APPENDIX 1
MINES AND PROSPECTS IN THE MONTOYA BUTTE QUADRANGLE

The mines and prospects in Montoya Butte are shown in Figure A1-1 (Fig. 5, McLemore, 2011). Brief descriptions of mines and prospects are in Table A1-1. Descriptions of the Taylor (NMSO0073) and Apache Warm Springs (NMSO0152) deposits are in the chapter on Mineral Resources. Descriptions of the minor prospects are below.

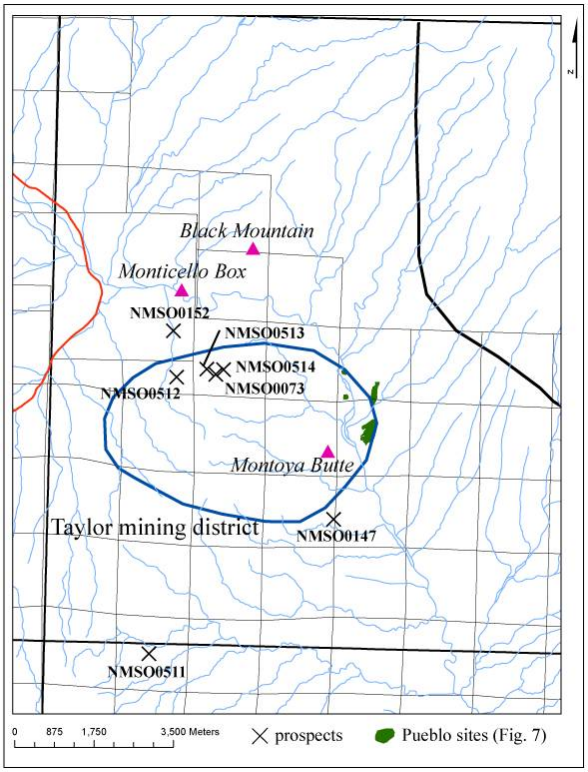


FIGURE A1-1. Mines and prospects in the Montoya Butte quadrangle.

TABLE A1-1. Mines and prospects in the Montoya Butte quadrangle. Mine Id number is from the New Mexico Mines Database (McLemore et al., 2005a, b). UTM is in meters and zone 13, NAD27. Be—beryllium, F—fluorite, Cu—copper, U—uranium, Pb—lead, Zn—zinc, Ag—silver, Bi—bismuth. (NMSO0511 is just south of Montoya Butte quadrangle in the Jaralosa Mountain quadrangle).

Mine Id number	Mine name	Township	Range	Section	Latitude	Longitude	UTM easting	UTM northing
NMSO0152	Apache Warm Springs	9S	7W	6	33.56212	107.59562	259040	3716432
NMSO0073	Taylor	9S	7W	5, 6	33.553674	107.58519	259977	3715471
NMSO0147	Cocar	9S	7W	15, 16	33.525492	107.55638	262583	3712279
NMSO0512	unknown	9S	7W	6	33.55291	107.59451	259117	3715408
NMSO0513	unknown	9S	7W	5	33.554692	107.58737	259785	3715589
NMSO0514	unknown	9S	7W	5	33.554639	107.58342	260152	3715574
NMSO0511	unknown	9S	7W	30	33.4978877	107.599485	258502	3709317

Mine Id number	Commodities	Development	Depth of workings	Geology	Ore Mineralogy
NMSO0152	Be, F	trenches, drilling		fractures and faults in rhyolite	fluorite, bertrandite
NMSO0073	Cu, U, Be, Pb, Zn, Ag, Bi, F	shaft, adit	38 m		pyrite, chalcocite, malachite, azurite
NMSO0147	U, F, Au, Ag, Cu	pit	1 m	quartz vein, N30E dip 80-90° NW, N130°	quartz, pyrite, calcite
NMSO0512	Au, Ag	pit	1 m	quartz vein	pyrite, quartz, Mn oxides
NMSO0513	Au, Ag	pit	1.5 m	1.2 m vein, brecciated	pyrite, quartz, Mn oxides
NMSO0514	Au, Ag, Cu	2 pits	1.2 m	brecciated quartz vein	pyrite, quartz, Cu and Mn oxides
NMSO0511	Ag	pit	1 m	quartz vein, N85°, 15 m long	quartz, calcite, trace pyrite

Description of Mineral Prospects in the Montoya Butte Quadrangle

The Cocar prospect (NMSO0147) consists of a shallow pit, 1 m deep and 6 m wide, exposing part of a brecciated quartz-calcite vein in latite of Montoya Butte that is approximately 3 m wide and 200 m long (Fig. A1-2). The host rock is silicified adjacent to the vein, with minor epidote present. The vein strikes N30°E and dips 80-90°NW. Trace amounts of pyrite, malachite, and fluorite are found in the vein locally.

a) Cocar pit showing trend of vein.

b) Vein filled fractures at Cocar pit.

c) Quartz vein in latite at Cocar.

d) Quartz breccia vein in latite at Cocar.

e) Quartz breccia vein in latite at Cocar.

f) Cocar pit.

g) Quartz vein at Cocar pit.

h) Coarse calcite at Cocar.

FIGURE A1-2. Photographs of the Cocar prospect (NMSO0147).

Prospect NMSO0512 is a small prospect pit (1 m deep) that exposes a quartz vein, approximately 100 m long and less than 1 m wide, southwest of the Taylor mine (Fig. A1-3).

The vein consists of quartz, manganese oxides, and a trace amount of pyrite and fluorite, and cuts the latite of Montoya Butte. The latite adjacent to the vein is altered to quartz, chlorite, and epidote.

FIGURE A1-3. Views of the prospect pit and quartz vein in prospect NMSO0512.

Prospect NMSO0513 is a small prospect pit (1.5 m deep) that exposes a brecciated quartz vein, approximately 100 m long and less than 1 m wide, west of the Taylor mine (Fig. A1-4). The vein consists of quartz, manganese oxides, and a trace amount of pyrite, and cuts the latite of Montoya Butte. The latite adjacent to the vein is altered to quartz, chlorite, and epidote.

FIGURE A1-4. Views of the prospect pit and quartz vein in prospect NMSO0513.

Prospect NMSO0514 is a small prospect pit (1.5 m deep) that exposes the northern part of the Taylor vein (Fig. A1-5). The vein consists of quartz, manganese oxides, malachite, chrysocolla, and a trace amount of pyrite and cuts the latite of Montoya Butte. The latite adjacent to the vein is altered to quartz, chlorite, and epidote.

FIGURE A1-5. View of the prospect pit and quartz vein in prospect NMSO0514.

Prospect NMSO0511 is a small prospect pit (1 m deep) of brecciated quartz vein, south of the Montoya Butte quadrangle, in the Jaralosa Mountain quadrangle (Fig. A1-5). The vein consists of quartz, manganese oxides, malachite, chrysocolla, and a trace amount of pyrite and fluorite, and cuts the andesite of Monticello Canyon. The andesite adjacent to the vein is altered to quartz, chlorite, and epidote.

FIGURE A1-6. Views of the prospect pit and quartz vein in prospect NMSO0511. Green mineral in bottom photographs is malachite.

APPENDIX 2
WATER WELLS AND SPRINGS IN THE MONTOYA BUTTE QUADRANGLE

Water wells and springs in the Montoya Butte quadrangle are in Table A2-1and shown in Figure A2-1. The data used were compiled from the New Mexico State Engineer (which were compiled from driller's records), Myers et al. (1994), and field mapping by the author. Exploration drill holes at the Apache Warm Springs beryllium deposit also contain water level information and are in Appendix 7. In the New Mexico State Engineer data base and Myers et al. (1994), the wells were located by section, township and range and the locations of the wells were not always field checked. More recent wells are located by handheld GPS units in the New Mexico State Engineer data base. The author verified the locations of wells and springs in the Montoya Butte quadrangle. Some problems exist with the literature data. For example, Myers et al. (1994) places the Spring Canyon well (water elevation 6065 ft in his figure 12) south of Alamosa Creek, when actually the well is north of Alamosa Creek and Ojo Caliente spring, which has a water elevation of 6230 ft. Some of the wells in the New Mexico State Engineer's data base are actually locations of stock tanks with no known wells drilled; some local ranchers informed me that they reported their stock tanks as wells in order to protect their water supplies.

The temperature and water level measurements reported by the New Mexico State Engineer and Myers et al. (1994) were made on wells over a period of several decades and these measurements can change during the year with the change in seasons and, certainly can change over decades. The stratigraphic units reported relies on that reported by the drillers (i.e. determination of alluvium verses Datil aquifers), who had limited geologic training and locally in some cases guessed the rock type and/or stratigraphic unit. It is quite possible that some wells in the Alamosa basin reported to be in the Datil aquifer are actually in Permian/Pennsylvanian sediments, especially south of the Montoya Butte quadrangle. Permian/Pennsylvanian sedimentary rocks underlie the volcanic rocks forming the Datil aquifer (Maldonado, 1980; Harrison, 1994; McLemore, 2011) and would be present if the Datil volcanic rocks were absent (see Harrison, 1992, 1994 for regional cross sections in the Winston basin to the south). Although, there are problems with some of the well data, they are the best data available and must be used, but must be used with caution. Currently the Alamosa basin is being examined by the NMBGMR as part of the aquifer mapping project.

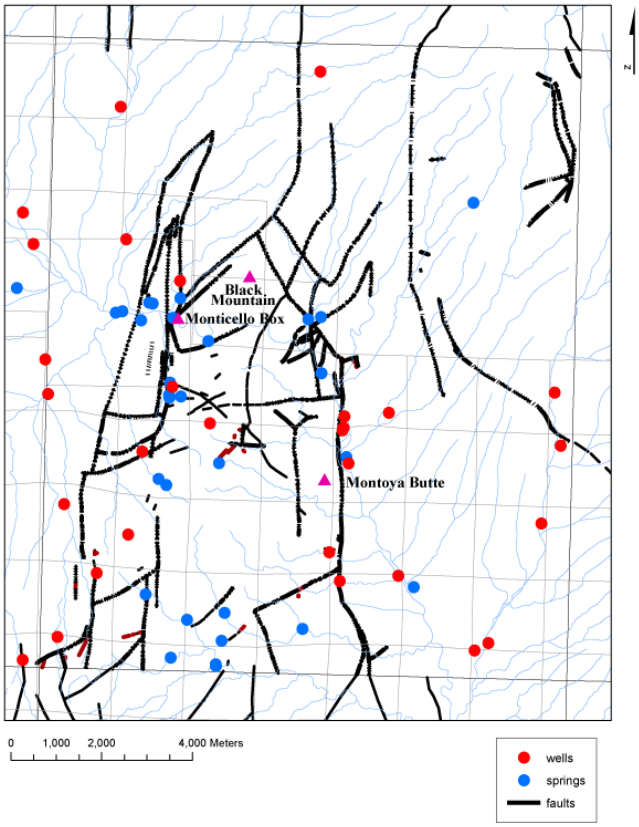


FIGURE A2-1. Location of wells and springs in the Montoya Butte quadrangle.

TABLE A2-1. Water wells and springs in the Montoya Butte quadrangle. UTM is in meters. Elevation is in feet. Units are defined in text.

number	name	type	well number	section	township	range	UTM east	UTM north
8S.7W.23.441	Park Tank spring	spring		23	8S	7W	265753	3719823
8S.7W.31.144	spring	cold spring		31	8S	7W	258610	3717625
8S.7W.31.223a	spring	cold spring		31	8S	7W	258686	3717606
8S.7W.31.241	Ojo Caliente	warm spring		31	8S	7W	259296	3717721
8S.7W.31.311	seep	seep		31	8S	7W	258019	3717433
8S.7W.31.334	spring	spring		31	8S	7W	258427	3717231
8S.7W.32.243	spring	spring		32	8S	7W	259905	3716775
8S.7W.33.412a	Bar A cabin spring	spring		33	8S	7W	262113	3717258
8S.7W.33.412b	Bar A spring	spring		33	8S	7W	262391	3717307
8S.8W.36.411	seep	seep		36	8S	8W	257870	3717401
9S.7W.10.141	seneca seep	seep		10	9S	7W	262951	3714228
9S.7W.23.114	bog (m256)	seep		23	9S	7W	264439	3711367
9S.7W.28.124	Spring	spring		28	9S	7W	260084	3709632
9S.7W.29.142	spring	spring		29	9S	7W	260079	3709667
9S.7W.36.342	spring	spring		36	9S	7W	266203	3707009
9S.7W.6.414	seep	seep		6	9S	7W	259048	3715595
9S.7W.6.423	Alum Spring	acid spring		6	9S	7W	259056	3715541

number	name	type	well number	section	township	range	UTM east	UTM north
9S.7W.8.411	spring	spring		8	9S	7W	260145	3714097
10S.8W.3.242	Pinon spring	spring		3	10S	8W		
8S.6W.11.44	Twentyfive Yard spring	spring		11	8S	6W	275354	3723078
8S.7W.4.232	RG 66464	spring		4	8S	7W	262404	3716070
	spring	spring					259306	3715562
	spring	spring					258815	3713748
	spring	spring					258526	3711209
	spring	spring					259070	3715864
	spring	spring					258985	3713610
	spring	spring					259132	3717284
	Indian Spring	spring					270764	3736130
	Tool Spring	spring					271777	3735429
	Cub Spring	spring					272957	3727917
	spring	spring					275563	3723311
	spring	spring					259306	3715562
	spring	spring					259084	3709814
	spring	spring					260200	3710190
	spring	spring					259439	3710650
	spring	spring					260075	3709641
	spring	spring					260271	3710800
	spring	spring					261984	3710449
7S.8W.33.330		well	RG 26078	33	7S	8W	251874	3727020
8S.8W.3.331		well	RG 73473	3	8S	8W	253301	3725001
9S.7W.10.444	well	well	RG 63931	10	9S	7W	254033	3713546
9S.7W.15.313	well	well		15	9S	7W	262541	3712135
9S.7W.25.111	well	well	RG 77150	25	9S	7W	265734	3709971
9S.7W.3.443	well	well		3	9S	7W	263857	3715198
9S.7W.36.321	well	well	RG 54154	36	9S	7W	266082	3707502
9S.8W.25.121	well	well	RG 57950	25	9S	8W	256549	3710277
8S.7W.16.232	deep well	well		16	8S	7W	262340	3722708
8S.7W.30.313	well	well	484	30	8S	7W	258069	3719016
8S.7W.31.223b	Spring Canyon well	well	483	31	8S	7W	259254	3718102
8S.8W.13.442	headquarters	well		13	8S	8W	257943	3721930
9S.6W.13.244	Steel Windmill	well		13	9S	7W	267217	3712768
9S.6W.6.134	Upper	well		6	9S	6W	267506	3715644
9S.6W.7.114	Eds Windmill	well		7	9S	6W	267636	3714478
9S.7W.10.112a	Montoya	well		10	9S	7W	262854	3714874
9S.7W.10.112b	Maytag	well		10	9S	7W	262831	3714821
9S.7W.10.112c	well	well		10	9S	7W	262854	3714874
9S.7W.10.112d	well	well		10	9S	7W	262831	3714821
9S.7W.10.312	Bennie mill	well		10	9S	7W	262964	3714092

number	name	type	well number	section	township	range	UTM east	UTM north
9S.7W.18.312	Bennie	well		18	9S	7W	258107	3712528
9S.7W.22.114	well	well		22	9S	7W	262770	3711503
9S.7W.24.334	Lower Windmill	well		24	9S	7W	266047	3710143
9S.7W.3.313	well	well		3	9S	7W	262877	3715126
9S.7W.6.412	Alum well	well	SD 05055	6	9S	7W	259085	3715771
9S.7W.6	new well	well		6	9S	7W	257955	3715833
9S.7W.7.144	Allison well	well	RG 77845	7	9S	7W	258419	3714349
9S.7W.8.121	Chavez well	well		8	9S	7W	259905	3714973
9S.8W.1.331	headquarters	well		1	9S	8W	256343	3715613
9S.8W.13.123	Rattlesnake well	well	RG 77838	13	9S	8W	256694	3713198
9S.8W.24.221	McReedy	well		24	9S	8W	257414	3711678

number	elevation	depth	water depth	water elevation	gallons/ minute	Temperature C	unit	comment
8S.7W.23.441	6830	0	0	6830				
8S.7W.31.144	6210	0	0	6210		28	QTs	
8S.7W.31.223a	6220	0	0	6220		27	QTs	
8S.7W.31.241	6230	0	0	6230		27.5	QTs	
8S.7W.31.311	6200	0	0	6200			Qal	
8S.7W.31.334	6210	0	0	6210			Qal	
8S.7W.32.243	6200	0	0	6200			Qal	near old cabin south Box
8S.7W.33.412a	6190	0	0	6190			Td	fault, sustainable
8S.7W.33.412b	6210	0	0	6210			Td	rhyolite lava, sustainable
8S.8W.36.411	6200	0	0	6200				
9S.7W.10.141	5970	0	0	5970				
9S.7W.23.114	5810	0	0	5810				water in bog
9S.7W.28.124	6360	0	0	6360				sustainable
9S.7W.29.142	6380	0	0	6380				
9S.7W.36.342	5670	0	0	5670				salt grass
9S.7W.6.414	6380	0	0	6380				
9S.7W.6.423	6416	0	0	6416	0.25	16	Td-Tas	
9S.7W.8.411	6800	0	0	6800				
10S.8W.3.242	7520			7520				
8S.6W.11.44	8630	0	0	8630			Td	
8S.7W.4.232	6120	0	0	6120			Td	elev changed using topo
	6440	0	0	6440			Td-latite	
	6640	0	0	6640			Td-latite	
	6680	0	0	6680			Td-latite	
	6360	0	0	6360			Td-latite	
	6680	0	0	6680			Td-latite	
	6190	0	0	6190			Qal	
	7590			7590				

number	elevation	depth	water depth	water elevation	gallons/ minute	Temperature C	unit	comment
	7540			7540				
	9840			9840				
	8640			8640				
7S.8W.33.330	6620	140	30	6590				
8S.8W.3.331	6500	360	280	6220				
9S.7W.10.444	6520	200	23	6497				
9S.7W.15.313	6190	10	10	6180			Td	
9S.7W.25.111	6080							
9S.7W.3.443	6090							dry hole
9S.7W.36.321	5853	42	20	5833				
9S.8W.25.121	7000	500						
8S.7W.16.232	7035	780	758	6277	3		Td	
8S.7W.30.313	6336	90	82	6254	3	17	Qal	
8S.7W.31.223b	6155	90	89.7	6065			Qal	
8S.8W.13.442	6525	270						
9S.6W.13.244	6045	60						sand up at 60 ft, can dry up
9S.6W.6.134	6280	50	50	6230	7		Qal	continuous
9S.6W.7.114	6190	200	140	6050				can dry up
9S.7W.10.112a	5990	170		5990				
9S.7W.10.112b	5990	150		5990				
9S.7W.10.112c	5990			5990				west Montoya, water
9S.7W.10.112d	5990			5990				
9S.7W.10.312	6720	190	62.7	6657				
9S.7W.18.312	6720	190	63	6657	2	18	Qu	
9S.7W.22.114	6110						Td	
9S.7W.24.334	5840	60						dry, will produce in wet season
9S.7W.3.313	5990							north Denny house, water
9S.7W.6.412	6390		29.2	6361			Qal	
9S.7W.6	6360						Qal	
9S.7W.7.144	6550	80	20	6529	1	19	Qal	
9S.7W.8.121	6717	190	44	6673			Qal	
9S.8W.1.331	6310	120	48.7	6261			Qal	Myers et al. (1995)
9S.8W.13.123	6620	336	243.22	6377		17	Td	
9S.8W.24.221	6797		61	6736			Qal	

number	reference	field	geologic control
8S.7W.23.441		5/3/2007	lithologic

number	reference	field	geologic control
8S.7W.31.144		5/23/2008	fault
8S.7W.31.223a	Roybal (1991, no. 482)	5/23/2008	fault
8S.7W.31.241		10/13/2007	fault
8S.7W.31.311	field (5/23/08)	5/23/2008	
8S.7W.31.334		6/17/2008	fault
8S.7W.32.243	Randy Furr (5/14/08)	5/14/2008	
8S.7W.33.412a	Randy Furr (5/14/08)	5/14/2008	
8S.7W.33.412b	Randy Furr (5/14/08)	5/14/2008	
8S.8W.36.411	field (5/23/08)	5/23/2008	
9S.7W.10.141	Randy Furr (5/14/08)	5/14/2008	5/14/08, no. 254
9S.7W.23.114	Randy Furr (5/14/08)	5/14/2008	
9S.7W.28.124	Randy Coil (5/22/08)	5/22/2008	
9S.7W.29.142			
9S.7W.36.342	Randy Furr (5/14/08)	5/14/2008	
9S.7W.6.414		12/30/2008	fault
9S.7W.6.423	Roybal (1991, no. 521)	12/30/2008	fault
9S.7W.8.411	Randy Furr		
10S.8W.3.242	Myers et al. (1994)		
8S.6W.11.44	WATERS	topo	
8S.7W.4.232	WATERS	topo	
	field (4/17/09, 426)	4/17/2009	
	field (6/8/09, 500)	6/8/2009	
	field (4/30/09, 66)	4/30/2009	
	field (6/3/09, 485)	6/3/2009	
	field (6/9/09)	6/9/2009	
	topo		
	topo		
	topo		
	topo		
	field (4/17/09)	4/17/2009	dike
	field (6/11/09, 512)	6/11/2009	
	field (9/1/09, 530)	9/1/2009	
	field (9/1/09, 536)	9/1/2009	
	field (9/1/09, 537)	9/1/2009	
	field (9/5/09, 561)	9/5/2009	
	field (9/5/09, 566)	9/5/2009	
7S.8W.33.330	WATERS		
8S.8W.3.331	WATERS		
9S.7W.10.444	NMSE WATERS		
9S.7W.15.313		6/18/2008	fault
9S.7W.25.111	NMSE WATERS		
9S.7W.3.443			
9S.7W.36.321	NMSE WATERS		
9S.8W.25.121	NMSE WATERS		
8S.7W.16.232	Roybal (1991, no. 485), Myers et al. (1994)		
8S.7W.30.313	Roybal (1991, no. 484), Myers et al. (1994)		probably fault

number	reference	field	geologic control
8S.7W.31.223b	Roybal (1991, no. 483), Myers et al. (1994)	10/24/2007	fault
8S.8W.13.442	Myers et al. (1994)		
9S.6W.13.244	Randy Coil (5/22/08)	5/22/2008	Qt
9S.6W.6.134	Randy Coil (5/22/08), Myers et al. (1995)	5/22/2008	fractures
9S.6W.7.114	Randy Coil (5/22/08)	5/22/2008	possible fault in Qt
9S.7W.10.112a	Randy Furr (5/14/08)	5/14/2008	
9S.7W.10.112b	Randy Furr (5/14/08)	5/14/2008	
9S.7W.10.112c	Randy Furr (5/14/08)	5/14/2008	
9S.7W.10.112d	Randy Furr (5/14/08)	5/14/2008	
9S.7W.10.312			
9S.7W.18.312	Roybal (1991, no. 518)		latite foliation
9S.7W.22.114		6/20/2008	fault
9S.7W.24.334	Randy Coil (5/22/08)	5/22/2008	
9S.7W.3.313	Randy Furr (5/14/08)	5/14/2008	
9S.7W.6.412			fault
9S.7W.6	well found in field		
9S.7W.7.144	Roybal (1991, no. 520), NMSE WATERS		latite foliation
9S.7W.8.121	Randy Furr (5/14/08), Myer et al. (1995)	5/14/2008	
9S.8W.1.331			
9S.8W.13.123	Roybal (1991, no. 514)		Qt
9S.8W.24.221	Myers et al. (1994)		

APPENDIX 3
GEOCHEMICAL ANALYSES OF SAMPLES COLLECTED FROM THE MONTOYA BUTTE QUADRANGLE AND ADJACENT AREAS

Selected samples collected for this project were analyzed for major and trace elements by X-ray fluorescence (XRF) at the Washington State University; selected samples were analyzed for Be, Li, and U by induced coupled plasma spectroscopy (ICP) at the NMBGMR chemistry laboratory (see Appendix 8). Laboratory methods and analytical precision are described in McLemore and Frey (2009) and Johnson et al. (1999). Location of samples is in Figure A3-1.

TABLE A3-1. Location and description of samples from the Montoya Butte quadrangle. UTM is in meters and zone 13, NAD27.

Field identification number	Sample description	UTM easting	UTM northing	Date collected
MONT-1-05	gray dike Tl	262252	3714984	6/6/2005
MONT-2-05	latite Tpl	262252	3714984	6/6/2005
MONT-3-05	andesite dike Tmb	262016	3715160	6/6/2005
MONT-4-05	gray latite Tpl	261111	3715481	6/6/2005
MONT-5-05	altered rock Tas	261111	3715481	6/6/2005
MONT-6-05	dump	263399	3713238	6/6/2005
MONT-7-05	latite Tpl	262728	3715406	6/7/2005
MONT-8-05	red clay, fault gauge Tas	259194	3717327	9/4/2005
MONT-9-05	andesite Tmb	259193	3717275	9/4/2005
MONT-10-05	quartz latite dike Tql	261226	3717225	9/4/2005
MONT-11-05	andesite dike Tmb	261910	3716750	9/4/2005
MONT-12-05	rhyolite Tas	262750	3714476	9/4/2005
MONT-13-05	latite Tpl	271373	3708508	9/24/1995
MONT-15-05	quartz latite dike Tql	262539	3713385	10/14/2005
MONT-17-05	latite Tpl	262485	3713699	10/14/2005
MONT-19-05	rhyolite Tac	262170	3717253	10/15/2005
MONT-20-05	black, top soil Qt	263202	3714256	10/16/2005
MONT-21-05	brown soil Qt	263202	3714256	10/16/2005
MONT-22-05	gray floodplain soil Qa	263718	3712496	10/16/2005
MONT-24-05	andesite Tmb	259855	3717613	11/10/2005
MONT-25-05	ash flow tuff, unwelded Tac	259654	3717814	11/10/2005
MONT-26-05	latite Tpl	260526	3716209	11/15/2005
MONT-27-05	granite Tgr	260210	3715819	11/15/2005
MONT-29-05	rhyolite Tac	266035	3710085	11/19/2005
MONT-30-05	rhyolite Tac	266406	3706317	11/19/2005
MONT-31-05	altered tuff Tas	259847	3716664	11/20/2005
MONT-32-05	altered tuff Tstc	259847	3716664	11/20/2005
MONT-33-05	1 inch stockwork quartz-pyrite vein	259016	3716002	11/20/2005
MONT-34-05	andesite dike Tmb	259076	3715884	11/20/2005
MONT-35-05	red clay Tas	259039	3716465	11/20/2005
MONT-36-05	gossan Tas	259078	3716522	11/20/2005
MONT-37-05	rhyolite Tstc	259001	3716741	11/20/2005
MONT-38-05	andesite dike Tmb	261112	3717538	11/21/2005
MONT-39-05	rhyolite Tac	261105	3717853	11/21/2005

Field identification number	Sample description	UTM easting	UTM northing	Date collected
MONT-40-05	rhyolite Tvp	260534	3717724	11/21/2005
MONT-41-05	rhyolite Tvp	260525	3717740	11/21/2005
MONT-42-05	andesite dike Tmb	261990	3717485	11/22/2005
MONT-43-05	rhyolite Tvp	267598	3715011	12/28/2005
MONT-44-05	crusts from seep Tas	259002	3715582	12/30/2005
MONT-45-05	ferricrete Tas	259002	3715582	12/30/2005
MONT-46-05	altered tuff Tas	259002	3715582	12/30/2005
MONT-47-05	latite Tpl	258799	3715150	12/30/2005
MONT-48-05	ash flow tuff, welded Tt	260312	3719795	12/30/2005
MONT-49-06	rhyolite Tac	265958	3710294	1/11/2006
MONT-50-06	granite Til	268002	3717304	4/18/2006
MONT-51-06	granite Til	267939	3720932	4/18/2006
MONT-52-06	basalt QTb	264850	3711538	5/31/2006
MONT-53-06	rhyolite Tac	267620	3720028	6/1/2006
MONT-54-06	soil Q	262689	3715868	6/3/2006
MONT-55-06	soil Q	261171	3717271	6/3/2006
MONT-57-06	soil Q	263729	3712510	6/3/2006
MONT-58-06	quartz latite Tpl	265106	3715686	6/21/2006
MONT-59-06	rhyolite Tvp	265962	3717315	6/21/2006
MONT-60-07	red clay Tas	259222	3716411	4/20/2007
MONT-61-07	white clay Tas	259222	3716411	4/20/2007
MONT-62-07	soil Tas	259222	3716411	4/20/2007
MONT-63-07	virtophyre Tac	264720	3719741	6/2/2007
MONT-65-07	virtophyre Tac	263332	3716917	6/2/2007
MONT-66-07	rhyolite dike Tr	263151	3717003	6/2/2007
MONT-67-07	sand below clay Qa	262857	3715561	6/4/2007
MONT-68-07	clay above sand Qa	262857	3715561	6/4/2007
MONT-69-07	clay Qt	263121	3714778	6/4/2007
MONT-70-07	latite Tpl	281153	3700265	6/18/2007
MONT-71-07	rhyolite Tac	262897	3717953	6/20/2007
MONT-72-07	lava Tt	261952	3719252	6/21/2007
MONT-74-07	select of thin vein of white/brown clay	263141	3714038	10/13/2007
DIC5	monzonite Tgr	260196	3691012	
ARAGON2	rhyolite Tr	278959	3702495	
VIN 5	monzonite Tgr			

TABLE A3-2. Major oxides (in %) and trace elements (in ppm) of whole-rock samples from the Montoya Butte quadrangle. Locations are in Table A3-1. * Total Fe reported as FeO.

	MONT 1	MONT 2	MONT 3	MONT 4	MONT 5	MONT 6	MONT 7	MONT 8	MONT 9	MONT 10	MONT 11	MONT 12
	Tl	Tpl	Tmb	Tpl	Tas	dump	Tpl	Tas	Tmb	Tql	Tmb	Tas
SiO_2	66.82	72.54	53.10	63.90	73.13	38.23	68.87	68.54	63.49	67.18	54.19	71.20
TiO_2	0.539	0.313	1.258	0.686	0.308	0.026	0.435	0.194	0.693	0.428	1.167	0.350
Al_2O_3	15.51	14.10	16.15	16.08	9.13	1.21	14.02	13.20	16.14	13.62	16.50	14.63
FeO*	2.66	1.60	7.53	3.98	0.34	4.91	2.32	1.05	3.66	2.29	6.53	1.69
MnO	0.069	0.077	0.157	0.098	0.001	0.184	0.092	0.064	0.082	0.047	0.099	0.082

	MONT 1	MONT 2	MONT 3	MONT 4	MONT 5	MONT 6	MONT 7	MONT 8	MONT 9	MONT 10	MONT 11	MONT 12
MgO	0.95	0.47	3.56	1.62	0.00	0.18	0.73	1.27	1.71	1.13	4.62	0.48
CaO	1.50	0.51	4.87	1.98	0.17	0.15	1.81	1.09	2.86	3.15	5.82	0.69
Na_2O	3.75	3.29	2.77	4.06	0.65	0.08	2.62	2.87	3.81	2.56	3.44	4.47
K_2O	4.96	5.00	3.34	3.97	1.35	0.14	4.13	3.55	3.61	3.70	3.29	4.94
P_2O_5	0.179	0.088	0.338	0.254	0.147	0.031	0.138	0.028	0.243	0.188	0.442	0.102
SO_3	0.03	0.02	0.02	0.01	3.17	2.12	0.03	0.03	0.00	0.03	0.04	0.00
Cl								0.06	0.01	0.00	0.01	0.00
LOI	2.53	1.73	6.11	2.98	10.39	5.82	4.01	7.42	3.27	4.57	3.29	0.95
Total	99.50	99.73	99.21	99.60	98.79	53.09	99.21	99.37	99.59	98.89	99.44	99.59
Ni	bd	bd	4	bd	bd	50	bd	5	7	9	47	7
Cr	1.5	1.5	0.9	2.5	4.0	bd	1.5	0.7	3.8	3.7	73.6	1.2
Sc	8	5	17	9	5	1	6	3	9	5	15	6
V	43	10	170	66	31	19	27	6	66	35	152	18
Ba	1610	1374	645	1137	735	70	814	280	1080	862	1409	1077
Rb	165	171	140	140	3	112	154	173	117	135	108	185
Sr	265	165	284	291	243	35	111	70	359	320	1189	213
Zr	248	239	171	256	130	0	230	216	255	186	190	253
Y	38	38	30	36	12	0	35	49	34	17	19	35
Nb	12.5	13.2	7.0	11.1	6.7	0.0	11.0	32.8	12.3	12.3	8.2	14.2
Ga	16	13	16	18	10	0	15	20	18	21	22	17
Cu	2	1	18	0	0	9903	9	3	7	10	27	4
Zn	53	40	73	68	3	16539	58	65	66	45	88	43
Pb	27	20	12	19	98	129011	122	28	16	18	12	20
La	39	39	29	39	29	25	41	47	37	44	41	42
Ce	85	87	57	77	55	1536	81	84	80	77	82	84
Th	13	15	3	11	10	68	13	23	11	18	4	16
Nd	37	37	28	36	24	21	35	41	34	30	41	35
U	5	5	1	4	2	bd	4	4	3	5	bd	2
Bi	bd	bd	bd	bd	bd	41.6	bd					
Cs	2.9	5.1	7.7	1.4	0.2	bd	2.3					
Be						0.2		3.9				

	MONT 13	MONT 15	MONT 17	MONT 19	MONT 20	MONT 21	MONT 22	MONT 24	MONT 25	MONT22	MONT 24	MONT2 5
	Tpl	Tql	Tpl	Tac	Qt	Qt	Qa	Tmb	Tac	Qa	Tmb	Tac
SiO_2	50.25	60.56	62.69	76.53	70.34	70.22	62.41	59.88	70.82	62.41	59.88	70.82
TiO_2	0.932	0.825	0.632	0.210	0.498	0.493	0.528	0.840	0.380	0.528	0.840	0.380
Al_2O_3	15.26	16.46	16.39	11.24	13.84	12.62	12.94	16.63	15.60	12.94	16.63	15.60
FeO*	4.81	4.87	3.56	1.42	2.48	2.34	4.01	5.09	1.81	4.01	5.09	1.81
MnO	0.139	0.171	0.092	0.079	0.073	0.078	0.243	0.086	0.060	0.243	0.086	0.060
MgO	3.38	1.10	1.52	0.32	0.56	0.46	1.44	1.69	0.30	1.44	1.69	0.30
CaO	8.64	4.64	2.70	0.20	1.27	1.50	2.35	4.76	1.09	2.35	4.76	1.09
Na_2O	3.83	3.54	4.43	3.48	2.60	2.77	1.86	3.78	4.37	1.86	3.78	4.37
K_2O	2.22	3.45	3.72	4.81	4.59	4.48	2.77	3.38	5.81	2.77	3.38	5.81
P_2O_5	0.349	0.350	0.223	0.014	0.110	0.342	0.233	0.259	0.069	0.233	0.259	0.069
SO_3	0.03	0.01	0.03	0.02	0.00367	0.02	0.05	0.01	bd	0.05	0.01	bd

	MONT 13	MONT 15	MONT 17	MONT 19	MONT 20	MONT 21	MONT 22	MONT 24	MONT 25	MON T22	MONT 24	MONT2 5
Cl	0.00	0.01	0.01	0.00025		0.00368						
LOI	9.30	3.12	2.84	1.39	3.71	4.22	10.97	3.43	0.53	10.97	3.43	0.53
Total	99.14	99.11	98.84	99.72	100.07	99.56	99.81	99.83	100.83	99.81	99.83	100.83
Ni	31	11	9	6	9	11	12	6	4	12	6	4
Cr	70.5	6.4	1.8	0.1	16.4	12.8	19.2	1.5	0.6	19.2	1.5	0.6
Sc	13	11	8	4	8	6	9	13	3	9	13	3
V	101	88	62	7	37	35	63	127	11	63	127	11
Ba	617	1160	988	12	402	386	576	996	1188	576	996	1188
Rb	71	91	117	294	177	171	141	100	107	141	100	107
Sr	715	549	360	52	104	118	269	440	206	269	440	206
Zr	286	316	254	432	431	450	236	244	363	236	244	363
Y	21	40	35	90	53	50	40	35	30	40	35	30
Nb	13.6	12.6	12.2	48.1	26.6	26.9	16.0	10.0	21.0	16.0	10.0	21.0
Ga	22	18	18	24	21	19	18	20	21	18	20	21
Cu	27	11	8	1	10	10	13	15	3	13	15	3
Zn	108	82	58	123	71	77	78	78	49	78	78	49
Pb	17	16	16	33	26	27	17	14	30	17	14	30
La	52	48	41	17	63	60	39	40	78	39	40	78
Ce	101	88	80	74	129	116	84	80	129	84	80	129
Th	9	12	12	36	19	19	14	10	14	14	10	14
Nd	41	42	35	25	57	54	36	37	49	36	37	49
U	2	1	4	8	5	7	7	4	2	7	4	2
Bi												
Cs												
Be												

	MONT 26	MONT 27	MONT 29	MONT 30	MONT 31	MONT 32	MONT 33	MONT 34	MONT 35	MONT 36	MONT 37	MONT 38
	Tpl	Tgr	Tac	Tac	Tas	Tstc	vein	Tmb	Tas	Tas	Ttsc	Tmb
SiO_2	64.26	74.18	74.19	73.75	73.77	73.40	92.80	52.09	63.11	66.92	70.37	65.02
TiO_2	0.624	0.219	0.190	0.197	0.675	0.703	0.639	1.025	0.687	0.537	0.19	0.540
Al_2O_3	15.97	14.05	11.48	11.36	15.33	16.30	2.37	16.96	17.94	13.38	12.47	16.19
FeO*	3.76	1.43	1.92	1.93	0.48	0.25	1.19	8.26	4.71	3.17	0.99	3.36
MnO	0.133	0.032	0.118	0.144	0.003	0.001	0.002	0.156	0.010	0.002	0.057	0.078
MgO	2.17	0.24	0.05	0.23	0.07	0.03	0.02	4.60	0.05	0.00	0.27	1.14
CaO	2.22	1.05	0.06	0.24	0.12	0.15	0.04	6.49	0.24	0.07	2.09	1.43
Na_2O	3.73	3.96	4.37	4.28	0.08	0.06	0.06	4.02	0.08	0.15	3.22	4.64
K_2O	3.81	4.82	4.59	4.59	3.03	1.69	0.56	1.75	0.78	1.77	5.17	4.59
P_2O_5	0.212	0.082	0.019	0.034	0.143	0.225	0.080	0.313	0.227	0.193	0.05	0.285
SO_3	0.02	bd	0.06	0.08	0.15	0.04	0.24	bd	1.25	1.43	0.04	bd
Cl												
LOI	2.89	0.66	0.46	0.89	4.57	5.50	1.42	3.26	10.24	11.95	2.51	2.03
Total	99.81	100.71	97.50	97.73	98.43	98.34	99.40	98.93	99.32	99.57	97.41	99.30
Ni	4	4	bd	bd	bd	bd	bd	25	bd	bd	bd	bd
Cr	3.5	1.7	1.8	2.6	1.1	3.6	3.6	41.7	1.8	1.9	1.5	0.2

	MONT 26	MONT 27	MONT 29	MONT 30	MONT 31	MONT 32	MONT 33	MONT 34	MONT 35	MONT 36	MONT 37	MONT 38
Sc	9	4	6	6	11	11	6	21	8	4	1.6	6
V	64	14	21	4	69	67	32	170	79	49	11.6	39
Ba	1120	1000	122	135	215	304	156	728	880	486	269.5	1247
Rb	132	158	451	475	73	43	19	36	4	3	122.2	124
Sr	278	288	11	16	812	892	44	879	622	1392	49.2	924
Zr	248	174	656	691	244	253	223	186	245	187	181.5	348
Y	34	22	89	101	44	42	21	28	26	16	38.9	33
Nb	10.6	15.9	79.7	85.2	10.7	11.5	10.8	6.3	10.6	8.5	21.6	13.0
Ga	18	17	28	28	21	22	3	18	18	11	17.1	15
Cu	33	3	1	1	bd	bd	2	36	4	8	bd	3
Zn	59	31	163	187	3	2	6	89	13	5	32	69
Pb	9	19	70	75	29	26	26	17	54	58	17.8	23
La	39	36	44	43	38	41	17	34	42	31	54.7	51
Ce	75	66	86	82	86	88	29	69	79	65	113.3	103
Th	11	19	69	73	13	14	5	2	11	7	16.3	11
Nd	33	26	27	24	41	48	15	33	35	24	43.8	42
U	4	3	16	14	5	6	2	1	5	2	3.5	3
Bi					bd	bd	bd	0.8	0.9	0.8		bd
Cs					bd	bd	0.5	3.4	0.1	2.3		1.0
Be			9.6	13.0								

	MONT 39	MONT 40	MONT 41	MONT 42	MONT 43	MONT 44	MONT 45	MONT 46	MONT 47	MONT 48	MONT 49	MONT 50
	Tac	Tvp	Tvp	Tmb	Tvp	Tas	Tas	Tas	Tpl	Tt	Tac	Til
SiO_2	76.46	77.89	77.52	68.24	74.54	26.35	54.99	61.64	64.68	74.85	75.11	76.33
TiO_2	0.209	0.175	0.16	0.450	0.264	0.28	0.72	1.14	0.48	0.16	0.193	0.221
Al_2O_3	11.23	10.94	10.33	15.49	12.07	6.84	11.36	21.59	16.04	12.31	10.98	11.74
FeO*	1.40	1.11	1.07	1.81	1.53	13.29	16.43	0.96	2.57	0.86	2.57	1.45
MnO	0.080	0.019	0.02	0.029	0.075	0.03	0.02	0.00	0.08	0.05	0.214	0.036
MgO	0.12	0.00	0.03	0.48	0.23	0.68	0.64	0.03	0.86	0.25	0.07	0.03
CaO	0.14	0.04	0.02	1.35	0.21	0.93	0.54	0.40	1.65	0.65	0.18	0.12
Na_2O	3.54	3.47	3.34	3.83	3.90	0.45	1.57	0.15	4.60	3.22	4.35	3.92
K_2O	4.86	4.96	4.77	5.45	5.03	0.74	2.86	0.09	4.21	5.11	4.44	4.98
P_2O_5	0.027	0.052	0.02	0.124	0.033	0.17	0.36	0.38	0.14	0.03	0.011	0.032
SO_3	bd	bd	0.006	bd	bd	3.42	0.83	1.14	0.03	bd	0.04	0.01
Cl												
LOI	1.04	0.77	0.56	1.54	1.15	45.50	7.07	10.66	2.46	1.24	0.67	0.48
Total	99.10	99.43	97.84	98.79	99.05	98.67	97.39	98.20	97.81	98.74	98.85	99.35
Ni	bd	bd	bd	bd	bd	15.90	13.20	5.40	6.90	5.90	7	5
Cr	0.9	3.0	2.1	1.6	0.6	4.6	5.9	3.0	2.5	0.5	1.1	1.3
Sc	4	4	3.5	5	4	5.2	7.4	12.2	8.3	2.7	9	5
V	9	6	2.6	27	11	36.0	98.6	151.1	30.8	5.0	1	3
Ba	10	21	12.2	1383	45	367.2	880.4	848.2	981.5	205.7	9	40
Rb	287	221	195.5	185	198	22.3	108.0	2.2	155.6	138.4	872	215
Sr	7	4	2.7	288	13	353.1	199.2	3388.3	220.8	126.9	6	8
Zr	448	351	337.8	377	533	102.4	212.9	243.6	263.9	137.9	1281	439

	MONT 39	MONT 40	MONT 41	MONT 42	MONT 43	MONT 44	MONT 45	MONT 46	MONT 47	MONT 48	MONT 49	MONT 50
Y	91	86	80.8	39	85	22.8	14.4	6.7	38.2	29.3	171	69
Nb	50.3	39.2	37.5	14.1	37.9	4.9	9.0	7.2	14.4	23.2	163.6	35.8
Ga	22	21	20.9	15	24	14.8	17.0	22.1	18.2	17.8	35	24
Cu	bd	1	bd	14	bd	138.0	10.8	4.7	3.6	2.9	1	1
Zn	119	59	65.5	57	95	33.4	113.0	2.6	57.9	27.9	331	60
Pb	44	21	29.3	342	25	11.9	16.9	26.5	35.0	16.5	115	5
La	25	21	24.3	56	47	17.9	10.0	35.0	44.9	45.8	58	32
Ce	69	65	62.6	117	114	38.9	24.4	76.3	90.8	88.8	113	88
Th	37	29	28.2	24	28	6.2	6.3	11.7	15.3	14.8	153	26
Nd	26	31	31.3	49	59	18.5	8.6	30.9	40.5	34.3	21	41
U	9	13	14	5	7	8.0	1.7	1.5	5.1	4.6	31	5
Bi	bd	bd		0.0	bd							
Cs	3.1	4.1		6.7	0.6							
Be			4.8			0.4					27.0	

	MONT 51	MONT 52	MONT 53	MONT 54	MONT 56	MONT 55	MONT 57	MONT 58	MONT 59	MONT 60	MONT 61	MONT 62
	Til	QTb	Tac	Q	Q	Q	Q	Tpl	Tvp	Tas	Tas	Tas
SiO_2	69.80	45.92	75.01	70.14	69.99	56.39	61.07	69.02	74.73	65.13	63.53	68.82
TiO_2	0.499	2.333	0.221	0.499	0.421	0.837	0.518	0.489	0.209	0.714	0.721	0.473
Al_2O_3	14.51	15.85	11.71	12.59	13.08	15.69	12.89	14.24	11.60	16.09	18.10	14.23
FeO*	2.16	11.14	1.42	2.89	2.11	5.78	3.57	2.61	1.45	2.63	3.76	2.54
MnO	0.069	0.168	0.076	0.069	0.064	0.112	0.172	0.109	0.089	0.002	0.014	0.115
MgO	0.14	6.83	0.11	0.68	0.71	3.08	1.44	0.29	0.15	0.13	0.78	0.29
CaO	0.50	9.48	0.13	1.34	1.31	4.84	2.36	0.81	0.11	0.12	0.05	0.69
Na_2O	4.24	3.32	4.13	3.04	2.77	3.96	1.92	4.57	4.01	0.32	0.97	4.52
K_2O	6.16	1.16	4.76	4.13	4.10	2.60	2.90	5.54	4.81	2.46	3.24	5.59
P_2O_5	0.117	0.732	0.017	0.122	0.083	0.312	0.229	0.110	0.014	0.293	0.193	0.097
SO_3	bd	0.04	0.06	0.05	bd	0.05	0.02	0.08	0.04	1.28	0.21	0.03
Cl												
LOI	0.66	2.37	0.47	2.82	4.45	5.71	11.97	0.60	0.73	9.69	7.00	0.91
Total	98.85	99.33	98.10	98.38	99.08	99.35	99.05	98.47	97.95	98.87	98.57	98.30
Ni	6	74	bd	2	3	14	6	bd	bd	bd	1	bd
Cr	2.2	163.6	2.7	10.6	17.4	24.4	19.0	1.2	1.7	5.1	3.5	1.9
Sc	10	26	5	6	7	13	8	8	5	8	9	8
V	15	217	7	46	37	114	58	4	5	68	70	3
Ba	226	637	39	536	531	945	541	1306	19	1456	485	1097
Rb	161	25	210	168	170	77	153	199	220	71	146	200
Sr	17	766	7	199	228	667	271	30	6	1308	119	27
Zr	753	192	398	301	250	238	223	847	430	256	258	820
Y	57	33	81	53	44	30	40	87	87	25	54	75
Nb	25.3	29.1	35.3	24.0	21.7	11.9	17.2	41.3	38.5	11.7	11.4	40.5
Ga	23	17	23	17	18	18	17	23	24	16	17	23
Cu	1	47	bd	8	7	25	12	1	bd	7	7	1
Zn	96	91	111	67	59	92	79	118	119	12	181	126
Pb	20	3	21	18	30	15	14	29	33	14	13	33

	MONT 51	MONT 52	MONT 53	MONT 54	MONT 56	MONT 55	MONT 57	MONT 58	MONT 59	MONT 60	MONT 61	MONT 62
La	113	43	29	43	39	36	42	76	28	39	42	77
Ce	298	78	75	87	83	78	81	158	80	87	89	164
Th	20	4	28	18	16	8	14	28	31	11	12	27
Nd	106	42	41	39	36	35	35	67	42	39	41	69
U	4	1	5	4	6	2	7	7	6	5	3	6
Bi					bd					2.3	bd	
Cs					17.3					0.7	8.7	
Be										1.0	1.5	

	MONT 63	MONT 65	MONT 66	MONT 67	MONT 68	MONT 69	MONT 70	MONT 71	MONT 72	MONT 74	DIC 5	ARAG ON2
	Tac	Tac	Tr	Qa	Qa	Qt	Tpl	Tac	Tt	vein	Tgr	Tr
SiO_2	77.40	58.63	73.69	72.18	69.85	69.94	66.18	70.15	75.32	56.77	63.87	84.66
TiO_2	0.228	1.060	0.179	0.441	0.631	0.564	0.439	0.489	0.343	0.616	0.56	0.11
Al_2O_3	10.19	17.73	12.68	12.30	12.95	12.60	15.40	14.09	11.82	13.40	16.62	9.72
FeO*	1.30	5.31	0.89	2.66	3.18	2.84	3.01	2.52	1.56	4.00	3.67	0.6
MnO	0.082	0.072	0.046	0.072	0.069	0.078	0.065	0.111	0.032	0.090	0.07	0.06
MgO	0.23	1.85	0.42	0.54	1.00	0.81	1.76	0.41	0.13	2.10	2.21	0.14
CaO	0.47	5.76	0.59	0.87	1.42	1.74	2.22	0.91	0.11	4.05	3.34	0.1
Na_2O	3.17	4.15	2.56	3.16	2.43	2.55	4.39	4.46	2.25	1.31	5.33	0.02
K_2O	4.04	2.04	5.45	4.45	3.51	3.90	3.15	5.49	6.57	2.85	2.94	2.64
P_2O_5	0.032	0.357	0.024	0.093	0.123	0.095	0.174	0.117	0.052	0.195	0.22	0.01
SO_3	bd	bd	0.02	bd	bd	0.02	bd	bd	0.01	1.02		
Cl												
LOI	1.85	2.11	2.15	1.81	4.27	3.90	2.60	0.33	0.74	11.33	0.62	1.89
Total	98.99	99.06	98.69	98.58	99.44	99.03	99.38	99.07	98.94	97.74	99.45	99.95
Ni	bd	26	bd	bd	8	5	13	bd	bd	bd	56	
Cr	0.1	52.1	0.9	6.0	21.7	22.7	22.1	1.3	4.1	3.0	49.0	6.0
Sc	5	13	2	5	7	6	5	8	5	8		
V	8	116	10	39	58	49	54	4	10	65	69	
Ba	511	971	171	465	624	569	1325	1403	147	829	1311	54
Rb	146	65	134	177	146	152	73	193	241	110	73	183
Sr	82	864	36	127	290	243	762	34	33	302	899	19
Zr	421	234	156	335	294	351	156	833	410	230	148	120
Y	71	21	36	53	40	43	21	80	38	28	14	36
Nb	29.9	12.0	24.0	26.4	20.2	22.9	6.3	40.3	23.4	10.0	5.0	39.0
Ga	19	21	17	18	16	16	19	20	15	15	20	18
Cu	0	34	2	2	12	8	7	0	1	12		
Zn	85	101	40	71	61	61	53	108	59	70	85	16
Pb	15	29	96	18	19	19	15	32	31	105	126	49
La	51	40	45	41	40	38	31	78	34	29		
Ce	109	82	100	86	77	84	49	152	103	66		
Th	22	2	16	19	12	15	4	24	18	10	5	26
Nd	53	36	37	41	35	38	23	70	34	25		
U	7	2	4	5	3	3	1	7	5	7	1	7
Bi	bd	bd	bd	bd	bd	bd	0.5	bd	bd	bd		

	MONT 63	MONT 65	MONT 66	MONT 67	MONT 68	MONT 69	MONT 70	MONT 71	MONT 72	MONT 74	DIC 5	ARAG ON2
Cs	0.3	5.3	0.1	1.9	5.7	3.9	0.2	4.8	3.1	7.9		
Be		2.3							1.5			

	ARAGON2	VIN 5
	Tr	Tgr
SiO_2	84.66	56.98
TiO_2	0.11	0.46
Al_2O_3	9.72	16.16
FeO*	0.6	3.32
MnO	0.06	0.1
MgO	0.14	2.09
CaO	0.1	2.81
Na_2O	0.02	4.1
K_2O	2.64	2.93
P_2O_5	0.01	0.24
SO_3		
Cl		
LOI	1.89	4.45
Total	99.95	93.64
Ni		10
Cr	6.0	19.0
Sc		
V		58
Ba	54	949
Rb	183	131
Sr	19	307
Zr	120	164
Y	36	16
Nb	39.0	8
Ga	18	18
Cu		
Zn	16	382
Pb	49	58
La		
Ce		
Th	26	4
Nd		
U	7	2
Bi		
Cs		
Be		

TABLE A3-3. Major oxides (in %) and trace elements (in ppm) of whole-rock samples of Quaternary-Tertiary basalts (<5 Ma) in central New Mexico shown in Figure. * Total Fe reported as Fe_2O_3. 1-McMillan et al. (2000), Haag (1991), 2-Fodor (1978), 3-Anthony et al. (1992).

Sample number	DH-12	DH-13	DH-14	DH-15	4	5	EBAS1	EBCM2	EB4
Location and age	Hillsboro basalt 4.5 Ma	Hillsboro basalt 4.2 Ma	Hillsboro basalt 4.2 Ma	Winston basalt 4.8 Ma	Hillsboro	Mimbres 6.29 Ma	Elephant Butte	Elephant Butte	Elephant Butte
Reference	1	1	1	1	2	2	3	3	3
SiO2	48.23	48.66	48.76	47.96	47.14	47.55	46.8	46.5	45.9
TiO2	1.85	2.1	2.06	2.27	2.06	1.93	1.89	2.12	1.85
Al2O3	15.79	16.2	16.25	15.18	16.55	15.74	16.1	15.6	13.8
Fe2O3*	12.06	12.57	12.28	13.09			11.5	12.5	11.5
Fe2O3					4.85	3.54			
FeO					6.67	7.47			
MnO	0.21	0.2	0.2	0.2	0.16	0.17	0.19	0.19	0.17
MgO	6.2	5.86	5.2	8.44	5.76	7.51	6.54	7.18	10.3
CaO	8.66	8.19	9.19	8.93	7.58	9.1	8.23	9.27	9.33
Na2O	4.1	4.09	3.86	3.31	3.69	2.98	3.76	3.3	2.92
K2O	1.72	1.84	1.86	1.24	2.06	1.32	1.45	1.76	1.41
P2O5	0.49	0.57	0.55	0.45	0.44	0.46	0.6	0.47	0.36
S									
LOI	3.21	0.82	1.44	0.2	1.5	0.61	2.85	1.23	1.77
Total	102.52	101.1	101.65	101.27	98.46	98.38	99.91	100.12	99.31
Ni	97	87	68	141	80	192			
Cr	136	117	89	203					
Sc	18.1	16	16.5	25					
V	124.5	135.8	127	202	155	220			
Ba	452	486	501	359					
Rb	34	34	36		40	28	58	52	30
Sr	697	695	686	527	680	580	721	644	550
Zr	156	162	168	139			156	137	1331
Y	30	29	33	27					
Nb	34	40	44	30			60	55	71
Cu					43	86			
Li					7	8			

Sample number	HBWS4	BM2	AN11
Location and age	Hillsboro	Black Mesa	Animas
Reference	3	3	3
SiO2	48.1	48.2	49.41
TiO2	2.07	1.99	1.85
Al2O3	16.1	14.8	15.85
Fe2O3*	12.4	11.7	10.35
MnO	0.19	0.18	0.16
MgO	6.01	8.49	7.47
CaO	7.91	8.71	9.64
Na2O	4.03	3.06	3.23
K2O	1.43	1.8	1.21
P2O5	0.57	0.47	0.37
S			
LOI	1.31	0.62	0.26

Sample number	HBWS4	BM2	AN11
Total	100.12	100.02	99.8
Rb	38	39	25
Sr	689	599	466
Zr	126	174	142
Nb	58	50	40

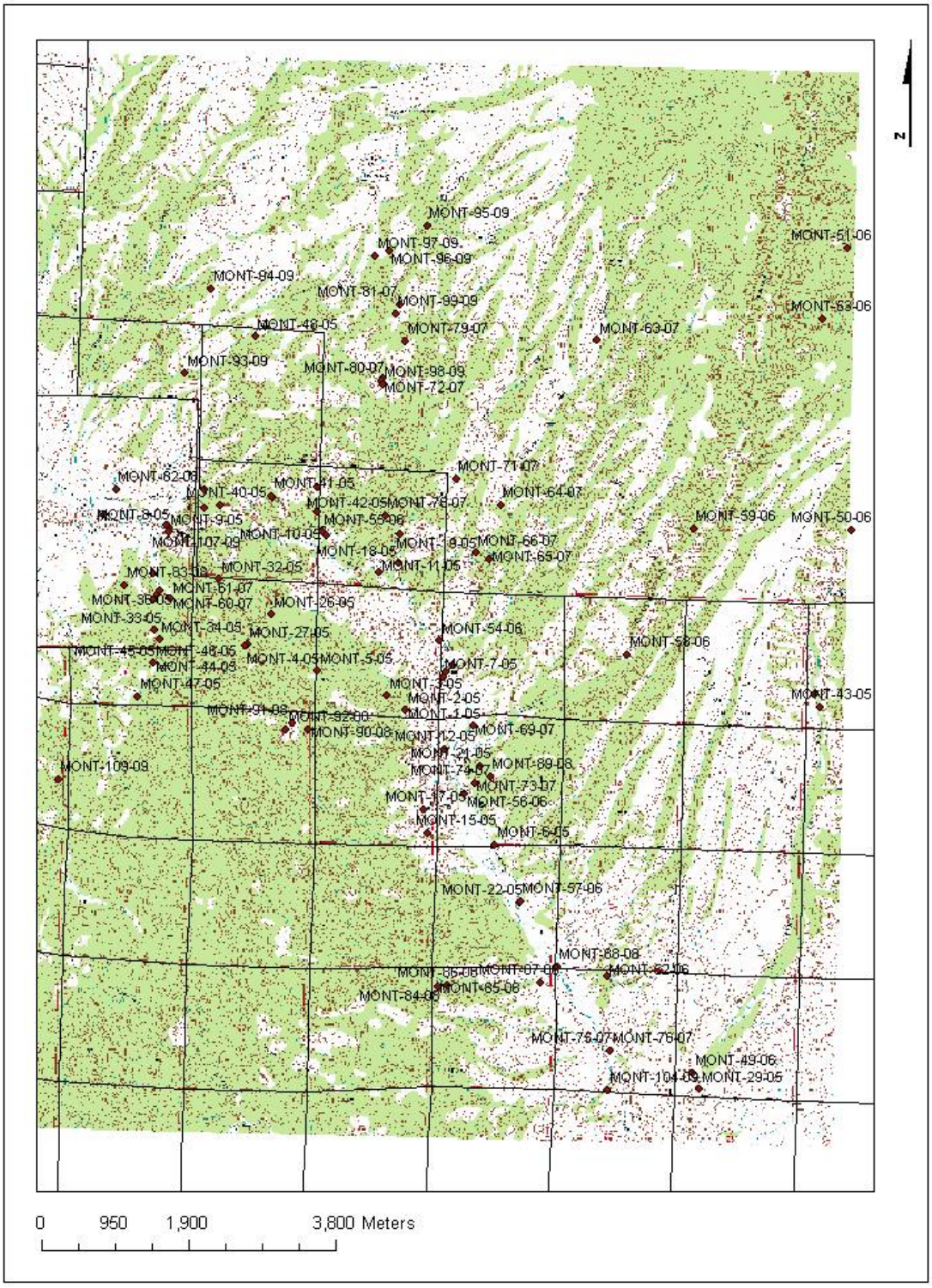
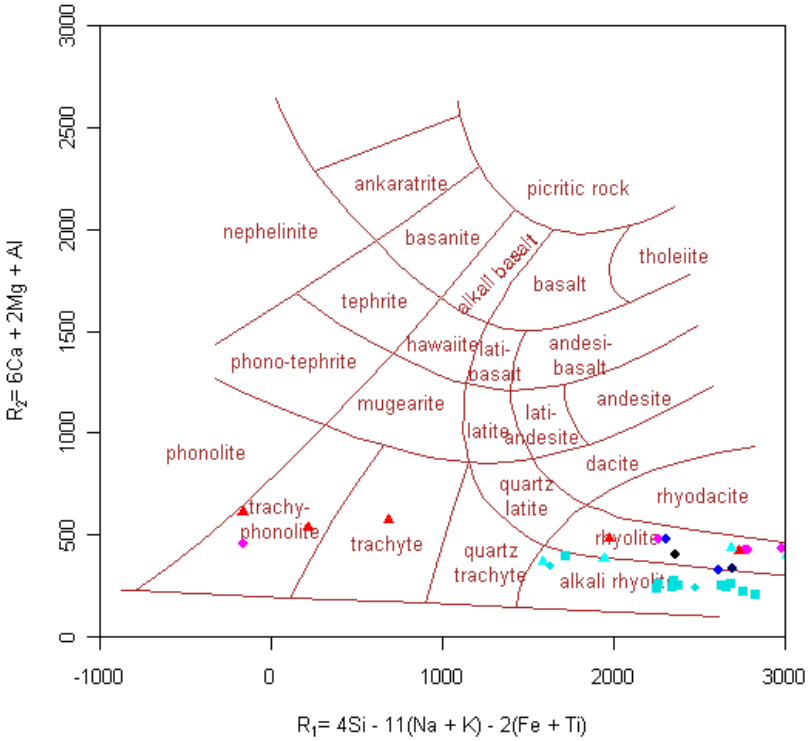


FIGURE A3-1. Location of samples collected for geochemical analyses from the Montoya Butte quadrangle.

Explanation of symbols—Turkey Springs Tuff (Tt) is dark blue circles. Vicks Peak Tuff (Tvp) and rhyolite of Alamosa Canyon (Tac) are blue squares. Granite of Kelly Canyon (Til) is blue diamond. Andesite dikes and andesite of Monticello Canyon (Tmb) are red triangles. Latite/quartz latite dikes and latite of Montoya Butte (Tql, Tl, Tpl) are pink ciricles. Granite intrusion (Tg) is black circle. Rhyolite dikes are dark blue diamonds.



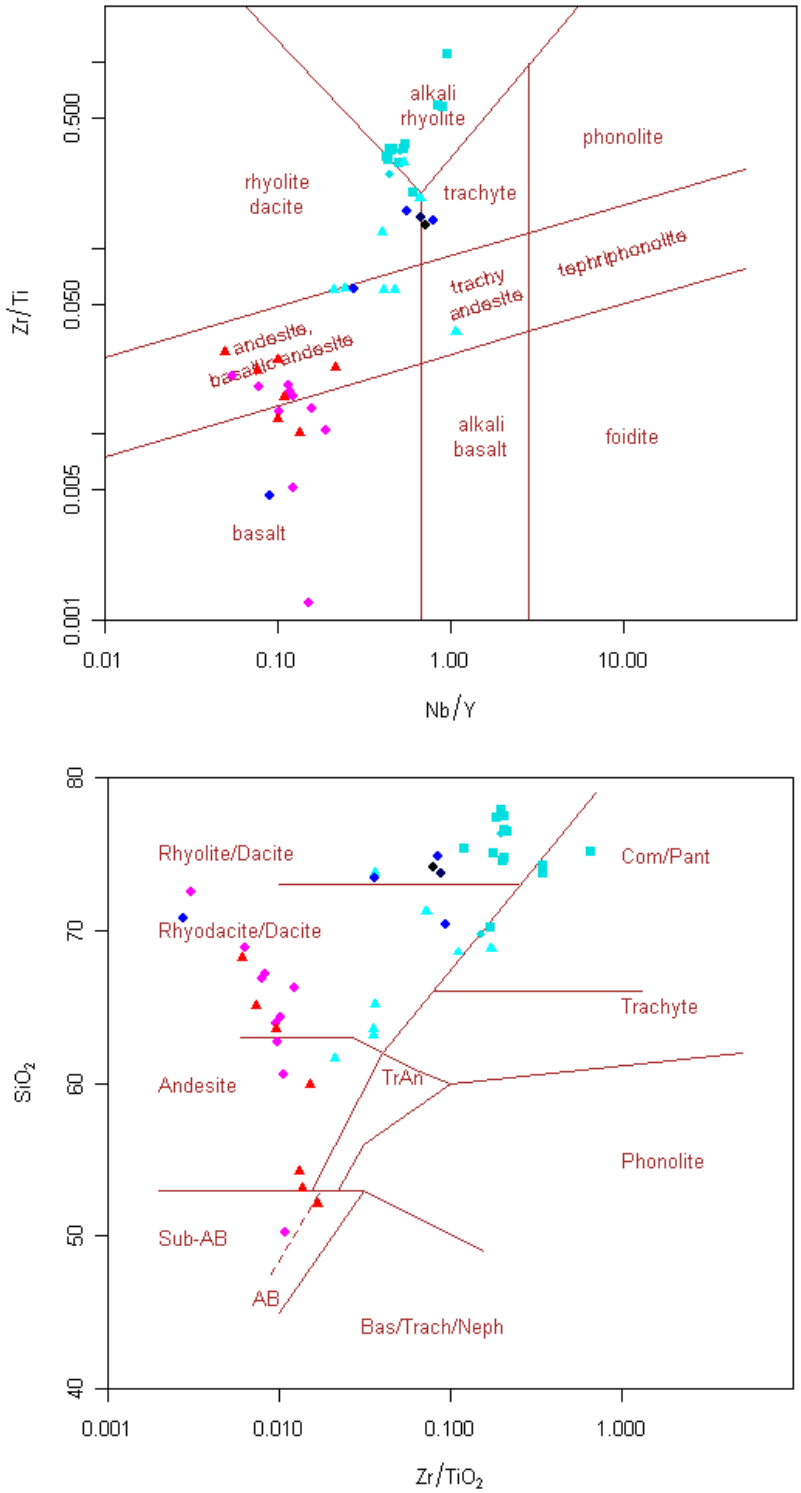


FIGURE A3-2. R1-R2 (de la Roche, 1980), Nb/Y-Zr/TiO_2 (Winchester and Floyd, 1977 as modified by Pearce, 1996), and Zr/TiO_2-SiO_2 (Winchester and Floyd, 1977) plots showing the classification of the samples from Montoya Butte quadrangle as alkali rhyolites, rhyolites, trachyphonolites/andesites, and trachyte. Vicks Peak Tuff, rhyolite of Alamosa Canyon (blue squares), and granite of Kelly Canyon (blue diamond) have similar chemical compositions. Tuff

of Alum Spring (Tas) is blue diamonds. The chemical composition of the older Sierra Cuchillo rocks (andesite of Monticello Canyon, latite of Montoya Butte, dikes and granite intrusion) differs from the younger rhyolites (Turkey Spring Tuff, tuff of Alum Mountain, Vicks Peak Tuff, rhyolite of Alamosa Canyon, and granite of Kelly Canyon).

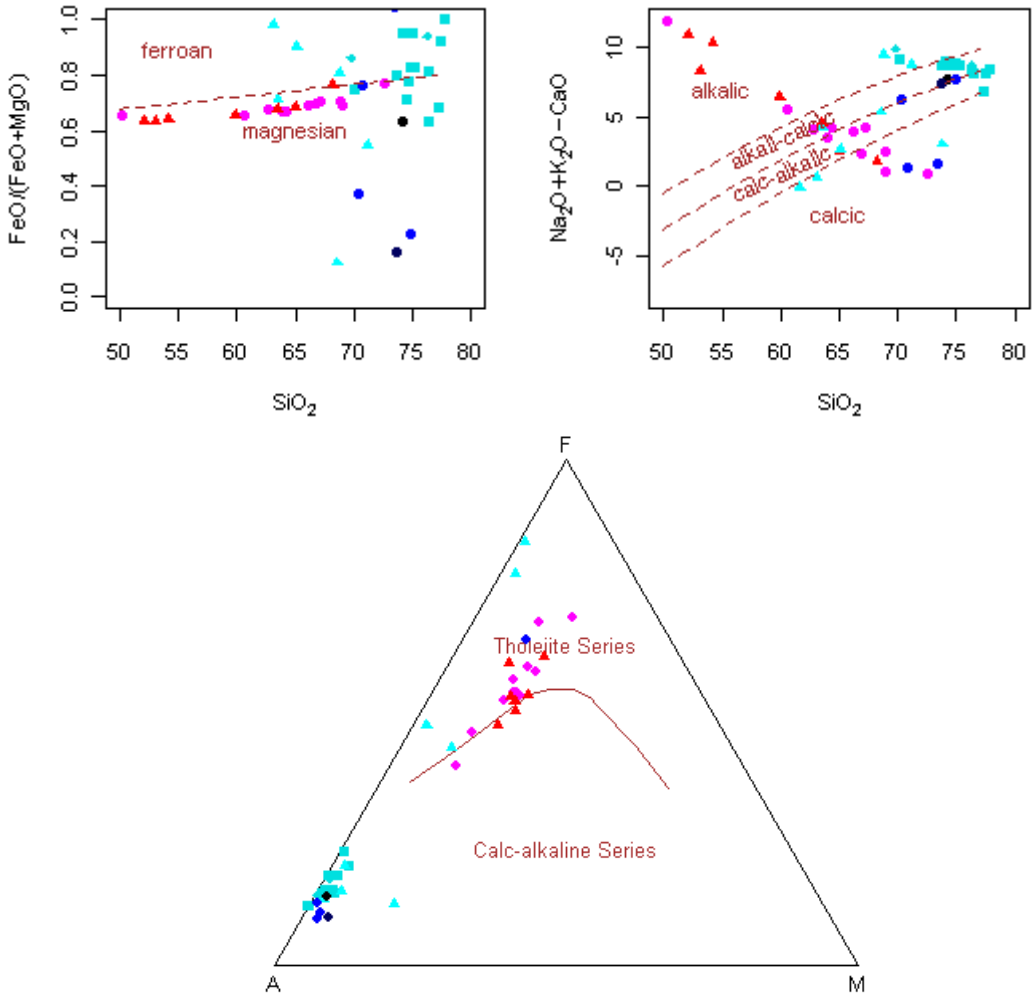


FIGURE A3-3. Chemical classification plots (FeO/(FeO+Mgo)-SiO2 and Na2O+K2O-CaO-SiO2 (Frost et al., 2001), AFM plot (Irvine and Barager, 1971). Symbols explained in Figure A3-2.

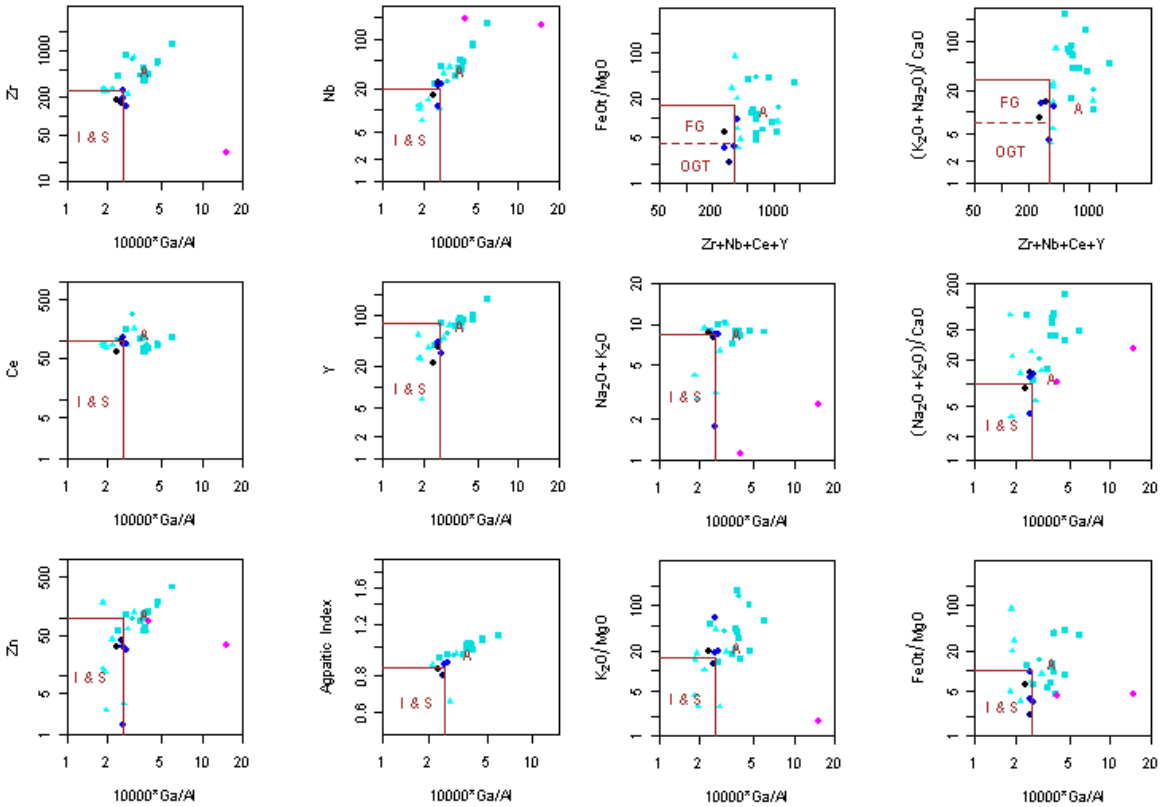
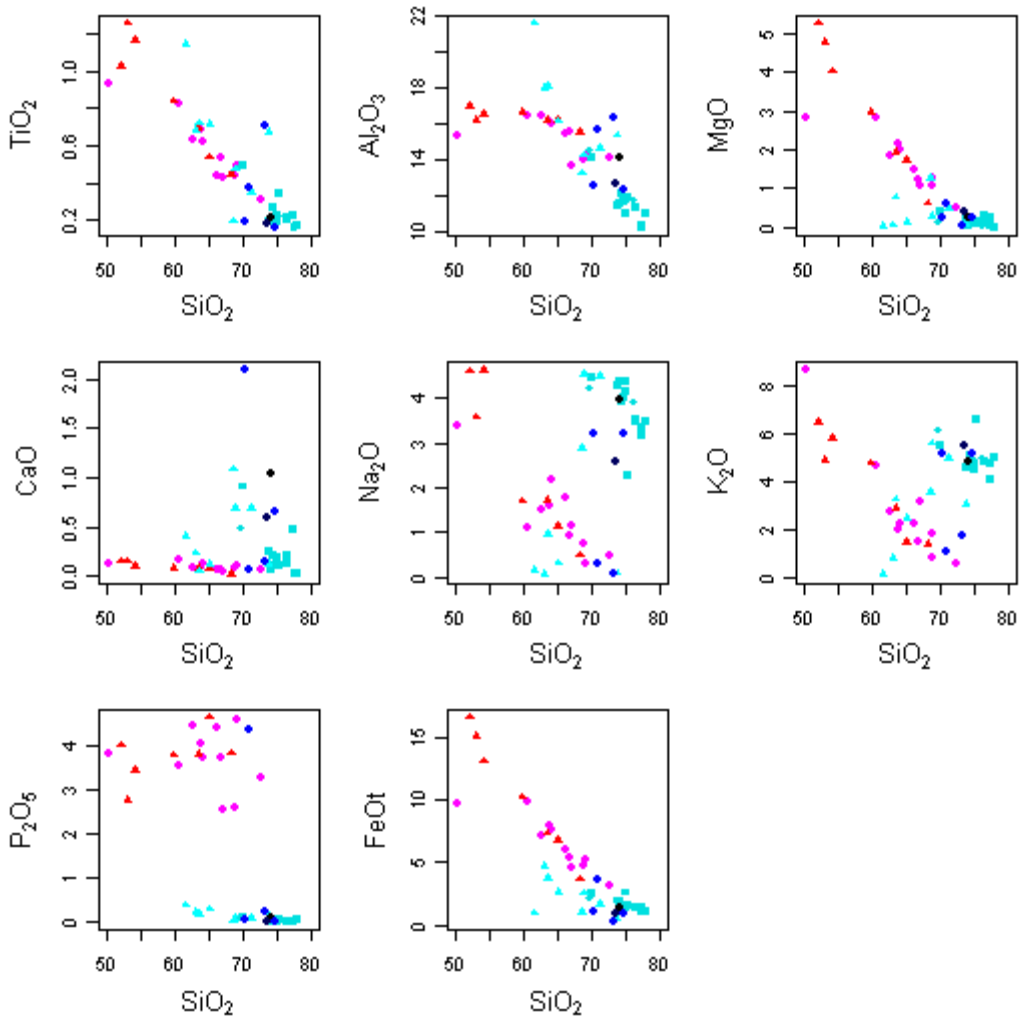


FIGURE A3-4. Chemical plots by Whalen et al. (1987) showing that the samples from Montoya Butte are A-type granites. Symbols explained in Figure A3-2.


TiO2
Al2O3
MgO
CaO
Na2O
K2O
P2O5
FeOt
SiO2

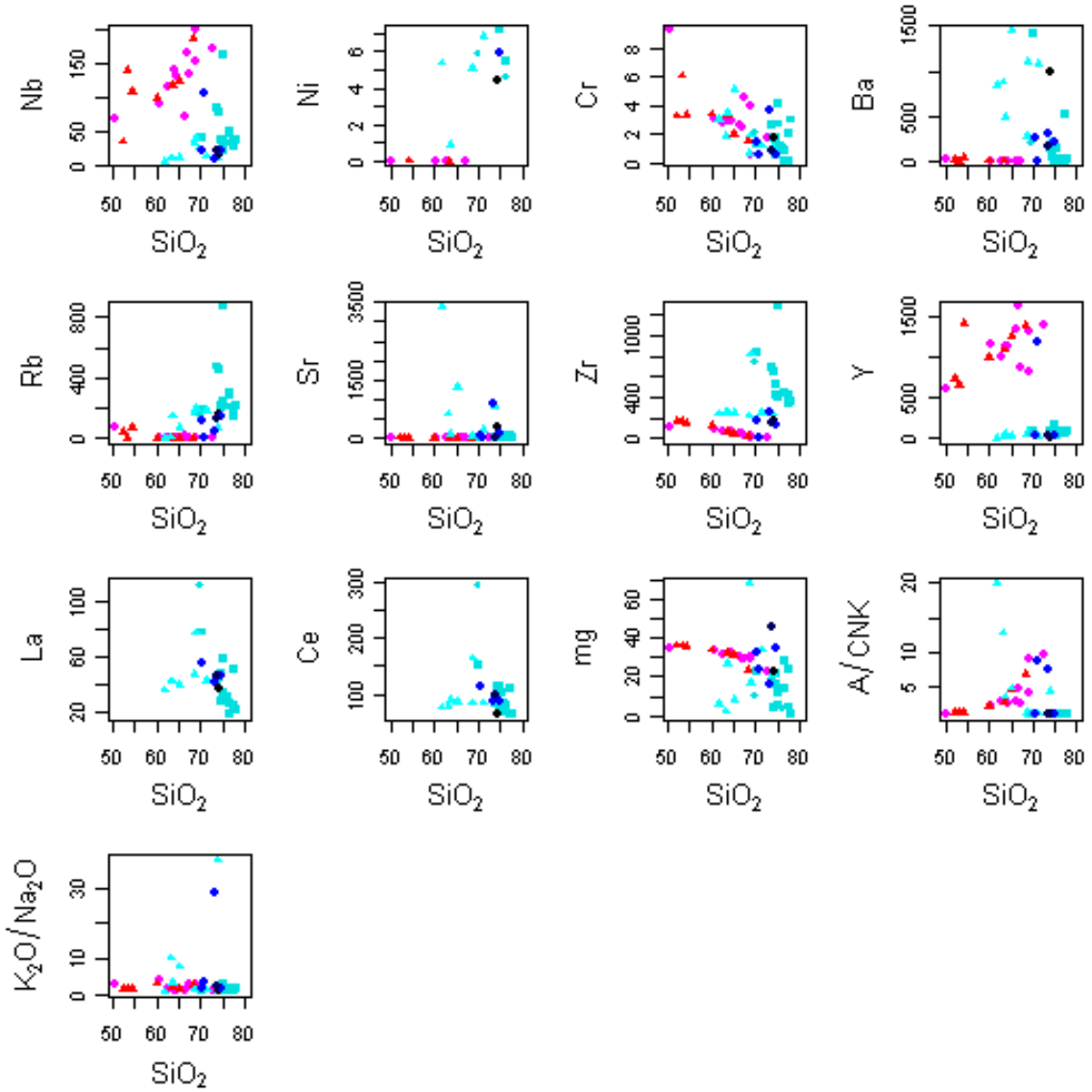
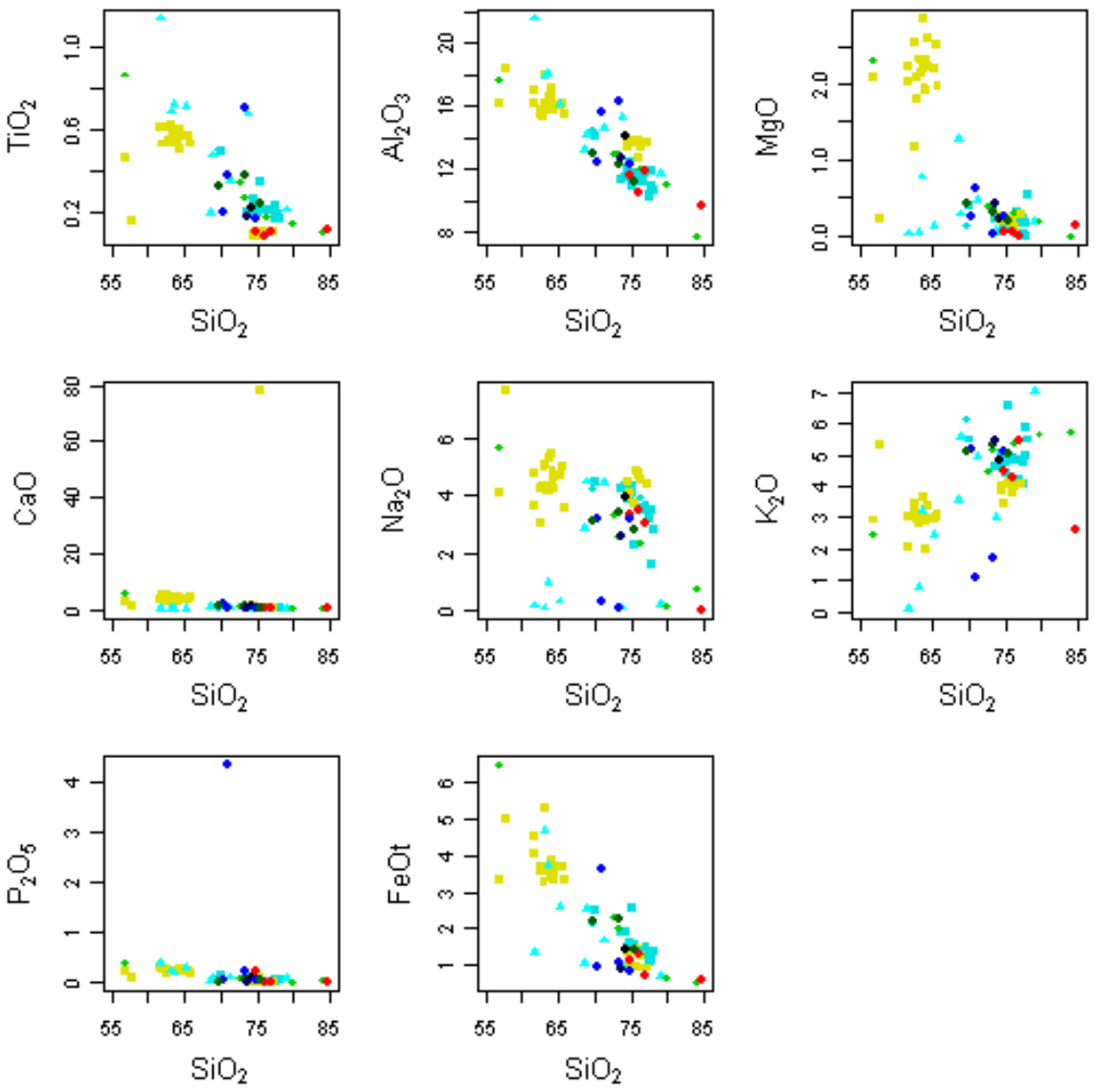


FIGURE A3-5. Major and trace elements plots verses SiO_2 of samples from the Montoya Butte quadrangle. Symbols explained in Figure A3-2.


TiO2
Al2O3
MgO
CaO
Na2O
K2O
P2O5
FeOt
SiO2
55
65
75
85

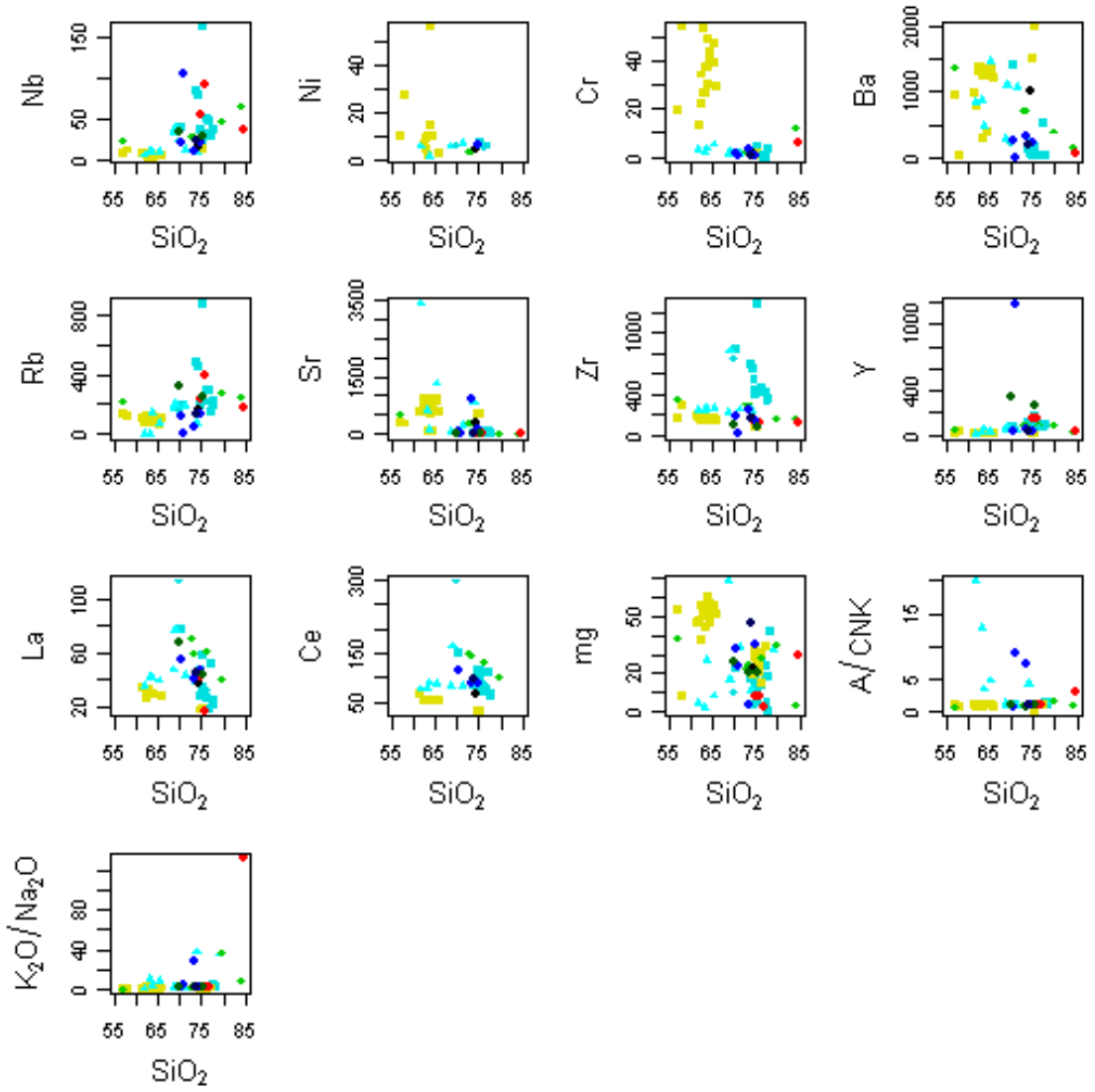
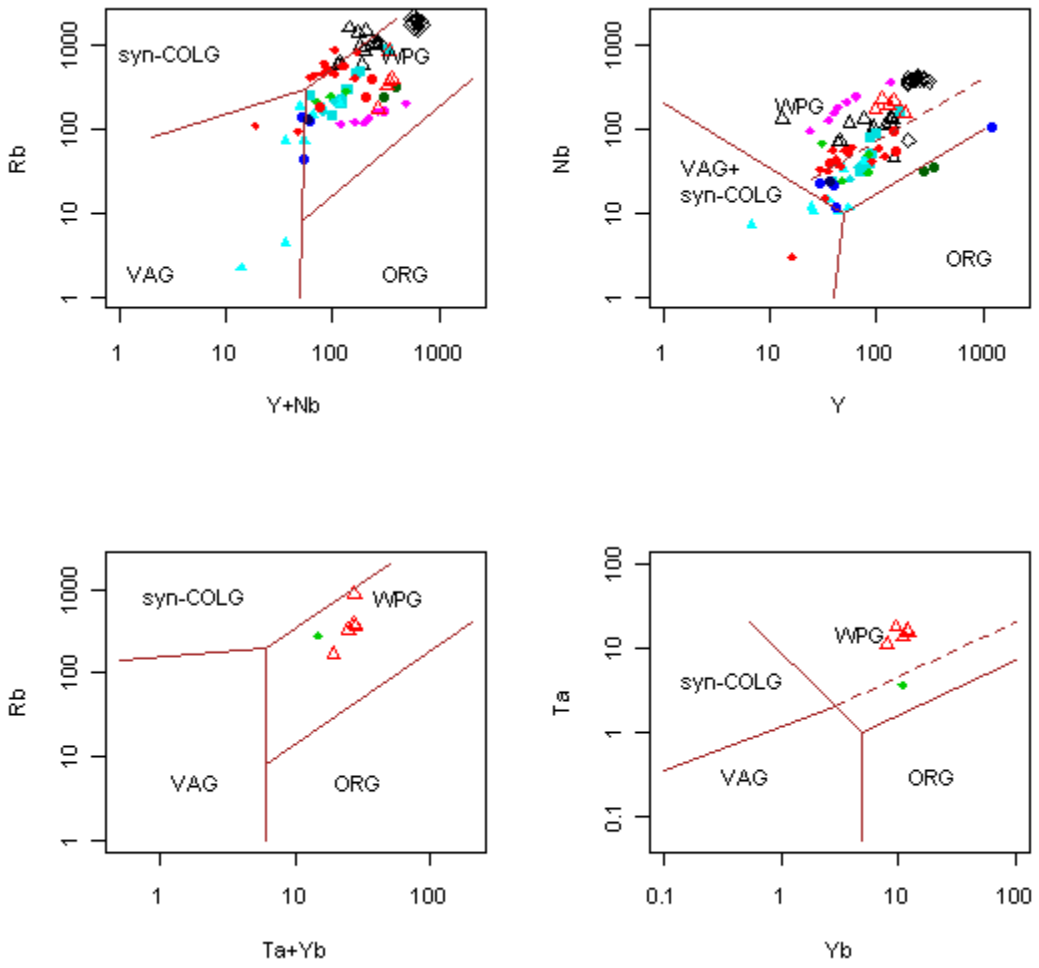
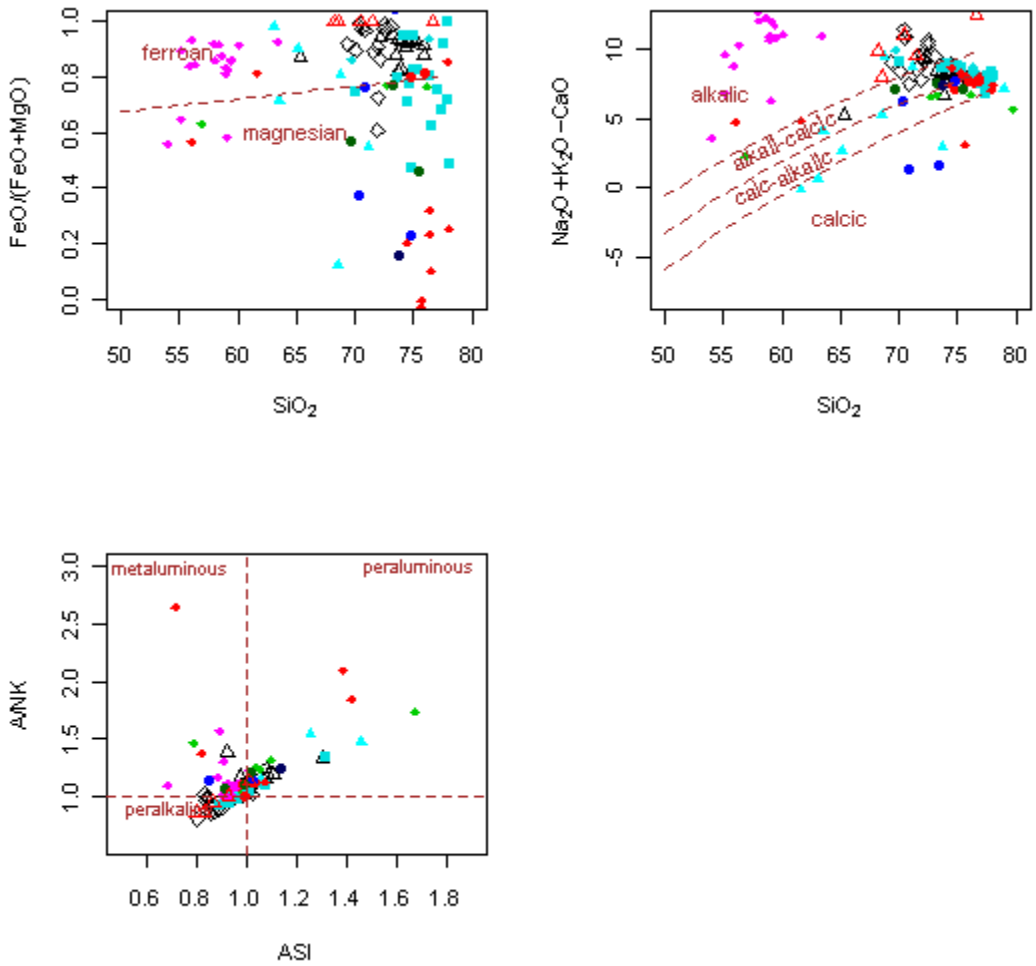


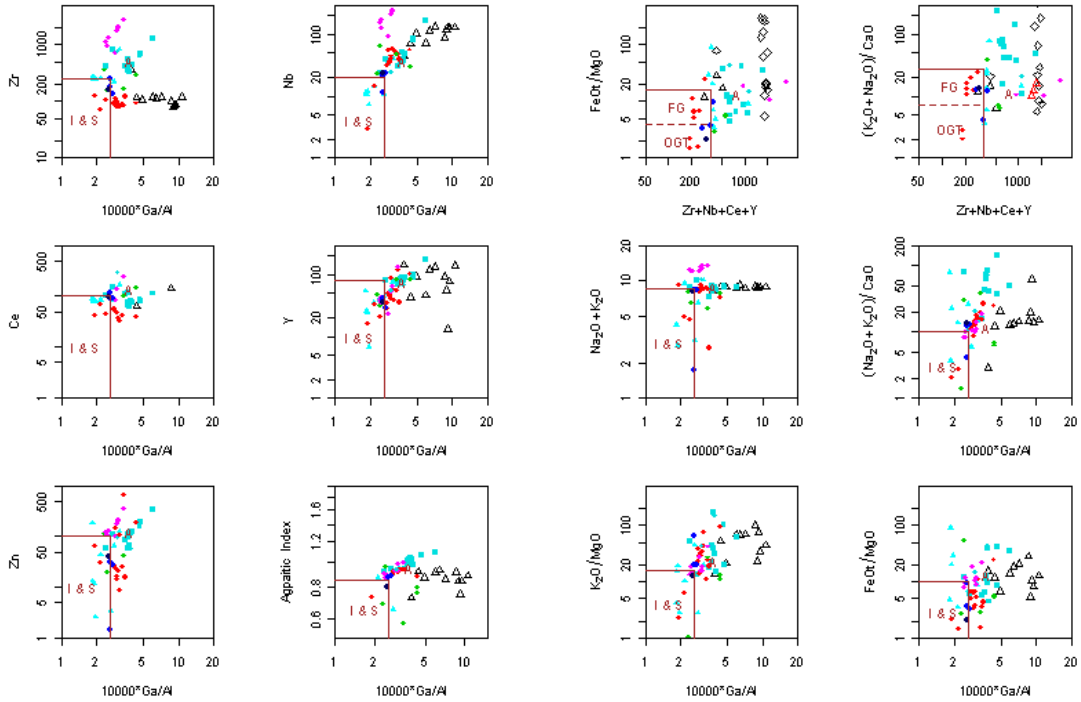
FIGURE A3-6. Major and trace elements plots verses SiO_2 of rhyolite samples from the Montoya Butte quadrangle and from elsewhere in the Sierra Cuchillo and San Mateo Mountains. Symbols of samples from the Montoya Butte quadrangle are explained in Figure A3-2. Cuchillo laccolith is yellow squares and younger aplite is red triangles, Iron Mountain rhyolite is dark green diamond, porphyritic rhyolite is light green triangle.



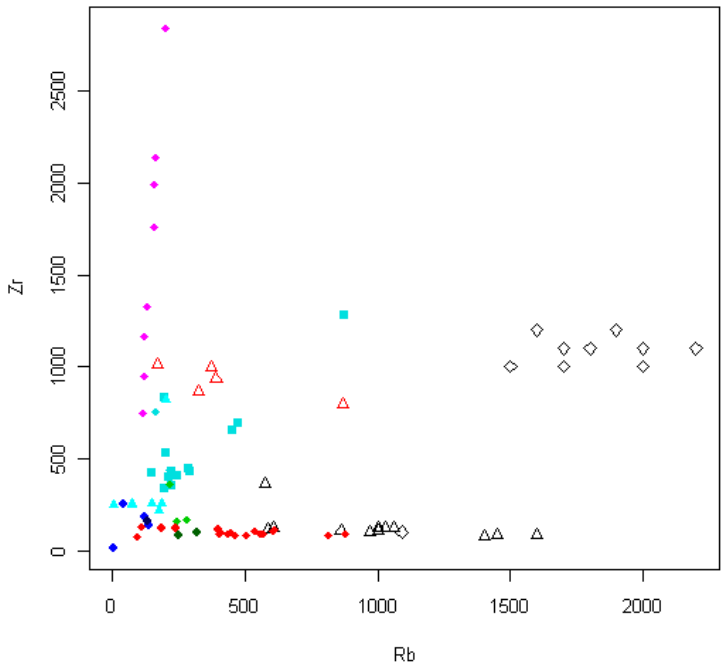
(a) Tectonic chemical plots by Pearce et al. (1984) shows that the rhyolites and granites associated with beryllium deposits



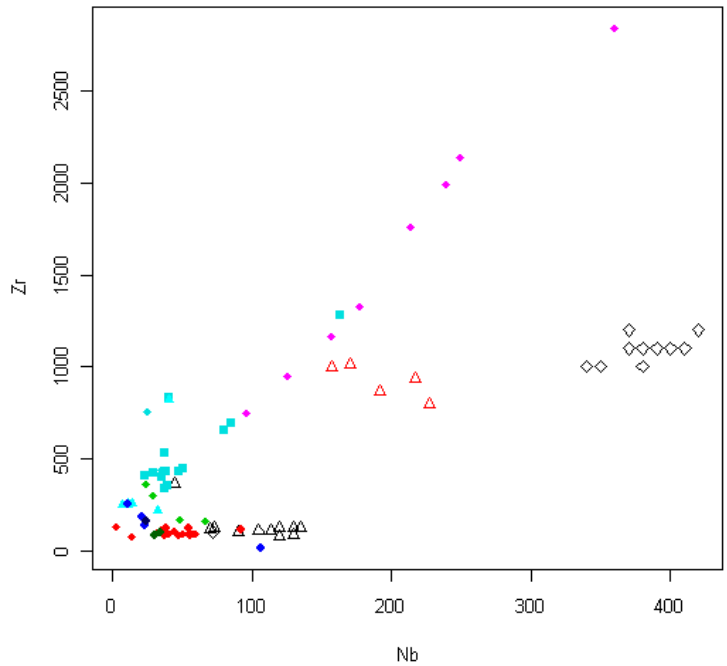
(b) Frost et al. (2001)



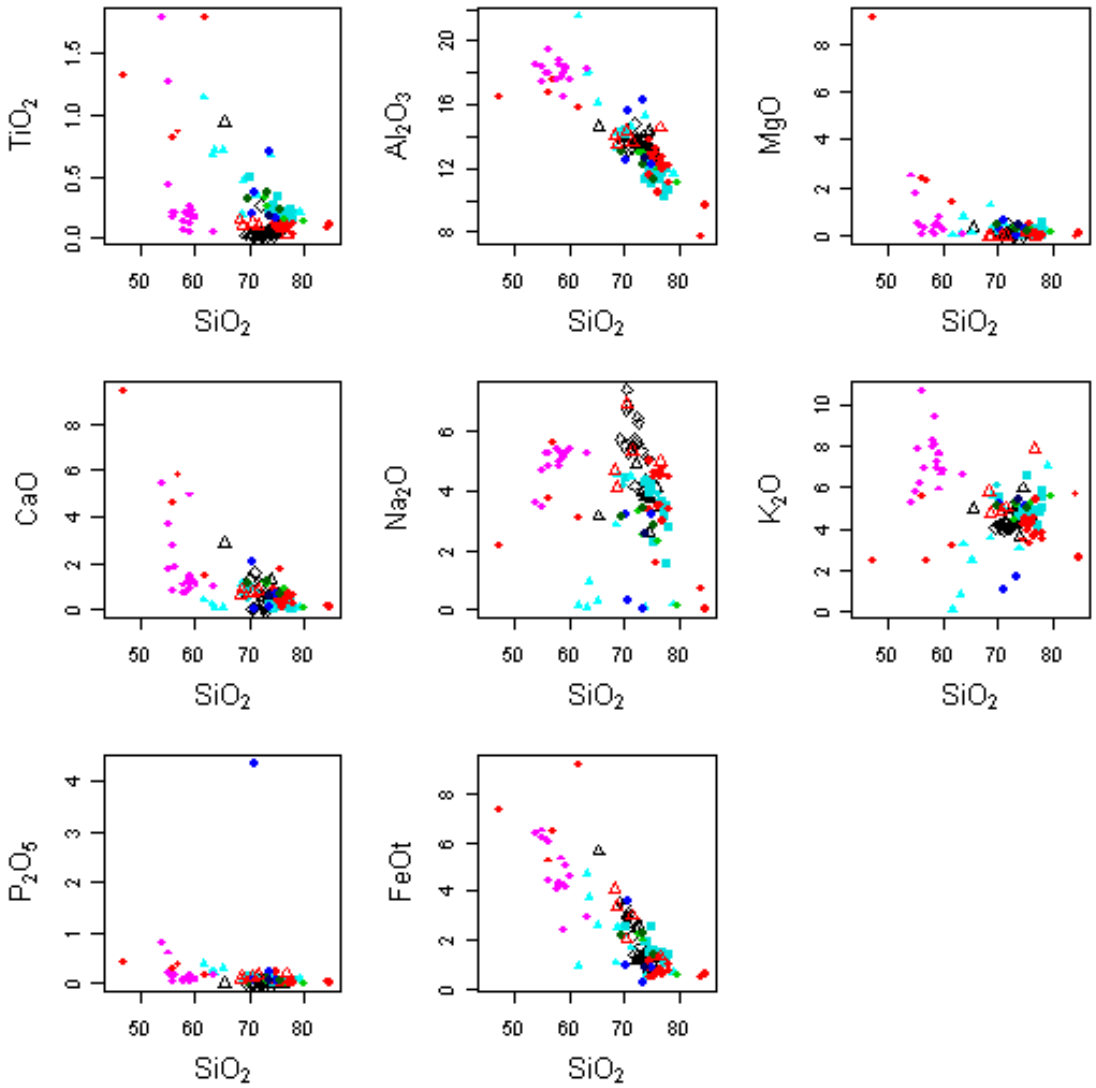
(c) Whalen et al. (1987)

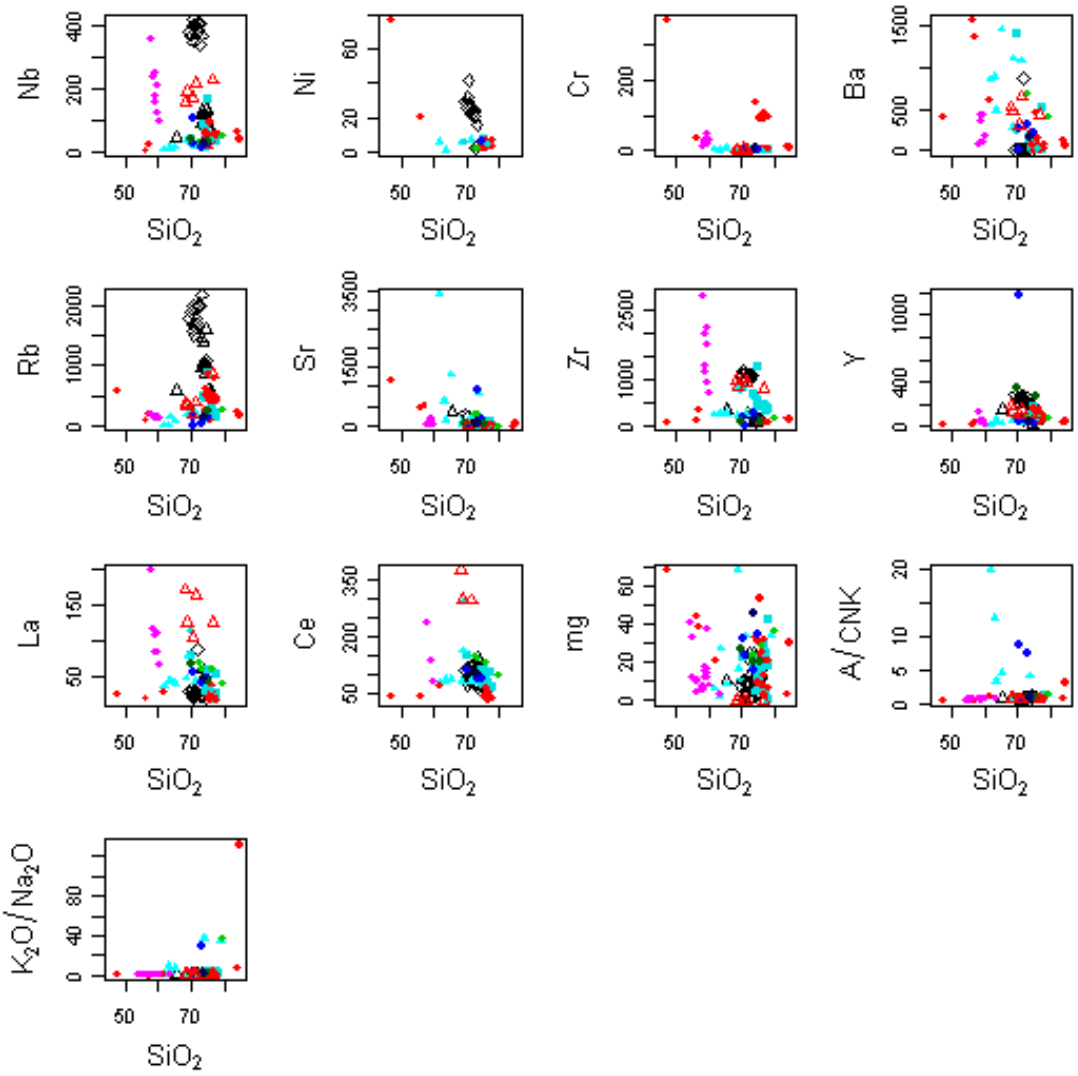


(d) Rb-Zr plot



(e) Zr-Nb plot


TiO2
Al2O3
MgO
CaO
Na2O
K2O
P2O5
FeOt
SiO2



(f) Major and trace elements

FIGURE A3-7. Chemical plots of the rhyolites from Montoya Butte quadrangle and other Be-hosted rhyolite deposits. Explanation of symbols—Turkey Springs Tuff (Tt) is dark blue circles. Vicks Peak Tuff (Tvp) and rhyolite of Alamosa Canyon (Tac) are blue squares. Granite of Kelly Canyon (Til) is blue diamond. Younger Sierra Cuchillo aplite is red triangles, Iron Mountain rhyolite is dark green diamond, porphyritic rhyolite is light green triangle. The rhyolite at Aguachile, Mexico is red open triangles. Sierra Blanca, Texas rhyolites are black diamonds. Granites from the Victorio Mountain granites, Luna County, NM are red diamonds. The Cornudas Mountains syenites, Otero County, New Mexico are pink diamonds. Rhyolites from the Spor Mountain deposit, Utah are black open triangles.

APPENDIX 4
MEASUREMENTS OF FAULTS, JOINTS, FRACTURES, FOLIATION, AND BEDDING IN THE MONTOYA BUTTE QUADRANGLE

Strikes and dips of foliation, bedding, and directions of faults, dikes, and veins from the Montoya Butte quadrangle are in Table A4-1 and located in McLemore (2011).

TABLE A4-1. Strikes and dips of foliation, bedding, and directions of faults, dikes, and veins from the Montoya Butte quadrangle. Strikes and dips are in degrees. UTM easting and northing are in zone 13, NAD27. Units are defined in Table 3.

Station	Strike (azimuth)	Dip	Dip direction	Feature	UTM Easting	UTM Northing	Unit	Comments
546	150	25	SW	bedding	257003	3708453	Py	
548	155	30	E	bedding	256268	3709632	Py	
549	150	20	E	bedding	256350	3709696	Py	
550	110	25	E	bedding	256551	3709737	Py	
5	110	90		dike	262016	3715160	andesite	4 ft wide, veins
15	100	90		dike	262591	3714840	andesite	
71	60	90		dike	259079	3715858	andesite	
72	45	90		dike	261112	3717538	andesite	
78	70	90		dike	262042	3716719	andesite	
125	70	90		dike	262595	3716029	andesite	
126	60	90		dike	262275	3716059	andesite	
274	60	90		dike	262401	3716023	andesite	
277	60	90		dike	262132	3716531	andesite	
276	60	80	W	dike	261957	3716577	andesite	
419	320	90		dike	259900	3715042	andesite	
420	10	90		dike	260198	3715293	andesite	
426	90	90		dike	259306	3715562	andesite	
431	115	90		dike	259326	3715785	andesite	
507	345	90		dike	257337	3710221	andesite	
433	130	90		dike	259785	3715589	andesite cut by veins	
371	130	90		dike	261766	3713045	andesite-latite	
44	20	90		dike	262698	3712928	basalt	5 ft wide
445	80	90		dike	258983	3714578	basalt	
486	80	90		dike	258815	3713748	basalt	
366	115	90		dike	261439	3714920	basalt dike	
338	90	90		dike	262013	3714768	dike	
344	330	90		dike	262443	3714679	dike	
348	105	90		dike	261434	3713975	dike	
32	105	90		dike	262539	3713385	latite	5 ft wide
33	325	90		dike	262534	3713514	latite	20 ft wide
38	325	90		dike	262290	3713648	latite	5 ft wide
40	145	90		dike	262275	3713282	latite	
41	125	90		dike	262268	3713172	latite	
275	10	80	W	dike	261673	3716768	latite	
350	320	90		dike	260827	3714408	rhyolite	
359	315	90		dike	260784	3714806	rhyolite	
414	20	90		dike	262457	3720991	rhyolite	
519	0	90		dike	257023	3711415	rhyolite	
548	345	60	W	dike	256268	3709632	rhyolite	

Station	Strike (azimuth)	Dip	Dip direction	Feature	UTM Easting	UTM Northing	Unit	Comments
351	130	90		dike	261212	3714458	Tpl	
9	40	90		dike	260758	3715697	Tql	
MONT10	30	90		dike	261226	3717225	Tql	same as 9, 50 ft wide
484a	110	90		dike	258797	3715564	Tr	
338	85	90		dike	262105	3714749	basalt dike	
57	70	90		fault	260008	3716780	andesite	acid sulfate
329	60	90		fault	261896	3711398	andesite	calcite vein
432	130	90		fault	259528	3715679	andesite	
476	20	90		fault	258554	3713302	andesite	silicified, brecciated
504	15	90		fault	258412	3711936	andesite	fractures, brecciation
559	335	90		fault	260114	3711193	andesite, latite	silicified, brecciated
360	0	90		fault	260708	3714723	granite, Tpl	
169	60	80	N	fault	264298	3717854	Qt	
390	15	90		fault	258985	3719140	Qt	
402	15	90		fault	262530	3721227	silicified	
85	10	90		fault	262252	3717938	Tac	brecciated, fractured
114	50	90		fault	267620	2720028	Tac	fractures, brecciation
236	25	90		fault	261750	3718107	Tac	silicified, brecciated
242	310	90		fault	259541	3717743	Tac	
244	335	90		fault	259745	3718189	Tac	
65	340	50	W	fault	259070	3716528	Tas	
48	20	90		fault	259194	3717327	Tmb	main fault
80	75	90		fault	262016	3716867	Tmbx	silicified, brecciated
4	75	70	S	fault	262252	3714984	Tpl	normal
7	90	90		fault	261707	3715514	Tpl	3 ft fracture zone
19	70	90		fault	262180	3715496	Tpl	brecciated, fractured, veins
27	0	90		fault	262824	3713050	Tpl	main range fault, slickenslides, fractured
28	70	90		fault	262725	3713172	Tpl	small
319	5	90		fault	262676	3712443	Tpl	
347	0	90		fault	261739	3714103	Tpl	
370	0	90		fault	261838	3712588	Tpl	
499	50	90		fault	258260	3711398	Tpl	brecciation
522	95	90		fault	258161	3710380	Tpl	
391	18	90		fault	258903	3719152	Tt	
397	15	90		fault	259219	3719620	Tt	
398	0	90		fault	264450	3723763	Tt	
113	15	80	W	fault	267851	3719869	Tvp	fractures, brecciation
217	320	90		fault	262833	3716414	-	jasperoid
398	0	90		fault	264450	3723763	-	
400	10	90		fault	259862	3721418	-	
408	0	90		fault	261812	3720685	-	
532	90	90		fault	260274	3710636	-	
569	10	90		fault	263335	3709928	-	
570	70	90		fault	263647	3709860	-	
167a	110	90		fault	264693	3718715	-	
639	60	90		fault	259995	3717258	-	
54	60	10	N	foliation	259657	3717581	andesite	
331	80	20	SE	foliation	262245	3711425	andesite	
440	90	10	S	foliation	264853	3710078	andesite	
443	0	15	W	foliation	258788	3714727	andesite	
451	60	30	NW	foliation	258002	3713597	andesite	
472	55	40	SW	foliation	258501	3713846	andesite	

Station	Strike (azimuth)	Dip	Dip direction	Feature	UTM Easting	UTM Northing	Unit	Comments
474	60	20	NW	foliation	258447	3713550	andesite	
498	340	20	W	foliation	257886	3712824	andesite	
515	355	15	W	foliation	260059	3709769	andesite	
516	60	15	SE	foliation	259333	3709920	andesite	
520	125	15	E	foliation	257662	3710460	andesite	
528	0	40	W	foliation	257376	3710656	andesite	
529	155	30	S	foliation	259694	3717077	andesite	
538	115	20	S	foliation	260431	3709703	andesite	
539	40	15	SE	foliation	260511	3709507	andesite	
540	60	20	SE	foliation	260801	3709427	andesite	
556	160	20	N	foliation	259203	3711078	andesite	
561	140	40	N	foliation	260271	3710800	andesite	
565	155	30	E	foliation	261500	3710121	andesite	
568	10	20	E	foliation	263030	3710260	andesite	
609	60	15	E	foliation	263166	3709498	andesite	
637	30	10	E	foliation	259411	3718921	andesite	
638	60	10	N	foliation	259508	3717123	andesite	
562	155	15	S	foliation	260374	3710628	basalt	
46	140	30	N	foliation	262170	3717253	Tac	
73	35	50	W	foliation	261105	3717853	Tac	
74	5	90		foliation	260892	3718056	Tac	
83	130	35	N	foliation	262039	3717625	Tac	
84	130	75	N	foliation	262275	3718033	Tac	
86	355	55	E	foliation	262325	3717542	Tac	
87	333	55	W	foliation	262382	3717313	Tac	
89	340	30	W	foliation	267422	3715339	Tac	
96	50	20	S	foliation	267548	3714833	Tac	
99	330	25	SW	foliation	265777	3710116	Tac	
121	50	20	W	foliation	267190	3718875	Tac	
137	110	10	S	foliation	267312	3718616	Tac	
138	90	10	S	foliation	267114	3718365	Tac	
148	330	25	W	foliation	266373	3721769	Tac	
149	0	25	W	foliation	266382	3720662	Tac	
155	350	25	W	foliation	265236	3717675	Tac	
156	350	40	W	foliation	265102	3717591	Tac	
168	0	5	W	foliation	264482	3718298	Tac	
175	30	20	W	foliation	265037	3720689	Tac	
182	10	25	W	foliation	263081	3717003	Tac	
187	45	55	W	foliation	262944	3717446	Tac	
192	350	10	W	foliation	263327	3718761	Tac	
195	45	40	W	foliation	263057	3718180	Tac	
195	350	20	W	foliation	263057	3718180	Tac	
199	65	45	W	foliation	262572	3717588	Tac	
203	350	10	W	foliation	265756	3724543	Tac	
219	85	20	N	foliation	262451	3718076	Tac	
233	70	30	W	foliation	261987	3717484	Tac	
235	40	20	N	foliation	261846	3718015	Tac	
245	335	15	E	foliation	259878	3718254	Tac	
247	300	50	NE	foliation	260682	3718701	Tac	
438	100	10	N	foliation	264853	3710078	Tac	
570	130	10	S	foliation	263647	3709860	Tac	
571	120	20	W	foliation	264659	3710602	Tac	
204a	25	10	W	foliation	260156	3719730	Tac	

Station	Strike (azimuth)	Dip	Dip direction	Feature	UTM Easting	UTM Northing	Unit	Comments
242a	10	20	W	foliation	259541	3717743	Tac	
583	160	80	W	foliation	265151	3710698	Tac	
590	95	10	N	foliation	264719	3711014	Tac	
614	35	15	SE	foliation	264293	3709947	Tac	
621	40	20	S	foliation	264774	3709245	Tac	
653	350	10	N	foliation	259914	3718251	Tac	
195a	350	20	W	foliation	263057	3718180	Tac	
65	340	50	W	foliation	259070	3716528	Tas	
69	0	35	W	foliation	259076	3716522	Tas	
428	90	20	S	foliation	259196	3716424	Tas	
428	90	20	S	foliation	259196	3716424	Tas	
601	120	30	S	foliation	259166	3716486	Tas	
603	80	20	N	foliation	259320	3716490	Tas	
604	65	20	S	foliation	264864	3710087	Tas	
536	45	25	S	bedding	259738	3710252	Tmbx	
467	40	20	W	bedding	264910	3722755	volcaniclastic	
79	100	10	N	foliation	262028	3716795	Tmbx	
437	130	20	S	foliation	259502	3715920	Tmbx	
453	15	10	W	foliation	258164	3713459	Tmbx	
465	340	50	W	foliation	259070	3716528	Tmbx	
123	55	25	E	foliation	262757	3715768	Tmbx	
125	105	25	S	foliation	262595	3716029	Tmbx	
279	345	85	E	foliation	262677	3715867	Tpl	
1	80	35	N	foliation	262625	3714973	Tpl	
2	80	40	N	foliation	262557	3715030	Tpl	
4	110	30	S	foliation	262252	3714984	Tpl	
9	335	10	S	foliation	260758	3715697	Tpl	
11	345	90		foliation	262648	3714798	Tpl	
14	120	45	W	foliation	262587	3715237	Tpl	
16	160	90		foliation	262523	3714833	Tpl	
17	90	60	S	foliation	262260	3715211	Tpl	
18	70	30	S	foliation	262359	3715248	Tpl	
20	80	40	S	foliation	262134	3715518	Tpl	
21	60	90		foliation	262035	3715891	Tpl	
22	110	90		foliation	262073	3715781	Tpl	
22	125	25	S	foliation	262073	3715781	Tpl	
23	60	15	S	foliation	261997	3715667	Tpl	
24	24	90		foliation	262005	3715583	Tpl	
29	340	35	W	foliation	262656	3713179	Tpl	
30	70	60	N	foliation	262607	3713255	Tpl	
31	110	30	S	foliation	262534	3713301	Tpl	
32	65	20	NE	foliation	262539	3713385	Tpl	
35	60	35	NE	foliation	262527	3713671	Tpl	
39	90	35	S	foliation	262283	3713400	Tpl	
39	120	15	S	foliation	262283	3713400	Tpl	
95	115	10	N	foliation	260312	3719795	Tpl	
124	130	20	S	foliation	262689	3715868	Tpl	
201	330	35	W	foliation	262679	3716014	Tpl	
214	105	35	S	foliation	262450	3716162	Tpl	
231	340	90		foliation	261969	3717021	Tpl	
232	100	85	N	foliation	261971	3717061	Tpl	
317	55	15	S	foliation	262744	3712170	Tpl	
319	30	25	W	foliation	262676	3712443	Tpl	

Station	Strike (azimuth)	Dip	Dip direction	Feature	UTM Easting	UTM Northing	Unit	Comments
328	40	10	W	foliation	261841	3711497	Tpl	
342	100	10	S	foliation	261971	3714660	Tpl	
339	160	25	W	foliation	261944	3714854	Tpl	
345	80	15	S	foliation	262296	3714222	Tpl	
346	140	10	E	foliation	261863	3714126	Tpl	
347	30	25	S	foliation	261739	3714103	Tpl	
355	35	35	NW	foliation	261402	3714772	Tpl	
357	45	15	SW	foliation	261045	3714779	Tpl	
365	90	25	S	foliation	261196	3715003	Tpl	
367	95	40	S	foliation	262467	3712389	Tpl	
369	85	15	S	foliation	262115	3712577	Tpl	
375	75	15	S	foliation	262421	3712650	Tpl	
376	80	10	S	foliation	262493	3712137	Tpl	
378	65	20	S	foliation	262449	3711900	Tpl	
416	90	20	S	foliation	259195	3715386	Tpl	
434	50	90		foliation	259992	3715790	Tpl	
444	90	25	S	foliation	258832	3714655	Tpl	
445	100	25	S	foliation	258983	3714578	Tpl	
447	80	10	S	foliation	259408	3714133	Tpl	
448	325	25	W	foliation	259462	3713958	Tpl	
449	120	25	E	foliation	259018	3713828	Tpl	
479	60	30	S	foliation	259040	3713034	Tpl	
483	0	30	W	foliation	259377	3712789	Tpl	
483	140	30	S	foliation	258795	3715705	Tpl	
484	15	15	E	foliation	259239	3713099	Tpl	
485	340	15	E	foliation	258985	3713610	Tpl	
489	130	15	S	foliation	259259	3714589	Tpl	
499	40	15	S	foliation	258260	3711398	Tpl	
521	130	15	NE	foliation	258031	3710609	Tpl	
542	120	20	S	foliation	261176	3709834	Tpl	
MONT7	100	25	S	foliation	262728	3715406	Tpl	
327	65	60	W	foliation	261771	3711339	Tpl, Tan	calcite
204	85	10	N	foliation	260231	3719769	Tt	
237	100	5	N	foliation	262251	3719738	Tt	
385	60	15	SW	foliation	259407	3719318	Tt	
395	350	20	W	foliation	259748	3720415	Tt	
398	315	15	W	foliation	264450	3723763	Tt	
401	20	20	W	foliation	259153	3720463	Tt	
405	70	30	NW	foliation	261856	3720831	Tt	
409	0	10	W	foliation	262057	3720802	Tt	
410	120	25	N	foliation	261954	3719179	Tt	
411	100	10	N	foliation	262028	3719386	Tt	
412	100	10	N	foliation	262197	3719608	Tt	
465	340	50	W	foliation	259070	3716528	Tt	
650	40	5	W	foliation	259557	3717758	Tt	
205	105	20	N	foliation	261941	3719217	Tt	
88	315	20	SW	foliation	267468	3716086	Tvp	
88	315	30	SW	foliation	267659	3716460	Tvp	
90	340	30	SW	foliation	267598	3715011	Tvp	
100	60	25	E	foliation	267743	3716677	Tvp	
101	60	20	E	foliation	267849	3717001	Tvp	
112	105	15	S	foliation	268037	3719853	Tvp	
118	140	15	S	foliation	267369	3719378	Tvp	

Station	Strike (azimuth)	Dip	Dip direction	Feature	UTM Easting	UTM Northing	Unit	Comments
119	120	10	S	foliation	267132	3719090	Tvp	
122	145	10	S	foliation	267602	3718869	Tvp	
131	80	60	NE	foliation	265248	3717213	Tvp	
134	135	30	W	foliation	265644	3716664	Tvp	
135	110	30	W	foliation	265780	3717081	Tvp	
136	120	20	W	foliation	265962	3717315	Tvp	
139	140	20	S	foliation	266752	3718060	Tvp	
142	110	20	S	foliation	267015	3717873	Tvp	
144	20	35	W	foliation	267078	3722942	Tvp	
145	350	20	W	foliation	267128	3922682	Tvp	
151	345	20	W	foliation	266083	3709737	Tvp	
152	345	15	W	foliation	265963	3719388	Tvp	
153	345	10	W	foliation	265530	3718171	Tvp	
154	350	40	W	foliation	265356	3717813	Tvp	
159	10	25	W	foliation	266133	3719774	Tvp	
160	340	20	W	foliation	266577	3719605	Tvp	
161	320	15	W	foliation	266568	3719817	Tvp	
162	40	10	NW	foliation	265708	3719853	Tvp	
163	10	30	W	foliation	265538	3719677	Tvp	
164	10	30	W	foliation	265325	3719415	Tvp	
165	20	25	W	foliation	265127	3719136	Tvp	
167	330	35	W	foliation	264693	3718715	Tvp	
171	320	20	W	foliation	267462	3720482	Tvp	
178	15	15	W	foliation	264720	3719741	Tvp	
228	10	5	W	foliation	265342	3721213	Tvp	
250	330	20	N	foliation	260226	3719027	Tvp	
251	345	12	N	foliation	259821	3718598	Tvp	
347	330	25	E	foliation	261739	3714103	Tvp	
454	70	25	N	foliation	257541	3714751	Tvp	
455	90	40	N	foliation	257723	3714350	Tvp	
455	90	40	N	foliation	257723	3714350	Tvp	
457	120	30	N	foliation	257753	3714477	Tvp	
457	120	30	N	foliation	257753	3714477	Tvp	
458	70	25	N	foliation	257541	3714751	Tvp	
610	345	40	W	foliation	263319	3709667	Tvp	
102	340	90		intrusive contact	268002	3717304	Til, Tvp	
417	10	90		joints	259433	3715189	andesite	
158	320	90		joints	264866	3717092	Tvp	
159	90	90		joints	266133	3719774	Tvp	
159a	90	90		joints	266133	3719774	Tvp	
477	65	90		veins	258682	3713183	calcite	silicified, brecciated
486	330	90		veins	258815	3713748	calcite	
502	45	90		veins	258369	3711868	calcite	
509	70	90		veins	257410	3712124	calcite	
531	45	90		veins	260300	3710173	calcite	
538	0	90		veins	260431	3709703	calcite	
361	100	90		veins	260637	3714806	quartz	
415	60	90		veins	259117	3715408	quartz	
422	60	90		veins	260152	3715574	quartz	
510	0	90		veins	257377	3711806	quartz	
518	85	90		veins	258502	3709317	quartz	
523	105	90		veins	258103	3710276	quartz	

Station	Strike (azimuth)	Dip	Dip direction	Feature	UTM Easting	UTM Northing	Unit	Comments
532	115	90		veins	260274	3710636	quartz	
535	110	90		veins	259439	3710650	quartz	
433	130	90		veins	259785	3715589	quartz vein	
325	45	90		veins	262395	3711143	Tmbx	calcite
10	75	80	N	veins	263399	3713238	Tpl	Taylor shaft, pits, 10 ft wide
322	130	90		veins	262599	3712242	Tpl	calcite
322	0	90		veins	262790	3712131	Tpl	calcite, main fault
446	80	90		veins	259229	3714367	Tpl	
373	125	90		veins	262115	3713105	Tpl	
563	60	90		veins	260636	3710404	Tpl	
582	15	5	E	bedding	265256	3710724	cong	
640	350	10	N	bedding	259141	3717458	cong	
641	120	10	S	bedding	259196	3717507	cong	
642	120	5	S	bedding	259291	3717730	cong	
651	120	15	N	bedding	259656	3718027	cong	
272	10	5	W	bedding	258477	3717926	Qt	
592	120	10	N	bedding	264777	3711170	Qt	
632	120	15	E	bedding	259184	3717886	Qt	
633	350	15	E	bedding	259122	3718000	Qt	
612	120	10	N	bedding	263574	3709843	sand	
495	20	40	W	bedding	256965	3712547	sediments	
36	60	30	NE	bedding	262550	3713716	cong	
206	315	20	W	bedding	263764	3723087	cong	
243	40	12	E	bedding	259656	3718029	cong	
198	325	30	E	bedding	262594	3717569	cong	
221	15	55	W	bedding	262589	3718275	cong	
222	10	50	W	bedding	262624	3718387	cong	
223	0	22	W	bedding	262841	3718944	cong	
224	10	15	W	bedding	263011	3719129	cong	
225	10	15	W	bedding	-	-	cong	
240	40	20	E	bedding	259183	3717468	cong	
241	25	18	E	bedding	259374	3717675	cong	
385	20	20	SW	bedding	259407	3719318	cong	
386	340	20	SW	bedding	259304	3719332	Qal	
388	10	15	SW	bedding	259159	3719245	Qal	
130	10	10	W	bedding	264091	3715405	Qt	
309	0	0		bedding	269491	3696406	QTsf	
311	0	0		bedding	271418	3696800	QTsf	
314	0	0		bedding	258626	3716665	QTsf	
208	5	15	W	bedding	263141	3714038	sand	
352	90	20	S	bedding	261472	3714558	siltstone	

APPENDIX 5
CLAY MINERAL ANALYSES OF SAMPLES FROM THE MONTOYA BUTTE QUADRANGLE

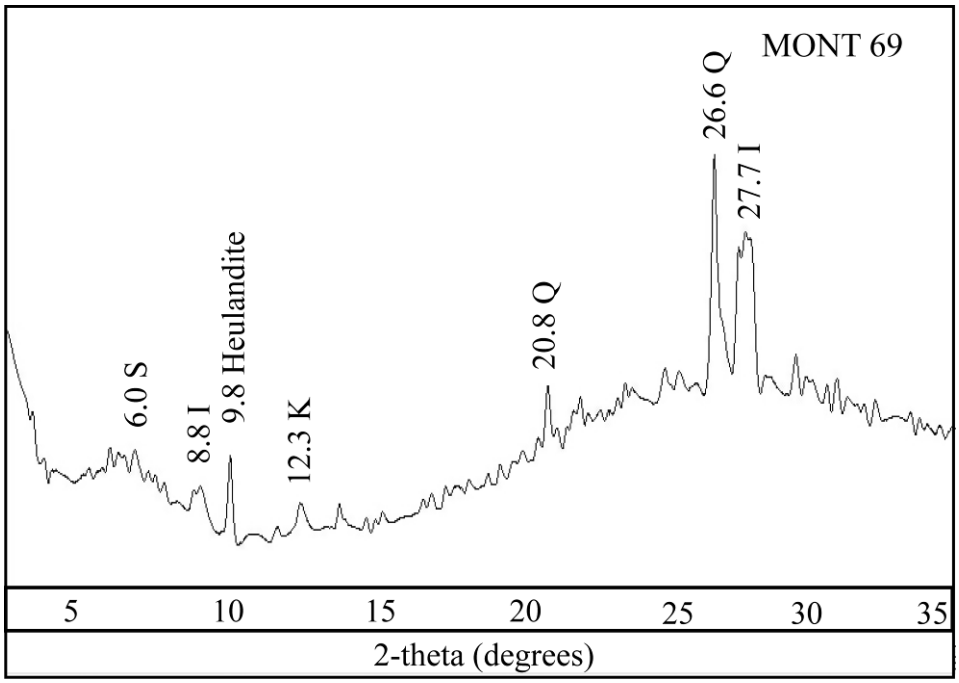
Clay mineralogy on selected samples from Red Paint Canyon and soil profiles was determined by X-ray Diffraction methods (XRD) using the procedure by Hall (2004; McLemore and Frey, 2009). Sample location are located in Appendix 3, Figure A3-1.

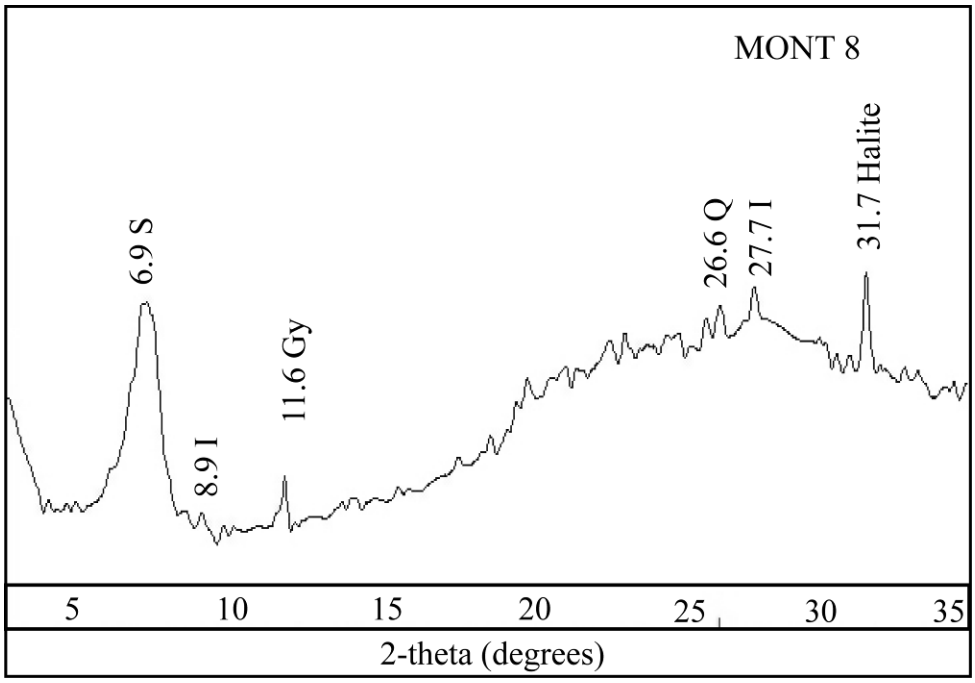
TABLE A5-1. Clay mineral analyses of selected samples from Montoya Butte. Clay minerals are in parts per ten of clay-size fraction of the sample.

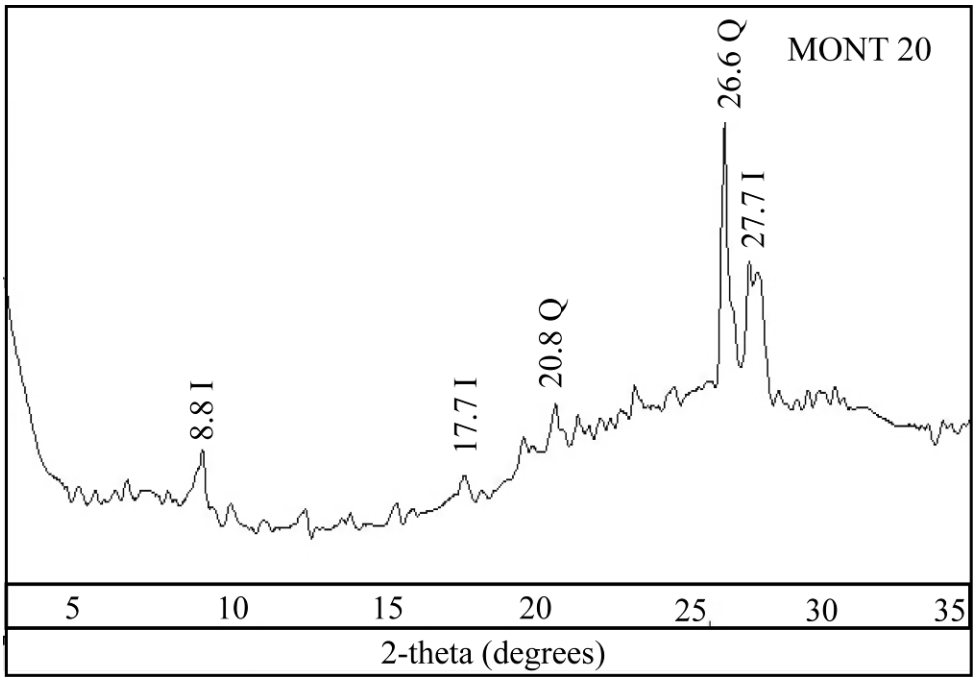
Sample Number	Kaolinite	Illite	Smectite	Chlorite	Mixed illite-smectite	Total	Comments	Location
Red Paint Canyon								
MONT 08	1	1	3	1	4	10	red clay, fault gauge	Monticello Box
MONT 31	2	2	0	0	6	10	altered tuff, Tas	Red Paint Canyon
MONT 35	10	0	0	0	0	10	red clay	Red Paint Canyon
MONT 60	3	5	0	0	2	10	red clay	Red Paint Canyon
MONT 61	2	3	3	0	2	10	white clay	Red Paint Canyon
MONT 62	3	3	2	0	2	10		Red Paint Canyon
soils								
MONT 20	1	4	1	3	1	10	black, top soil	Victorio
MONT 21	2	6	2	0	0	10	brown	Victorio
MONT 22	0	3	4	1	2	10	gray floodplain soil	Victorio
MONT 54	0	2	7	0	1	10	soil	floodplain
MONT 55	0	7	2	0	1	10	soil	floodplain near quartz latite
MONT 56	1	6	3	0	0	10	soil	gate
MONT 57	0	0	9	0	1	10	soil	below gate
MONT 69	3	3	2	0	2	10	clay	

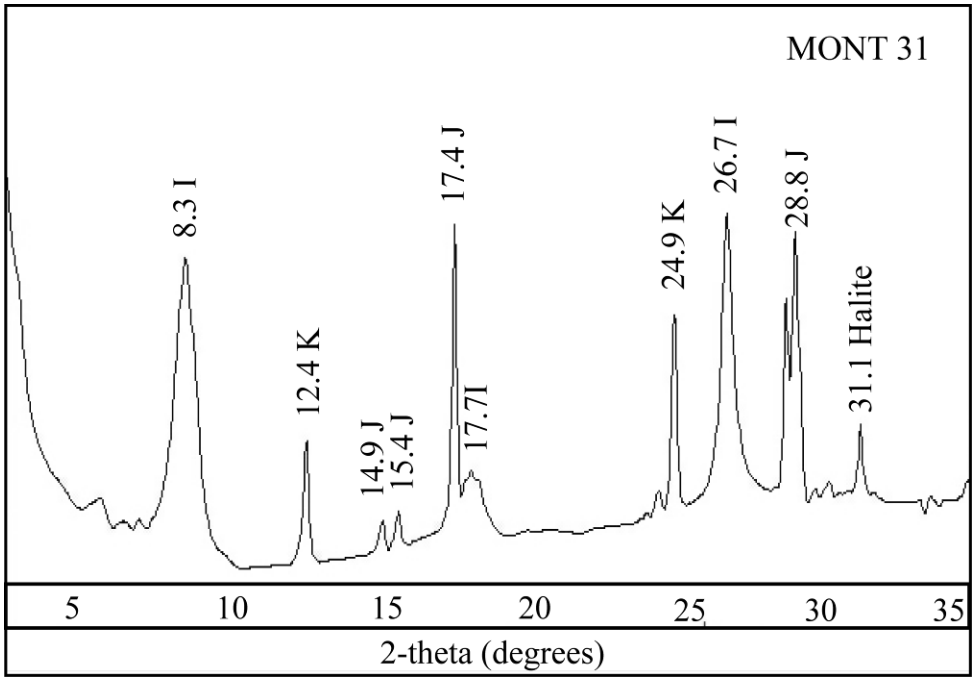
X-ray diffractograms on clay separates

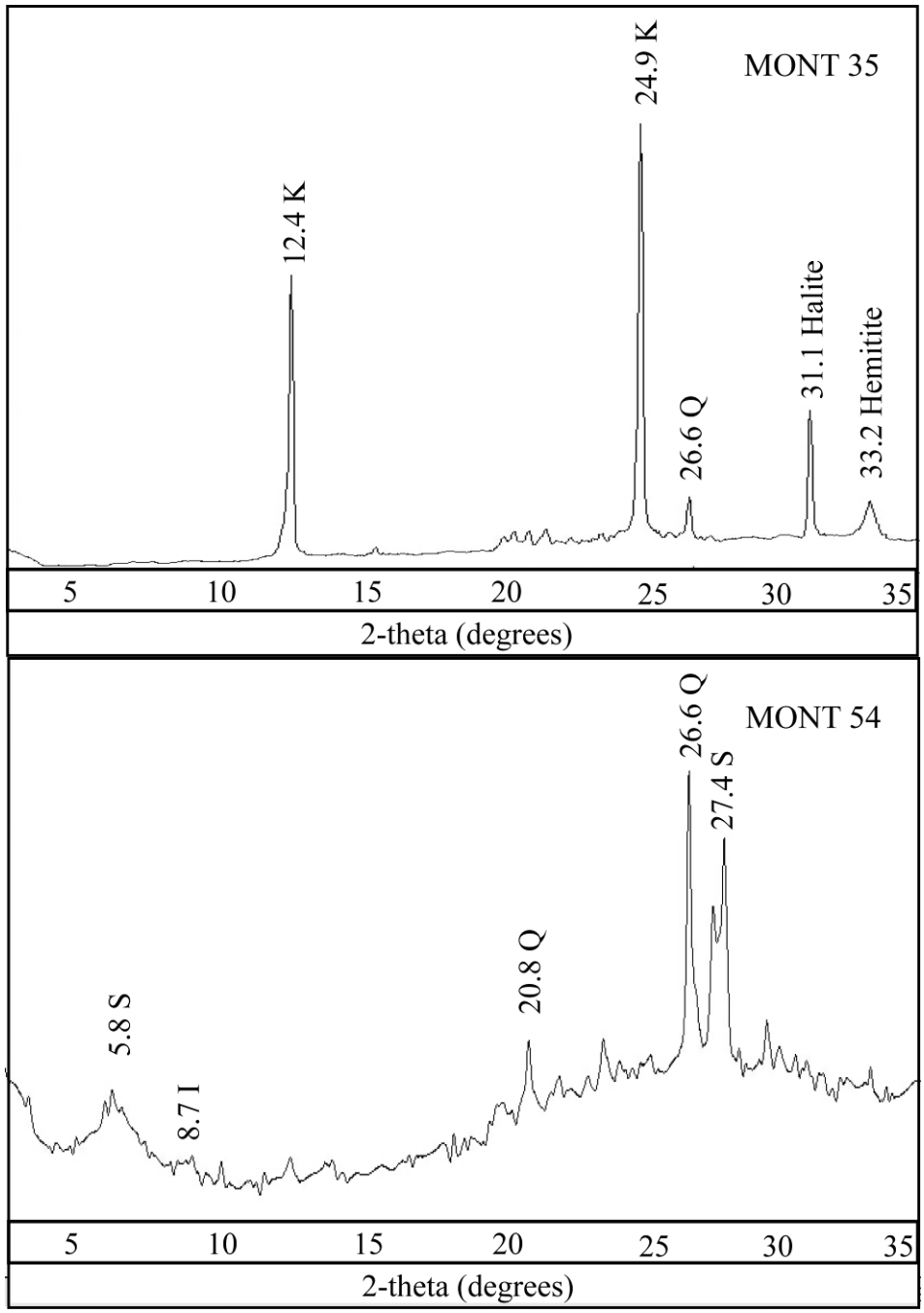
I-illite
S-smectite
K-kaolinite
Q-Quartz
Gy-gypsum
J-jarosite

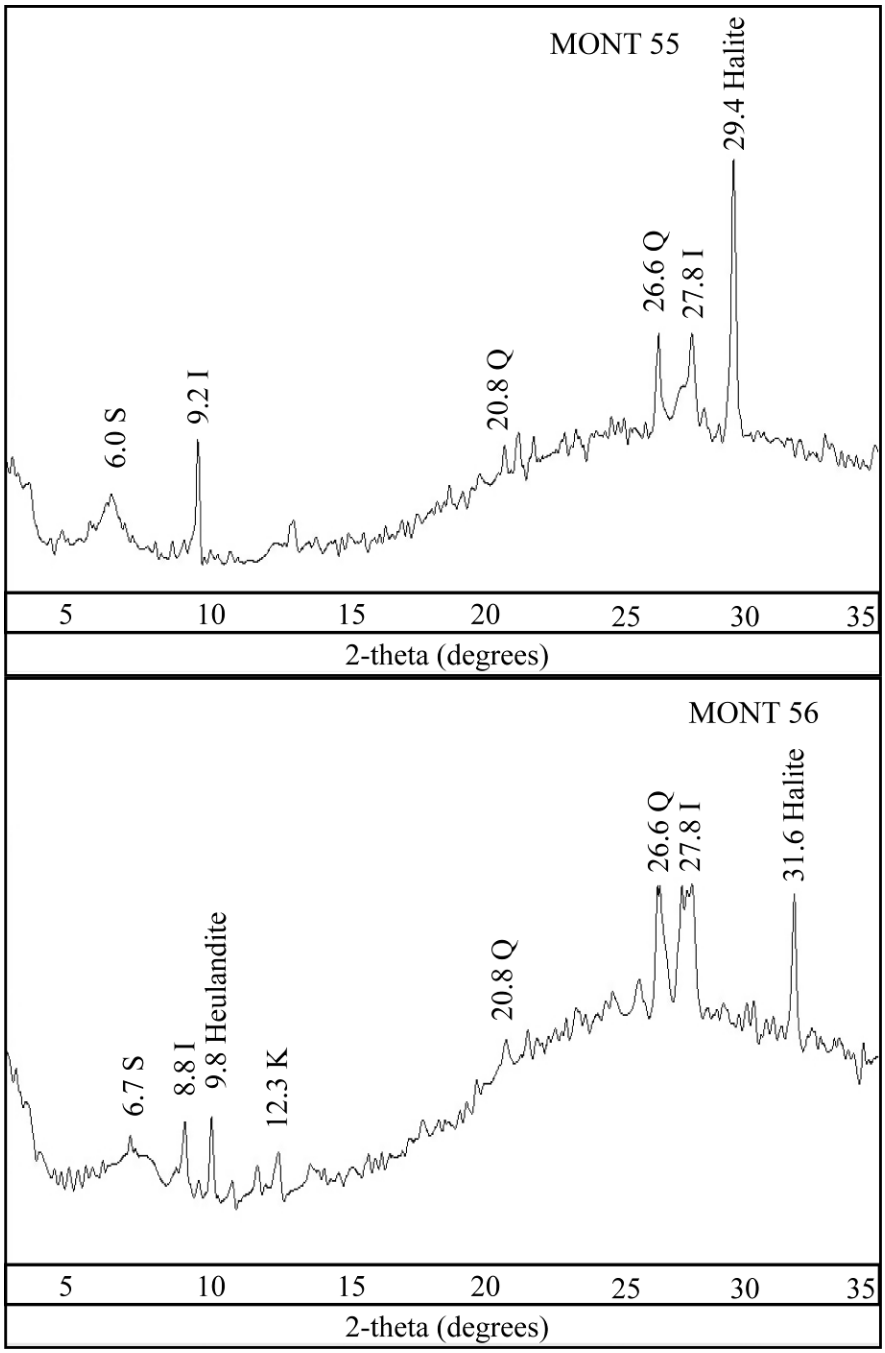

MONT 69
6.0 S
8.8 I
9.8 Heulandite
12.3 K
20.8 Q
26.6 Q
27.7 I
5
10
15
20
25
30
35
2-theta (degrees)

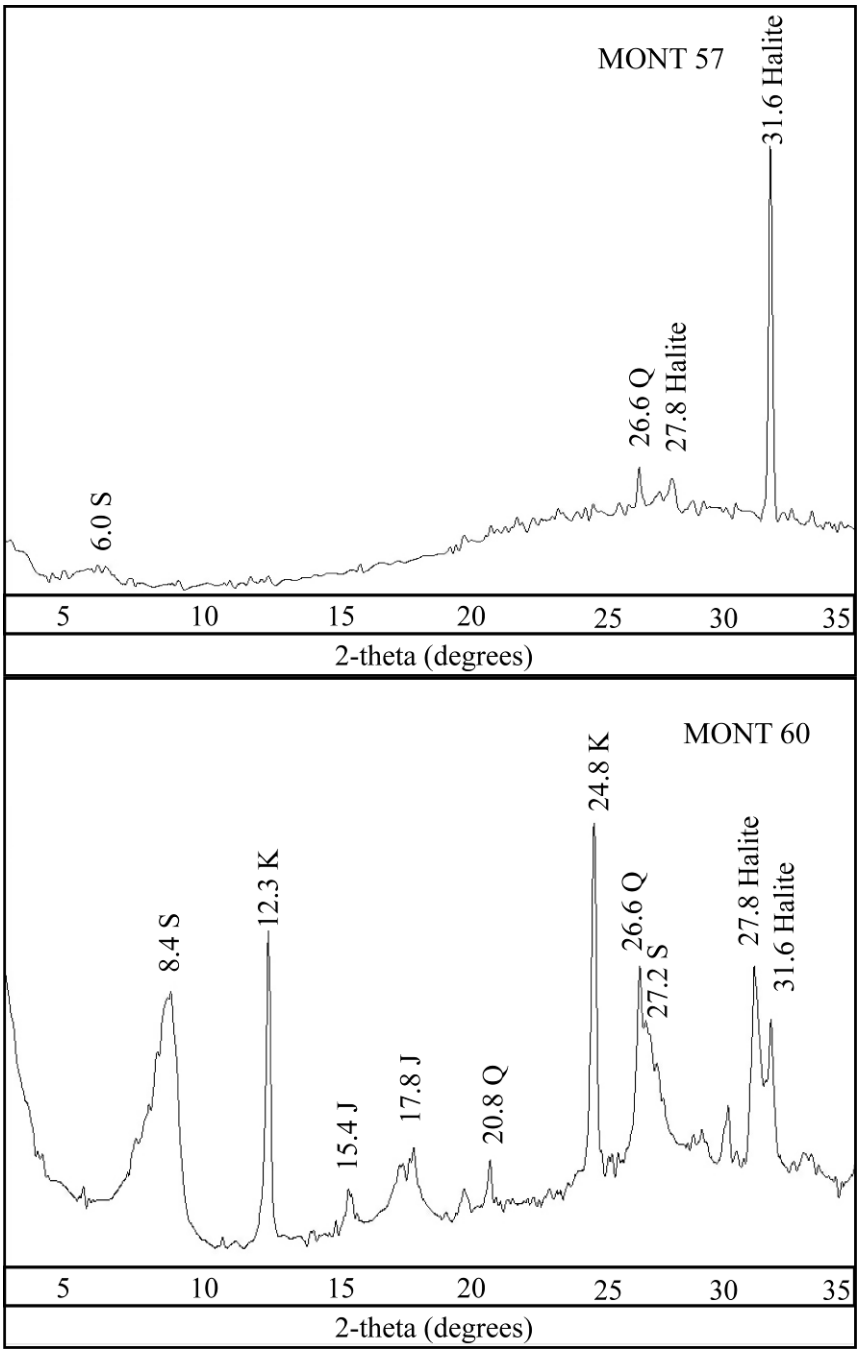

MONT 8
6.9 S
8.9 I
11.6 Gy
26.6 Q
27.7 I
31.7 Halite
5
10
15
20
25
30
35
2-theta (degrees)

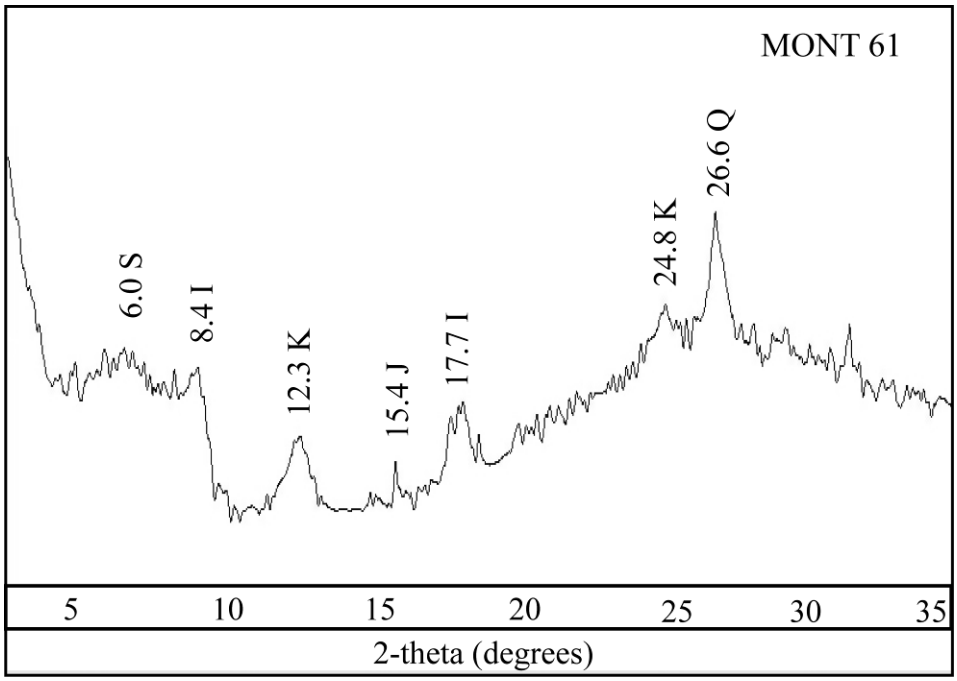

MONT 20
8.8 I
17.7 I
20.8 Q
26.6 Q
27.7 I
5
10
15
20
25
30
35
2-theta (degrees)

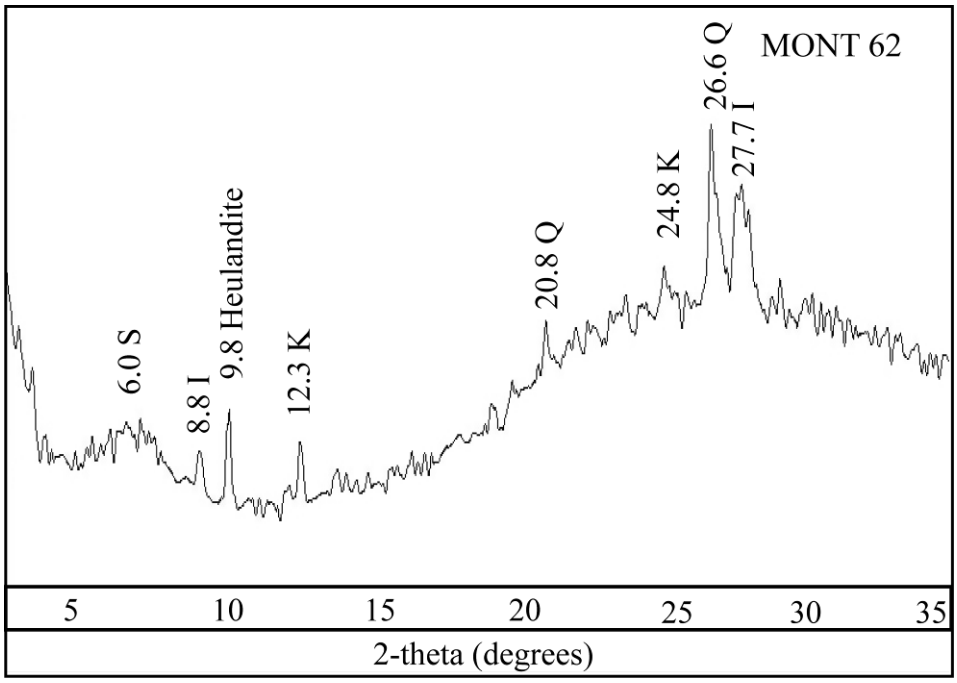

MONT 31
8.3 I
12.4 K
14.9 J
15.4 J
17.4 J
17.7I
24.9 K
26.7 I
28.8 J
31.1 Halite
5
10
15
20
25
30
35
2-theta (degrees)


MONT 35
12.4 K
24.9 K
26.6 Q
31.1 Halite
33.2 Hemitite
5
10
15
20
25
30
35
2-theta (degrees)
MONT 54
5.8 S
8.7 I
20.8 Q
26.6 Q
27.4 S
5
10
15
20
25
30
35
2-theta (degrees)


MONT 55
6.0 S
9.2 I
20.8 Q
26.6 Q
27.8 I
29.4 Halite
5
10
15
20
25
30
35
2-theta (degrees)
MONT 56
6.7 S
8.8 I
9.8 Heulandite
12.3 K
20.8 Q
26.6 Q
27.8 I
31.6 Halite
5
10
15
20
25
30
35
2-theta (degrees)


MONT 57
6.0 S
26.6 Q
27.8 Halite
31.6 Halite
5
10
15
20
25
30
35
2-theta (degrees)
MONT 60
8.4 S
12.3 K
15.4 J
17.8 J
20.8 Q
24.8 K
26.6 Q
27.2 S
27.8 Halite
31.6 Halite
5
10
15
20
25
30
35
2-theta (degrees)


MONT 61
6.0 S
8.4 I
12.3 K
15.4 J
17.7 I
24.8 K
26.6 Q
5
10
15
20
25
30
35
2-theta (degrees)


MONT 62
6.0 S
8.8 I
9.8 Heulandite
12.3 K
20.8 Q
24.8 K
26.6 Q
27.7 I
5
10
15
20
25
30
35
2-theta (degrees)

APPENDIX 6
^{40}AR/^{39}AR GEOCHRONOLGY RESULTS FOR SAMPLES MONT104, 105, AND 106
By M. Heizler, October 25, 2010 (Iinternal Report NMGRL-IR-702)

Three samples were submitted for age determinations. Sample locations are in Appendix 3.

Introduction

Dr. Virginia McLemore from the New Mexico Bureau of Geology and Mineral Resources submitted three samples for ^{40}Ar/^{39}Ar dating. From tuff samples Mont104 and Mont105 sanidine was extracted for single crystal dating, whereas biotite from Mont108 latite was separated and step-heated. The data define 3 distinct volcanic eruptions at ~37.5, 28.4 and 24.5 Ma.

^{40}Ar/^{39}Ar Analytical Methods and Results

The samples were irradiated for 7 hours at the UGGS TRIGA reactor in Denver, CO along with the standard Fish Canyon tuff sanidine as a neutron flux monitor. Sanidine samples were analyzed by the single crystal laser fusion (SCLF) method and the biotite was step-heated within a Mo double vacuum resistance furnace (Table A6-1.) Flux monitor sanidine crystals were fused in a single step using the CO_2 laser. Additional methodology specific to this report and summary age data are provided in Table 1 and general operational details for the NMGRL can be found at internet site http://geoinfo.nmt.edu/publications/openfile/argon/home/html.

Age probability diagrams for the sanidine samples are given in Figure A6-1 and reveal normally distributed age populations for both Mont104 and Mont105 (Table 2). Mont104 provides a weighted mean age of 28.38±0.03 Ma for 14 of the 15 crystals analyzed with an outlier crystal yielding an age of ca. 31 Ma (Fig. 1; Table 2). This outlier is interpreted to be a xenocrystic K-feldspar. All of the 14 crystals of Mont105 combine to yield an age of 24.50±0.04 Ma with no apparent outliers as demonstrated by the MSWD value for the population of 1.08 (Fig. A6-1; Table A6-2).

The age spectrum for Mont108 biotite is somewhat disturbed with initial ages climbing from ca. 28 to 38 Ma before decreasing across the remainder of the spectrum to ~36 Ma (Fig. A6-2; Table A6-3). The final two steps comprise ~60% of the spectrum and yield a weighted mean age of 35.70±0.05 Ma. Although the spectrum is not ideal and perhaps affected by ^{39}Ar recoil, the assigned age is considered accurate.

Discussion

The 3 samples yield 3 discrete eruptive events. Mont105 provides an age of 35.70±0.05 Ma whereas Mont104 records an eruption at 28.38±0.03 Ma and finally Mont105 yields the youngest eruption at 24.50±0.04 Ma. Overall the data have simple interpretations and the reported results are considered accurate within the cited uncertainties.

TABLE A6-1. Summary of assigned ages and analytical methods.

BULK SPECTRA								
Sample	L#		Plateau Age	±	MSWD	$\%^{39}Ar$	n	
MONT108	59098		35.7	0.05	0.6	61.5	2	
SINGLE CRYSTAL								
			Mean					
Sample	L#		Age	±	MSWD	$\%^{39}Ar$	n	
Mont104	59097		28.378	0.036	1.26	NA	14	
Mont105	59076		24.50	0.039	1.08	NA	14	
L# = Lab number								
n = number of steps for plateau or number of single crystals analyzed								
$\%^{39}Ar$ = percentage of total ^{39}Ar comprising the plateau steps.								
NA = Not applicable								
Methods								
Sample preparation and irradiation:								
Minerals separates obtained by standard heavy liquid, magnetic and hand-picking techniques.								
Separates were loaded into machined Al discs and irradiated for 7 hours in central timble of USGS TRIGA reactor, Denver, CO.								
Neutron flux monitor Fish Canyon Tuff sanidine (FC-2). Assigned age = 28.02 Ma (Renne et al., 1998)								
Instrumentation:								
Mass Analyzer Products 215-50 mass spectrometer on line with automated all-metal extraction system.								
Laser fusion using a 50 watt Synrad CO_2 laser.								
Furnace step-heating in double vacuum Mo resistance furnace.								
Furnace analysis: Reactive gases removed during a 7 minute heating with a SAES GP-50 getter operated at ~450°C.								
Additional cleanup (3 minutes) following heating with 2 SAES GP-50 getters, 1 operated at ~450°C and 1 at 20°C.								
Gas also exposed to a W filament operated at ~2000°C.								
Laser fusion analysis: Reactive gases removed during a 3 minute reaction with 2 SAES GP-50 getters,								
1 operated at ~450°C and 1 at 20°C. Gas also exposed to a W filament operated at ~2000°C and a cold finger operated at -140°C.								
Analytical parameters:								
Electron multiplier sensitivity averaged:								
Laser - 5.5×10^{-17}: Furnace - 8.0×10^{-17} (both in moles/pA).								
Total system blank and background: Laser fusion = 40, 0.5, 0.2, 3.0, 0.5 x 10^{-17} moles for masses 40, 39, 38, 37, 36, respectively.								
Total system blank and background: Furnace = 75, 0.9, 0.1, 1.0, 4.7 x 10^{-17} moles for masses 40, 39, 38, 37, 36, respectively.								
J-factors determined to a precision of ± 0.1% by CO_2 laser-fusion of 6 single crystals from each of 10 radial positions around the 20 hole irradiation tray.								
Correction factors for interfering nuclear reactions were determined using K-glass and CaF_2 and are as follows:								
NM-225: $(^{40}Ar/^{39}Ar)_K = 0.010 \pm 0.001$; $(^{36}Ar/^{37}Ar)_{Ca} = 0.000280 \pm 0.000005$; and $(^{39}Ar/^{37}Ar)_{Ca} = 0.00070 \pm 0.00005$.								

TABLE A6-2. Argon isotope data for single crystal sanidine samples.

	ID	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$	$^{39}Ar_K$	K/Ca	$^{40}Ar^*$	Age	±1s
				(x 10^{-3})	(x 10^{-15} mol)		(%)	(Ma)	(Ma)
	Mont104, Sanidine, J=0.0015326±0.07%, D=1.005±0.001, NM-225K, Lab#=59097								
	13	11.31	0.2350	3.665	1.953	2.2	90.6	28.09	0.26
	11	11.19	0.0158	3.137	3.887	32.4	91.7	28.14	0.15
	9	12.17	0.0790	6.347	3.820	6.5	84.6	28.23	0.16
	1	11.18	0.1031	2.956	3.860	5.0	92.3	28.26	0.14
	5	10.68	0.0478	1.202	4.646	10.7	96.7	28.30	0.12
	14	11.14	0.0705	2.788	4.810	7.2	92.7	28.30	0.12
	15	10.95	0.0818	2.123	10.767	6.2	94.3	28.307	0.072
	2	10.54	0.0448	0.7293	7.471	11.4	98.0	28.320	0.079
	8	10.82	0.0438	1.585	8.293	11.6	95.7	28.379	0.080
	7	11.06	0.0493	2.343	11.046	10.3	93.8	28.430	0.077
	3	11.09	0.0729	2.395	7.884	7.0	93.7	28.467	0.085
	4	10.80	0.1630	1.403	6.148	3.1	96.3	28.506	0.097
	12	10.98	0.2333	1.899	6.107	2.2	95.1	28.60	0.10
	6	35.18	0.0166	83.58	8.714	30.8	29.8	28.73	0.38
x	10	13.20	0.1563	6.644	3.457	3.3	85.2	30.82	0.17
	Mean age ± 1s		n=14	MSWD=1.26		10.5 ±19.0		28.378	0.036
	Mont105, Sanidine, J=0.0014967±0.05%, D=1.005±0.001, NM-225G, Lab#=59076								
	18	9.592	0.0253	1.851	2.283	20.2	94.3	24.24	0.36
	17	9.326	0.0151	0.8905	3.859	33.9	97.2	24.28	0.20
	09	9.313	0.0183	0.8002	5.157	27.9	97.5	24.32	0.15
	07	9.295	0.0150	0.6755	7.540	33.9	97.9	24.37	0.12
	11	9.279	0.0092	0.6078	6.101	55.5	98.1	24.38	0.13
	08	9.272	0.0193	0.5621	6.516	26.4	98.2	24.40	0.12
	15	9.417	0.0240	1.030	8.346	21.2	96.8	24.42	0.11
	19	9.462	0.0197	1.148	4.787	26.0	96.4	24.45	0.16
	12	9.229	0.0086	0.3473	3.826	59.4	98.9	24.45	0.20
	16	9.219	0.0176	0.2167	5.287	29.1	99.3	24.53	0.14
	06	9.202	0.0263	0.1027	6.280	19.4	99.7	24.57	0.12
	13	9.256	0.0114	0.2655	8.297	44.6	99.2	24.589	0.093
	10	9.213	0.0150	-0.0172	9.115	34.0	100.1	24.697	0.091
	14	9.288	0.0139	0.2053	4.325	36.6	99.4	24.72	0.18
	Mean age ± 1s		n=14	MSWD=1.08		33.4 ±24.6		24.498	0.039
	Notes:								
	Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interfering reactions.								
	Errors quoted for individual analyses include analytical error only, without interfering reaction or J uncertainties.								
	Mean age is weighted mean age of Taylor (1982). Mean age error is weighted error								
	of the mean (Taylor, 1982), multiplied by the root of the MSWD where MSWD>1, and also								
	incorporates uncertainty in J factors and irradiation correction uncertainties.								

	Decay constants and isotopic abundances after Steiger and Jäger (1977).					
	x symbol preceding sample ID denotes analyses excluded from mean age calculations.					
	Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard at 28.02 Ma					
	Decay Constant (LambdaK (total)) = 5.543e-10/a					
	Correction factors:					
	$(^{39}Ar/^{37}Ar)_{Ca}$ = 0.0007 ± 5e-05					
	$(^{36}Ar/^{37}Ar)_{Ca}$ = 0.00028 ± 2e-05					
	$(^{40}Ar/^{39}Ar)_{K}$ = 0.010 ± 0.002					

TABLE A6-3. Argon isotope data for step-heated biotite Mont108.

	ID	Temp	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$	$^{39}Ar_K$	K/Ca	$^{40}Ar^*$	^{39}Ar	Age	±1s
		(°C)			(x 10^{-3})	(x 10^{-15} mol)		(%)	(%)	(Ma)	(Ma)
	Mont108, Biotite, 5 mg, J=0.0015324±0.07%, D=1.005±0.001, NM-225K, Lab#=59098-01										
X	A	600	112.4	0.0929	346.0	5.18	5.5	9.0	3.3	27.9	1.4
X	B	700	54.48	0.2962	145.8	2.84	1.7	21.0	5.2	31.29	0.91
X	C	850	35.01	0.1046	75.96	5.80	4.9	35.9	8.9	34.42	0.46
X	D	920	21.11	0.0310	26.05	6.57	16.4	63.5	13.1	36.69	0.23
X	E	1000	17.77	0.0233	14.10	11.4	21.9	76.6	20.5	37.21	0.17
	F	1110	15.48	0.0422	7.710	28.1	12.1	85.3	38.5	36.122	0.092
	G	1210	14.40	0.0626	4.554	57.6	8.1	90.7	75.6	35.729	0.064
	H	1680	14.20	0.0294	3.960	38.0	17.4	91.8	100.0	35.653	0.073
	Integrated age ± 1s			n=8		155.6	9.6		K2O=7.80 %	35.54	0.12
	Plateau ± 1s		steps G-H	n=2	MSWD=0.62	95.600			61.5	35.70	0.050
	Notes:										
	Isotopic ratios corrected for blank, radioactive decay, and mass discrimination, not corrected for interfering reactions.										
	Errors quoted for individual analyses include analytical error only, without interfering reaction or J uncertainties.										
	Integrated age calculated by summing isotopic measurements of all steps.										
	Integrated age error calculated by quadratically combining errors of isotopic measurements of all steps.										
	Plateau age is inverse-variance-weighted mean of selected steps.										
	Plateau age error is inverse-variance-weighted mean error (Taylor, 1982) times root MSWD where MSWD>1.										
	Plateau error is weighted error of Taylor (1982).										
	Decay constants and isotopic abundances after Steiger and Jäger (1977).										
	X preceding sample ID denotes analyses excluded from plateau age calculations.										
	Weight percent K_2O calculated from ^{39}Ar signal, sample weight, and instrument sensitivity.										
	Ages calculated relative to FC-2 Fish Canyon Tuff sanidine interlaboratory standard at 28.02 Ma										
	Decay Constant (LambdaK (total)) = 5.543e-10/a										
	Correction factors:										

	$(^{39}Ar/^{37}Ar)_{Ca}$ = 0.0007 ± 5e-05							
	$(^{36}Ar/^{37}Ar)_{Ca}$ = 0.00028 ± 2e-05							
	$(^{40}Ar/^{39}Ar)_{K}$ = 0.010 ± 0.002							

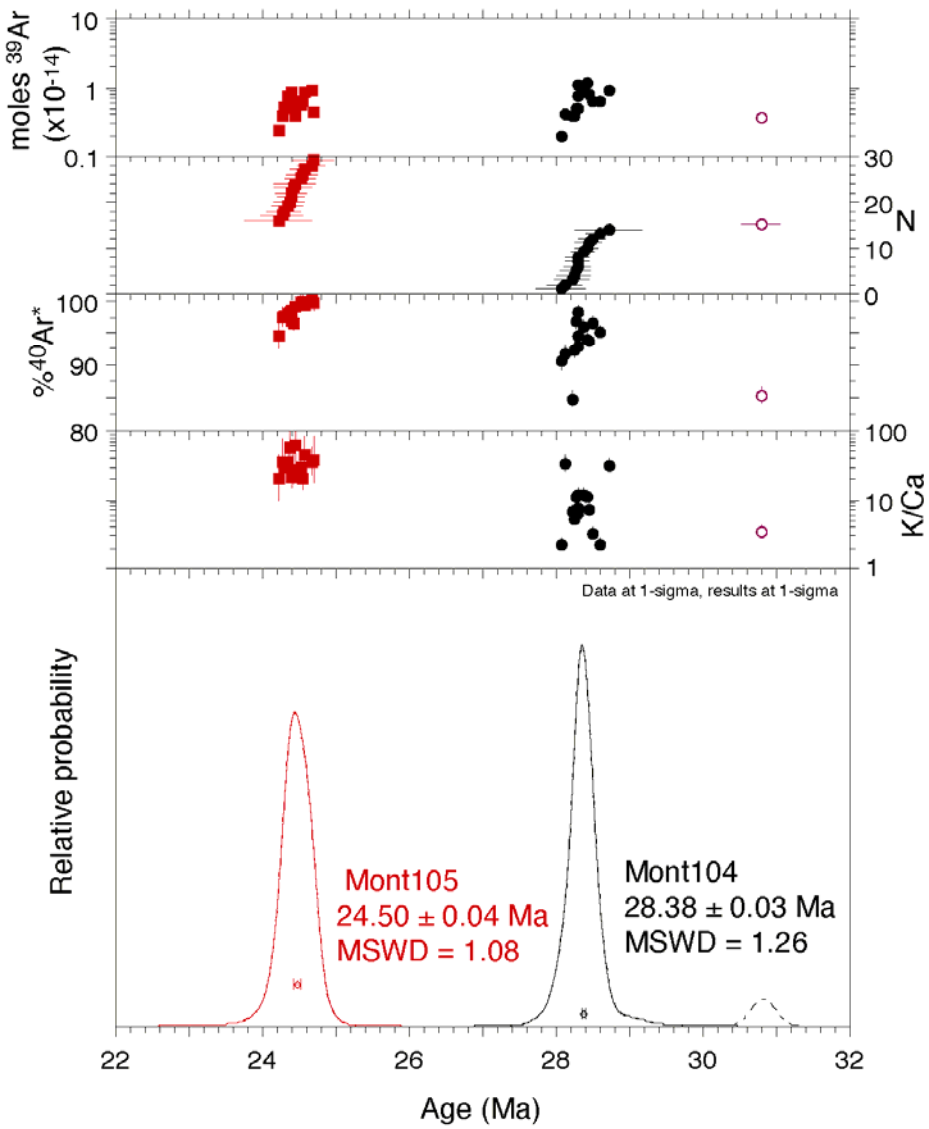


FIGURE A6-1. Age probability and auxiliary diagrams for single crystal laser fusion data for Mont104 and Mont105 sanidine. Filled symbols are data calculation whereas open symbols are excluded.

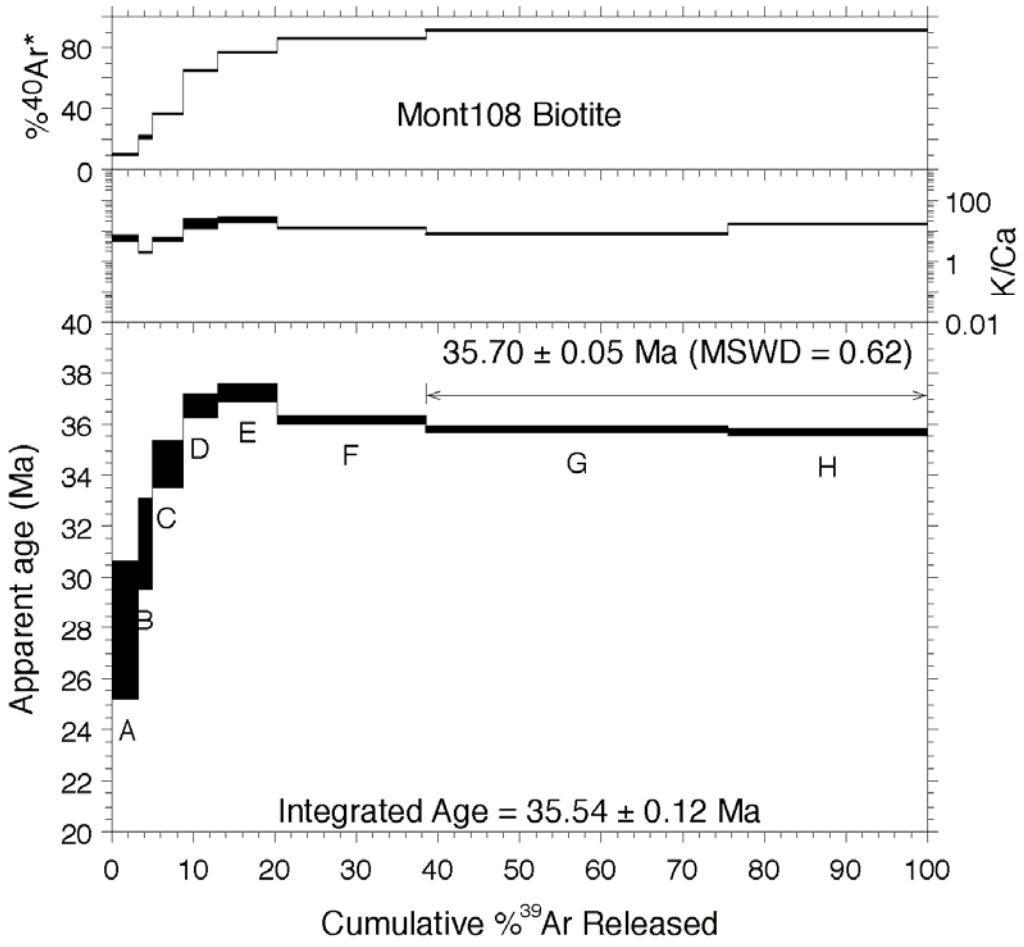


FIGURE A6-2. Age, K/Ca and radiogenic yield diagrams for Mont108 biotite.

APPENDIX 7
SUMMARY OF DRILLING BY THE U.S. BUREAU OF MINES AND BE RESOURCES, INC.

Information from drill holes drilled by the U.S. Bureau of Mines (Meeves, 1966) and BE Resources, Inc. are summarized in this appendix. The location of the drill holes is in Figure 34. It is difficult to differentiate the rhyolites from the drill cuttings or the written descriptions and to correlate them to specific rhyolite units mapped in the Montoya Butte quadrangle, because of their overall similarity, alteration, and complex faulting in the Red Paint Canyon fault zone. The units exposed at the surface in Red Paint Canyon are Turkey Springs Tuff (Tt) and rhyolite of Alum Spring (Tas) and likely are found in the upper portions of the holes drilled. It is believed that the Turkey Springs Tuff (Tt) and rhyolite of Alum Spring (Tas) overlie the rhyolite of Alamosa Canyon (Tac) and possibly the Vicks Peak Rhyolite (Tvp), but exact contacts cannot be determined from the available data. This complexity is typical of rhyolite intrusion complexes, such as domes found in the Spor Mountain area (Lindsey and Shawe, 1986). A geologic map and cross section of the Apache Warm Springs deposit is in Figure 34.

TABLE A7-1. Location and description of exploration drill holes in the Apache Warm Springs beryllium deposit (from Meeves, 1966 and P and E Mining Consultants Inc., 2009). UTM is in meters and is zone 13 NAD27. Water levels are from unpublished drill logs, BE Resources, Inc.

Hole identification number	UTM east	UTM north	Elevation (ft)	Total Depth (ft)	Water level (ft)	Elevation of water (ft)		Comments
BE18A	258876	3716389	6368	205	177	6191	mud	immediate vicinity of USBM hole
BE19	258864	3716360	6379	265	166	6213	mud	immediate vicinity of USBM hole
BE20	258942	3716508	6308	150	53	6255	static water level	immediate vicinity of USBM hole
BE21	258875	3716421	6359	285	265	6094	mud	immediate vicinity of USBM hole
BE22	258882	3716449	6359	360	200	6159	mud	immediate vicinity of USBM hole
BE23	258821	3716383	6410	305	295	6115	mud	immediate vicinity of USBM hole
BE24	258663	3716387	6386	580	375	6011	mud	0.5 mile south
BE25	258471	3716201	6413	800	500	5913	water	0.5 mile south
BE26	258471	3716201	6363	640	140	6223	water	0.5 mile south
BE27	258564	3716482	6350	800	200	6150	water	0.5 mile south
BE28	258577	3716598	6316	626	200	6116	water	0.5 mile south
BE29	258628	3716656	6312	800	200	6112	water	0.5 mile south
BE30	258226	3716359	6447	900	400	6047	water	0.5 mile south
BE31	258452	3716045	6491	850	400	6091	water	0.5 mile south
USBM1	258939	3716415		110				
USBM2	258942	3716390		100				
USBM3	258955	3716408		182				
USBM4	258942	3716383		140				
USBM5	258932	3716380		155				
USBM6	258940	3716403		125				
USBM7	258920	3716395		110				
USBM8	258924	3716415		165				
USBM9	258950	3716433		180				
USBM10	258948	3716370		150				
USBM11	258974	3716399	6325	110				

Hole identification number	UTM east	UTM north	Elevation (ft)	Total Depth (ft)	Water level (ft)	Elevation of water (ft)		Comments
USBM12	258907	3716407		140				
USBM13	258907	3716389		135				
USBM14	258892	3716400		200				
USBM15	258892	3716382		150				
USBM16	258892	3716361		145				
USBM17	258921	3716365		105				
USBM18	258879	3716418		170				

TABLE A7-2. Drill hole Be18A. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units		Top (ft)	Bottom (ft)	Be (ppm)
0	135	6368	6368	6233	gray rhyolite		130	140	37.9
135	144	6368	6233	6224	fractured light to green rhyolite		140	150	20.8
144	158	6368	6224	6210	permeable tuff with mud		150	155	31.7
158	177	6368	6210	6191	gray-red rhyolite		155	160	81.7
177	205	6368	6191	6163	permeable tuff with mud		160	165	942.8
							165	170	2200.0
							170	175	1100.0
							175	180	1800.0
							180	185	2600.0
							185	190	2200.0
							190	195	1100.0
							195	200	816.9

TABLE A7-3. Drill hole Be19. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units		Top (ft)	Bottom (ft)	Be (ppm)
0	148	6379	6379	6231	gray rhyolite		130	140	15.4
148	166	6379	6231	6213	red rhyolite		140	150	21.7
166	180	6379	6213	6199	permeable tuff with mud		150	155	13.3
180	265	6379	6199	6114	red rhyolite		155	160	14.6
							160	165	14.0
							165	170	14.1
							170	175	10.7
							175	180	12.3
							180	185	12.4
							185	190	15.3
							190	195	11.1
							195	200	8.6
							200	205	6.6
							205	210	6.0
							210	215	4.8
							215	220	3.9
							220	225	7.7
							225	230	6.1
							230	235	4.8
							235	240	21.5
							240	245	3.5
							245	250	5.2
							250	255	5.3
							255	260	7.0

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units		Top (ft)	Bottom (ft)	Be (ppm)
							260	265	4.3

TABLE A7-4. Drill hole Be20. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units		Top (ft)	Bottom (ft)	Be (ppm)
0	150	6308	6308	6158	gray rhyolite		70	75	4.0
							75	80	3.1
							90	95	8.0
							95	100	14.5
							100	105	9.7
							105	110	7.4
							110	115	8.9
							115	120	6.2
							120	125	10.9
							125	130	11.2
							130	135	12.9
							135	140	8.5
							140	145	17.9
							145	148	11.5

TABLE A7-5. Drill hole Be21. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units
0	82	6359	6359	6277	tan-brown rhyolite
82	200	6359	6277	6159	gray rhyolite
200	265	6359	6159	6094	red rhyolite
265	285	6359	6094	6074	permeable tuff with mud

TABLE A7-6. Drill hole Be22. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units		Top (ft)	Bottom (ft)	Be (ppm)
0	174	6359	6359	6185	gray rhyolite		175	180	1.3
174	200	6359	6185	6159	red rhyolite		180	185	1.1
200	220	6359	6159	6139	permeable tuff with mud		185	190	9.5
220	250	6359	6139	6109	red rhyolite		190	195	13.1
250	340	6359	6109	6019	permeable tuff with mud		195	200	17.7
340	350	6359	6019	6009	red rhyolite		200	205	13.8
350	360	6359	6009	5999	fine grained, tan rhyolite		205	210	13.4
							210	215	14.0
							215	220	9.0
							220	225	4.4
							225	230	3.1
							230	235	2.8
							235	240	2.6
							240	245	2.8
							245	250	2.3
							250	255	2.0
							255	260	4.8
							260	265	9.5

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units		Top (ft)	Bottom (ft)	Be (ppm)
							265	270	10.3
							270	275	11.4
							275	280	10.6
							280	285	12.0
							285	290	10.8
							290	295	10.5
							295	300	10.7
							300	305	10.8
							305	310	13.9
							310	315	15.2
							315	320	11.5
							320	325	10.8
							325	330	8.9
							330	335	11.2
							335	340	11.1
							340	345	7.5
							345	350	8.1
							350	355	8.1
							355	360	8.3

TABLE A7-7. Drill hole Be23. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units		Top (ft)	Bottom (ft)	Be (ppm)
0	280	6410	6410	6130	gray rhyolite		342	347	3.9
280	295	6410	6130	6115	red rhyolite		347	352	3.6
295	305	6410	6115	6105	permeable tuff with mud		352	357	3.6

TABLE A7-8. Drill hole Be24. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units		Top (ft)	Bottom (ft)	Be (ppm)
0	378	6386	6386	6008	rhyolite		357	362	3.5
378	390	6386	6008	5996	brown red rhyolite		362	367	3.6
390	420	6386	5996	5966	purple rhyolite		367	372	3.5
420	440	6386	5966	5946	brown red rhyolite		372	377	3.3
440	460	6386	5946	5926	permeable tuff with mud		377	382	3.2
460	480	6386	5926	5906	brown red rhyolite		378	380	2.8
480	500	6386	5906	5886	purple rhyolite		380	390	2.8
500	555	6386	5886	5831	purple brown red rhyolite		390	400	3.5
555	580	6386	5831	5806	gray clay		400	410	3.5
							410	420	3.4
							420	430	3.3
							430	440	3.5
							440	450	4.3
							450	460	5.2
							460	470	4.6
							470	480	4.6
							480	490	4.1
							490	500	4.1
							500	510	4.1
							510	520	4.0
							520	530	3.8

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units		Top (ft)	Bottom (ft)	Be (ppm)
							530	540	4.0
							540	550	4.2
							550	560	3.7
							560	570	3.5
							570	580	3.9

TABLE A7-9. Drill hole Be25. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units		Top (ft)	Bottom (ft)	Be (ppm)
0	560	6413	6413	5853	rhyolite		560	570	5.3
560	580	6413	5853	5833	permeable tuff with mud		570	580	2.6
580	640	6413	5833	5773	purple rhyolite		640	650	2.9
640	690	6413	5773	5723	brown red permeable tuff		650	660	2.9
690	740	6413	5723	5673	purple rhyolite		660	670	3.0
740	780	6413	5673	5633	brown red permeable tuff		670	680	2.9
780	800	6413	5633	5613	wired rhyolite		680	690	2.9
							740	750	3.1
							750	760	3.1
							760	770	3.1
							770	780	4.4
							780	790	5.0
							790	800	6.5

TABLE A7-10. Drill hole Be26. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units
0	300	6363	6363	6063	rhyolite
300	310	6363	6063	6053	dark gray to black rhyolite
310	320	6363	6053	6043	brown red permeable tuff
320	370	6363	6043	5993	purple rhyolite
370	390	6363	5993	5973	brown rhyolite
390	440	6363	5973	5923	red rhyolite
440	475	6363	5923	5888	purple rhyolite
475	540	6363	5888	5823	brown red rhyolite
540	595	6363	5823	5768	brown red permeable tuff
595	640	6363	5768	5723	rhyolite

TABLE A7-11. Drill hole Be27. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units
0	20	6350	6350	6330	surface gravels
20	200	6350	6330	6150	buff clay
200	530	6350	6150	5820	rhyolite
530	545	6350	5820	5805	brown red permeable tuff
545	590	6350	5805	5760	purple rhyolite
590	650	6350	5760	5700	brown red rhyolite
650	700	6350	5700	5650	purple rhyolite
700	760	6350	5650	5590	brown red permeable tuff
760	800	6350	5590	5550	rhyolite

TABLE A7-12. Drill hole Be28. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units
0	20	6316	6316	6296	surface gravels
20	180	6316	6296	6136	buff clay
180	370	6316	6136	5946	rhyolite
370	430	6316	5946	5886	purple rhyolite
430	480	6316	5886	5836	brown red permeable tuff
480	540	6316	5836	5776	purple rhyolite
540	600	6316	5776	5716	brown red permeable tuff
600	624	6316	5716	5692	brown rhyolite
624	626	6316	5692	5690	rhyolite

TABLE A7-13. Drill hole Be29. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units
0	475	6312	6312	5837	rhyolite
475	490	6312	5837	5822	brown red permeable tuff
490	595	6312	5822	5717	purple rhyolite
595	650	6312	5717	5662	brown red permeable tuff
650	750	6312	5662	5562	purple rhyolite
750	800	6312	5562	5512	rhyolite

TABLE A7-14. Drill hole Be30. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units
0	20	6447	6447	6427	surface gravels
20	300	6447	6427	6147	buff clay
300	620	6447	6147	5827	rhyolite
620	635	6447	5827	5812	red permeable tuff
635	690	6447	5812	5757	purple rhyolite
690	745	6447	5757	5702	brown red permeable tuff
745	780	6447	5702	5667	purple rhyolite
780	895	6447	5667	5552	brown red permeable tuff
895	900	6447	5552	5547	rhyolite

TABLE A7-15. Drill hole Be31. Location is in Table A7-1.

Top (ft)	Bottom (ft)	Collar elevation (ft)	Top elevation (ft)	Bottom elevation (ft)	Description of rock units
0	20	6491	6491	6471	surface gravels
20	270	6491	6471	6221	buff clay
270	600	6491	6221	5891	rhyolite
600	690	6491	5891	5801	purple rhyolite
690	720	6491	5801	5771	brown red permeable tuff
720	790	6491	5771	5701	purple rhyolite
790	825	6491	5701	5666	brown red permeable tuff
825	860	6491	5666	5631	rhyolite

TABLE A7-16. Be analyses for USBM drill holes. Locations are in Table A7-1.

Drill Hole number	Top (ft)	Bottom (ft)	Be (%)
USBM1	0	15	2.05
USBM1	55	90	0.43
USBM2	0	20	0.91
USBM2	45	70	0.15
USBM3	0	10	0.49
USBM3	55	70	0.91
USBM3	70	90	0.08
USBM4	0	20	0.68
USBM4	35	40	0.23
USBM4	45	50	0.04
USBM4	125	130	0.25
USBM5	20	70	0.39
USBM5	130	140	0.17
USBM5	140	155	0.11
USBM6	0	35	0.41
USBM6	55	95	0.89
USBM7	40	55	0.84
USBM7	65	110	0.51
USBM8	110	135	1.00
USBM9	0	20	0.78
USBM12	105	140	0.55
USBM13	55	60	0.93
USBM13	85	110	0.45
USBM14	165	190	0.88
USBM15	125	140	0.38

APPENDIX 8
BERYLLIUM ANALYSIS OF SAMPLES FROM THE MONTOYA BUTTE QUADRANGLE

Selected samples collected for this project were analyzed for Be (beryllium), Li (lithium), and U (uranium) by induced coupled plasma spectroscopy (ICP) at the NMBGMR chemistry laboratory (also see Appendix 3). Laboratory methods and analytical precision are described in McLemore and Frey (2009). Sample locations are in Appendix A3, Table A3-1. Table A8-1 also includes chemical analyses reported in the literature.

TABLE A8-1. Be, Li, and U analyses of selected samples. UTM northing and easting is in zone 13.

Field identification number	Sample description	UTM easting	UTM northing	Be ppm	U ppm	Li ppm	Reference
MONT-6-05	dump	263399	3713238	0.2	0.0	72.0	This report
MONT-8-05	red clay, fault gauge	259194	3717327	3.9	6.0	99.0	This report
MONT-44-05	crusts from seep	259002	3715582	0.4	8.0	12.0	This report
MONT-60-07	red clay	259222	3716411	1.0	5.0	16.0	This report
MONT-61-07	white clay	259222	3716411	1.5	3.0	18.0	This report
MONT-65-07	virtophyre	263332	3716917	2.3	2.0	12.0	This report
MONT-72-07	tuff	261987	3717484	1.5	2.6	18.0	This report
MONT-100-09	clay	258992	3716391	730.0	8.1	12.0	This report
MONT-101-09	altered tuff	258992	3716391	16.0	5.1	11.0	This report
MONT-102-09	gray rhyolite	258992	3716391	10.0	4.6	7.0	This report
MONT-103-09	granite	260176	3715814	2.4	2.4	15.0	This report
MONT-104-09	rhyolite	264853	3710078	5.7	5.1	21.0	This report
MONT-105-09	tuff	259161	3717366	2.7	2.5	20.0	This report
MONT-106-09	red clay	259161	3717366	3.7	2.8	127.0	This report
MONT-107-09	andesite			1.9	3.0	30.0	This report
MONT-108-09	latite	262761	3715470	2.3	3.6	29.0	This report
MONT-29-05	rhyolite	266035	3710085	9.6	16.0	69.0	This report
MONT-30-05	rhyolite	266406	3706317	13.0	14.0	74.0	This report
MONT-41-05	rhyolite	260525	3717740	4.8	14.0	19.0	This report
MONT-49-06	basalt	265958	3710294	27.0	31.0	125.0	This report
	amethyst-rich Tac			0.5			Maldonado (1974)
	amethyst -poor Tac			1.4			Maldonado (1974)
AWS-16	Vicks Peak			6.0		7	Correa (1980, 1981)
AWS-11	altered Vicks Peak			7.0	10	8	Correa (1980, 1981)
AWS-9	fault zone			30.0	78	90	Correa (1980, 1981)

APPENDIX 9
EVALUATION OF THE NURE DATA FOR THE ALAMOSA CREEK BASIN

Description

A regional geochemical database, including stream sediments (Fig. A9-1) and waters exists for the state of New Mexico that was generated from reconnaissance surveys as part of the U.S. Department of Energy's National Uranium Resource Evaluation (NURE) program during 1974-1984 (McLemore and Chamberlin, 1986). Field sampling techniques are detailed in Sharp and Aamodt (1978). The NURE data is typically arranged by 1x2-degree quadrangles, although a few areas were sampled and evaluated in greater detail (Estancia Basin, Grants uranium district, and San Andres and Oscura Mountains area). Total number of stream-sediment samples in the state analyzed was 27,798 and 12,383 water samples were analyzed. Chemical analyses for New Mexico were performed at two national laboratories (Los Alamos and Oak Ridge) and each laboratory utilized different analytical techniques and analyzed sediments for different elements (Hansel and Martell, 1977; Cagle 1977; Aredt et al., 1979). Only the stream sediments from Alamosa Basin were examined for this report.

Some of the NURE data are problematic (Haxel, 2002; McLemore, 2010a) and the entire data set should be used with caution. Some of the recognized problems of the NURE data include inconsistent sampling techniques, variability in density of sampling, different size fractions used for analysis, different laboratories, different analytical techniques and analytical errors, and different analytical detection limits. However, the data extracted from the Alamosa Basin were collected and analyzed at the same time by the same parties, eliminating most of these problems. Methods of evaluating the validity of NURE data in New Mexico include examining histograms, comparing the NURE data with average upper crustal values, comparing data for pairs of statistically similar elements, such as Zr-Hf, Th-U, and La-Ce (Haxel, 2002), comparing descriptive statistics and histograms for different laboratories, and examining the descriptive statistics between the 1x2-degree quadrangles. In addition, there are several areas in New Mexico where subsequent stream-sediment surveys have been completed and show similar geochemical patterns as the with the NURE data (Ellinger, 1988; Ellinger and Cepeda, 1991; Watrus, 1998; New Mexico Bureau of Mines and Minerals Resources et al., 1998). Some NURE samples have been re-analyzed by the U.S. Geological Survey and most samples compare well.

The main purposes of the NURE program were to provide an assessment of the nation's uranium resources and to identify areas favorable for uranium mineralization. The NURE data were not designed to reveal uranium or other mineral deposits, but if the NURE data are used with caution, the data can be used to identify areas of potential geochemical interest for further study. Ultimately, field examination of these identified areas must be conducted.

Elemental geochemical patterns in stream-sediment and water samples can be used in environmental studies to detect areas of anomalously high concentrations of elements and perhaps to distinguish between natural background and possible contamination from mining and other anthropogenic inputs (Schreck et al., 2005; McLemore, 2010a), as well as identify areas for potential economic mineral resources. Numerous studies have utilized the NURE data for New Mexico to evaluate mineral-resource potential (Laughlin et al., 1985; Bartsch-Winkler and Donatich, 1995; Bartsch-Winkler, 1997; New Mexico Bureau of Mines and Mineral Resources et al., 1998; McLemore et al., 2001). Zumlot (2006) presented an evaluation of the NURE data for the entire state and used slightly different statistical techniques then used in this report and presented much of the data analysis on a web site

(https://webspace.utexas.edu/howarifm/www/NURE/1nm.htm/). Different approaches to evaluating the NURE data is another method of validating the data set.

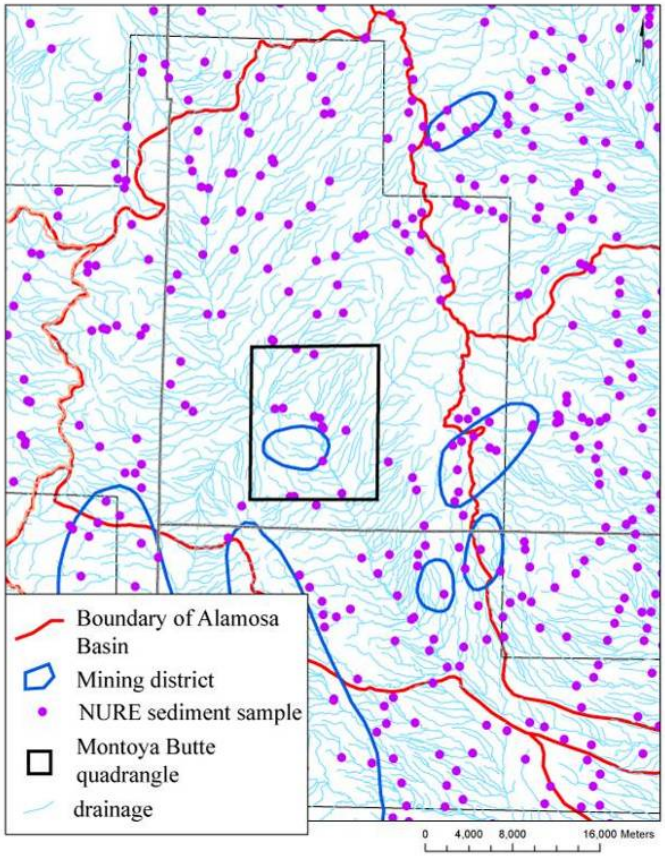


FIGURE A9-1. Distribution of NURE stream sediment samples in Alamosa Creek basin, New Mexico (Smith, 1997). Names of mining districts are in Figure 8. Red squares are mines and prospects.

Methods of Study

The NURE data for New Mexico were downloaded from Smith (1997). Samples from the Alamosa Basin were extracted from the data. Below detection values (i.e. concentrations of 0 and negative values) were eliminated from the data set to form a processed data set. Statistical analysis was performed on the processed data (Wellmer, 1998; Grunsky, 2010). The processed NURE data were entered into GIS ArcMap, along with mining districts (Fig. A9-1), mines from the New Mexico Mines Database (McLemore et al., 2005), and the state geologic map (New Mexico Bureau of Geology and Mineral Resources, 2003). Single element maps were plotted for selected areas using ArcMap. Descriptive statistics, histograms, box plots, scatter plots, and cumulative frequency plots were created using data for the entire state and for each 1x2-degree quadrangle. Outliers were identified, located (using search in ArcMap), and determined if they were due to analytical error or atypical abundance (i.e. geochemical anomalies). Many times, three or more outliers are found together. Since the sample density is not very detailed, single outliers could have geochemical significance.

TABLE A9-1. Descriptive statistics of processed NURE stream-sediment samples in the Alamosa Basin area, New Mexico, using WinStat. Data are in parts per million (ppm), unless otherwise stated. Upper crustal abundance is from Rudnick and Gao (2005). Note the difference in the mean for Cr and Ni values and the upper crustal abundance for Cr and Ni which suggests that Cr and Ni NURE chemical analyses could be problematic. The other elements have mean values similar to the upper crustal abundance and are likely valid chemical analyses.

	U	Ag	Al (%)	B	Ba	Be	Ca (%)
Number of samples	169	6	168	59	168	168	168
Mean	3.7	3.7	5.9	13.2	563.7	2.4	1.5
Variance	1.7	5.9	0.4	6.8	16786.8	8.5	1.3
Standard deviation	1.3	2.4	0.6	2.6	129.6	2.9	1.1
Minimum	1.6	2.0	3.0	10.0	116.0	1.0	0.2
Maximum	15.2	8.0	7.6	23.0	900.0	38.0	6.8
5th Percentile	2.1		5.2	10.0	335.9	1.0	0.6
25th Percentile	3.1	2.0	5.6	11.0	500.3	2.0	0.8
Median	3.6	2.5	5.9	13.0	552.5	2.0	1.1
75th Percentile	4.1	5.8	6.3	15.0	641.3	2.0	1.9
Geometric mean	3.6	3.1	5.9	13.0	546.4	2.1	1.2
Geometric Standard Deviation	1.3	1.8	1.1	1.2	1.3	1.5	1.9
Abundance in the upper crust (ppm)	2.7	0.5	15.4	17	628	2.1	3.6

	Ce	Cr	Cu	Fe (%)	Hf	K (%)	La
Number of samples	168	168	168	168	7	168	168
Mean	87.9	38.6	19.0	2.9	18.0	1.7	42.8
Variance	389.4	362.2	134.4	1.8	12.7	0.1	153.6
Standard deviation	19.7	19.0	11.6	1.3	3.6	0.3	12.4
Minimum	45.0	16.0	7.0	1.0	15.0	0.6	17.0
Maximum	187.0	142.0	88.0	9.5	23.0	2.6	112.0
5th Percentile	62.0	20.0	7.0	1.3		1.2	28.0
25th Percentile	74.3	26.3	12.0	2.1	15.0	1.5	35.0
Median	85.0	33.0	17.0	2.8	16.0	1.7	42.0
75th Percentile	99.0	44.0	22.0	3.5	23.0	1.9	47.0
Geometric mean	85.8	35.3	16.6	2.7	17.7	1.6	41.3
Geometric Standard Deviation	1.2	1.5	1.6	1.5	1.2	1.2	1.3
Abundance in the upper crust (ppm)	63	92	28	5	5.3	2.8	31

	Li	Mg (%)	Na (%)	Nb	Ni	P	Pb	Sc
Number of samples	168	168	168	168	168	168	168	168
Mean	25.8	0.6	1.3	20.0	15.9	510.6	24.1	6.6
Variance	29.6	0.1	0.1	43.6	54.1	109428.0	105.0	3.7
Standard deviation	5.4	0.3	0.2	6.6	7.4	330.8	10.2	1.9
Minimum	16.0	0.1	0.3	8.0	6.0	60.0	11.0	3.0
Maximum	50.0	1.5	2.0	39.0	56.0	1913.0	102.0	14.0
5th Percentile	18.0	0.3	0.9	10.0	7.0	165.8	13.0	4.0
25th Percentile	22.0	0.4	1.1	15.0	11.0	256.5	19.0	5.0
Median	26.0	0.5	1.2	19.0	14.5	443.0	22.0	6.0
75th Percentile	28.0	0.7	1.4	24.0	20.0	673.0	28.0	8.0
Geometric mean	25.3	0.5	1.2	18.9	14.5	424.4	22.7	6.3
Geometric Standard Deviation	1.2	1.6	1.2	1.4	1.5	1.9	1.4	1.3
Abundance in the upper crust (ppm)	24	2.5	3.3	12	47	1500	17	14

	Sr	Th	Ti (%)	V	Y	Zn	Zr
Number of samples	168	158	168	168	168	168	168
Mean	271.7	11.0	3985.7	74.6	28.9	85.4	94.2
Variance	14438.0	27.7	3154920.0	2425.1	552.4	8850.7	709.5
Standard deviation	120.2	5.3	1776.2	49.2	23.5	94.1	26.6
Minimum	41.0	2.0	1286.0	17.0	11.0	40.0	35.0
Maximum	729.0	25.0	15595.0	411.0	280.0	1246.0	222.0
5th Percentile	121.5	3.0	2086.6	26.0	14.0	52.5	54.5
25th Percentile	189.3	7.0	2884.3	46.0	20.0	62.0	78.0
Median	245.5	10.0	3651.5	66.5	26.0	70.0	93.0
75th Percentile	323.8	14.0	4565.8	89.0	32.0	88.0	106.8
Geometric mean	247.3	9.6	3700.4	64.0	26.0	76.3	90.7
Geometric Standard Deviation	1.6	1.7	1.4	1.7	1.5	1.4	1.3
Abundance in the upper crust (ppm)	320	10.5	0.6	97	21	67	193

Issues and concerns encountered with the NURE data

Normality of the data

Normal distributions of geochemical data should not be assumed (Rollinson, 1993) and can be determined by histograms or other statistical methods. Classical statistical analysis requires that the data are normal or log-normal and represent one population. However, regional geochemical data such as the NURE data typically are not normal or log-normal distributions, especially if the data consists of large number of samples because the data are characterized by a variety of factors. More than one process could have produced the concentrations in the samples and this could be interpreted as more than one population of data. Some of these factors affecting geochemical data include variations in sampling technique, different analytical procedures, sampling and analytical errors, variations in lithology, terrain differences, changing climate, different stream orders, flash floods, and existence of permanent and ephemeral streams sampled, and, ultimately most of these factors result in different processes that control elemental distribution in the samples (i.e. mineralization, pollution; Reimann and Filzmoser, 2000; Bounessah and Atkin, 2003). Some additional factors affecting analyses of water samples are seasonal effects of chemistry, flow rates, depth and source of the sample, among others.

Statistical analysis can be (and generally is) performed on the data even though the data are not normal or log-normal distributions, but the resulting analysis does not always produce consistent or statistically valid results (Reimann and Filzmoser, 2000; Matschullat et al., 2000). The data can be logarithmically transformed to approach normality, but geochemical data rarely results in normal distributed data. Statistically determined outliers (both low and high) can be identified using box plots and, then the outliers are subsequently removed to produce a more normal distribution (Bounessah and Atkin, 2003). Another approach is to use statistics only as a guide and plot the elements as point data in GIS ArcMap and visually examine the plots for distribution patterns.

Below detection values

For some elements, much of the geochemical data are values of zero or below the detection limit for a specific element. These values can be eliminated from the database (method used in this evaluation), but subsequent analysis could be skewed to the higher end of the concentration range for that element. Another technique is to arbitrary assign the concentration value as 0.5% or 0.75% of the detection limit (used by Zumlot, 2006). Some studies do not

examine elements where too many samples are below the detection limit. In this report, the values of zero and below the detection limit were eliminated from the data set.

Identification of geochemical anomalies and background

Identification of geochemical anomalies (i.e. outliers) and background concentration is not always simple. An orientation or analog study can be performed in a non-mineralized or uncontaminated site to define a local threshold against which anomalies can be judged. Anomalies can be determined by statistical methods such as selecting the upper 2.5% of the data or the mean plus 2σ (standard deviation) as geochemical anomalies (Hawkes and Webb, 1962). However, these statistical methods do not always account for different geochemical processes that form the anomalies nor do they always account for two or more overlapping populations. The geochemical threshold also can be determined by plotting a cumulative frequency plot and the threshold value is at the break in slope (Matschullat et al., 2000). The box plot also can be used to define the upper and lower threshold (Bounessah and Atkin, 2003; Reimann et al., 2002, 2005). These later two techniques begin to account for different geochemical processes and for two or more overlapping populations. The data also can be compared to average crustal abundance or other averaged data. Table A9-2 summarizes the upper threshold for REE and other elements using these techniques.

TABLE A9-2. Upper concentration thresholds (i.e. outliers) for selected elements (in ppm) calculated by different methods.

Method	U	Th	La	Ce	Y	Cu	Pb	Zn	Be	Li	Nb	Co	Cr	Reference
Upper crustal abundance	2.7	10.5	31	63	21	28	17	67	2.1	24	12	17.3	92	Rudnick and Gao (2005)
Mean (entire state)	3.3	9.5	29.4	61.9	15.8	22.5	20.2	69.8	1.6	26.3	12.6	8.2	38.5	NURE data
Median (entire state)	2.9	8.5	27	58	3.7	19	16	59	1	24	11	7	33	NURE data
Mean (Alamosa Basin)	3.7	11.0	42.8	87.9	28.9	19.0	24.1	85.4	2.4	25.8	20.0	8.9	38.6	NURE data
Median (Alamosa Basin)	3.6	10.0	42.0	85.0	26.0	17.0	22.0	70.0	2.0	26.0	19.0	8.0	33.0	NURE data
Mean + 2σ (Alamosa Basin)	6.4	21.5	67.5	127	76.0	42.1	44.6	274	8.3	36.7	33.1	16.4	76.7	Hawkes and Webb (1962)
Box plot (Alamosa Basin)	4.1	14.0	47.0	99.0	32.0	22.0	28.0	88.0	2.0	28.0	24.0	11.0	44.0	Bounessah and Atkin (2003)
Threshold value	4	14	47	99	32	22	28	88	2	28	24	17	44	This report

Method	Zr	Sr	V
Upper crustal abundance	193	320	97
Mean (entire state)			
Median (entire state)			
Mean (Alamosa Basin)	94.2	271.7	74.6
Median (Alamosa Basin)	93.0	245.5	66.5
Mean + 2σ (Alamosa Basin)			
Box plot (Alamosa Basin)			
Threshold value	150	400	100

Scale of the survey

The scale of the geochemical survey or the distance between samples is dependent upon the purpose of the geochemical survey. The purpose of the NURE data was to identify regions in the United States that could have uranium deposits at the surface. Thus, the sampling techniques employed were not always sufficient for the detection of individual deposits or mines or that required for most environmental studies.

Geochemical anomaly maps

There are several ways to display geochemical element maps. Point maps of the raw data are used to display absolute concentrations of individual samples (used in this report). Symbols for specific ranges of concentration can be used (Chamberlin, 2009; McLemore, 2010a). The point data can be krigged (Laughlin et al, 1985) or contoured. Other techniques can be employed (Zumlot, 2006; Zumlot et al., 2009).

Statistics and Geochemical Anomaly Maps

Correlation coefficients of the NURE geochemical data are in Table A9-3. Factor analysis is in Table A9-4. The following statistical plots (Fig. A9-2) for each element of NURE stream sediment data for samples in the Alamosa basin area include a box plot, Q-Q plot, histogram, and frequency histogram plot. Geochemical anomaly maps are in Figure A9-3.

TABLE A9-3. Correlation coefficients of processed NURE stream-sediment samples in the Alamosa Basin area.

	U	Al	B	Ba	Be	Ca	Ce	Co	Cr	Cu	Fe	K	La
U	1.00												
Al	-0.52	1.00											
B	-0.15	0.15	1.00										
Ba	-0.57	0.63	0.29	1.00									
Be	0.28	-0.24	0.15	-0.24	1.00								
Ca	-0.28	0.15	0.22	0.48	0.17	1.00							
Ce	0.62	-0.10	-0.05	-0.12	0.18	-0.12	1.00						
Co	-0.40	0.47	0.31	0.64	-0.05	0.64	0.10	1.00					
Cr	-0.23	0.39	0.27	0.49	-0.07	0.51	0.13	0.86	1.00				
Cu	-0.12	0.41	0.39	0.44	0.04	0.41	0.06	0.69	0.69	1.00			
Fe	-0.23	0.36	0.28	0.57	0.08	0.52	0.22	0.84	0.85	0.65	1.00		
K	0.16	0.00	-0.20	-0.36	-0.13	-0.65	0.02	-0.61	-0.42	-0.39	-0.39	1.00	
La	0.67	-0.17	-0.06	-0.24	0.20	-0.23	0.90	-0.15	-0.09	-0.12	-0.04	0.07	1.00
Li	-0.23	0.23	0.23	-0.01	0.03	-0.11	-0.27	-0.18	-0.21	-0.18	-0.25	0.12	-0.14
Mg	-0.43	0.49	0.34	0.63	0.09	0.79	-0.16	0.82	0.68	0.59	0.68	-0.62	-0.29
Mn	0.01	-0.18	0.17	-0.03	0.70	0.19	0.05	0.05	0.09	0.25	0.18	-0.19	-0.01
Mo	0.20	-0.42	0.76	0.27	-0.25	0.84	0.40	0.63	0.68	0.02	0.26	-0.56	0.32
Na	-0.17	0.52	-0.39	0.34	-0.21	-0.02	0.21	0.26	0.29	0.26	0.34	0.17	0.04
Nb	0.47	-0.24	-0.24	-0.45	0.02	-0.40	0.48	-0.32	-0.11	-0.20	-0.10	0.58	0.48
Ni	-0.36	0.46	0.41	0.54	-0.05	0.57	-0.07	0.87	0.83	0.66	0.69	-0.48	-0.22
P	-0.19	0.49	0.36	0.63	0.09	0.61	0.09	0.76	0.66	0.80	0.74	-0.48	-0.12
Pb	0.23	-0.25	0.18	-0.08	0.38	0.30	0.17	0.15	0.11	0.10	0.07	-0.17	0.09
Sc	-0.28	0.57	0.42	0.62	-0.07	0.43	0.13	0.83	0.77	0.67	0.76	-0.50	0.02
Sr	-0.42	0.57	0.15	0.75	-0.10	0.62	-0.07	0.74	0.65	0.53	0.68	-0.49	-0.22
Th	0.26	-0.21	-0.18	-0.40	0.03	-0.46	0.22	-0.53	-0.33	-0.43	-0.41	0.44	0.33
Ti	-0.09	0.31	0.06	0.46	-0.12	0.32	0.32	0.72	0.81	0.64	0.91	-0.20	0.05
V	-0.18	0.38	0.16	0.52	-0.11	0.42	0.23	0.81	0.87	0.73	0.94	-0.31	-0.04
Y	0.84	-0.38	-0.11	-0.47	0.27	-0.22	0.61	-0.34	-0.21	-0.10	-0.24	-0.07	0.74
Zn	0.01	-0.08	0.23	0.03	0.90	0.37	0.11	0.23	0.23	0.25	0.40	-0.26	0.03
Zr	0.17	0.37	-0.03	0.22	-0.08	-0.10	0.36	0.32	0.33	0.48	0.43	0.20	0.26

	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Sc	Sr	Th	Ti
Li	1.00												
Mg	0.04	1.00											
Mn	-0.01	0.15	1.00										
Mo	-0.46	0.34	0.30	1.00									
Na	-0.17	0.14	-0.14	-0.50	1.00								
Nb	-0.25	-0.52	-0.10	0.35	0.12	1.00							
Ni	-0.03	0.75	0.04	0.76	0.13	-0.30	1.00						
P	-0.21	0.76	0.14	0.14	0.31	-0.31	0.63	1.00					
Pb	-0.16	0.08	0.49	0.94	-0.20	0.11	0.12	0.09	1.00				
Sc	-0.02	0.70	0.05	0.24	0.22	-0.32	0.74	0.68	-0.04	1.00			
Sr	-0.08	0.77	-0.03	0.14	0.47	-0.38	0.64	0.72	-0.05	0.68	1.00		
Th	0.01	-0.52	-0.10	-0.19	-0.10	0.65	-0.37	-0.53	0.05	-0.39	-0.45	1.00	
Ti	-0.36	0.47	0.01	0.04	0.45	0.16	0.60	0.65	-0.03	0.65	0.57	-0.25	1.00
V	-0.31	0.60	0.03	0.10	0.42	-0.01	0.68	0.74	-0.01	0.74	0.65	-0.38	0.97
Y	-0.03	-0.27	-0.02	-0.06	-0.24	0.19	-0.26	-0.17	0.09	-0.10	-0.30	0.14	-0.20
Zn	-0.03	0.35	0.79	0.37	-0.11	-0.09	0.22	0.31	0.40	0.19	0.14	-0.13	0.17
Zr	-0.20	0.09	-0.18	-0.19	0.32	0.33	0.29	0.42	-0.11	0.36	0.24	0.06	0.58

	V	Y	Zn
Y	-0.22	1.00	
Zn	0.19	-0.01	1.00
Zr	0.52	0.06	-0.04

TABLE A9-4. Factor analysis of processed NURE stream-sediment samples in the Alamosa Basin area. Significant factor values greater than 0.5 are highlighted. Factor 1 represents concentrations of heavy and resistant minerals. Factor 2 represents rock-forming minerals. Factor 4 represents minerals containing REE.

Factors	1	2	3	4	5	6	Communality
Cr	0.92	-0.15	0.01	0.04	-0.08	-0.06	0.88
V	0.91	-0.05	-0.02	0.02	0.24	-0.20	0.92
Fe	0.87	-0.18	0.21	0.07	0.19	-0.16	0.90
Co	0.87	-0.42	0.01	-0.05	-0.02	0.00	0.93
Ti	0.86	0.09	-0.05	0.12	0.26	-0.28	0.92
Ni	0.86	-0.24	0.00	-0.09	-0.17	0.16	0.85
Sc	0.76	-0.38	-0.03	0.08	0.09	0.29	0.82
Cu	0.73	-0.08	0.21	-0.28	0.23	0.07	0.72
P	0.67	-0.40	0.22	-0.19	0.33	-0.04	0.80
Mg	0.63	-0.60	0.19	-0.19	-0.05	0.13	0.85
Zr	0.49	0.44	-0.13	0.12	0.48	0.13	0.71
Nb	-0.03	0.74	-0.06	0.48	-0.05	-0.26	0.85
K	-0.42	0.71	-0.14	0.09	0.23	0.10	0.77
U	-0.15	0.69	0.14	0.37	-0.02	-0.35	0.78
Ba	0.41	-0.64	-0.12	-0.02	0.40	0.04	0.76
Ca	0.47	-0.59	0.25	-0.11	-0.22	-0.24	0.75
Th	-0.32	0.53	-0.06	0.45	-0.25	0.03	0.66
Be	-0.03	0.04	0.94	0.07	-0.03	0.07	0.90
Zn	0.21	-0.07	0.94	0.02	-0.04	0.00	0.93
Mn	0.01	-0.06	0.89	-0.03	-0.07	-0.05	0.81
Pb	0.12	-0.09	0.50	0.13	-0.35	-0.35	0.53
La	-0.02	0.13	0.03	0.94	0.16	-0.02	0.93
Ce	0.19	0.12	0.09	0.86	0.26	-0.20	0.90
Y	-0.18	0.30	0.06	0.76	-0.08	0.25	0.77
Na	0.14	-0.02	-0.15	0.24	0.75	-0.12	0.68
Li	-0.18	-0.04	0.04	-0.01	-0.15	0.82	0.73
Al	0.31	-0.31	-0.19	0.06	0.46	0.60	0.81
Sum of squares	7.82	3.98	3.20	3.08	1.96	1.84	21.87
Percent of variance	28.95	14.72	11.85	11.42	7.24	6.82	81.00

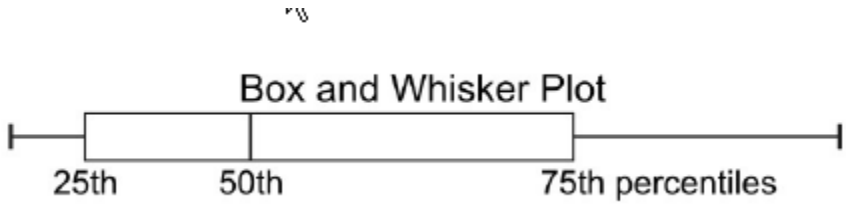
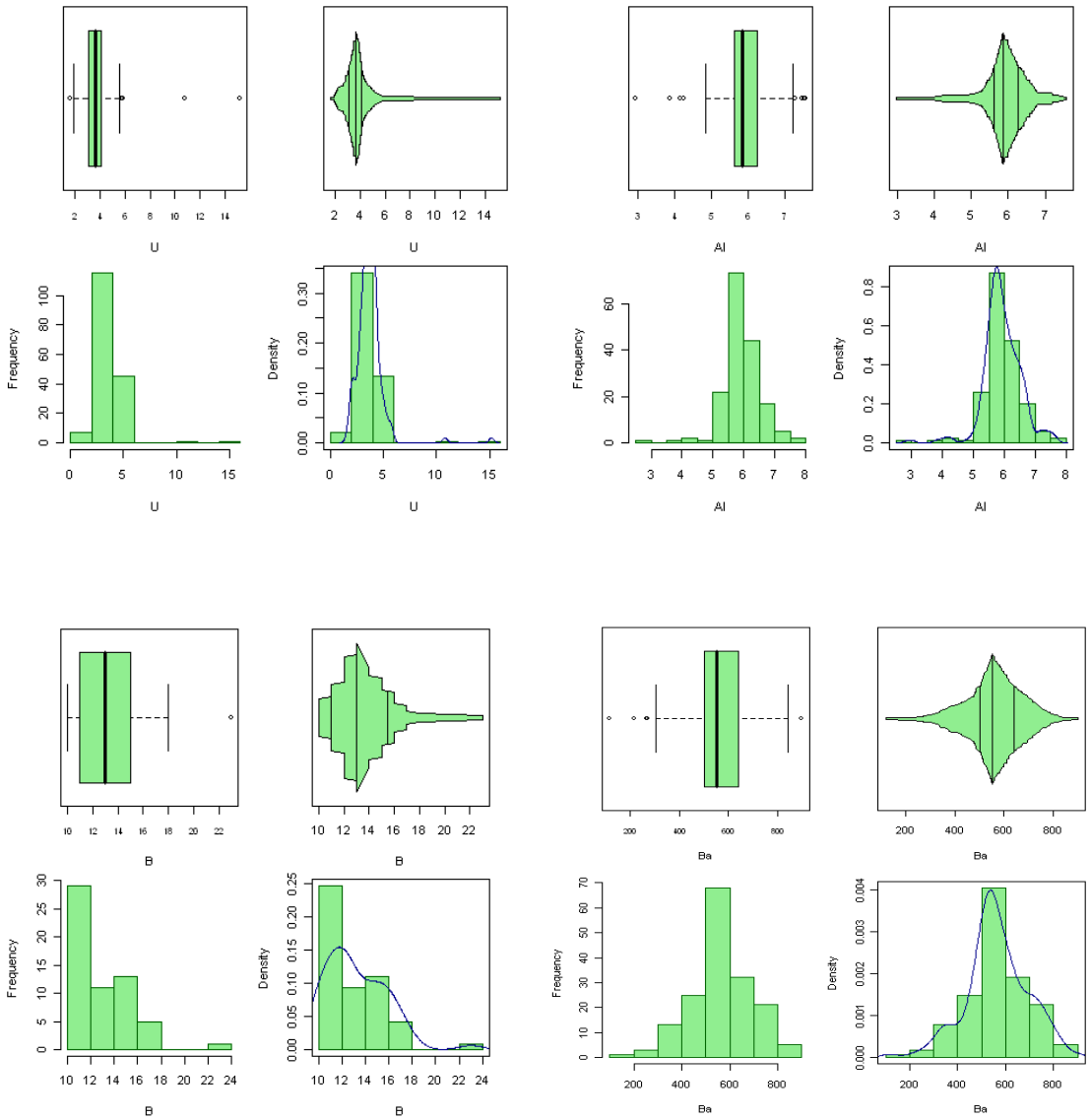
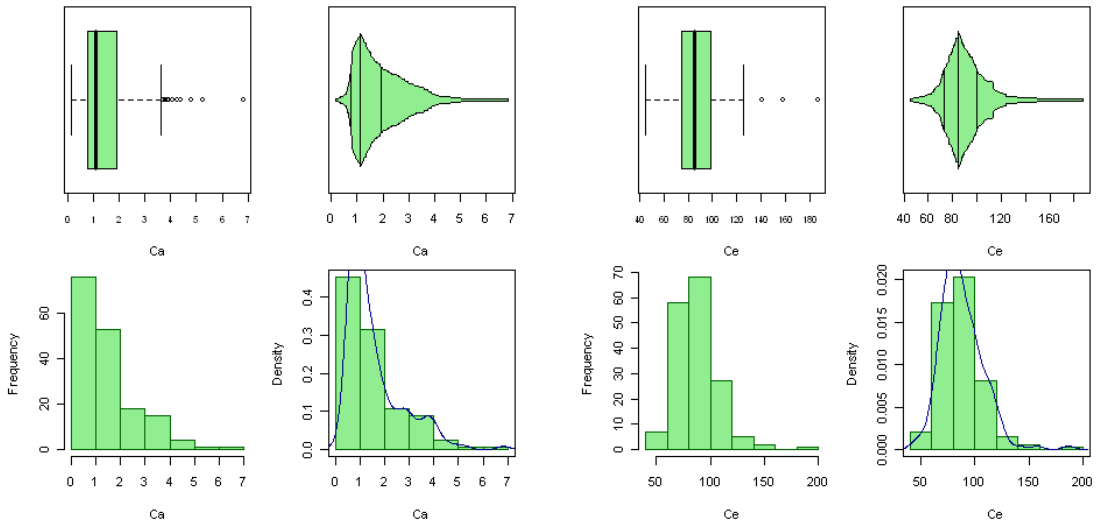


FIGURE A9-1. Description of the box plot.


U
Al
Frequency
Density
B
Ba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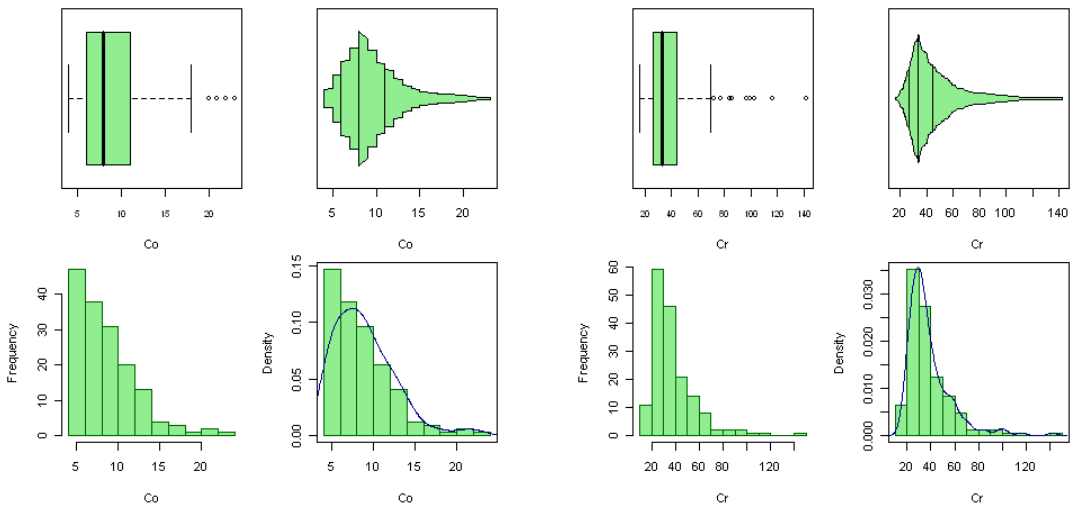
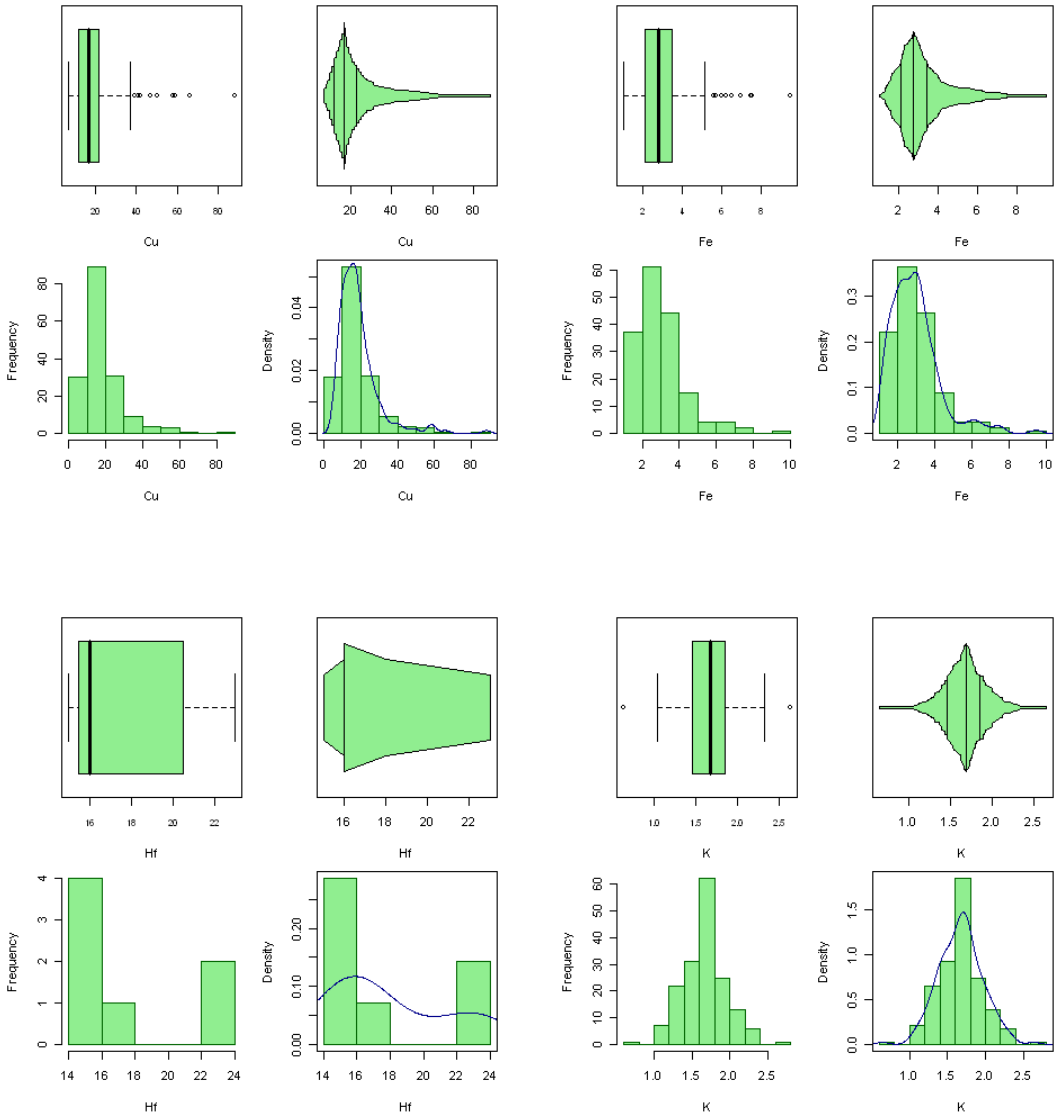
Ca
Ce
Ce
Frequency
Density
Frequency
Density
Ca
Ca
Ce
Ce


Co
Co
Cr
Cr
Frequency
Density
Frequency
Density
Co
Co
Cr
Cr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Cu
Fe
Fe
Frequency
Density
Frequency
Density
Cu
Cu
Fe
Fe
Hf
Hf
K
K
Frequency
Density
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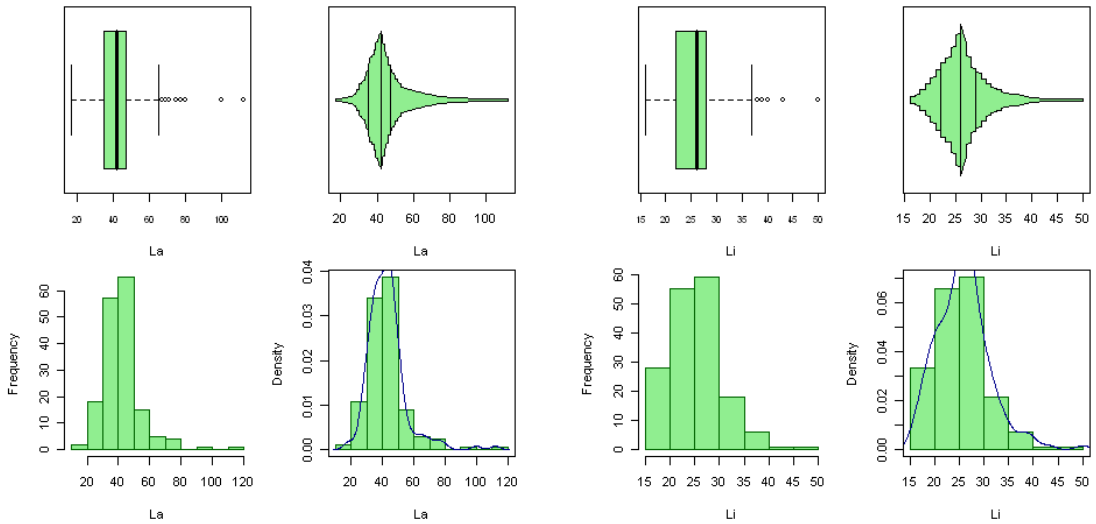
Density
Hf
Hf
K
K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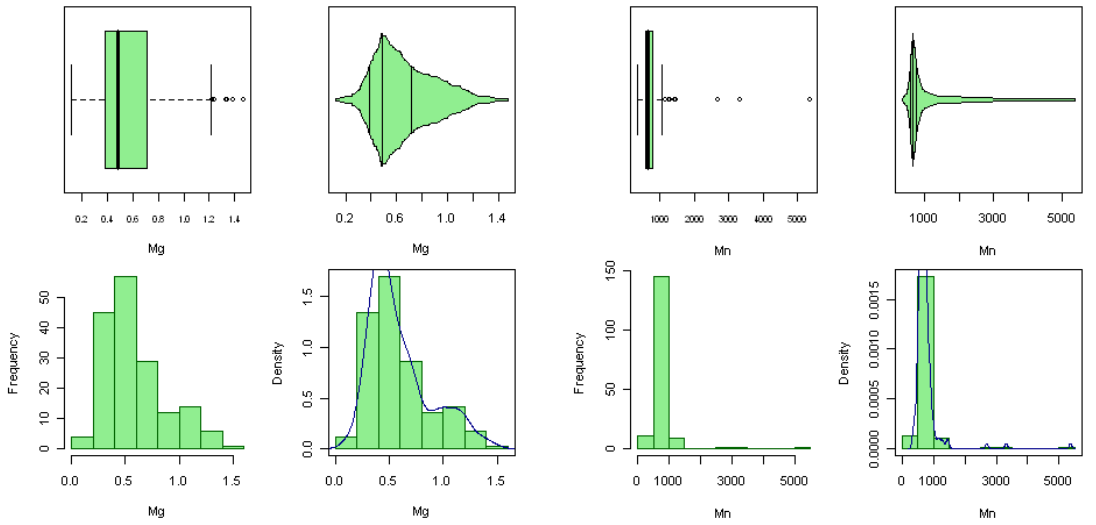
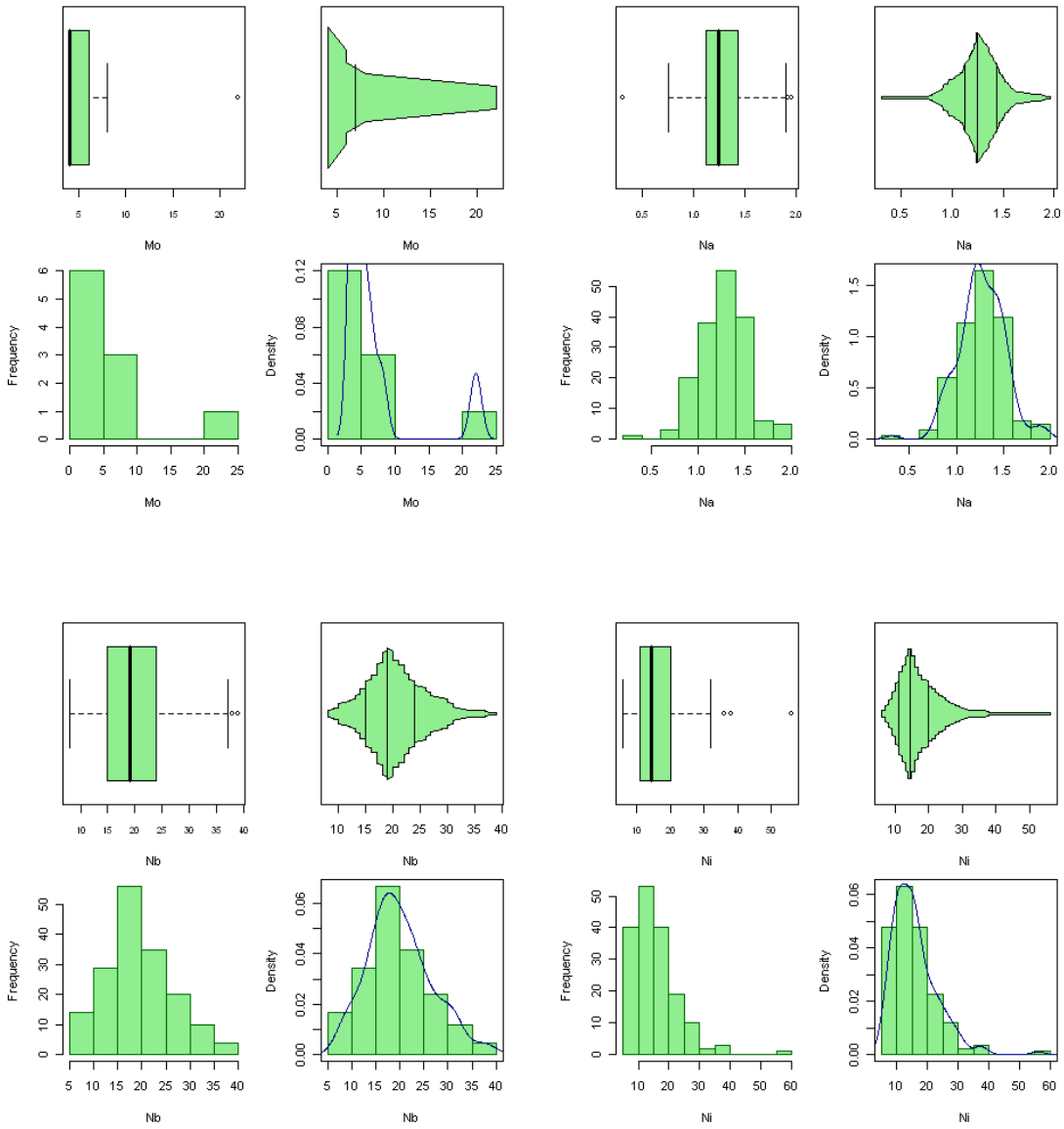
La
Li
Li
Frequency
Density
Frequency
Density
La
La
Li
Li


Mg
Mg
Mn
Mn
Frequency
Density
Frequency
Density
Mg
Mg
Mn
Mn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Mo
Na
Na
Frequency
Density
Frequency
Density
Mo
Mo
Na
Na
Nb
Nb
Ni
Ni
Frequency
Density
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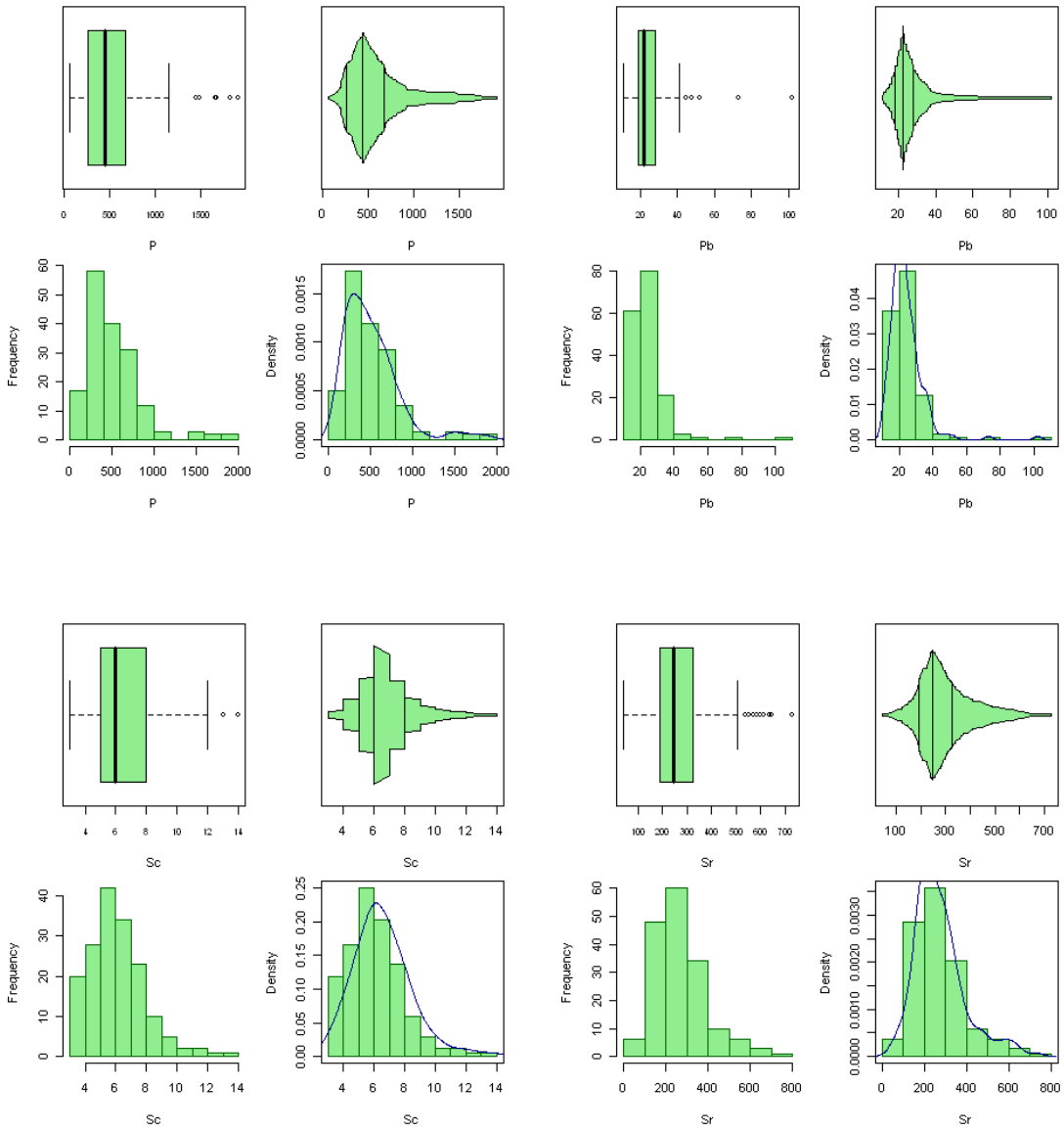
Density
Nb
Nb
Ni
Ni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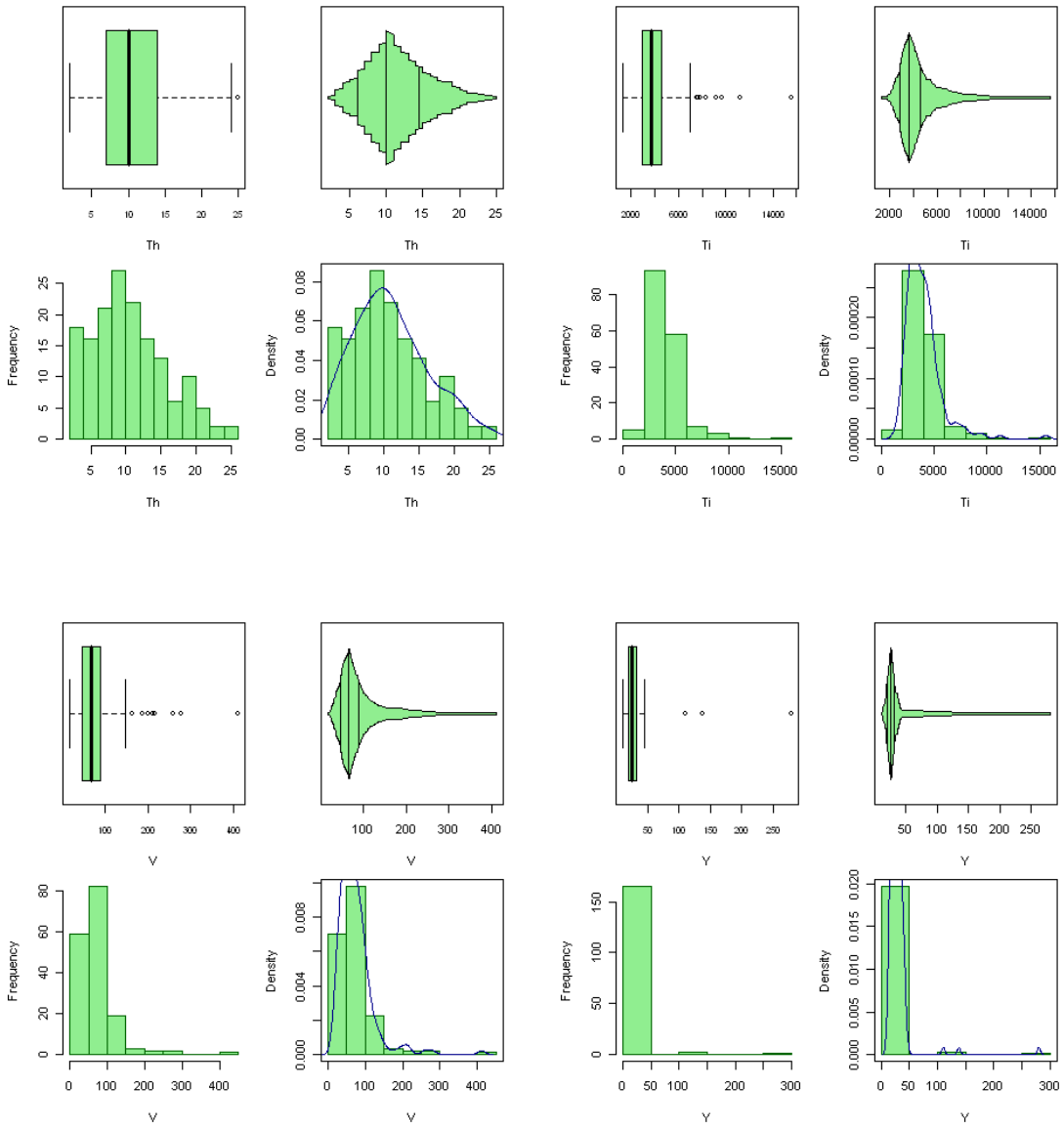
Pb
Sc
Sr
Frequency
Density


Th
Th
Ti
Ti
Frequency
Density
Frequency
Density
Th
Th
Ti
Ti
V
V
Y
Y
Frequency
Density
Frequency
Density
V
V
Y
Y

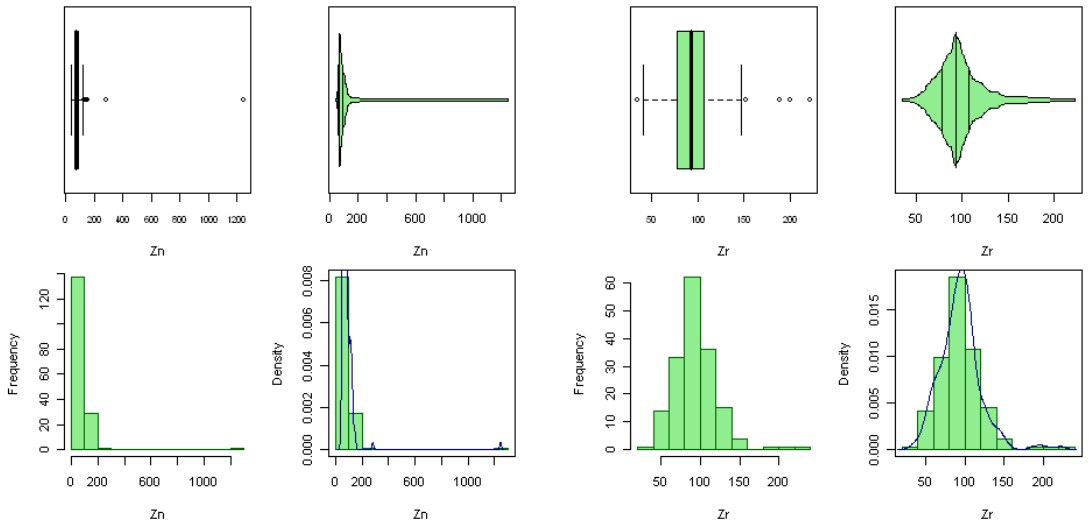
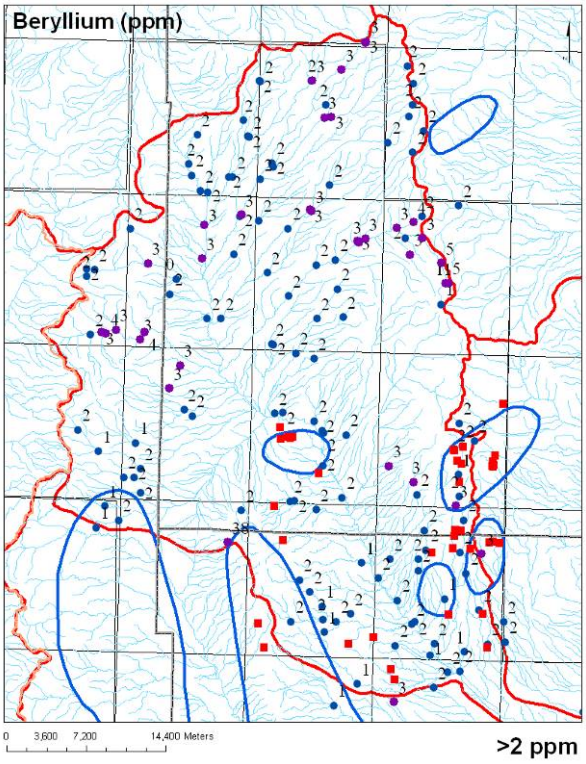
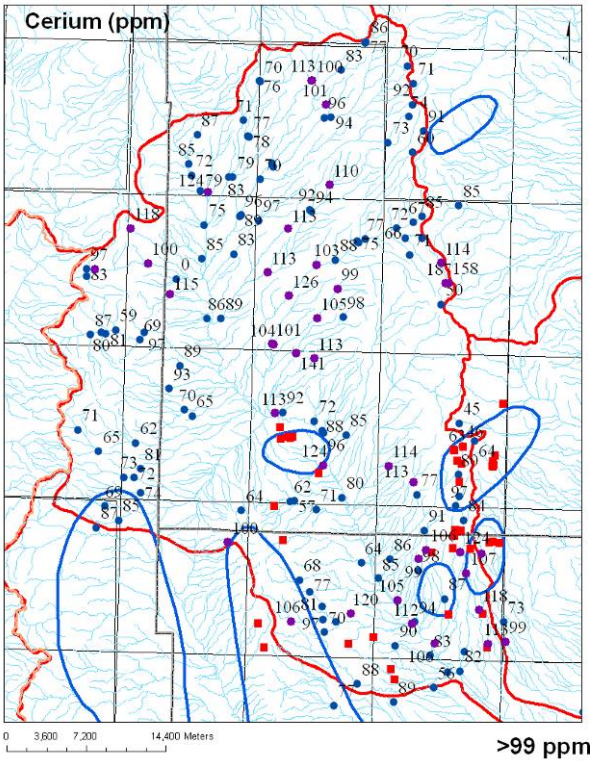
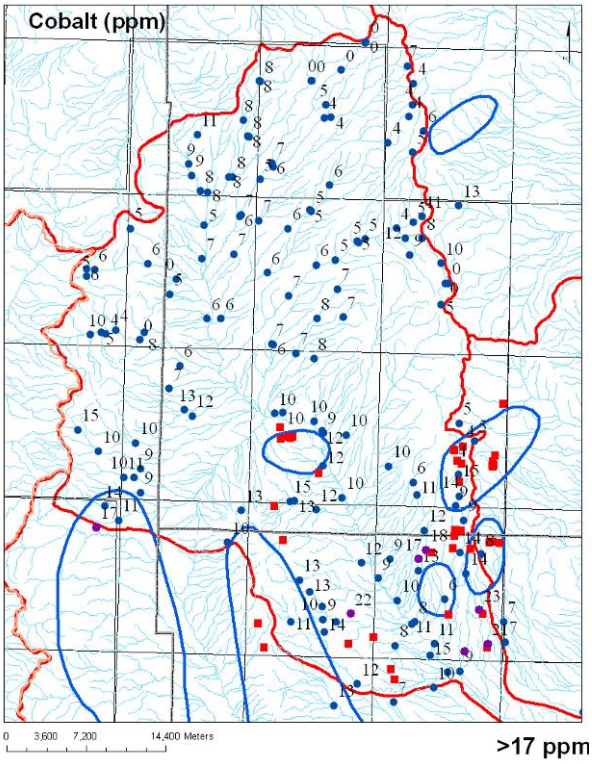
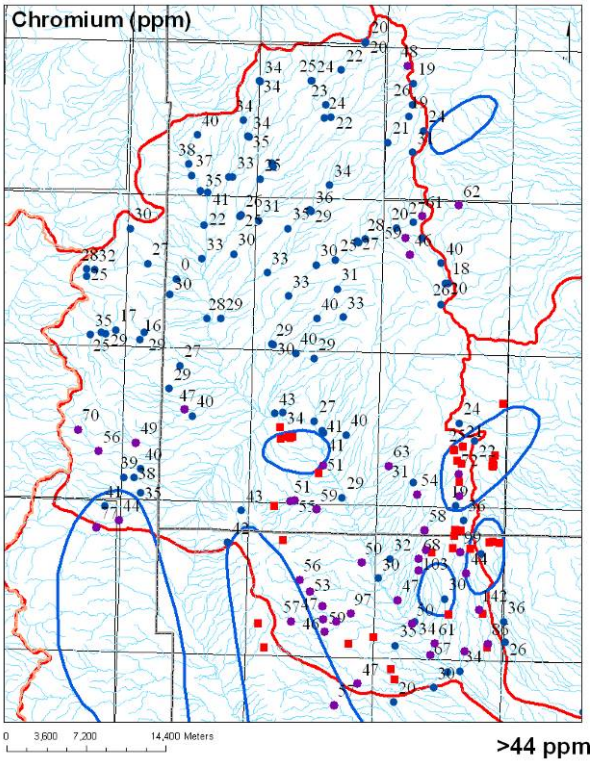


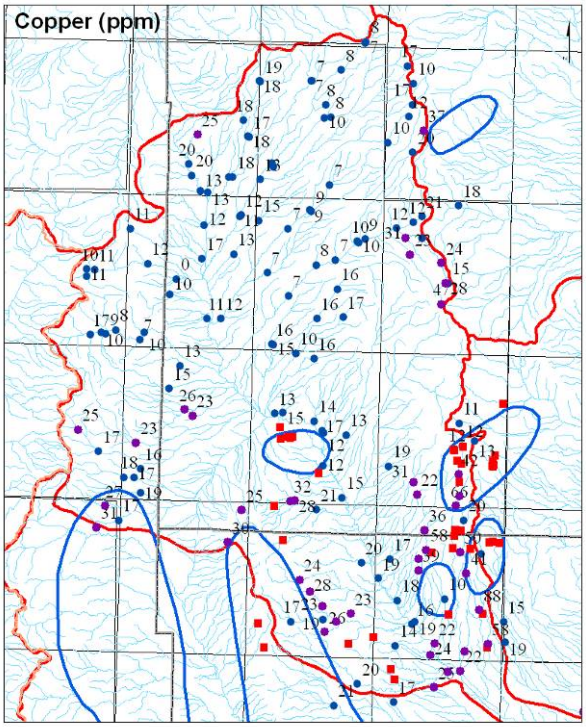
FIGURE A9-2. Boxplots of elements of data from the Alamosa Basin area.


Beryllium (ppm)
0 3,600 7,200 14,400 Meters
>2 ppm

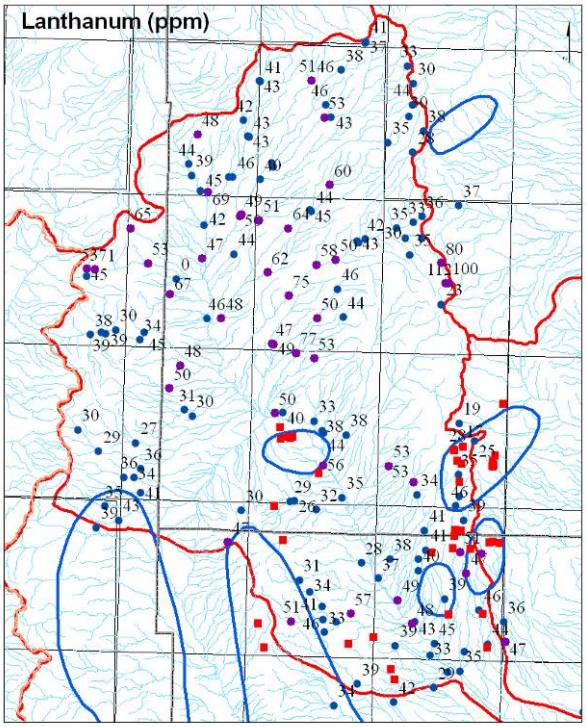

Cerium (ppm)
0 3,600 7,200 14,400 Meters
>99 ppm


Cobalt (ppm)
0 3,600 7,200 14,400 Meters
>17 ppm


Chromium (ppm)
0 3,600 7,200 14,400 Meters
>44 ppm



>22 ppm



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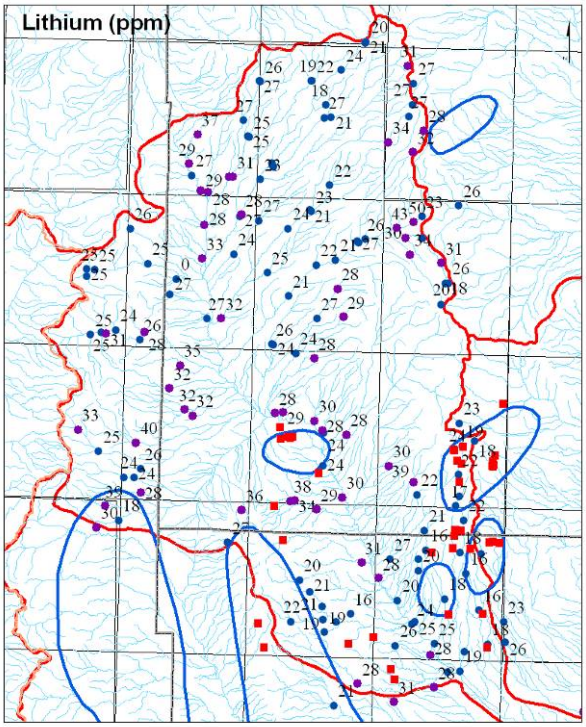

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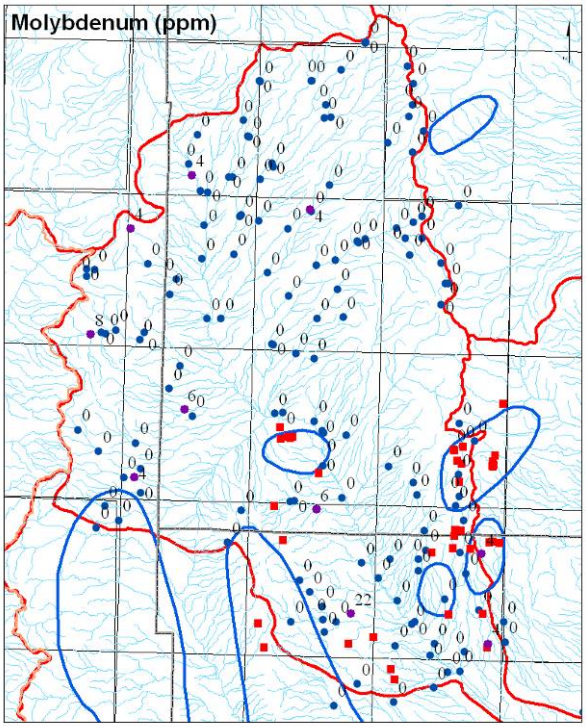

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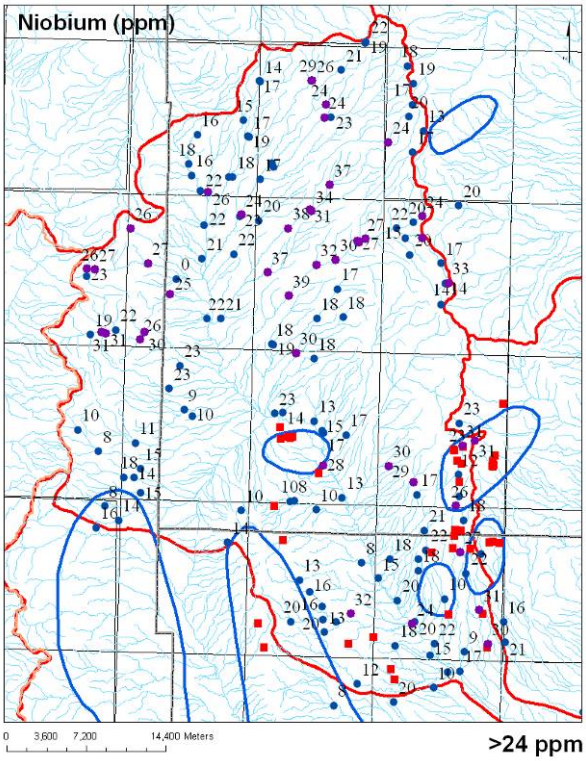

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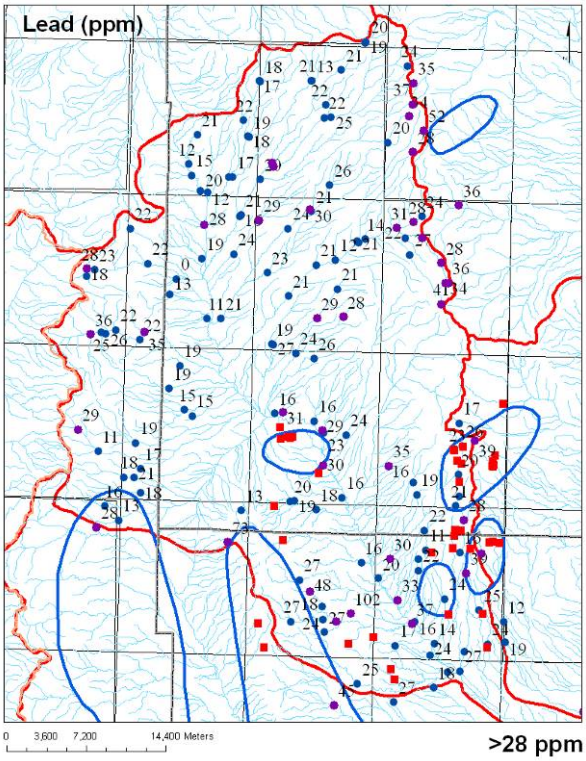

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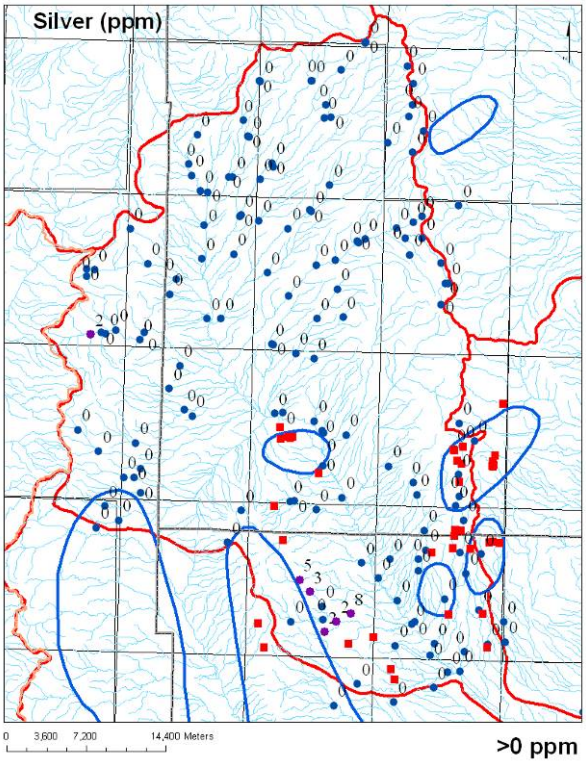

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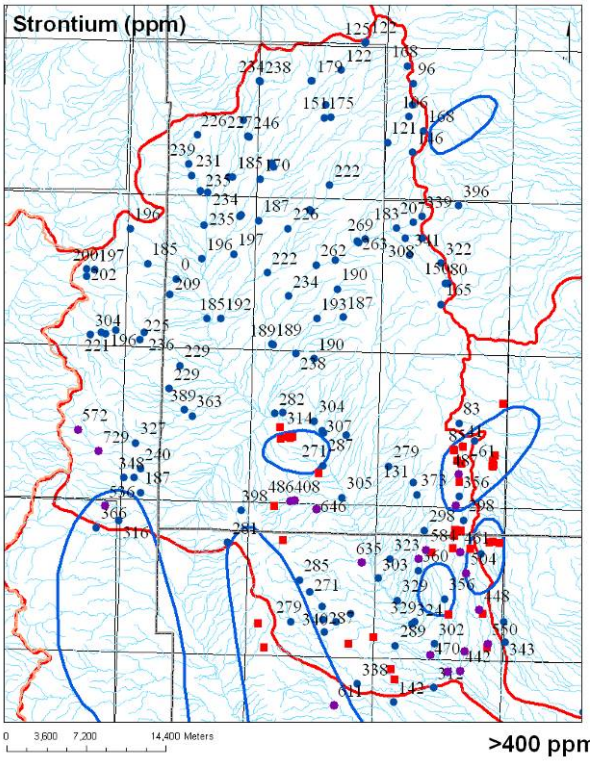

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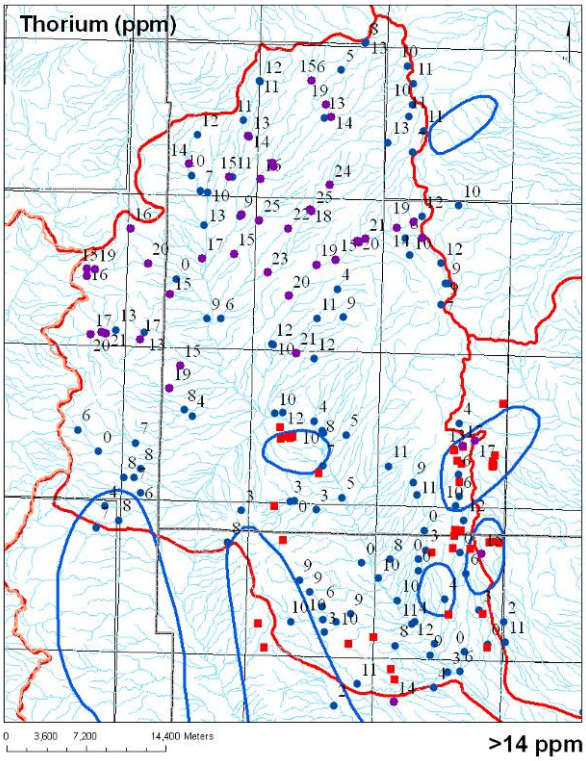

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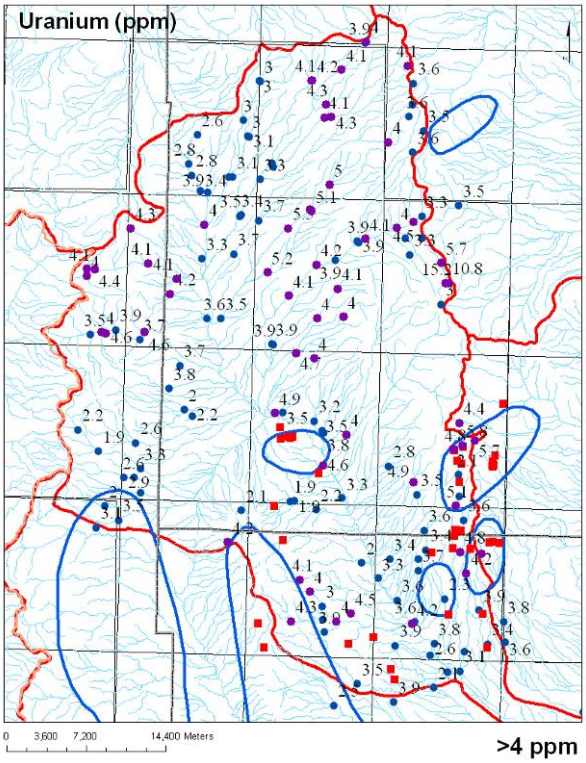

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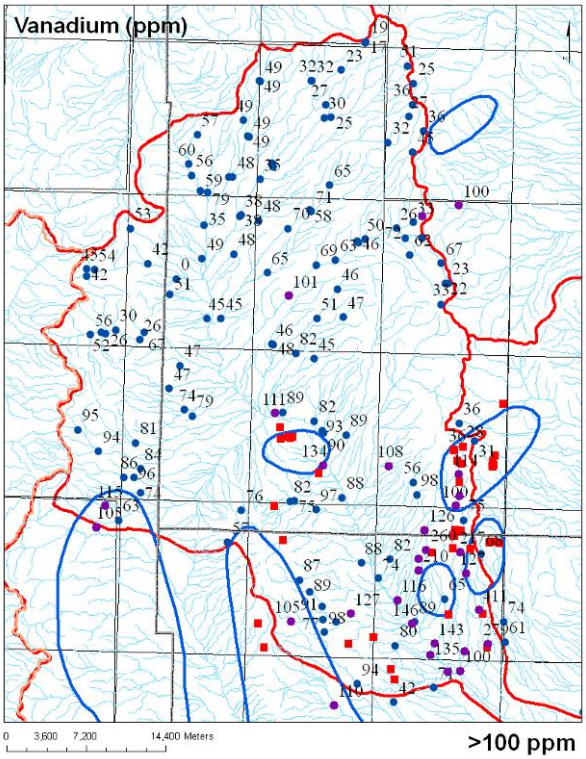

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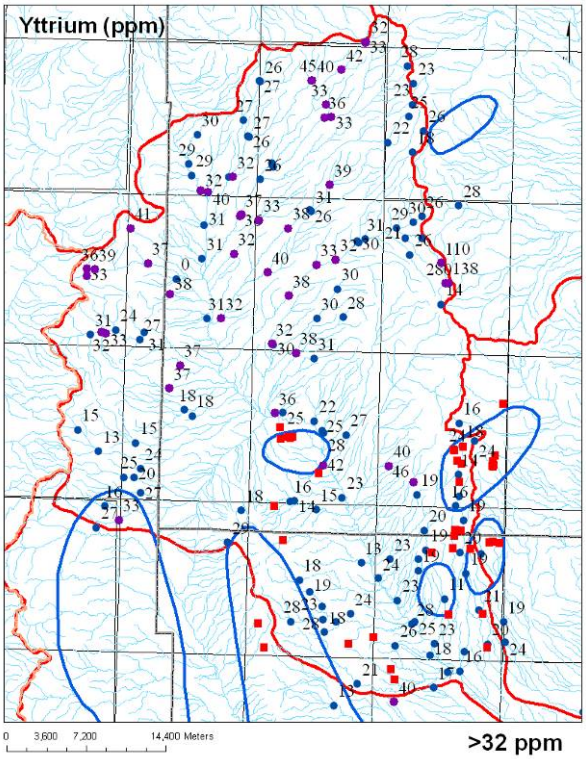

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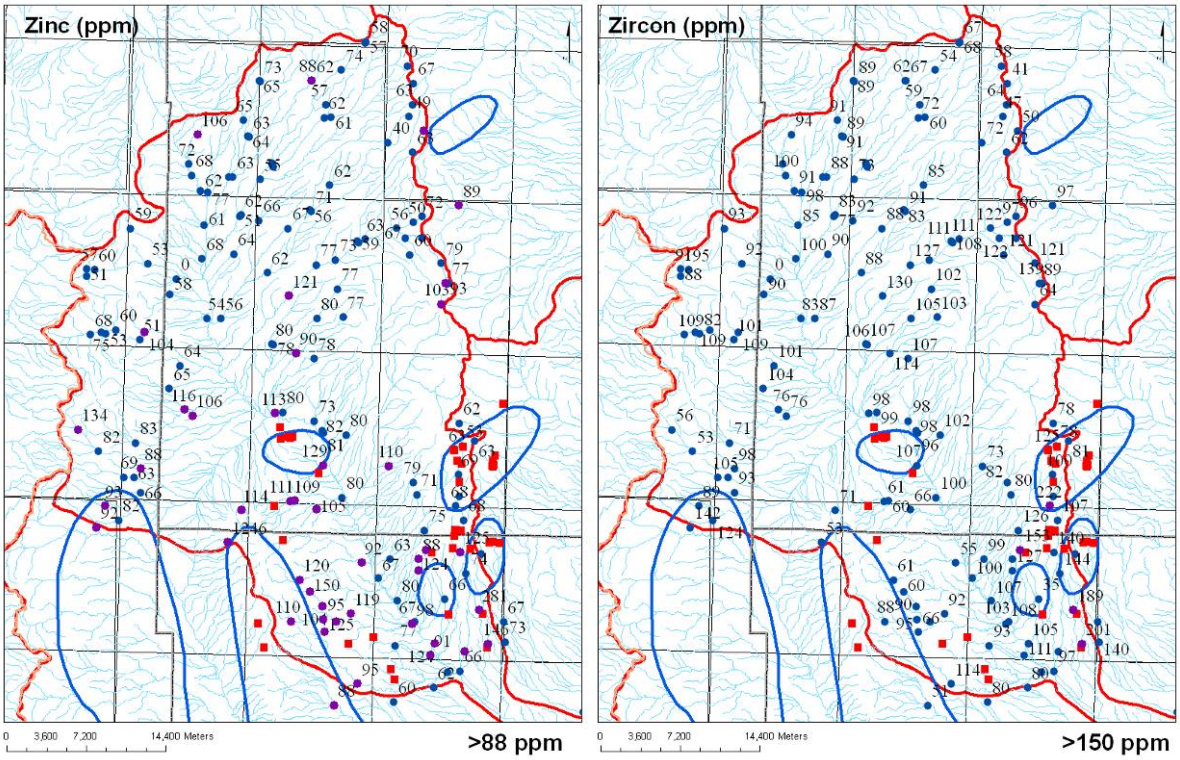

FIGURE A9-3. Geochemical anomaly maps of selected elements of stream-sediment geochemical data from the Alamosa Basin area. See Figure 33 for key to symbols; purple circles are geochemical anomalies and blue circles are stream sediment samples. Names of mining districts (blue polygons) are in Figure 8. Red squares are mines and prospects.

APPENDIX 10
STRATIGRAPHIC SECTIONS

Black Mountain

Station	UTM N	UTM E	Elevation at base (ft)	Unit	Description	Thickness (ft)
Top	260809	3718206	7107			
			6860	Tac	undulatory flow banding, rounded quartz phenocrysts (<5%, except in gas cavities), and locally contorted and overturned rhyolite flows	247
			6440	Tvp	pinkish gray to brown gray, moderately to densely welded, phenocryst-poor rhyolite ignimbrite (ash flow tuff), rhyolite	420
Base	260539	3717329	6150	Tmb	fine grained to aphanitic to locally porphyritic, dense to locally amygdaloidal, dark gray to reddish gray to reddish brown andesite	290

South Cañada Alamosa

Station	UTM N	UTM E	Elevation at base (ft)	Unit	Description	Thickness (ft)
Top	260724	3714699	7080			
			7000	Tvp	pinkish gray to brown gray, densely welded, phenocryst-poor rhyolite ignimbrite (ash flow tuff), rhyolite	80
			6800	Tpl	multiple, thinly foliated (platy), gray beds of latite to quartz latite lava flows	200
			6200	Tmbx (fault at base)	massive, poorly sorted, matrix-supported, greenish- to purplish-gray to dark gray, mudflows, breccias, and lahars	600
Base	260520	3717086	6160	Tmb	fine grained to aphanitic to locally porphyritic, dense to locally amygdaloidal, dark gray to reddish gray to reddish brown andesite	40

APPENDIX 11
ASSESSMENT OF MINERAL-RESOURCE POTENTIAL

This appendix briefly describes the process of evaluating the mineral-resource potential for a given area, as described by McLemore (1985) and McLemore et al. (2001) and based upon the process established by the U.S. Geological Survey (Goudarzi, 1984; Bartsch-Winkler and Donatich, 1995).

Definitions

Mineral resources are the naturally occurring concentrations of materials (solids, gas, or liquid) in or on the earth's crust that can be extracted economically under current or future economic conditions. Reports describing mineral resources vary from simple inventories of known mineral deposits to detailed geologic investigations.

A *mineral occurrence* is any locality where a useful mineral or material occurs. A *mineral prospect* is any occurrence that has been developed by underground or above ground techniques or by subsurface drilling. These two terms do not have any resource or economic implications. A *mineral deposit* is a sufficiently large concentration of a valuable or useful mineral or material that was extracted or may be extracted under current or future economic conditions. A *mine* is any prospect that produced or is currently producing a useful mineral or commodity.

The *mineral-resource potential* of an area is the probability that a mineral will occur in sufficient quantities so that it can be extracted economically under current or future conditions (Taylor and Steven, 1983). Mineral-resource potential is preferred in describing an area, whereas mineral-resource favorability is used in describing a specific rock type or geologic environment (Goudarzi, 1984). The mineral-resource potential is not a measure of the quantities of the mineral resources, but is a measure of the *potential* of occurrence. Factors that could preclude development of the resource, such as the feasibility of extraction, land ownership, accessibility of the minerals, or the cost of exploration, development, production, processing, or marketing, are not considered in assessing the mineral-resource potential.

Classification

Classification of mineral-resource potential differs from the classification of mineral resources. Quantities of mineral resources are classified according to the availability of geologic data (certainty), economic feasibility (identified or undiscovered), and as economic or uneconomic. Mineral-resource potential is a qualitative judgment of the probability of the existence of a commodity. Mineral-resource potential is classified as high, moderate, low, or no potential according to the availability of geologic data and relative probability of occurrence (Fig. A11-1).

High mineral-resource potential is assigned to areas where there are known mines or deposits where the geologic, geochemical, or geophysical data indicate an excellent probability that mineral deposits occur. All active and producing properties fall into this category as well as identified deposits in known mining districts or in known areas of mineralization. Speculative deposits, such as reasonable extensions of known mining districts and identified deposits or partially defined deposits within geologic trends are classified as high mineral-resource potential when sufficient data indicate a high probability of occurrence.

DEFINITIONS OF LEVEL OF RESOURCE POTENTIAL

N **No mineral resource potential** is a category reserved for a specific type of resource in a well defined area.

L **Low mineral-resource potential** is assigned to areas where geologic, geochemical, and geophysical characteristics indicated geologic environment where the existence of mineral resources is unlikely and is assigned to areas of no or dispersed mineralized rocks.

M **Moderate mineral-resource potential** is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence.

H **High mineral-resource potential** is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence. Assignment of high mineral-resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

DEFINITIONS OF LEVEL OF CERTAINTY

A Available information is not adequate for the determination of the level of mineral resource potential.

B Available information suggests the level of mineral-resource potential.

C Available information gives a good indication of the level of mineral-resource potential.

D Available information clearly defines the level of mineral-resource potential.

↑ *INCREASING LEVEL OF RESOURCE POTENTIAL*	U/A Unknown Potential	H/B High Potential	H/C High Potential	H/D High Potential
		M/B Moderate Potential	M/C Moderate Potential	M/D Moderate Potential
		L/B Low Potential	L/C Low Potential	L/D Low Potential
				N/D No Potential
INCREASING LEVEL OF CERTAINTY →				

FIGURE A11-1. Classification of mineral-resource potential and certainty of assurance (modified from Goudarzi, 1984).

Moderate mineral-resource potential is assigned to areas where geologic, geochemical, or geophysical data suggest a reasonable probability that undiscovered mineral deposits occur in formations or geologic settings known to contain economic deposits elsewhere. Speculative deposits in known mining districts or mineralized areas are assigned a moderate potential if evidence for a high potential of economic deposits is inconclusive. This assignment, like other classifications, can be revised when new information, new genetic models, or changes in economic conditions develop.

Low mineral-resource potential is assigned to areas where available data imply the occurrence of mineralization, but indicate a low probability for the occurrence of an economic deposit. This includes speculative deposits in geologic settings not known to contain economic deposits, but which are similar to geologic settings of known economic deposits. Additional data may be needed to better classify such areas.

No mineral-resource potential is assigned to areas where sufficient information indicates that an area is unfavorable for economic mineral deposits. This evaluation can include areas with dispersed but uneconomic mineral occurrences as well as areas that have been depleted of their mineral resources. Use of this classification implies a high level of geologic assurance to support such an evaluation, but it is assigned for potential deposits that are too deep to be extracted

economically, even though there may not be a high level of geologic assurance. These economic depths vary according to the commodity and current and future economic conditions.

Unknown mineral-resource potential is assigned to areas where necessary geologic, geochemical, and geophysical data are inadequate to classify an area otherwise. This assessment is assigned to areas where the degree of geologic assurance is low and any other classification would be misleading.