CHAPTER 61
SOURCE PROVENANCE OF OBSIDIAN AND BASALT ARTIFACTS FROM THE LAND CONVEYANCE AND TRANSFER PROJECT DATA RECOVERY PROGRAM, LOS ALAMOS NATIONAL LABORATORY

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INTRODUCTION

This study is focused on the source provenance of obsidian artifacts submitted by Los Alamos National Laboratory (LANL) from the Land Conveyance and Transfer Project Data Recovery Program between 2002 and 2005. All obsidian artifacts analyzed were produced from obsidian procured in the Jemez Mountains, Cerro Toledo Rhyolite, Valle Grande Rhyolite, and El Rechuelos. The dacite samples that could be assigned to source were procured from the Cerros del Rio dacite source on Bandelier National Monument or one of the two dacite sources in the Taos Plateau Volcanic Field.

ANALYSIS AND INSTRUMENTAL CONDITIONS

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).

The trace element analyses were performed in the Archaeological XRF Laboratory, Department of Earth and Planetary Sciences, University of California, Berkeley, using a Spectrace/ThermoNoran^{TM} *QuanX* energy dispersive X-ray fluorescence spectrometer. The spectrometer is equipped with an air-cooled Cu X-ray target with a 125-micron Be window, an X-ray generator that operates from 4 to 50 kV/0.02 to 2.0 mA at 0.02 increments, using an IBM PC based microprocessor and WinTraceTM reduction software. The X-ray tube is operated at 30 kV, 0.14 mA, using a 0.05-mm (medium) Pd primary beam filter in an air path at 200 seconds livetime to generate X-ray intensity Kα-line data for elements titanium (Ti), manganese (Mn), iron (as FeT), thorium (Th) using Lα line, rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). Trace element intensities were converted to concentration estimates by employing a least-squares calibration line 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 the high concentrations of iron and thus for all the other elements. Further details concerning the petrological choice of these elements in Southwest

obsidian is available in Shackley (1988, 1990, 1992, 1995; also Mahood and Stimac 1991; and Hughes and Smith 1993). Specific standards used for the best fit regression calibration for elements Ti through Nb include G-2 (basalt), AGV-1 (andesite), GSP-1, SY-2 (syenite), BHVO-1 (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), all USGS standards, BR-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). In addition to the reported values here, Ni, Cu, Zn, and Ga were measured, but these are rarely useful in discriminating glass sources and are not generally reported.

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 is analyzed during each sample run for obsidian artifacts to check machine calibration and is included in Table 10.1. Source assignment was made by comparison to regional source standards at Berkeley (see Shackley 1995, 2002, 2005a).

DISCUSSION

Obsidian Sample

While it is not surprising that the obsidian used to produce these tools and the resultant debitage is from the nearest sources in the Jemez Mountains, the proportion of these sources does deserve some discussion (see Tables 61.1 and 61.2; Figures 61.1 and 61.2). As noted in Chapter 10 (Volume 1), while all the major sources in the Jemez have eroded into the Rio Grande system, Valles Rhyolite (Cerro del Medio), a result of the last caldera collapse, has not eroded outside the caldera (see also Shackley 2005a). The Valles Rhyolite obsidian is the most common in the overall assemblage (56.25%) and was likely procured directly from Cerro del Medio or the erosional slopes into the caldera floor (Figure 61.1). El Rechuelos erodes from the small domes north and west of Polvadera Peak into the Rio Chama and has been found in secondary deposits as far south as the Cochiti Reservoir area in nodules up to about 49 mm in diameter. Cerro Toledo Rhyolite obsidian is available in various areas throughout the Pajarito Plateau as a result of the Rabbit Mountain ash flow eruptive event, including along the Rio Grande at Cerros del Rio (see Chapter 10, Volume 1; Shackley 2005a).

Table 61.1. Elemental concentrations and source assignment for archaeological specimens. All measurements in parts per million (ppm).

Site/Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
127627-93	927	488	5784	153	11	18	72	42	El Rechuelos
127634-19	911	456	5698	151	6	27	69	46	El Rechuelos
127634-8	919	583	9162	201	7	59	173	94	Cerro Toledo Rhy
127634-99	1009	482	9180	166	11	42	172	55	Valles Rhyolite
127635-103	1153	453	9740	168	9	38	179	56	Valles Rhyolite
127635-43	882	466	7547	184	9	56	159	94	Cerro Toledo Rhy

Site/Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
127635-6	932	423	8154	156	10	44	163	55	Valles Rhyolite
128804-224	1468	480	8919	157	7	42	154	53	Valles Rhyolite
128804-230	998	535	8334	181	5	58	156	91	Cerro Toledo Rhy
135290-1018	966	457	9080	160	11	39	161	60	Valle Grande Rhy
135290-1055	967	455	8082	140	11	40	160	55	Valle Grande Rhy
135290-1255	984	445	8525	150	14	36	160	51	Valle Grande Rhy
135290-1293	766	6206	3323	3	17	-3	9	-1	not obsidian
135290-1385	1004	449	8728	152	10	40	168	55	Valle Grande Rhy
135290-1470	846	562	8851	198	6	66	172	106	Cerro Toledo Rhy
135290-2141	947	401	8142	149	10	43	154	56	Valle Grande Rhy
135290-2142	1012	451	8883	156	13	42	156	59	Valle Grande Rhy
135290-2174	1007	425	8902	155	7	42	171	61	Valle Grande Rhy
135290-240	901	443	8548	149	7	43	163	55	Valle Grande Rhy
135290-7004	975	473	9570	154	12	45	167	52	Valle Grande Rhy
135292-20	853	521	8373	178	5	58	155	92	Cerro Toledo Rhy
135292-30	877	485	7914	169	10	55	151	94	Cerro Toledo Rhy
135292-33	950	460	9404	166	13	40	165	55	Valles Rhyolite
135292-39	895	479	5854	146	7	23	67	49	El Rechuelos
135292-63	925	448	8697	152	9	43	152	56	Valles Rhyolite
135292-66	890	594	8551	185	6	61	158	91	Cerro Toledo Rhy
135292-73	803	493	6789	151	5	45	135	85	Cerro Toledo Rhy
135292-89	920	496	5825	143	10	18	75	42	El Rechuelos
139418-104	857	421	8699	148	9	38	164	59	Valle Grande Rhy
139418-109	990	433	9153	161	17	34	164	55	Valle Grande Rhy
139418-111	835	534	8479	190	7	60	167	96	Cerro Toledo Rhy
139418-116	1017	449	9628	150	9	46	166	65	Valle Grande Rhy
139418-146	958	465	9504	159	14	40	171	66	Valle Grande Rhy
139418-149	1157	501	8486	137	11	39	179	61	Valle Grande Rhy
139418-155	703	472	9204	153	0	45	156	54	Valle Grande Rhy
139418-184	975	446	8213	150	13	40	159	54	Valle Grande Rhy
139418-192	916	456	5671	145	11	22	71	52	El Rechuelos
139418-259	964	564	8867	191	14	57	161	91	Cerro Toledo Rhy
139418-26	1029	445	9420	156	14	42	164	55	Valle Grande Rhy
139418-4	903	405	8860	157	8	37	169	47	Valle Grande Rhy
139418-53	829	535	8960	189	6	61	163	101	Cerro Toledo Rhy
4618-236	763	401	8496	146	13	39	166	50	Valle Grande Rhy
4618-250	1066	455	8392	138	11	44	152	42	Valle Grande Rhy
4618-273.07	1283	257	6072	110	7	7	142	33	unknown[1]
4618-326	1008	443	8460	148	11	42	163	56	Valle Grande Rhy
4618-371	1060	418	7761	141	6	42	146	51	Valle Grande Rhy
4618-379	927	386	7701	140	18	37	148	47	Valle Grande Rhy
4618-393-1	830	577	8643	192	10	61	165	103	Cerro Toledo Rhy
4618-393-2	981	394	7548	139	6	40	154	49	Valle Grande Rhy
4618-443	904	451	8270	147	15	46	157	42	Valle Grande Rhy

Site/Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
4618-547	923	523	8053	183	5	53	160	89	Cerro Toledo Rhy
4618-703	1605	277	6647	114	5	35	111	42	unknown
85404-30	1004	474	8743	147	7	51	160	47	Valles Rhyolite
85404-6	946	462	8957	159	8	40	163	59	Valles Rhyolite
85404-79	952	480	8788	152	8	42	167	58	Valles Rhyolite
85407-215	1024	406	8488	149	11	43	162	61	Valles Rhyolite
85407-380	974	544	6098	160	12	25	70	46	El Rechuelos
85407-401	884	496	8539	192	8	67	161	92	Cerro Toledo Rhy
85407-445	859	527	8356	185	5	56	168	97	Cerro Toledo Rhy
85407-451	885	614	8513	186	6	61	162	99	Cerro Toledo Rhy
85407-477	878	611	9082	193	5	59	172	92	Cerro Toledo Rhy
85407-493	897	573	8791	199	11	59	179	98	Cerro Toledo Rhy
85407-501	899	448	8507	149	5	50	157	64	Valles Rhyolite
85407-516	942	669	9618	213	5	64	173	93	Cerro Toledo Rhy
85407-596	1019	560	6096	153	5	12	66	53	El Rechuelos
85408-45	838	508	7711	171	9	53	141	90	Cerro Toledo Rhy
85408-63	863	538	8649	199	5	62	171	107	Cerro Toledo Rhy
85408-78	726	458	7170	160	5	49	133	79	Valles Rhyolite
85411-106	986	670	10128	221	7	72	180	111	Cerro Toledo Rhy
85411-145	1039	596	8918	194	7	65	173	104	Cerro Toledo Rhy
85411-148	831	628	8972	206	5	65	173	109	Cerro Toledo Rhy
85411-163	943	417	8076	141	5	39	157	52	Valles Rhyolite
85411-24	961	432	9027	159	10	43	164	59	Valles Rhyolite
85411-44	976	410	8532	156	7	44	165	51	Valles Rhyolite
85411-6	846	638	9388	209	9	68	170	108	Cerro Toledo Rhy
85411-84	1049	656	10701	222	11	60	191	117	Cerro Toledo Rhy
85411-91	964	499	9208	162	8	46	170	54	Valles Rhyolite
85411-93	1021	432	9185	149	10	39	169	50	Valles Rhyolite
85413-147	897	622	9305	214	6	61	176	109	Cerro Toledo Rhy
85413-151	870	557	8448	184	5	61	163	112	Cerro Toledo Rhy
85413-155	868	586	8891	193	7	57	169	106	Cerro Toledo Rhy
85413-157	994	700	10144	216	5	69	177	110	Cerro Toledo Rhy
85413-49	981	544	8715	197	8	62	172	89	Cerro Toledo Rhy
85413-539	1272	742	12247	217	6	62	184	113	Cerro Toledo Rhy
85413-55	860	589	8132	184	6	64	165	94	Cerro Toledo Rhy
85413-59	1011	604	8970	206	9	62	169	96	Cerro Toledo Rhy
85413-74	802	681	9317	204	5	64	175	104	Cerro Toledo Rhy
85413-91	848	516	8128	187	9	54	159	95	Cerro Toledo Rhy
85414-23	1053	579	8942	193	9	67	169	84	Cerro Toledo Rhy
85414-34	887	469	5729	149	10	23	71	49	El Rechuelos
85414-35	827	545	8531	197	7	63	169	101	Cerro Toledo Rhy
85414-36	945	561	8805	190	6	64	176	91	Cerro Toledo Rhy
85414-55	812	535	7407	164	5	56	142	89	Cerro Toledo Rhy
85859-109	1036	439	9031	150	14	48	162	58	Valle Grande Rhy

Site/Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
85859-118	970	366	8484	142	12	38	157	62	Valle Grande Rhy
85859-144-1	953	441	9119	153	10	42	163	53	Valle Grande Rhy
85859-144-2	877	464	8973	153	16	42	166	52	Valle Grande Rhy
85859-147	844	421	8268	144	10	37	141	49	Valle Grande Rhy
85859-148	903	343	8129	135	7	28	150	44	Valle Grande Rhy
85859-166	964	408	8677	152	12	38	165	58	Valle Grande Rhy
85859-169-1	878	438	8988	148	9	43	165	56	Valle Grande Rhy
85859-169-2	893	458	9036	163	11	42	163	58	Valle Grande Rhy
85859-172	1015	447	9443	157	8	44	170	59	Valle Grande Rhy
85859-235	1001	429	8501	148	12	40	161	54	Valle Grande Rhy
85859-257	992	451	8901	159	7	45	171	54	Valle Grande Rhy
85859-285	908	411	8746	154	9	35	159	62	Valle Grande Rhy
85859-30	1003	424	8957	154	16	43	170	49	Valle Grande Rhy
85859-38	895	433	8988	152	12	42	163	47	Valle Grande Rhy
85859-40	994	472	8990	155	9	42	161	62	Valle Grande Rhy
85861-1	1209	426	8504	142	12	36	159	61	Valles Rhyolite
85861-175	976	450	8762	157	5	42	164	59	Valles Rhyolite
85861-225	959	459	10156	171	9	41	179	70	Valles Rhyolite
85861-3	953	466	9277	163	11	39	173	58	Valles Rhyolite
85861-5	951	371	8311	149	13	37	162	45	Valles Rhyolite
85861-59	928	524	8495	191	7	63	169	101	Cerro Toledo Rhy
85861-78	929	397	8353	150	11	40	160	56	Valles Rhyolite
85861-79	939	573	8726	193	6	62	167	102	Cerro Toledo Rhy
85861-8	928	516	9269	161	6	40	166	63	Valles Rhyolite
85861-87	939	417	8589	153	8	45	164	55	Valles Rhyolite
85867-23	993	669	9609	206	6	63	183	103	Cerro Toledo Rhy
85867-35	846	554	8373	193	8	64	156	100	Cerro Toledo Rhy
85867-39	918	514	8203	197	5	59	176	98	Cerro Toledo Rhy
85869-160	898	427	8512	148	12	38	158	55	Valle Grande Rhy
85869-184	1198	466	9837	149	10	40	172	54	Valle Grande Rhy
85869-202	807	401	8673	136	16	47	149	50	Valle Grande Rhy
85869-265	933	483	8766	160	13	41	167	61	Valle Grande Rhy
85869-266	942	421	8746	154	11	46	156	48	Valle Grande Rhy
85869-267	894	492	8820	154	12	42	157	58	Valle Grande Rhy
85869-277	954	449	8758	148	10	39	162	55	Valle Grande Rhy
85869-322	945	402	8665	147	14	38	143	57	Valle Grande Rhy
85869-324	888	444	8414	151	14	41	164	59	Valle Grande Rhy
85869-75	898	542	8806	190	6	64	177	100	Cerro Toledo Rhy
86605-1	1264	489	8444	146	13	19	70	42	El Rechuelos
86605-27	840	557	8619	204	8	70	164	92	Cerro Toledo Rhy
86605-41	946	363	8354	147	11	41	169	50	Valles Rhyolite
86605-59	1007	452	9028	161	13	41	162	52	Valles Rhyolite
86606-47	1016	394	5938	124	16	48	118	59	Bear Springs Pk
86606-73	797	596	8938	201	5	64	174	101	Cerro Toledo Rhy

Site/Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
87430-107	876	436	8052	146	12	45	161	50	Valles Rhyolite
87430-127	951	422	8781	154	10	37	169	63	Valles Rhyolite
87430-131	984	610	8915	192	7	64	178	93	Cerro Toledo Rhy
87430-145-1	961	464	9537	168	13	50	178	51	Valles Rhyolite
87430-69	918	465	8548	153	10	40	165	53	Valles Rhyolite
99396-117	846	432	8821	152	9	45	158	55	Valle Grande Rhy
99396-126	938	562	8994	198	8	60	166	94	Cerro Toledo Rhy
99396-184	950	565	9533	199	10	62	176	103	Cerro Toledo Rhy
99396-186	971	389	8322	149	13	40	154	55	Valle Grande Rhy
99396-189	981	423	5655	130	13	17	62	47	El Rechuelos
99396-201	843	512	8303	183	6	67	163	101	Cerro Toledo Rhy
99396-229	1100	447	9294	166	14	44	167	44	Valle Grande Rhy
99396-240	955	474	9150	161	17	44	166	58	Valle Grande Rhy
99396-289	1280	467	9417	143	13	35	145	40	Valle Grande Rhy
99396-318	936	460	6132	149	12	24	66	59	El Rechuelos
99396-354	988	558	9753	197	8	58	171	98	Cerro Toledo Rhy
99396-376	938	452	8420	181	8	53	161	92	Cerro Toledo Rhy
99396-385	926	431	5531	147	12	22	66	51	El Rechuelos
99396-397	997	401	9076	150	7	38	163	58	Valle Grande Rhy
99396-402	997	484	7746	161	11	54	143	84	unknown
99396-430	894	439	5650	150	9	18	79	48	El Rechuelos
99396-474	863	579	8589	184	6	57	168	96	Cerro Toledo Rhy
99396-48	814	547	9061	189	8	63	167	86	Cerro Toledo Rhy
99396-501	996	438	8745	151	12	47	161	54	Valle Grande Rhy
99396-54	983	420	9088	156	11	46	170	55	Valle Grande Rhy
99396-546	910	514	5929	146	9	19	67	53	El Rechuelos
99396-568	1140	581	8696	181	7	56	163	102	Cerro Toledo Rhy
99396-695	584	560	8764	198	0	70	165	101	Cerro Toledo Rhy
99396-84	911	373	7708	135	11	37	152	56	Valle Grande Rhy
99397-12	949	451	8623	153	12	42	167	55	Valle Grande Rhy
99397-32	901	399	8480	150	13	36	166	54	Valle Grande Rhy
99397-43	977	442	9361	162	13	42	167	55	Valle Grande Rhy
99397-5	896	440	8932	156	7	47	160	53	Valle Grande Rhy
99397-50	924	417	8579	147	11	32	163	54	Valle Grande Rhy
99397-60	974	461	8987	159	9	43	171	56	Valle Grande Rhy
99397-66	997	444	8863	152	10	44	162	61	Valle Grande Rhy
99397-67	999	448	9141	162	10	40	166	49	Valle Grande Rhy
99397-76	1019	441	8962	154	11	38	169	65	Valle Grande Rhy
99397-77	988	441	9471	160	12	46	163	54	Valle Grande Rhy
RGM1-S1	1658	309	13259	145	112	22	218	8	standard
RGM1-S1	1640	304	13207	152	112	21	217	9	standard
RGM1-S1	1490	318	13355	149	116	20	226	12	standard
RGM1-S1	1532	297	13255	150	112	22	219	11	standard
RGM1-S1	1539	310	13301	149	111	24	217	0	standard

Site/Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
RGM-SI	1731	297	13009	154	109	20	222	14	standard
RGM1-S3	1600	271	13029	150	108	19	225	9	standard
RGM1-S3	1518	321	13447	151	112	22	222	7	standard
RGM1-S3	1541	312	13456	152	113	18	229	11	standard
RGM1-S3	1678	309	13297	153	116	21	223	9	standard
RGM1-S3	1574	359	13303	154	111	19	230	11	standard

[1]It is possible that these relatively small samples are from one of the Jemez Mountains sources, but are outside the elemental concentrations for those sources, or they could be legitimately from, as yet unlocated sources (Davis et al. 1998).

Table 61.2. Cross-tabulation of site by obsidian source provenance.

		Source				Total
		Cerro Toledo	El Rechuelos	Unknown	Valles Rhyolite	
LA 4618	Count	2	0	2	7	11
	% w/in site	18.2	0	18.2	63.6	100
	% w/in source	3.4	0	50.0	7.1	6.3
	% of total	1.1	0	1.1	4.0	6.3
LA 85404	Count	0	0	0	3	3
	% w/in site	0	0	0	100	100
	% w/in source	0	0	0	3.0	1.7
	% of total	0	0	0	1.7	1.7
LA 85407	Count	6	2	0	2	10
	% w/in site	60.0	20.0	0	20.0	100
	% w/in source	10.2	14.3	0	2.0	5.7
	% of total	3.4	1.1	0	1.1	5.7
LA 85408	Count	3	0	0	0	3
	% w/in site	100	0	0	0	100
	% w/in source	16.9	0	0	0	5.7
	% of total	5.7	0	0	0	5.7
LA 85411	Count	5	0	0	5	10
	% w/in site	50.0	0	0	50.0	100
	% w/in source	8.5	0	0	5.1	5.7
	% of total	2.8	0	0	2.8	5.7
LA 85413	Count	10	0	0	0	10
	% w/in site	100.0	0	0	0	100
	% w/in source	16.9	0	0	0	5.7
	% of total	5.7	0	0	0	5.7
LA 85414	Count	4	1	0	0	5
	% w/in site	80.0	20.0	0	0	100
	% w/in source	6.8	7.1	0	0	2.8
	% of total	2.3	0.6	0	0	2.8
LA 85859	Count	0	0	0	16	16

		Source				Total
		Cerro Toledo	El Rechuelos	Unknown	Valles Rhyolite	
	% w/in site	0	0	0	100.0	100
	% w/in source	0	0	0	16.2	9.1
	% of total	0	0	0	9.1	9.1
LA 85861	Count	2	0	0	8	10
	% w/in site	20.0	0	0	80.0	100
	% w/in source	3.4	0	0	8.1	5.7
	% of total	1.1	0	0	4.5	5.7
LA 85867	Count	3	0	0	0	3
	% w/in site	100.0	0	0	0	100
	% w/in source	5.1	0	0	0	1.7
	% of total	1.7	0	0	0	1.7
LA 85869	Count	1	0	0	9	10
	% w/in site	10.0	0	0	90.0	100
	% w/in source	1.7	0	0	9.1	5.7
	% of total	0.6	0	0	5.1	5.7
LA 86605	Count	1	1	0	2	4
	% w/in site	25.0	25.0	0	50.0	100
	% w/in source	1.7	7.1	0	2.0	2.3
	% of total	0.6	0.6	0	1.1	2.3
LA 86606	Count	1	0	1	0	2
	% w/in site	50.0	0	50.0	0	100
	% w/in source	1.7	0	25.0	0	1.1
	% of total	0.6	0	0.6	0	1.1
LA 87430	Count	1	0	0	4	5
	% w/in site	20.0	0	0	80.0	100
	% w/in source	1.7	0	0	4.0	2.8
	% of total	0.6	0	0	2.3	2.8
LA 99396	Count	9	5	1	9	24
	% w/in site	37.5	20.8	4.2	37.5	100
	% w/in source	15.3	35.7	25.0	9.1	13.6
	% of total	5.1	2.8	0.6	5.1	13.6
LA 99397	Count	0	0	0	10	10
	% w/in site	0	0	0	100.0	100
	% w/in source	0	0	0	10.0	5.7
	% of total	0	0	0	5.7	5.7
LA 127627	Count	0	1	0	0	1
	% w/in site	0	100.0	0	0	100
	% w/in source	0	7.1	0	0	0.6
	% of total	0	0.6	0	0	0.6
LA 127634	Count	1	1	0	1	3
	% w/in site	33.3	33.3	0	33.3	100
	% w/in source	1.7	7.1	0	1.0	1.7

		Source				Total
		Cerro Toledo	El Rechuelos	Unknown	Valles Rhyolite	
	% of total	0.6	0.6	0	0.6	1.7
LA 127635	Count	1	0	0	2	3
	% w/in site	33.0	0	0	66.7	100
	% w/in source	1.7	0	0	2.0	1.7
	% of total	0.6	0	0	1.1	1.7
LA 128804	Count	1	0	0	1	2
	% w/in site	50.0	0	0	50.0	100
	% w/in source	1.7	0	0	1.0	1.1
	% of total	0.6	0	0	0.6	1.1
LA 135290	Count	1	0	0	9	10
	% w/in site	10.0	0	0	90.0	100
	% w/in source	1.7	0	0	9.1	5.7
	% of total	0.6	0	0	5.1	5.7
LA 135292	Count	4	2	0	2	8
	% w/in site	50.0	25.0	0	25.0	100
	% w/in source	6.8	14.3	0	2.0	4.5
	% of total	2.4	1.1	0	1.1	4.5
LA 139418	Count	3	1	0	9	13
	% w/in site	23.1	7.7	0	69.2	100
	% w/in source	5.1	7.1	0	91.	7.4
	% of total	1.7	0.6	0	5.1	7.4
TOTAL	Count	59	14	4	99	176
	% w/in site	33.5	8.0	2.3	56.3	100
	% w/in source	100.0	100.0	100.0	100.0	100
	% of total	33.5	8.0	2.3	56.3	100

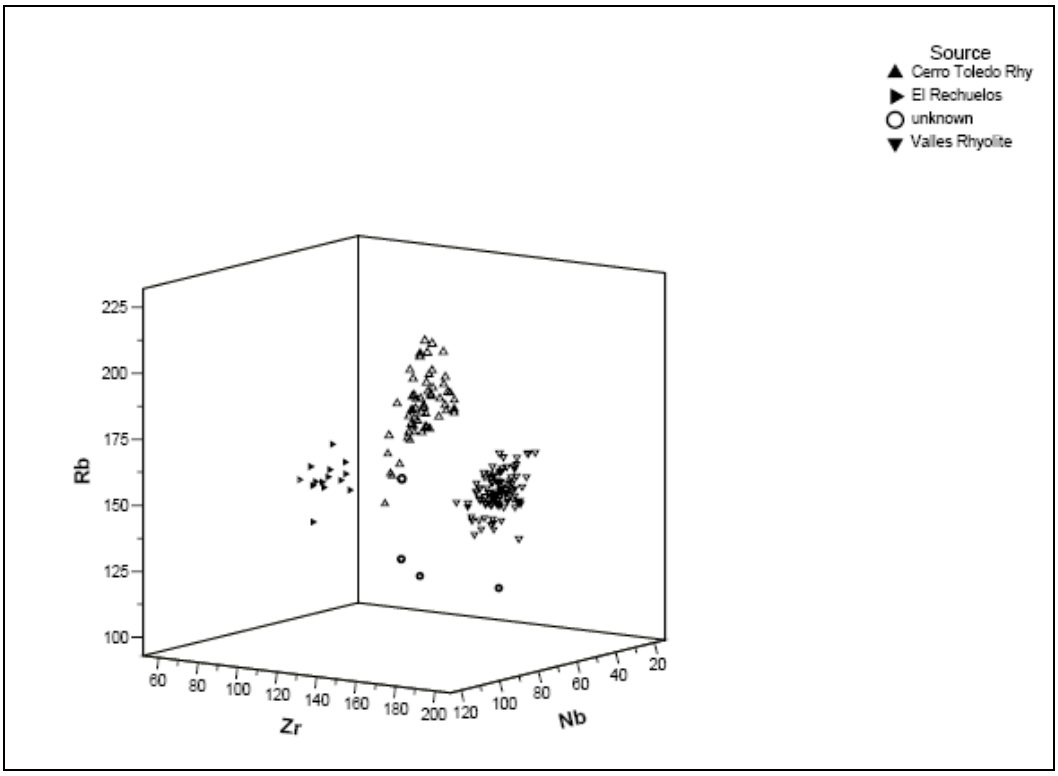

Figure 61.1. Rb, Zr, Nb three-dimensional plot of obsidian source provenance for all sites.

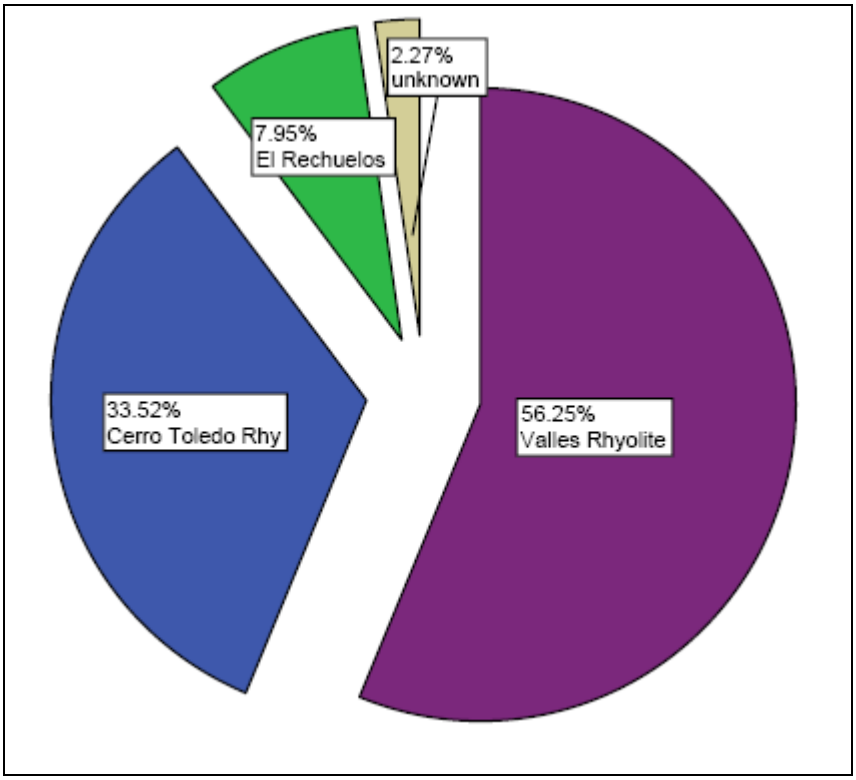

Figure 61.2. Distribution of obsidian source provenance from all sites.

Volcanic Rock Sample

Perhaps more interesting than the obsidian data from a source provenance standpoint, is the volcanic rock artifact sample (Table 61.3). While the artifacts produced from obsidian were produced from local sources, some of the other volcanic raw materials used to produce artifacts came from the Taos Plateau Volcanic Field, specifically San Antonio Mountain and the Newman Dome. It is possible that at least some of these artifacts were scavenged from Archaic period sites on the plateau, where artifacts produced from these sources are common, but it is not clear from this sample (see Shackley 2005b; Vierra et al. 2005). The "unknowns" in this assemblage are probably mafic or intermediate rocks found more locally, such as the mafic rocks in the Cerros de Rio Volcanic Field to the west.

Table 61.3. Elemental concentrations for volcanic rock artifact samples. All measurements in parts per million (ppm).

Site/Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
LA85403-FS44	3312	625	33357	43	867	22	209	11	Cerros del Rio
LA85403-FS30	1065	26010	3920	3	33	3	16	0	unknown
LA85403-FS22	844	16838	4847	3	41	12	21	13	unknown
LA85404-FS58	3790	765	34030	45	857	12	214	15	Cerros del Rio
LA87430-FS145 #2	4092	849	43423	62	208	21	79	26	Newman Dome
LA127627-FS23	3021	863	26547	160	345	26	242	20	unknown
LA127634FS88	3576	704	33983	45	848	21	209	14	Cerros del Rio
LA127635FS47	3375	637	32729	47	861	12	212	20	Cerros del Rio
LA135292FS71	3586	674	36559	59	616	20	253	18	Cerros del Rio
LA85408FS12	683	9537	3310	3	207	0	12	5	unknown
LA85408FS30	777	29577	3863	3	253	3	8	16	unknown
LA85411FS59	3554	728	34370	44	852	21	210	30	Cerros del Rio
LA85411FS158	4846	858	43402	59	235	19	97	12	Newman Dome
LA85414FS18	2518	484	21782	51	591	14	150	13	San Antonio Mtn
LA85861FS97	3648	637	33390	45	864	15	203	30	Cerros del Rio
LA86606FS6	4565	1231	42959	82	737	28	252	7	unknown
LA85867FS20	4244	843	36215	52	797	30	188	15	Cerros del Rio
LA85867FS14	4218	919	33362	46	730	23	165	18	Cerros del Rio
LA85867FS13	3987	516	33814	89	659	19	232	8	unknown
LA135290FS2060	3424	747	34026	49	875	12	216	29	Cerros del Rio
LA135290FS252	3319	645	31963	46	835	16	203	25	Cerros del Rio
LA135290FS224	2132	381	21539	30	623	7	162	19	unknown
LA135290FS1901	3053	585	30447	38	812	17	206	31	Cerros del Rio
LA86605-FS91	3318	581	31014	47	822	22	206	18	Cerros del Rio
LA86605-FS89A	4026	1124	45013	55	612	31	160	4	San Antonio Mtn
LA127634-FS80	4474	224	41483	131	63	34	225	17	unknown