895	420	12634	178	12	48	167	54	Valles Rhy-Cerro del Medio
362-13	LA 111333	899	502	12834	192	15	44	166	48	Valles Rhy-Cerro del Medio
362-14	LA 111333	976	450	12741	179	14	41	157	49	Valles Rhy-Cerro del Medio
362-15	LA 111333	1202	607	14757	189	16	39	154	47	Valles Rhy-Cerro del Medio
362-16	LA 111333	1403	443	12505	156	12	35	146	42	Valles Rhy-Cerro del Medio
362-17	LA 111333	955	522	13354	184	15	43	159	53	Valles Rhy-Cerro del Medio
367-1	LA 111333	493	480	11780	207	10	63	174	98	Cerro Toledo Rhy
367-2	LA 111333	556	348	11442	156	11	41	161	51	Valles Rhy-Cerro del Medio
368-1	LA 111333	648	400	11852	161	14	42	167	56	Valles Rhy-Cerro del Medio
369-1	LA 111333	623	411	12089	172	12	44	171	59	Valles Rhy-Cerro del Medio
382-1	LA 111333	664	418	12052	171	11	42	164	56	Valles Rhy-Cerro del Medio
382-2	LA 111333	866	497	13297	195	14	48	171	53	Valles Rhy-Cerro del Medio
382-3	LA 111333	743	441	12657	181	9	46	174	57	Valles Rhy-Cerro del Medio
382-4	LA 111333	1288	421	12143	163	13	45	150	49	Valles Rhy-Cerro del Medio
387-1	LA 111333	707	429	12276	177	11	45	169	60	Valles Rhy-Cerro del Medio
392-1	LA 111333	603	395	12034	160	12	47	163	59	Valles Rhy-Cerro del Medio
394-1	LA	507	485	11753	201	9	63	173	99	Cerro Toledo Rhy

	111333									
405-1	LA 111333	681	434	12562	180	15	46	174	55	Valles Rhy-Cerro del Medio
408-1	LA 111333	788	434	12583	175	14	47	160	54	Valles Rhy-Cerro del Medio
408-2	LA 111333	1253	437	12657	172	14	46	158	53	Valles Rhy-Cerro del Medio
412-1	LA 111333	535	334	11275	147	9	40	158	51	Valles Rhy-Cerro del Medio
416-1	LA 111333	605	390	11795	161	13	43	164	54	Valles Rhy-Cerro del Medio
416-2	LA 111333	645	333	10978	145	11	41	146	46	Valles Rhy-Cerro del Medio
416-3	LA 111333	723	392	12081	166	12	42	162	52	Valles Rhy-Cerro del Medio
416-4	LA 111333	534	474	11957	206	8	65	174	95	Cerro Toledo Rhy
426-1	LA 111333	582	394	11714	162	13	42	158	61	Valles Rhy-Cerro del Medio
426-2	LA 111333	752	451	12533	180	13	46	169	55	Valles Rhy-Cerro del Medio
430-1	LA 111333	623	442	10269	165	11	21	75	44	El Rechuelos
430-2	LA 111333	721	425	12208	173	12	41	163	56	Valles Rhy-Cerro del Medio
432-1	LA 111333	556	523	12210	219	11	70	173	100	Cerro Toledo Rhy
434-1	LA 111333	781	449	12740	188	12	46	183	53	Valles Rhy-Cerro del Medio
434-10	LA 111333	690	412	12240	172	13	45	175	57	Valles Rhy-Cerro del Medio
434-11	LA 111333	676	439	12236	168	10	47	167	58	Valles Rhy-Cerro del Medio
434-12	LA 111333	917	492	13238	188	12	50	176	53	Valles Rhy-Cerro del Medio
434-13	LA 111333	744	420	12260	179	12	46	180	61	Valles Rhy-Cerro del Medio
434-14	LA 111333	726	422	12264	179	15	48	174	61	Valles Rhy-Cerro del Medio
434-15	LA 111333	722	435	12303	177	12	46	175	57	Valles Rhy-Cerro del Medio

434-16	LA 111333	695	422	12244	172	12	48	177	61	Valles Rhy-Cerro del Medio
434-17	LA 111333	580	417	12023	170	12	45	169	59	Valles Rhy-Cerro del Medio
434-18	LA 111333	599	410	12117	169	13	46	174	58	Valles Rhy-Cerro del Medio
434-19	LA 111333	669	411	12099	166	11	43	168	56	Valles Rhy-Cerro del Medio
434-2	LA 111333	548	396	11836	166	14	47	167	56	Valles Rhy-Cerro del Medio
434-20	LA 111333	771	432	12344	173	8	49	178	58	Valles Rhy-Cerro del Medio
434-21	LA 111333	740	432	12185	173	9	51	173	58	Valles Rhy-Cerro del Medio
434-22	LA 111333	646	358	11606	163	11	45	170	53	Valles Rhy-Cerro del Medio
434-23	LA 111333	638	418	12066	176	10	44	173	66	Valles Rhy-Cerro del Medio
434-24	LA 111333	750	475	12867	191	12	53	177	58	Valles Rhy-Cerro del Medio
434-25	LA 111333	658	351	11468	157	11	45	163	54	Valles Rhy-Cerro del Medio
434-3	LA 111333	766	446	12438	180	13	48	177	55	Valles Rhy-Cerro del Medio
434-4	LA 111333	585	386	11809	166	14	46	167	52	Valles Rhy-Cerro del Medio
434-5	LA 111333	806	421	12225	170	11	45	167	50	Valles Rhy-Cerro del Medio
434-6	LA 111333	569	361	11428	156	12	42	157	54	Valles Rhy-Cerro del Medio
434-7	LA 111333	741	441	12491	186	11	47	176	57	Valles Rhy-Cerro del Medio
434-8	LA 111333	675	420	12186	169	12	44	171	54	Valles Rhy-Cerro del Medio
434-9	LA 111333	649	417	12416	183	11	45	175	60	Valles Rhy-Cerro del Medio
464-1	LA 111333	493	514	12085	219	9	66	173	97	Cerro Toledo Rhy
464-2	LA 111333	550	398	10094	156	12	23	66	48	El Rechuelos
464-3	LA	640	471	11936	207	8	63	174	101	Cerro Toledo Rhy

	111333									
464-4	LA 111333	565	487	11959	207	10	71	182	104	Cerro Toledo Rhy
473-1	LA 111333	527	523	12349	218	9	63	182	91	Cerro Toledo Rhy
483-1	LA 111333	406	466	11556	191	8	64	161	95	Cerro Toledo Rhy
483-2	LA 111333	608	557	12603	223	9	67	174	98	Cerro Toledo Rhy
483-3	LA 111333	571	491	11818	198	11	61	168	99	Cerro Toledo Rhy
483-4	LA 111333	552	480	11803	206	12	67	175	96	Cerro Toledo Rhy
483-5	LA 111333	605	500	12028	201	11	65	177	94	Cerro Toledo Rhy
483-6	LA 111333	953	444	11473	193	8	60	164	87	Cerro Toledo Rhy
483-7	LA 111333	587	507	12064	211	9	65	174	98	Cerro Toledo Rhy
483-8	LA 111333	554	471	11793	207	8	65	172	100	Cerro Toledo Rhy
535-1	LA 111333	1286	544	10952	180	14	24	72	48	El Rechuelos
535-2	LA 111333	840	502	10670	175	12	21	74	53	El Rechuelos
535-3	LA 111333	596	416	10219	153	14	25	73	43	El Rechuelos
535-4	LA 111333	1103	543	11239	174	13	21	65	45	El Rechuelos
535-5	LA 111333	541	378	10008	151	14	22	69	51	El Rechuelos
535-6	LA 111333	643	416	10324	156	13	24	71	49	El Rechuelos
535-7	LA 111333	921	468	10335	162	14	23	71	43	El Rechuelos
535-8	LA 111333	591	431	10378	162	14	24	73	48	El Rechuelos
535-9	LA 111333	713	457	10549	163	13	20	71	49	El Rechuelos
535-10	LA 111333	675	439	10269	155	13	21	65	46	El Rechuelos

535-11	LA 111333	639	468	10523	171	14	23	73	44	El Rechuelos
535-12	LA 111333	707	358	10268	144	12	21	69	44	El Rechuelos
535-13	LA 111333	718	446	10553	167	12	22	72	46	El Rechuelos
535-14	LA 111333	819	468	10694	165	11	21	69	44	El Rechuelos
535-15	LA 111333	857	423	10347	149	13	21	67	44	El Rechuelos
535-16	LA 111333	629	461	10493	179	13	23	74	47	El Rechuelos
535-17	LA 111333	686	436	10290	163	14	24	83	40	El Rechuelos
535-18	LA 111333	702	475	10612	166	15	25	78	52	El Rechuelos
535-19	LA 111333	912	546	11207	182	14	26	70	46	El Rechuelos
535-20	LA 111333	938	474	10919	168	18	20	71	45	El Rechuelos
535-21	LA 111333	667	498	10759	173	12	22	73	44	El Rechuelos
535-22	LA 111333	878	430	10456	154	11	23	70	42	El Rechuelos
535-23	LA 111333	959	455	10651	163	13	26	71	46	El Rechuelos
535-24	LA 111333	789	452	10506	165	12	20	68	44	El Rechuelos
535-25	LA 111333	835	512	10815	168	14	22	69	49	El Rechuelos
535-26	LA 111333	815	436	10574	155	13	25	68	47	El Rechuelos
535-27	LA 111333	825	499	10929	174	11	24	73	42	El Rechuelos
535-28	LA 111333	905	482	10826	160	12	25	64	43	El Rechuelos
535-29	LA 111333	1003	531	10951	177	12	18	63	41	El Rechuelos
535-30	LA 111333	810	466	10698	168	13	24	73	42	El Rechuelos