Title

MAJOR, MINOR, AND TRACE ELEMENT COMPOSITION OF THE NEWMAN DOME DACITE, TAOS PLATEAU VOLCANIC FIELD, NORTHERN NEW MEXICO: GEOARCHAEOLOGICAL INTERPRETATIONS

Permalink

https://escholarship.org/uc/item/3072234h

Author

Shackley, M. Steven

Publication Date

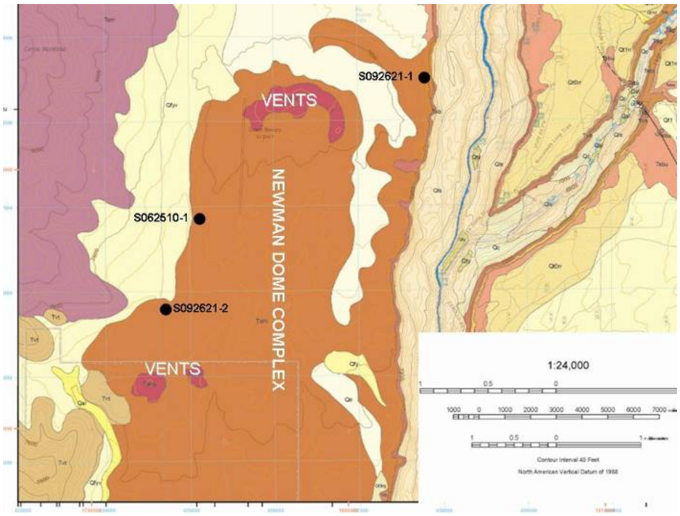
2021-10-04

GEOARCHAEOLOGICAL XRF LAB
A GREEN SOLAR FACILITY

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

MAJOR, MINOR, AND TRACE ELEMENT COMPOSITION OF THE NEWMAN DOME DACITE, TAOS PLATEAU VOLCANIC FIELD, NORTHERN NEW MEXICO: GEOARCHAEOLOGICAL INTERPRETATIONS

DRAFT



Portion of *Geologic Map of the Guadalupe Mountain Quadrangle* (adapted from Kelson et al. 2008) showing the Newman Dome complex and sampling locations for the analysis (see also Shackley 2011a and Figure 1)

by

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

Report Prepared for

Natalie Sanford and Cassandra Keyes
Bureau of Land Management
Taos, New Mexico

4 October 2021

INTRODUCTION

The Newman Dome pyroxene dacite dome complex in the Taos Plateau Volcanic Field is a prominent stone tool raw material that was used for stone tool production for at least 11,000 years throughout northern New Mexico and southern Colorado, and perhaps beyond (Boyer 2010; Newman and Nielsen 1987; Shackley 2011a; Vierra 2010; Figures 1 and 2 herein). The analysis here of 24 source samples is an extension of the earlier study (Shackley 2011a) and indicates that this extensive dacite dome complex is compositionally homogeneous in trace elements at least in the northern and central portion of the dome complex (Tables 1 and 2, Figures 3 and 4).

ANALYSIS AND INSTRUMENTATION

All rock 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 2011b).

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 from 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.

Trace Element Analysis

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 $K\alpha_1$-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), and $L\alpha_1$-line data for 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 2011b). Further details concerning the petrological choice of these elements in Southwest volcanic rocks is available in Shackley (1988, 1995, 2005, 2021; Shackley et al. 2016, 2018; 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).

Major and Minor Oxide Analysis

Analysis of the major oxides of Si, Al, Ca, Fe, K, Mg, Mn, Na, and Ti is performed under the multiple conditions elucidated below. This fundamental parameter analysis (theoretical with standards), while not as accurate as destructive analyses (pressed powder and fusion disks) is usually within a few percent of actual, based on the analysis of USGS RGM-1 obsidian or USGS AGV-1 andesite standard (see also Shackley 2011b). The fundamental parameters (theoretical) method is run under conditions commensurate with the elements of interest and calibrated with 11 USGS standards (RGM-1, rhyolite; AGV-2, andesite; BHVO-1, hawaiite; BIR-1, basalt; G-2, granite; GSP-2, granodiorite; BCR-2, basalt; W-2, diabase; QLO-1, quartz latite; STM-1, syenite), and one Japanese Geological Survey rhyolite standard (JR-1). See Lundblad et al. (2011) for another set of conditions and methods for oxide analyses.

Conditions Of Fundamental Parameter Analysis[1]:

Low Za (Na, Mg, Al, Si, P)

Voltage	6 kV	Current	Auto[2]
Livetime	100 seconds	Counts Limit	0
Filter	No Filter	Atmosphere	Vacuum
Maximum Energy	10 keV	Count Rate	Low

Mid Zb (K, Ca, Ti, V, Cr, Mn, Fe)

Voltage	32 kV	Current	Auto
Livetime	100 seconds	Counts Limit	0
Filter	Pd (0.06 mm)	Atmosphere	Vacuum
Maximum Energy	40 keV	Count Rate	Medium

High Zb (Sn, Sb, Ba, Ag, Cd)

Voltage	50 kV	Current	Auto
Livetime	100 seconds	Counts Limit	0
Filter	Cu (0.559 mm)	Atmosphere	Vacuum
Maximum Energy	40 keV	Count Rate	High

Low Zb (S, Cl, K, Ca)

Voltage	8 kV	Current	Auto
Livetime	100 seconds	Counts Limit	0
Filter	Cellulose (0.06 mm)	Atmosphere	Vacuum
Maximum Energy	10 keV	Count Rate	Low

[1] Multiple conditions designed to ameliorate peak overlap identified with digital filter background removal, least squares empirical peak deconvolution, gross peak intensities and net peak intensities above background.

[2] Current is set automatically based on the mass absorption coefficient.

The data from the WinTrace software were translated directly into Excel for Windows and into SPSS ver. 27 or JMP 12.0.1 for statistical manipulation as appropriate. The USGS standards are analyzed during each sample run of ≤ 19 samples for obsidian artifacts to evaluate machine calibration (Table 1).

DISCUSSION

The field visit to the Newman Dome in the Taos Plateau Volcanic Field (TPVF) on 26 September 2021 was facilitated by the Taos Field Office of the Bureau of Land Management to examine the archaeological use of the source, and to collect additional samples of source rock for further analysis beyond that collected during the reconnaissance in June of 2010 (Shackley 2011a). Additionally, a sample (S092621-1-1) from the interior flow rock on the eastern edge of the dome near the Rio Grande Gorge was extracted for a potential $^{40}Ar/^{39}Ar$ date, but subsequent research revealed that a sample from the northern vent was previously dated by $^{40}Ar/^{39}Ar$ to 4.11±0.13 Ma in 1998 as well as 92 other dates in the TPVF as a MS thesis in geochemistry by Robert Appelt at the New Mexico Institute of Mining and Technology's Geochronology Laboratory (Appelt 1998; see also Kelson et al. 2008; Figures 1 and 2 herein). The name "Newman Dome" is adopted here and was in the 2011 publication since it has been called an "unnamed dome", "Cerro Sin Nombre" and "Unnamed Cerrito East of Montoso (UCEM) in all other publications (Appelt 1998; Kelson et al. 2008; Lipman and Mehnert 1979; McMillan and Dungan 1986; Shackley 2011a; Thompson and McMillan 1992; Zimmerman and Kudo 1979). It was first examined for archaeological consideration by Jay Newman, although he used "Cerro Montoso" even though Montoso is an olivine andesite shield volcano just to the west (Newman and Nielsen 1987; Shackley 2011a; see also Boyer 2010).

Geological Context: The Taos Plateau Volcanic Field

The Taos Plateau Volcanic Field located between the Sangre de Cristo Mountain range to the east and the Tusas Range to the west is the largest and compositionally most variable such field in association with the Rio Grande Rift with over 35 shields and domes in the field covering 7000 km^2 (Kelson et al. 2008; Lipman and Mehnert 1979). Most of the eruptive events from mafic through intermediate to silicic volcanism date between about 4.5 Ma and 2.0 Ma, although some olivine andesite shields are over 5 Ma, such as Cerro Montoso, over one million years older than Newman Dome (5.88±0.88 Ma by $^{40}Ar/^{39}Ar$; Appelt 1998). Because of the tectonic extension of the Rio Grande rift, many of the andesite through rhyolite eruptive events are derived from relatively shallow material in the crust, and particularly for the andesites and dacites, and in concert with the effects of magma mixing, fractionation and magma evolution, the oxide compositions are very similar with alkalis at about the same proportion, but the silica often just on either side of the andesite/dacite line (McMillan and Dungan 1986; Zimmerman and Kudo 1979; see Figure 4 herein). Generally, the volcanic field forms an imperfect concentric pattern about 50 km across with tholeitic shields in the center and increasingly silicic domes toward the edges (i.e. No Agua Peaks rhyolite, and Newman Dome dacite; Lipman and Mehnert 1979:289). With regard to "artifact quality" dacite raw material for stone tool production, Newman and Nielsen characterize the Newman Dome, Cerro Negro Mountain, Ute Mountain, and San Antonio Mountain as the most aphyric and "finest grained" and Tres Orejas Mountain, and Guadalupe Mountain as coarser grained (Newman and Nielsen 1987:263; see Figure 2 herein). None of these sources however have the same composition or are the same age as Newman Dome (Appelt 1998; McMillan and Dungan 1986; Shackley 2011a). In 2012 Robert Dello-Russo, then with the Laboratory of Anthropology, Museum of New Mexico, sent 15 samples from two "quarries" the Oatman Quarry and the La Junta Quarry on the east side of the Rio Grande Gorge. The trace element concentrations (Zn, Rb, Ba) indicate that the La Junta quarry was probably derived from the Newman Dome magma source even though it is located across the Rio Grande Gorge from the Newman Dome vents (about 1 Ma older than the Servilleta basalt), although there is some variability in Zr (Shackley 2012). Signaling the crustal contamination of the upper Rio Grande volcanics, the La Junta quarry dacite is technically an andesite, and the Oatman quarry material a dacite with similar alkali-silica concentrations to Newman Dome (Shackley 2012:15 and Figure 4 herein; see Zimmerman and Kudo 1979).

The Newman Dacite Dome

The Newman Dome as noted above has been variously named (or not named) as noted above. I have named it Newman Dome for Jay Newman's first discussion of the volcanic feature in an archaeological context (Newman and Nielson 1987; Shackley 2011, 2013). He used the term "Cerro Montoso" due the proximity to the andesite shield of that name just to the west of the Newman Dome Complex (see Figures 1 and 2).

For any number of reasons, Newman Dome has been generally ignored by geologists, although Appelt (1998) included a sample from the northern vent in his dating study of the TPVF and most mention in the geological literature is as the Unnamed Cerrito East of Montoso (UCEM). It has been classified as a pyroxene dacite, indeed all the dacites in the field are considered to be pyroxene dacites (see Turner et al. 2018). Thin sectioning and optical petrography will verify this assessment (see thin section image of a San Antonio Mountain sample in Shackley 2011a:1003).

Preliminary sampling of the dacite was on the southwestern margin of the dome complex north of the two southern vents (Locality S062510-1; Figure 1). The composition was homogeneous and similar to the results of the XRF study reported by Newman and Nielsen (1987; see Shackley 2011, 2013; Figures 3 and 4 herein). Furthermore, the recent sampling near the northern vents near where Appelt's date was acquired (S092621-1), as well as south of the earlier collection (S092621-2) indicates that the trace element and alkali-silica composition of the larger dome complex is remarkably similar throughout (Figures 3 and 4). The density of core, debitage, and biface preforms attributable to all time periods is starkly evident on the surface throughout the dome complex, especially near the vents where correspondingly the density of geological dacite is also highest.

In a study of Archaic projectile point raw materials from the Early through Late Archaic, Newman Dome dacite was the most commonly used dacite for projectile point production from at least southern Colorado to the Santa Fe valley, New Mexico (Vierra 2013:156, Figure 9.11; c.f. Keyes 2021). It is not yet clear how much of this dacite was procured from the Taos Plateau source or secondary deposits in Rio Grande Quaternary alluvium (see Shackley 2021). Nevertheless, the quality of the Newman Dome dacite was recognized prehistorically throughout the entire Southwest chronology (Newman and Nielsen 1987; Shackley 2011a, 2013; Vierra 2013).

Newman Dome is certainly a major toolstone resource in the U.S. Southwest particularly in New Mexico and southern Colorado. Whether this volcanic rock raw material is present outside Colorado and New Mexico is yet to be determined, mainly since there have been so few projects investigating dacite raw materials in archaeological contexts anywhere (Boyer 2010; Keyes 2021; Shackley 2011, 2013, 2017, 2019; Vierra 2013).

REFERENCES CITED

Appelt, R.M.
1998 *^{40}Ar/^{39}Ar Geochronology and Volcanic Evolution of the Taos Plateau Volcanic Field, Northern New Mexico and Southern Colorado.* MS thesis, New Mexico Institute of Mining and Technology, Socorro.

Boyer, J.L.
2010 Identifying Volcanic Material Sources in the Taos Valley. In *Threads, Tints, and Edification: Papers in Honor of Glenna Dean.* Papers of the Archaeological Society of New Mexico, Albuquerque, pp. 21-32.

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.

Govindaraju, K.
1994 1994 Compilation of Working Values and Sample Description for 383 Geostandards. *Geostandards Newsletter* 18 (special issue).

Hampel, Joachim H.
1984 Technical Considerations in X-ray Fluorescence Analysis of Obsidian. In *Obsidian Studies in the Great Basin*, edited by R.E. Hughes, pp. 21-25. Contributions of the University of California Archaeological Research Facility 45. Berkeley.

Hildreth, W.
1981 Gradients in Silicic Magma Chambers: Implications for Lithospheric Magmatism. *Journal of Geophysical Research* 86:10153-10192.

Hughes, Richard E., and Robert L. Smith
1993 Archaeology, Geology, and Geochemistry in Obsidian Provenance Studies. *In Scale on Archaeological and Geoscientific Perspectives*, edited by J.K. Stein and A.R. Linse, pp. 79-91. Geological Society of America Special Paper 283.

Kelson, K.I., P.W. Bauer, and R. Thompson
2008 Geologic Map of the Guadalupe Mountain Quadrangle, Taos County, New Mexico. Open-file Digital Geologic Map OF-GM-169. New Mexico Bureau of Geology and Mineral Resources, Socorro, New Mexico.

Keyes, C.
2021 Stemmed Points in the Southwest. In *Current Perspectives on Stemmed and Fluted Technologies in the American Far West*, edited by K. McDonough, J. Pratt, and R. Rosencrance. University of Utah Press, Salt Lake City (in preparation).

Le Maitre, R., Bateman, P., Dudek, A.; Keller, J., Lameyre, J., Le Bas, M.; Sabine, P., Schmid, R., Sorensen, H., Streckeisen, A., Woolley, A., Zanettin, B.
1989 A Classification of Igneous Rocks and Glossary of Terms. *Recommendations of the International Union of Geological Sciences Subcommission on the Systematics of Igneous Rocks*, edited by R.W. Le Maitre. Blackwell, 193 p. Oxford.

Lipman, P.W., and H.H. Mehnert
1979 The Taos Plateau Volcanic Field, Northern Rio Grande Rift, New Mexico. In *Rio Grande Rift: Tectonics and Magmatism*, edited by R.E. Riecker, pp. 289-311. American Geophysical Union, Washington, DC.

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

McCarthy, J.J., and F.H. Schamber
1981 Least-Squares Fit with Digital Filter: A Status Report. In *Energy Dispersive X-ray Spectrometry*, edited by K.F.J. Heinrich, D.E. Newbury, R.L. Myklebust, and C.E. Fiori, pp. 273-296. National Bureau of Standards Special Publication 604, Washington, D.C.

McMillan, N.J., and M.A. Dungan
1986 Magma Mixing as a Petrogenetic Process in the Development of the Taos Plateau Volcanic Field, New Mexico. *Journal of Geophysical Research* 91, B6:6029-6045.

Newman, J.R., and R.L. Nielsen
1987 Initial Notes on the X-ray Fluorescence Characterization of the Rhyodacite Sources of the Taos Plateau, New Mexico. *Archaeometry* 29:262-274.

Schamber, F.H.
1977 A Modification of the Linear Least-Squares Fitting Method which Provides Continuum Suppression. In *X-ray Fluorescence Analysis of Environmental Samples*, edited by T.G. Dzubay, pp. 241-257. Ann Arbor Science Publishers.

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

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

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

2011a Sources of Archaeological Dacite in Northern New Mexico. *Journal of Archaeological Science* 38:1001-1007.

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

2012 An X-Ray Fluorescence Analysis of Major, Minor, and Trace Element Composition of Andesite and Dacite Source Rocks from Northern New Mexico. Report prepared for Robert Dello-Russo, Office of Archaeological Studies, Museum of New Mexico, Santa Fe.

2013 The Geochemistry and Archaeological Petrology of Volcanic Raw Materials in Northern New Mexico: Obsidian and Dacite Sources in Upland and Lowland Contexts. In B.J. Vierra (Ed.), *From Mountain Top to Valley Bottom:Understanding Past Land Use in the Northern Rio Grande Valley, New Mexico*, pp. 17-32. University of Utah Press, Salt Lake City.

2017 Major Oxide, Minor Oxide, and Trace Element Analysis of Andesite and Dacite Artifacts from 5LA1211 and 5LA1416, Southern Colorado. Report prepared for Sara Cullen, Department of Anthropology, University of Colorado, Boulder.

2019 Energy-Dispersive X-Ray Fluorescence (EDXRF) Whole Rock Analysis of Major, Minor and Trace Elements for Archaic Period Artifacts from the Tularosa Basin, Southern New Mexico. Report prepared for Cassandra Keyes, Department of Anthropology, University of New Mexico, Albuquerque

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

Shackley, M.S., L.E. Morgan, and D. Pyle
2018 Elemental, Isotopic, and Geochronological Variability in Mogollon-Datil Volcanic Province Archaeological Obsidian, Southwestern USA: Solving Issues of Inter-Source Discrimination. *Geoarchaeology* 33:486-497.

Thompson, R.A., and N.J. McMillan
1992 *A Geologic Overview and One-Day Field Guide to the Taos Plateau Volcanic Field, Taos County, New Mexico*. Open-File Report 92-528, U.S. Department of Interior, U.S. Geological Survey, Denver, Colorado.

Turner, K.J., R.A. Thompson, M.A. Cosca, R.R. Shroba, C.F. Chan, and L.E. Morgan
2018 Geologic Map of the San Antonio Mountain Area, northern New Mexico and southern Colorado. Scientific Investigations Map 3417, US Geological Survey, Denver, Colorado.

Vierra, B.J.
2013 Archaic Foraging Technology and Land Use in the Northern Rio Grande, New Mexico. In *From Mountain Top to Valley Bottom: Understanding Past Land Use in the Northern Rio Grande Valley, New Mexico*, edited by B.J. Vierra, pp 145-160. University of Utah Press, Salt Lake City.

Zimmerman, C., and A.M. Kudo
1979 Geochemistry of Andesites and Related Rocks, Rio Grande Rift, New Mexico. In *Rio Grande Rift: Tectonics and Magmatism*, edited by R.E. Riecker, pp. 355-381. American Geophysical Union, Washington, DC.

Table 1. Elemental concentrations and source assignments for the source samples, USGS RGM-1 rhyolite standard and AGV-1 andesite standard. All measurements in weight percent (%) or parts per million (ppm) as noted.

SAMPLE	Ga	Rb	Sr	Y	Zr	Nb	Ba	Pb	Th			
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm			
S092621-1-1	15	66	215	26	96	15	481	9	4			
S092621-1-2	18	70	234	22	100	19	485	6	5			
S092621-2-1	18	69	215	23	91	13	416	11	9			
S092621-2-2	16	60	218	22	91	15	380	31	8			
S092621-2-3	19	56	242	22	97	16	479	40	4			
S092621-2-4	20	69	238	22	96	20	501	17	6			
S092621-2-5	20	67	229	27	97	14	481	106	4			
S092621-2-6	17	65	203	22	107	9	543	117	16			
S092621-2-7	18	61	228	26	101	18	526	19	4			
S092621-2-8	19	68	223	19	90	13	423	30	4			
S092621-2-9	19	62	218	21	93	21	450	15	4			
S092621-2-10	17	63	227	25	92	15	427	13	5			
S092621-2-11	19	57	224	17	90	14	404	23	6			
S092621-2-12	18	63	219	23	91	11	473	9	8			
S092621-2-13	18	61	212	17	92	16	439	9	4			
S062510-1-2	20	72	238	22	100	18	465	21	10			
S062510-1-3	18	61	232	22	95	13	426	19	6			
S062510-1-4	15	66	216	20	90	18	456	22	2			
S062510-1-5	18	60	208	18	93	14	422	18	2			
S062510-1-6	20	60	204	17	92	15	464	20	2			
S062510-1-7	17	70	227	20	94	15	438	20	2			
S062510-1-8	19	63	214	22	94	16	484	19	2			
S062510-1-9	18	64	214	19	99	15	433	20	8			
S062510-1-10	18	61	209	18	94	14	510	19	6			
RGM1-S4	16	151	107	23	221	6	810	25	16			
AGV1-S2	19	70	649	14	221	18	1093	26	4			
SAMPLE	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	V2O5	MnO	Fe2O3	∑
	%	%	%	%	%	%	%	%	%	%	%	
S062510-1	3.74	2.34	14.86	63.82	0.00	2.80	4.99	0.83	0.04	0.12	6.36	99.90
S092621-1-1	4.01	1.43	15.39	65.19	0.00	2.86	4.37	0.79	0.04	0.11	5.67	99.86
AGV1-this study	3.83	0.81	16.94	61.86	0.00	3.01	5.25	1.04	0.05	0.10	6.84	99.73
AGV-1 recommended	4.26±0.12	1.53±0.093	17.15±0.34	58.84±0.58	n.r.	2.92±0.37	4.94±0.14	1.05±0.05	n.r.	n.r.	6.77±0.19	

n.r. = not reported

Table 2. Trace element mean and central tendency for Newman Dome source standards. Measurements in parts per million (ppm).

Element	N	Minimum	Maximum	Mean	1 Std. Deviation
Ga	24	15	20	18.1	1.4
Rb	24	56	72	63.9	4.3
Sr	24	203	242	221.0	10.9
Y	24	17	27	21.3	2.9
Zr	24	90	107	94.9	4.3
Nb	24	9	21	15.2	2.7
Ba	24	380	543	458.6	39.8
Pb	24	6	117	26.4	27.4
Th	24	2	16	5.4	3.3

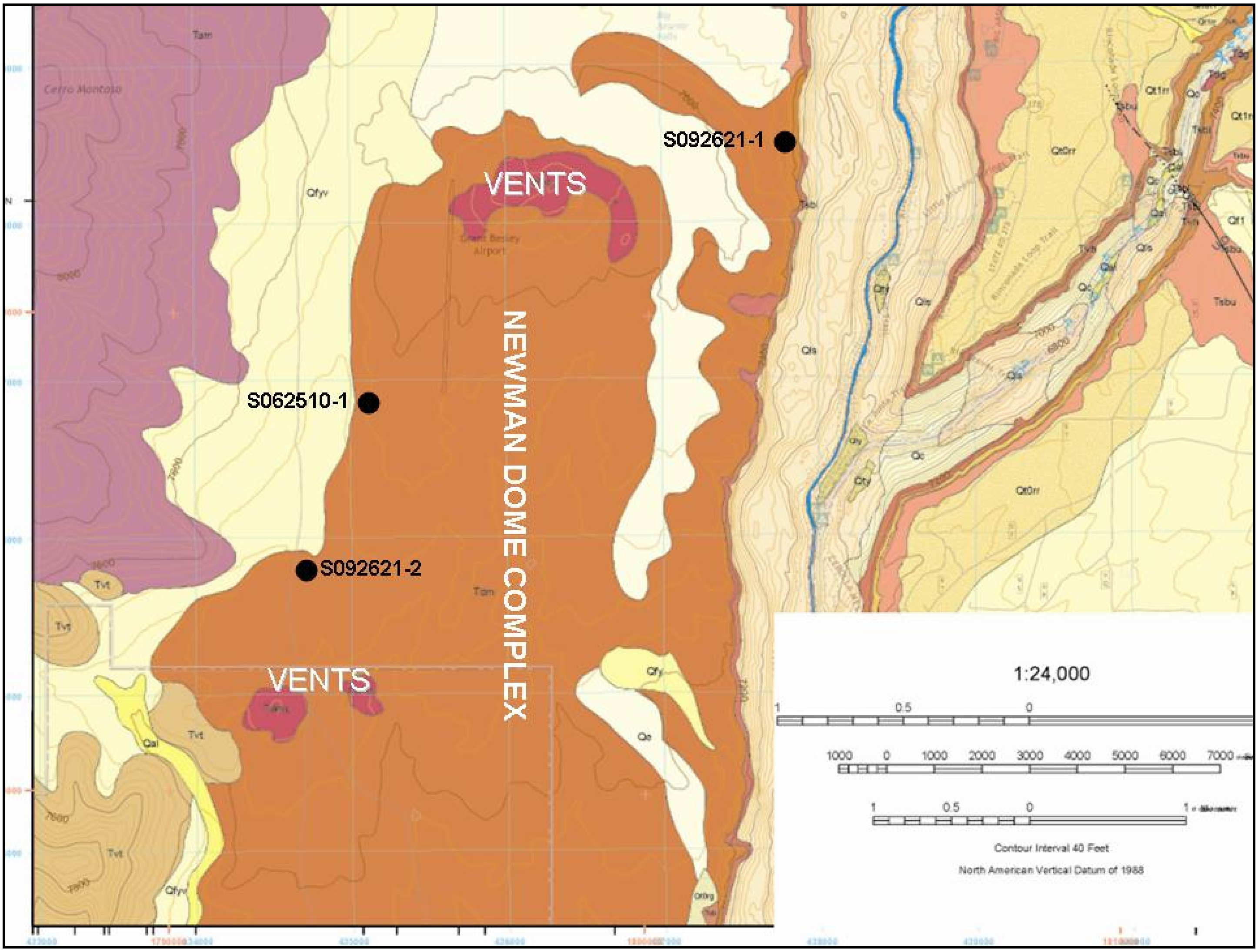


Figure 1. Adapted portion of *Geologic Map of the Guadalupe Mountain Quadrangle* (from Kelson et al. 2008) showing a portion of the Newman Dome complex and sampling locations for the analysis (see also Shackley 2011a)

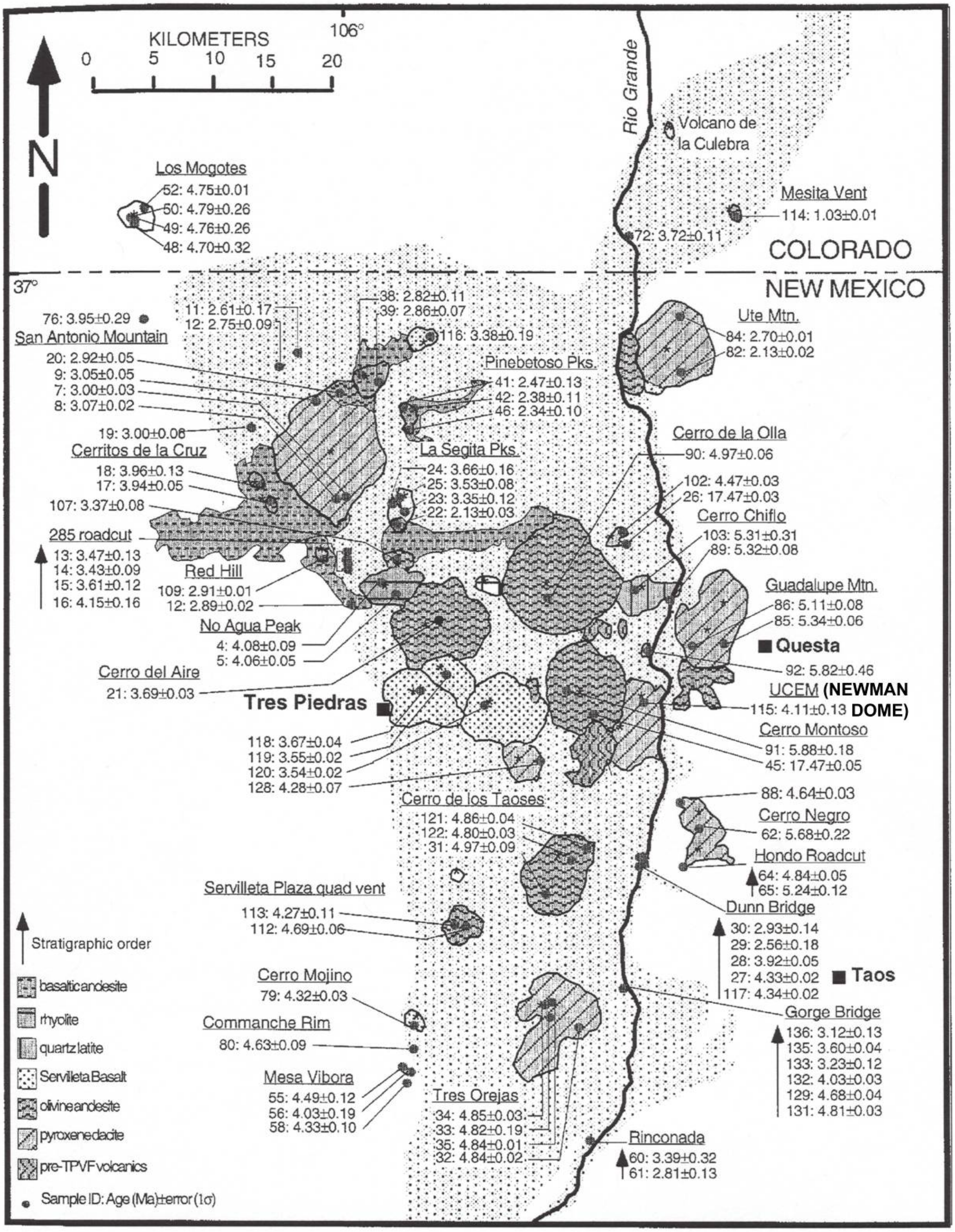


Figure 2. Taos Plateau volcanic field lithologies and dating locations from Appelt's 1998 study (Appelt 1998:10). Newman Dome recorded by Appelt as UCEM (Unnamed Cerrito East of Montoso). Note that all the pyroxene dacite dome complexes exhibit different dates. More recent dates at the San Antonio Mountain dacite dome are contemporaneous with those acquired by Appelt (Turner et al. 2018).

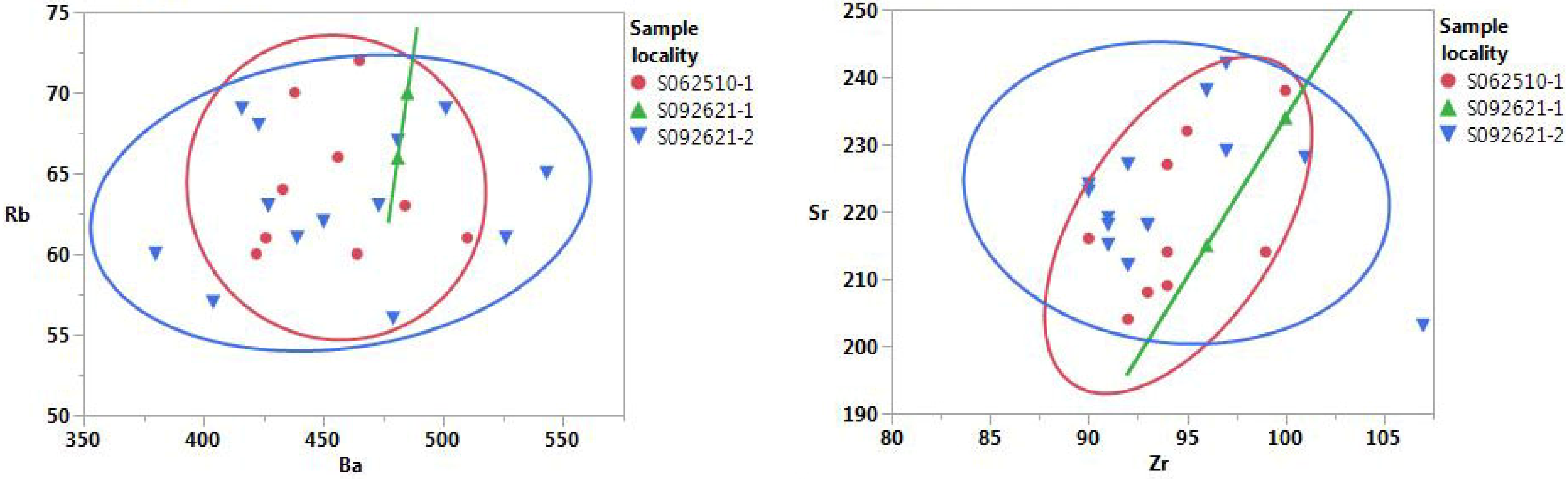


Figure 3. Ba/Rb and Zr/Sr bivariate plots of the source samples from the three localities. Confidence ellipses at 90%.

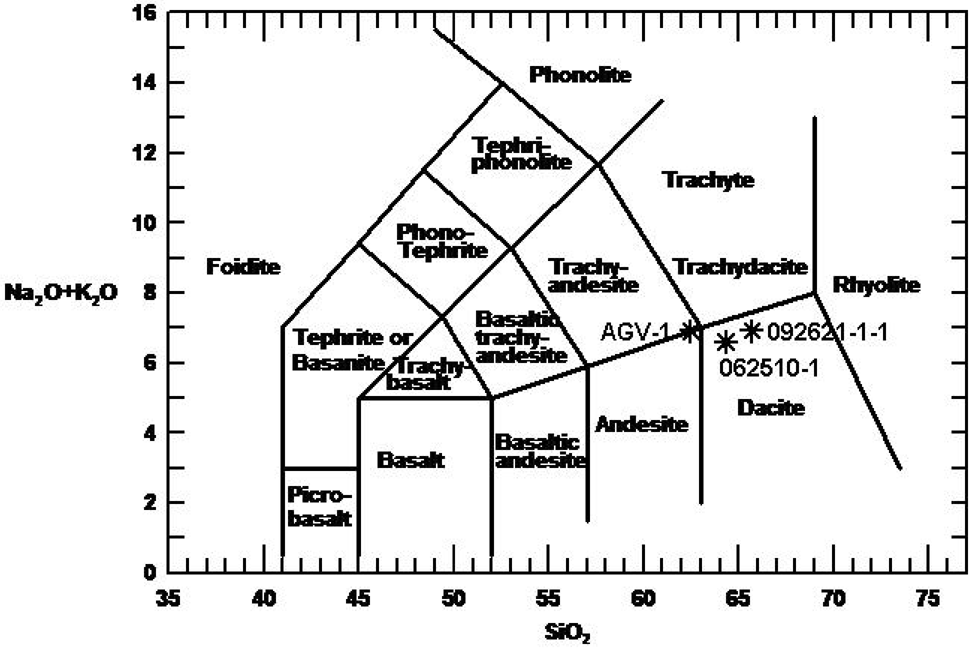


Figure 4. TAS plot of two source standards from the southwest portion (062510-1) and the northeast portion of the dome complex (092621-1-1), and USGS AGV-1 andesite standard from Table 1 (Le Maitre et al. 1989).