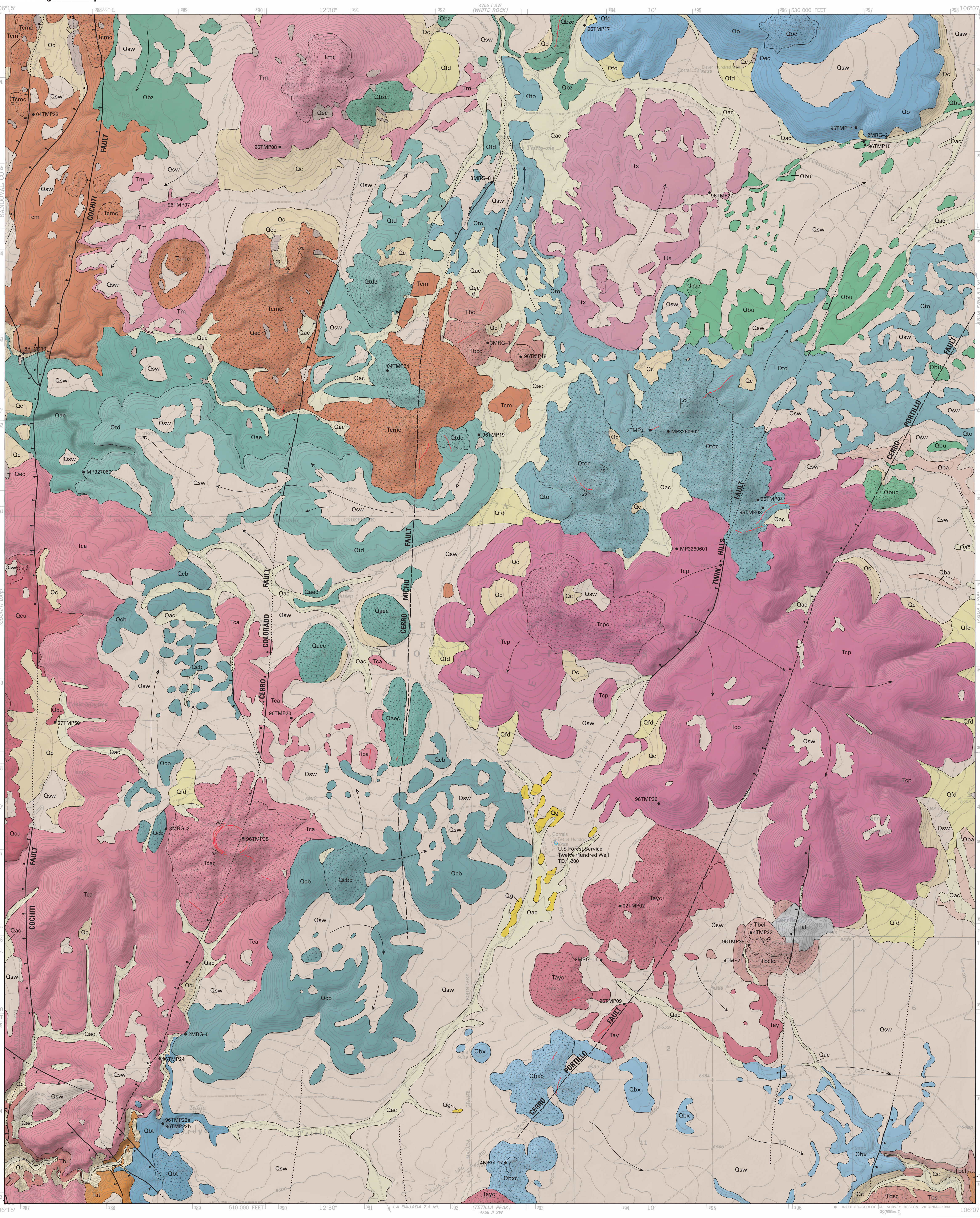
U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with the
National Park Service

Scientific Investigations Map 3179
Pamphlet accompanies Map



Base from U.S. Geological Survey Montoso Peak, New Mex., 1952, revised 1993
Shaded relief base generated from 10-m Digital Elevation Model (DEM) from the U.S. Geological Survey National Elevation Dataset available at *http://ned.usgs.gov/*.
North American Datum of 1927 (NAD 27)
Projection and 10,000-foot ticks: Universal Transverse Mercator
New Mexico coordinate system, central zone
1,000-meter ticks, Universal Transverse Mercator, zone 13

APPROXIMATE MEAN DECLINATION, 2010

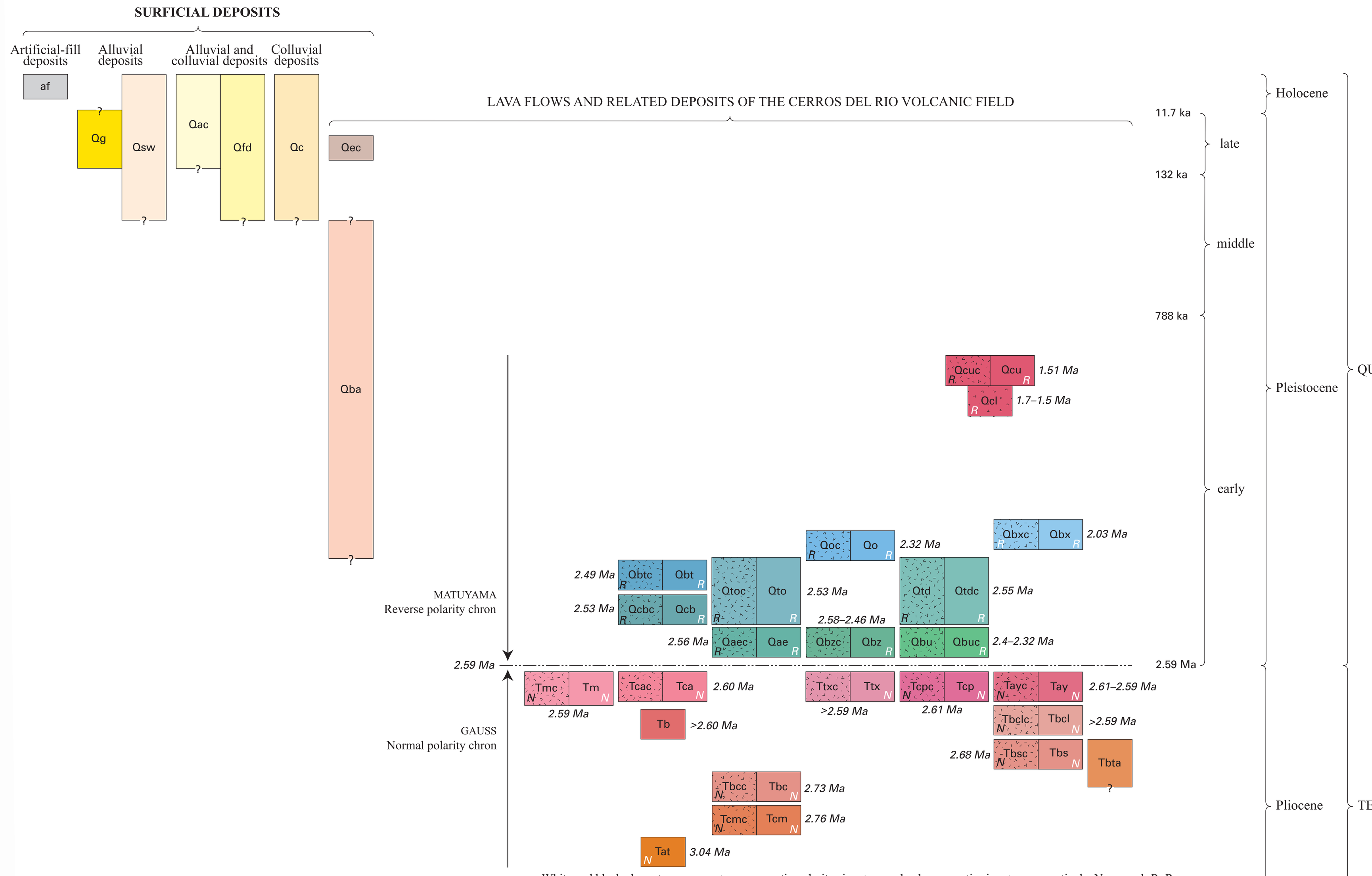
SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATAUM OF 1929

QUADRANGLE LOCATION

The geology was mapped from 1997 to 1999 and modified in 2004 to 2008. The primary mapping responsibilities were as follows: R. Thompson and M.L. Hudson mapped the volcanic deposits and faults and prepared the digital compilation of the geologic map, R.R. Shroba mapped the surficial deposits, M.L. Hudson and S.A. Minor mapped surface exposures of faults. M.L. Hudson conducted paleomagnetic studies for stratigraphic correlations, and D.A. Sawyer assisted with unit correlations with exposures on the adjoining Tetilla Peak quadrangle to the south.

CORRELATION OF MAP UNITS



White and black characters represent aeromagnetic polarity signature and paleomagnetic signature respectively. N, normal; R, Reverse. Approximate eruption ages from table 1.

LIST OF MAP UNITS

[Due to the addition of a shaded relief base, colors on the List of Map Units and Correlation of Map Units may not exactly match unit colors on the map]

SURFICIAL DEPOSITS

Artifical fill deposits

- af — **Artificial fill (latest Holocene)**

Alluvial deposits

- Qg — **Gravelly alluvium (Holocene? and late Pleistocene)**
- Qsw — **Sheetwash deposits (Holocene to middle? Pleistocene)**

Alluvial and colluvial deposits

- Qac — **Alluvium and colluvium, undivided (Holocene and late Pleistocene?)**
- Qfd — **Fan alluvium and debris-flow deposits, undivided (Holocene to middle? Pleistocene)**

Colluvial deposits

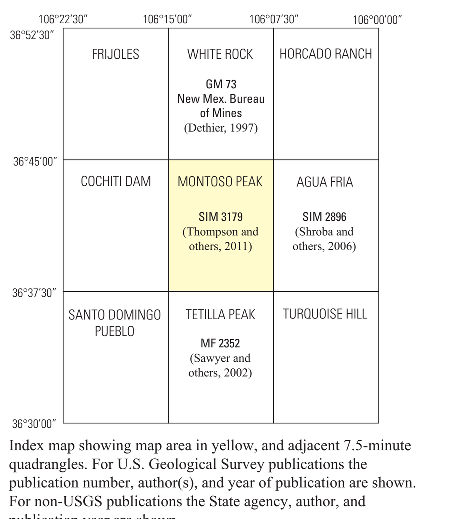
- Qc — **Colluvium, undivided (Holocene to middle? Pleistocene)**

LAVA FLOWS AND RELATED DEPOSITS OF THE CERROS DEL RIO VOLCANIC FIELD

- Qec — **El Cajete Member of the Valles Rhyolite (late Pleistocene)**
- Qba — **Basaltic alluvium (early? to middle? Pleistocene)**
- Qcu — **Andesite of Cochiti Volcano (early Pleistocene)**
- Qcl — **Lower unit**
- Qbx — **Basalt of Hill 7033 (early Pleistocene)**
- Qo — **Andesite of Ortiz Mountain (early Pleistocene)**
- Qto — **Basaltic andesite of Twin Hills (early Pleistocene)**
- Qtd — **Basalt of Hill 7065 (early Pleistocene)**
- Qbt — **Basalt of Tetilla Hole (early Pleistocene)**
- Qcb — **Basalt of Colorado Peak (early Pleistocene)**
- Qae — **Basaltic andesite of Arroyo Eighteen (early Pleistocene)**
- Qbz — **Basalt of Hill 6929 (early Pleistocene)**
- Qbu — **Basalt of Cañada Ancha (early Plesistocene)**
- Tm — **Basalt of Montoso Peak (Pliocene)**
- Tca — **Andesite of Colorado Peak (Pliocene)**
- Ttx — **Basaltic andesite of Thirty-One Draw (Pliocene)**
- Tcp — **Andesite of Cerrita Portillo (Pliocene)**
- Tay — **Basalt of Caja del Rio (Pliocene)**
- Tb — **Basalt of La Bajada Rim (Pliocene)**
- Tbcl — **Basaltic andesite of Arroyo Calabasas (Pliocene)**
- Tbs — **Basalt of Tsinat Mesa (Pliocene)**
- Tbta — **Basaltic tephra and Ancha Formation, undivided (Pliocene)**
- Tbc — **Basaltic andesite of Cerro Micho (Pliocene)**
- Tcm — **Andesite of Cerro Micho (Pliocene)**
- Tat — **Andesite of Tetilla Peak (Pliocene)**

EXPLANATION

- **Contact**
- **Normal fault**—Dashed where inferred from aerial photographs, dotted where concealed; bar and ball on apparent downthrown side
- **Lineament**—Located using aerial photographs and reduced to pole aeromagnetic map; coincides with zones of minor fracturing and faulting
- **Cinder deposits**—Indicated by a "c" at the end of the unit label
- **Lava flow direction**—Inferred lava flow direction for select volcanic rock units
- **Dike**
- 30 — **Inclined bedding**—Showing strike and dip
- U.S. Forest Service Twelve Hundred Well TD 1,200 — **Water well**—Approximately located. Showing name and total depth (TD) in feet
- 3MRG–1 — **Sample location**—With sample number



Index map showing map area in yellow, and adjacent 7.5-minute quadrangles. For U.S. Geological Survey publications the publication number, author(s), and year of publication are shown. For non-USGS publications the State agency, author, and publication year are shown.

CONVERSION FACTORS

Multiply	By	To obtain
millimeters	0.03937	inches (in.)
centimeters (cm)	0.3937	inches (in.)
meters (m)	3.281	feet (ft)
kilometers (km)	0.6214	miles (mi)

DIVISION OF QUATERNARY AND NEOGENE TIME USED IN THIS REPORT[1]

Period or subperiod	Epoch		Age
Quaternary	Holocene		0–11.7 ka
	Pleistocene	late	11.7–132 ka
		middle	132–788 ka
		early	788–2.59 Ma
Neogene	Pliocene		2.59–5.33 Ma
	Miocene		5.33–23.0 Ma

[1]Ages of time boundaries are those of the U.S. Geological Survey Geologic Names Committee (2010) except those for the late-middle Pleistocene and middle-early Pleistocene boundaries, which are those of Richmond and Fullerton (1986). Ages are expressed in ka for kilo-annum (thousand years) and Ma for mega-annum (million years).

Table 1. *Map units, eruption ages, and volcanic rock names for the Cerros del Rio volcanic field*

Map unit name	Map unit symbol	Eruptive series	Eruption age[1] (Ma)	Volcanic rock name[2]
Upper andesite of Cochiti Volcano	Qcu	3	1.51	Andesite/trachyandesite
Lower andesite of Cochiti Volcano	Qcl	3	1.7–1.5	Andesite/basaltic andesite
Basalt of Hill 7033	Qbx	2	2.03	Basalt
Andesite of Ortiz Mountain	Qo	2	2.32	Trachyandesite/trachyte
Basaltic andesite of Twin Hills	Qto	2	2.53	Basaltic trachyandesite
Basalt of Hill 7065	Qtd	2	2.55	Basaltic trachyandesite/trachybasalt
Basalt of Tetilla Hole	Qbt	2	2.49	Trachybasalt
Basalt of Colorado Peak	Qcb	2	2.53	Trachybasalt
Basaltic andesite of Arroyo Eighteen	Qae	2	2.56	Basaltic trachyandesite
Basalt of Hill 6929	Qbz	2	2.58>Qbz>2.46	Trachybasalt
Basalt of Canada Ancha, upper unit	Qbu	2	2.4>Qbu>2.32	Basaltic trachyandesite
Basalt of Montoso Peak	Tm	1	2.59	Basalt/trachybasalt
Andesite of Colorado Peak	Tca	1	2.6	Trachyandesite
Basalt of La Bajada Rim	Tb	1	>2.6	Basalt/basaltic andesite
Basaltic andesite of Thirty-One Draw	Ttx	1	>2.59	Basaltic trachyandesite
Andesite of Cerrita Portillo	Tcp	1	2.61	Trachyandesite
Basalt of Caja del Rio	Tay	1	2.61–2.59	Trachybasalt
Basalt of Arroyo Calabasas, lower unit	Tbcl	1	>2.59	Trachybasalt/tranchyandesite
Basalt of Tsinat Mesa	Tbs	1	2.68	Trachybasalt/basaltic trachyandesite
Basaltic andesite of Cerro Micho	Tbc	1	2.73	Basalt/basaltic trachyandesite
Andesite of Cerro Micho	Tcm	1	2.76	Trachyandesite
Andesite of Tetilla Peak	Tat	1	3.04	Trachyandesite/andesite

[1]Approximate eruption ages are based on one or more ages where determined for the map area or estimated based on stratigraphic postion. $^{40}Ar/^{39}Ar$ ages for select samples from each map unit are reported in the text.
[2]Modified root names based on IUGS rock classification (LeBas and Streckeisen, 1991).

Table 2. *Whole rock major oxide and trace element analyses of representative Cerros del Rio volcanic field samples*
[LOI, loss on ignition]

Quadrangle	Tetilla Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Tetilla Peak	Turqoise Hill	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak
Eruption series	1	1	1	1	1	1	1	1	2	1	1
Map unit	Tat	Tcm	Tcm	Tbc	Tbcc	Tbs	Tbs	Tayc	Tay	Tcac	Tca
Sample no.	96TTP01	04TMP23	6RTCD10	3MRG–1	96TMP18	96DTP04	96TTH02A	02TMP02	2MRG–11	96TMP38	96TMP20
major elements wt% oxides											
SiO_2	62.19	59.00	60.00	52.70	52.40	50.20	50.70	48.90	48.90	56.09	59.48
TiO_2	0.62	0.79	0.73	1.35	1.45	1.51	1.42	1.81	1.79	0.93	0.78
Al_2O_3	14.89	15.8	15.7	14.6	15.2	15.4	15.1	15.4	15.3	15.7	16.09
Fe_2O_3	4.54	5.84	5.44	7.99	8.33	9.02	8.82	10.8	10.7	6.7	5.74
MnO	0.09	0.10	0.1	0.13	0.14	0.15	0.15	0.17	0.17	0.11	0.1
MgO	2.69	3.90	3.09	7.10	6.74	6.91	7.1	7.57	7.47	4.3	3.47
CaO	5.12	5.92	5.54	8.25	8.03	7.81	7.46	8.97	9.01	6.88	5.63
Na_2O	4	4.12	4.41	3.68	3.31	3.94	3.5	3.67	3.49	4.38	4.04
K_2O	2.91	2.46	2.63	2.06	2.12	2.18	2.14	1.95	1.93	2.22	2.32
P_2O_5	0.51	0.56	0.51	0.70	0.68	0.89	0.81	0.89	0.87	1.01	0.54
LOI	1.9	0.75	1.19	1.26	0.94	1.44	1.64	0.1	0.38	0.84	1.42
Total	99.46	99.24	99.34	99.82	99.34	99.45	98.84	100.23	100.01	99.16	99.61
trace elements (ppm)											
Cr	40.8	77.10	70	218.00	218.00	194	195	174.00	169.00	26.7	61.5
Ni	35.2	69.60	58	173.00	174.00	129	134	120.00	136.00	62.7	49.4
Ba	1420	1340	1540	1070	928	1310	1270	1130	1070	1840	1330
Rb	53.4	38.10	43.9	39.80	37.20	37.8	38.8	35.70	33.70	33.2	35.5
Th	10.7	9.91	10.8	8.08	7.59	10.7	10.8	7.32	6.85	11	8.7
Ta	2.51	2.15	1.9	2.64	2.49	3.15	3.04	2.90	2.67	2.98	1.98
La	53.9	58.30	61.4	48.60	46.50	64.6	64.2	58.60	56.70	93.1	57
Ce	92	95.00	101	86.60	81.50	120	116	113.00	107.00	155	94.8
Sr	907	1010	998	796	764	1080	1100	1240	1180	1720	994
Sm	5.78	5.89	5.9	7.17	6.37	8.65	8.28	10.10	9.76	8.81	6.2
Zr	191	182	141	186	187	214	204	230	232	226	179
Hf	4.44	4.33	4	4.21	3.97	4.41	4.26	5.05	4.82	4.9	4.4
Tb	0.604	0.64	0.71	0.75	0.74	0.889	0.832	1.00	0.95	0.81	0.644
Yb	1.78	1.74	1.8	2.09	2.06	2.36	2.08	2.54	2.39	2.09	1.87

Quadrangle	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak
Eruption series	1	1	1	1	1	1	1	1	1	1	2
Map unit	Tca	Tcp	Tcp	Tcp	Tm	Tm	Tbcl	Tbcl	Tbcl	Ttx	Qbu
Sample no.	96TMP24	MP3260601	96TMP04	96TMP36	96TMP08	96TMP07	96TMP35	04TMP21	04TMP22	96TMP27	2MRG–2
major elements wt% oxides											
SiO_2	60.70	57.70	60.60	60.03	50.00	51.00	54.70	54.70	52.90	52.79	52.10
TiO_2	0.66	1	0.87	0.86	1.59	1.47	1.57	1.64	1.42	1.44	1.47
Al_2O_3	15.6	16.1	15.8	15.89	16.4	16.2	15.5	15.5	15.5	17.91	17.5
Fe_2O_3	5.49	6.44	5.46	5.67	10.4	9.88	9.60	9.83	10.1	8.09	8.66
MnO	0.1	0.1	0.09	0.09	0.16	0.15	0.14	0.14	0.14	0.13	0.14
MgO	3.82	3.15	2.45	3.06	6.1	5.82	3.87	4.21	6.12	4.04	4.67
CaO	5.52	5.78	4.8	5.3	9.22	8.73	6.84	6.99	7.91	6.82	7.65
Na_2O	4.05	4.44	3.97	4.12	3.74	3.7	3.77	3.72	3.49	4.75	4.3
K_2O	2.44	2.65	3.31	2.73	1.4	1.54	1.82	1.67	1.35	2.14	2.06
P_2O_5	0.42	0.9	0.71	0.7	0.53	0.51	0.62	0.66	0.41	0.95	0.92
LOI	0.83	1.34	1.36	0.97	0	0.17	0.81	0.39	0.26	0.2	0.39
Total	99.63	99.60	99.42	99.42	99.54	99.17	99.24	99.45	99.60	99.26	99.86
trace elements (ppm)											
Cr	105.00	10.10	19.7	31.4	153	157	82.20	77.60	198.00	6.13	59.80
Ni	63.80	31.70	28.4	40.11	67.3	65.9	39.20	43.40	82.00	25.4	51.90
Ba	1260	1990	1680	1570	763	865	1000	972	758	1820	1340
Rb	37.3	42.8	51.6	45.2	22.2	23.9	29.70	23.90	21.50	24.8	28.70
Th	8.3	10.4	11.1	8.54	4.97	5.64	6.91	6.72	4.81	11.8	11.40
Ta	1.4	2.7	3.24	2.62	1.95	2.02	1.68	1.64	1.35	3.12	3.10
La	49	79.6	67.8	63.9	37.1	37.9	54.60	52.70	36.90	77.9	78.60
Ce	78	128	119	110	66.8	68.2	90.70	88.70	63.90	132	132.00
Sr	820	1570	1240	1160	752	704	557	580	526	1420	1420
Sm	4.8	7.4	7.52	7.36	6.59	6.19	6.35	6.25	4.98	8.92	9.45
Zr	162	229	198	205	159	167	201	198	150	266	264
Hf	4	5	4.96	4.98	3.52	3.62	4.55	4.40	3.55	5.47	5.46
Tb	0.65	0.95	0.696	0.701	0.771	0.727	0.81	0.80	0.73	0.916	0.93
Yb	1.7	1.9	1.87	1.94	2.14	2.13	2.20	2.19	2.09	2.39	2.57

Quadrangle	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak
Eruption series	2	2	2	2	2	2	2	2	2	2	2
Map unit	Qbu	Qbx	Qbx	Qae	Qae	Qbt	Qbt	Qcb	Qcb	Qto	Qto
Sample no.	96TMP15	4MRG–17	96TMP09	MP3270601	05TMP01	96TMP22a	96TMP22b	2MRG–5	3MRG–2	MP3260602	96TMP03
major elements wt% oxides											
SiO_2	51.65	46.80	47.30	56.70	55.30	50.00	49.71	50.10	50.20	52.90	50.10
TiO_2	1.46	1.75	1.88	1.1	1.18	1.54	1.53	1.55	1.52	1.24	1.44
Al_2O_3	17.3	15.1	15.6	17.5	17.1	17.5	17.49	17.9	17.5	15.7	16
Fe_2O_3	8.55	10.4	11.2	7.06	7.50	9.53	9.73	9.64	9.41	8.4	9.41
MnO	0.14	0.17	0.18	0.11	0.12	0.15	0.15	0.16	0.15	0.13	0.14
MgO	4.42	7.74	7.37	3.22	4.09	4.99	4.07	5.03	5.16	6.32	6.85
CaO	7.83	9.18	9.08	6.2	6.88	8.48	8.49	8.75	8.39	8.11	8.47
Na_2O	4.35	3.67	3.75	4.52	4.26	4.07	4.14	3.79	4.10	4.09	4.09
K_2O	2.04	1.25	1.85	2.13	1.90	1.85	1.81	1.78	1.82	1.82	1.75
P_2O_5	0.97	1.00	0.94	0.66	0.61	0.91	0.94	0.94	0.92	0.74	0.96
LOI	0.75	2.39	0.06	1.1	0.06	0.41	0.48	0.58	0.14	0.35	0.15
Total	99.46	99.45	99.21	100.30	99.00	99.43	98.54	100.22	99.31	99.80	99.36
trace elements (ppm)											
Cr	56	185.00	174	5.99	17.60	158.00	35.9	30.10	38.10	209.00	140.00
Ni	56.4	144.00	128	20.50	44.90	72.40	39.3	43.90	49.10	106.00	121.00
Ba	1590	1170	1090	1360	1060	947	1200	1360	1550	1220	1140
Rb	28.8	14.10	31	27.7	26.10	29.30	31.5	29.30	35.10	30.4	28.2
Th	10.4	9.43	8.47	10.6	8.18	5.63	9.3	9.51	10.10	10	11.2
Ta	3.07	2.97	3.2	1.7	1.74	2.02	2.71	2.71	2.74	2.2	2.2
La	76.8	71.30	69.5	69.4	51.90	39.40	69.2	71.60	74.80	67.5	79
Ce	126	125.00	123	107	85.60	70.80	121	126.00	129.00	106	123
Sr	1280	1330	1280	1140	946	704	1180	1310	1180	1280	1330
Sm	8.9	9.24	10.6	6.8	6.04	6.23	8.67	9.33	9.42	7.4	8.4
Zr	248	237	237	217	199	176	233	266	286	159	207
Hf	5.23	5.06	4.95	5	4.22	3.79	4.59	4.76	4.94	4	4
Tb	0.903	1.04	1.3	0.94	0.73	0.81	0.97	0.95	0.99	0.94	1.01
Yb	2.33	2.64	2.45	2.3	1.98	2.24	2.42	2.54	2.51	2.2	2.2

Quadrangle	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Montoso Peak	Cochiti Dam	Cochiti Dam	Cochiti Dam	Cochiti Dam	Montoso Peak	Cochiti Dam
Eruption series	2	2	2	2	2	2	2	3	3	3	3
Map unit	Qo	Qo	Qtd	Qtd	Qtdc	Qb	Qb	Qcl	Qcl	Qcu	Qcu
Sample no.	96TMP17	96TMP14	3MRG–8	96TMP19	04TMP24	96DCD01	96TCD01	6RTCD4	DN–96–28b	97TMP50	3MRG–4
major elements wt% oxides											
SiO_2	60.60	59.10	50.60	55.90	51.10	46.69	50.43	58.30	56.19	60.10	59.20
TiO_2	0.85	0.98	1.43	1.11	1.56	1.52	1.45	1.06	1.22	0.95	1.03
Al_2O_3	16.2	16.87	15.6	17.0	17.8	15.27	15.47	15.8	15.99	16.1	15.8
Fe_2O_3	5.56	6	9.11	6.85	8.76	12.35	9.72	7.42	8.11	6.83	7.07
MnO	0.09	0.09	0.15	0.11	0.14	0.17	0.15	0.11	0.12	0.1	0.11
MgO	2.68	2.78	7.11	3.17	4.28	8.03	6.68	3.75	4.68	3.2	3.70
CaO	5.17	5.49	8.52	6.41	7.16	10.03	8.45	6.43	6.78	5.73	5.99
Na_2O	4.21	4.39	3.72	4.20	4.68	3.27	3.55	4.22	3.70	4.11	3.90
K_2O	2.57	2.33	1.66	2.29	2.05	0.76	1.58	2.18	1.94	2.18	2.07
P_2O_5	0.48	0.59	0.77	0.66	0.95	0.6	0.58	0.38	0.46	0.43	0.40
LOI	0.99	0.92	0.48	1.30	0.06	1.32	1.83	0.42	0.34	0.42	0.25
Total	99.40	99.54	99.15	99.00	98.54	100.01	99.89	100.07	99.53	100.15	99.52
trace elements (ppm)											
Cr	19.00	8.58	223.00	7.31	3.09	266	205	70	98	56.80	63.30
Ni	28.80	20	139.00	22.40	24.10	155	139	46	71	42.60	45.00
Ba	1340	1670	1190	1470	1350	460	808	1180	978	1200	1220
Rb	35.00	33.4	21.90	27.20	31.80	14.8	26.9	32.3	30	37.6	30.10
Th	8.88	8.73	9.42	9.94	11.40	3.96	5.33	4.8	4.69	6.8	5.07
Ta	1.71	1.94	2.41	1.98	3.20	1.37	1.93	1	1.25	1.1	1.15
La	54.10	58.5	66.60	64.20	77.60	33.3	36.4	43.1	37.90	45.1	41.30
Ce	89.10	98.8	110.00	106.00	134.00	64.4	63.7	77.1	66.30	74.4	71.20
Sr	820	996	1180	1060	1390	779	663	778	792	797	685
Sm	5.89	6.89	7.77	7.06	8.95	6.31	5.51	5.6	5.76	5.3	5.89
Zr	218	230	224	224	251	173	161	143	148	171	184
Hf	5.08	5.21	4.64	5.26	5.38	2.99	3.29	4	3.91	4	4.48
Tb	0.67	0.704	0.91	0.82	0.97	0.785	0.701	0.71	0.65	0.75	0.66
Yb	1.89	1.94	2.36	2.12	2.59	2.19	2.04	1.8	1.85	1.8	1.95

Geologic Map of the Montoso Peak Quadrangle, Santa Fe and Sandoval Counties, New Mexico

By
Ren A. Thompson, Mark R. Hudson, Ralph R. Shroba, Scott A. Minor, and David A. Sawyer
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