Marion Peak Quadrangle, Fresno County, California—Analytic Data

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Marion Peak Quadrangle, Fresno County, California—Analytic Data

By JAMES G. MOORE

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Marion Peak Quadrangle, Fresno County, California—Analytic Data

By James G. Moore

Abstract

The Marion Peak 15-minute quadrangle includes about 620 km^2 on the west slope of the Sierra Nevada in Fresno County, California, between 36°45' and 37°00' N. latitude and 118°30' and 118°45 W. longitude. This report supplements the geologic map of the Marion Peak quadrangle by providing modal and chemical analyses of the granitic and volcanic rock samples.

Granitic rocks of the batholith underlie 95 percent of the quadrangle area. Most of the remaining area is underlain by septa of pre-batholithic metamorphosed sediments and volcanic rocks which occur between the individual granitic masses. Cenozoic volcanic rocks underlie a small area, and they include an eroded dacitic volcanic center and scattered erosional remnants of basaltic lava flows.

About 300 samples of typical plutonic and volcanic rocks were collected during the course of geologic mapping; of these, 30 granitic, 2 metavolcanic, and 9 Cenozoic volcanic rocks were chemically analyzed for their major elements, and most were also analyzed for selected trace elements. In addition, 178 samples of granitic rocks were analyzed modally for the volume percent of their constituent minerals. Measurements of specific gravity and magnetic susceptibility are also included.

The average chemical composition of the granitic rocks in the quadrangle, estimated from the analyzed samples, is a silicic granodiorite that contains 69.2 weight percent SiO_2.

INTRODUCTION

The Marion Peak quadrangle includes about 620 km^2 on the west slope of the Sierra Nevada in Fresno County, California, between 36°45' and 37°00' N. latitude, and 118°30' and 118°45' W. longitude. The quadrangle lies chiefly between the Middle and South Forks of the Kings River and is largely within Kings Canyon National Park. The crest of Monarch Divide, the high ridge between these forks of the Kings River, culminates at Mt. Harrington (11,005 feet) near the west quadrangle boundary, and Marion Peak (12,719 feet) near the northeast corner of the quadrangle. Lowest elevations of the quadrangle are near the west boundary on the Middle Fork of the Kings River (4604 feet) and the South Fork (4138 feet).

Granitic rocks of the Sierra Nevada batholithic complex underlie about 95 percent of the area of the quadrangle. This report supplements the geologic map of the Marion Peak quadrangle (Moore, 1978) by providing modal and chemical analyses of the granitic and volcanic rock samples.

Manuscript approved for publication, March 25, 1990.

GENERAL GEOLOGY AND AGE DETERMINATIONS

The geology of the quadrangle is dominated by granitic intrusions composing the Sierra Nevada batholithic complex, which was emplaced largely in the Cretaceous. Granitic rocks of the batholith underlie 95 percent of the quadrangle area. Most of the remaining area is underlain by thin septa of pre-batholithic metamorphosed sedimentary and volcanic rocks which occur between the individual granitic masses. Cenozoic volcanic rocks underlie a small area; they include an eroded dacitic volcanic center and scattered erosional remnants of basaltic lava flows.

The oldest rocks of the quadrangle are small masses of generally silicic metavolcanic rocks preserved primarily as septa between individual granitic intrusive masses. In the northeast corner of the quadrangle, these metavolcanic rocks are closely associated with a mass of sheared granitic rocks cut by mafic dikes tentatively assigned to the Late Jurassic Independence dike swarm (Chen and Moore, 1979). The metavolcanic rocks in the northeast corner are part of the south end of the Mount Goddard pendant in which radiometric ages of 131–143 Ma indicate a Late Jurassic age (Tobish and others, 1986). Silicic metatuffaceous rocks on the west-central margin of the quadrangle are part of the Boyden Cave pendant, which has yielded a radiometric age of 106 Ma (Saleeby and others, 1990). Hence the metamorphosed metavolcanic rocks of the quadrangle span some 37 m.y. and apparently represent the volcanic cover associated with two general periods of plutonic intrusion that occurred in the Late Jurassic and the mid-Cretaceous.

The Late Jurassic sequence of granitic rocks has not been dated within the quadrangle, but an age of 156 Ma (Tobish and others, 1986) for a granitic unit within the Mount Goddard pendant cut by mafic dikes north of the quadrangle provides a basis for estimating the age of the sheared granitic unit of similar character in the northeast corner of the quadrangle.

Several masses of mid-Cretaceous hypabyssal and plutonic rocks associated with the metavolcanic rocks of the Boyden Cave pendant have been dated west of the quadrangle by U/Pb zircon and Rb/Sr bulk-rock isochron methods (Saleeby and others, 1990), which refine some of the earlier U/Pb age data of Chen and Moore (1982). Those that extend into the Marion Peak quadrangle are the schistose granodiorite of Tombstone Creek (102 Ma), metadacite porphyry of Boulder Creek (105±3 Ma), granite of Grand Dike (103±2 Ma), and granodiorite of Lightning Creek (100 Ma).

K-Ar ages of samples collected outside the quadrangle that are a part of intrusive masses that extend into it include a biotite age of 81±3 Ma from granodiorite of the Cartridge Pass pluton (Dodge and Moore, 1968) and biotite ages of 80.4 Ma and a hornblende age of 86.1 Ma from the Paradise Granodiorite (Evernden and Kistler, 1970).

U/Pb ages of samples of Cretaceous granitic plutons collected within the quadrangle include Lookout Peak (97 Ma), North Dome (89?Ma), Paradise (83–86 Ma), and the heterogeneous granite of North Mountain, which has failed to yield a concordant age (Chen and Moore, 1982).

Cenozoic volcanic rocks within the quadrangle include the eroded Windy Peak dacitic volcanic neck and associated lava flows in the canyon of the Middle Fork of the Kings River, and small, flow remnants of potassic basaltic composition that are widely scattered over the western part of the quadrangle. Biotite and hornblende from the Windy Peak dacitic volcanic neck have been dated by the K-Ar method at 4.4±0.4 Ma, and 4.5±0.4 Ma, respectively; a pebble of dacite from the Kings River fan, apparently derived from the volcanic neck, yielded a whole rock age of 4.03±0.12 Ma (Huber, 1981).

The basaltic remnants within the quadrangle have not been dated. A basalt flow remnant 15 km west of the quadrangle on Rancheria Creek yielded a whole rock K-Ar age of 3.20±0.06 Ma and the basalt flow of Stony Flat 15 km west-southwest of the quadrangle yielded a whole rock K-Ar age of 3.40±0.06 Ma (Huber, 1981).

SAMPLING AND ANALYTIC METHODS

About 300 samples of typical plutonic and volcanic rocks were collected during the course of mapping within the quadrangle. Of these, 30 granitic, 2 metavolcanic, and 9 Cenozoic volcanic rocks were chemically analyzed for their major elements, and most were also analyzed for selected trace elements (tables 1 and 3). Older chemical analyses were performed by the rapid method of Shapiro and Brannock (1962). All other analyses were made by standard X-ray fluorescence techniques with Na_2O, and in some cases K_2O, determined by flame photometry. Ferrous iron, CO_2, H_2O^+, and H_2O^- were determined by standard wet chemical methods. The generally regular relation of SiO_2 to the other major elements in the analyzed granitic rocks is shown in the variation diagrams of figure 2.

Altogether, 178 samples of granitic rocks were analyzed modally for the volume percent of their constituent minerals (table 2). Modal analyses were made by counting over 1,000 points on stained rock slabs (Norman, 1974). The color differences provide a basis for identifying and measuring the volume percent of quartz, plagioclase, K-feldspar, and mafic minerals (chiefly biotite, hornblende, sphene, and magnetite.

The locations of analyzed samples are shown in figure 1, and the modal proportions of quartz, K-feldspar, and plagioclase in the granitic rocks appear in the triangular plots of figure 4, which provide the basis for naming the rocks according to the classification (fig. 3) of the International Union of Geological Sciences (Streckeisen, 1973).

Specific gravity was determined by weighing hand samples in air and water on a beam balance. Magnetic susceptibility was measured on 1 kilogram hand samples with a Geoinstruments JH–5 susceptibility meter. Direct readings in SI units $\times 10^{-5}$ were doubled in accordance with the procedures used for hand samples.

RELATION OF SIO_2 TO SPECIFIC GRAVITY, COLOR INDEX, AND MAGNETIC SUSCEPTIBILITY

The relation between major element chemical constituents and other parameters that can be measured more easily and at less cost can lead toward a better appraisal of compositional variation of the diverse plutonic rocks in a given area. Examination of about 200 analyses of granitic rock samples collected between 37° and 38° N. latitude in the Sierra Nevada (Bateman and others, 1984) indicates that the bulk specific gravity of hand specimens and volume percent of mafic minerals (color index) both correlate relatively well with each other and inversely with the weight percent of SiO_2 (fig. 5). The inverse correlation of bulk specific gravity with weight percent SiO_2 is particularly good (R^2=0.820), such that SiO_2=317.93–(sp. gr./0.010752). The analyzed granitic rocks within the quadrangle show these same general trends, but scatter is greater because of limited analyses (fig. 6).

Measurements of magnetic susceptibility show a direct relation to both specific gravity and volume percent of mafic minerals measured on the same samples (fig. 7).

AVERAGE GRANITIC ROCK COMPOSITION

The estimation of the average chemical composition of the granitic rocks in the quadrangle is useful for comparison with other areas, and ultimately for development of models for the genesis of the batholith. Because of its ease of measurement, specific gravity is generally obtained for a higher proportion of available samples than are other analytical procedures. An estimate of the average specific gravity of each pluton is derived from a weighted average of the determinations made on samples from that pluton. Then the average specific gravity of the plutonic rocks in the entire quadrangle is determined by considering the area of each mapped plutonic mass (table 4). From this grand average specific gravity, the average SiO_2 content of 69.2 weight percent is determined from the overall relation of specific gravity to SiO_2. Finally other major element concentrations are estimated for this average SiO_2 content from variation diagrams for all analyzed rocks in the quadrangle, thus establishing the overall estimate of the average plutonic rock in the quadrangle.

The 69.2 percent SiO_2 average for granitic rocks of the Marion Peak quadrangle is somewhat less than the 70.5 percent estimated for the Mt. Whitney quadrangle adjacent on the southeast (Moore, 1987), and more than the 68.2 percent estimated for the Mt. Pinchot quadrangle adjacent to the east (Moore, 1963). The estimated average composition of Mesozoic plutonic rocks of the Sierra Nevada is 68.4 percent (Dodge, 1972).

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FIGURES 1–7; TABLES 1–5

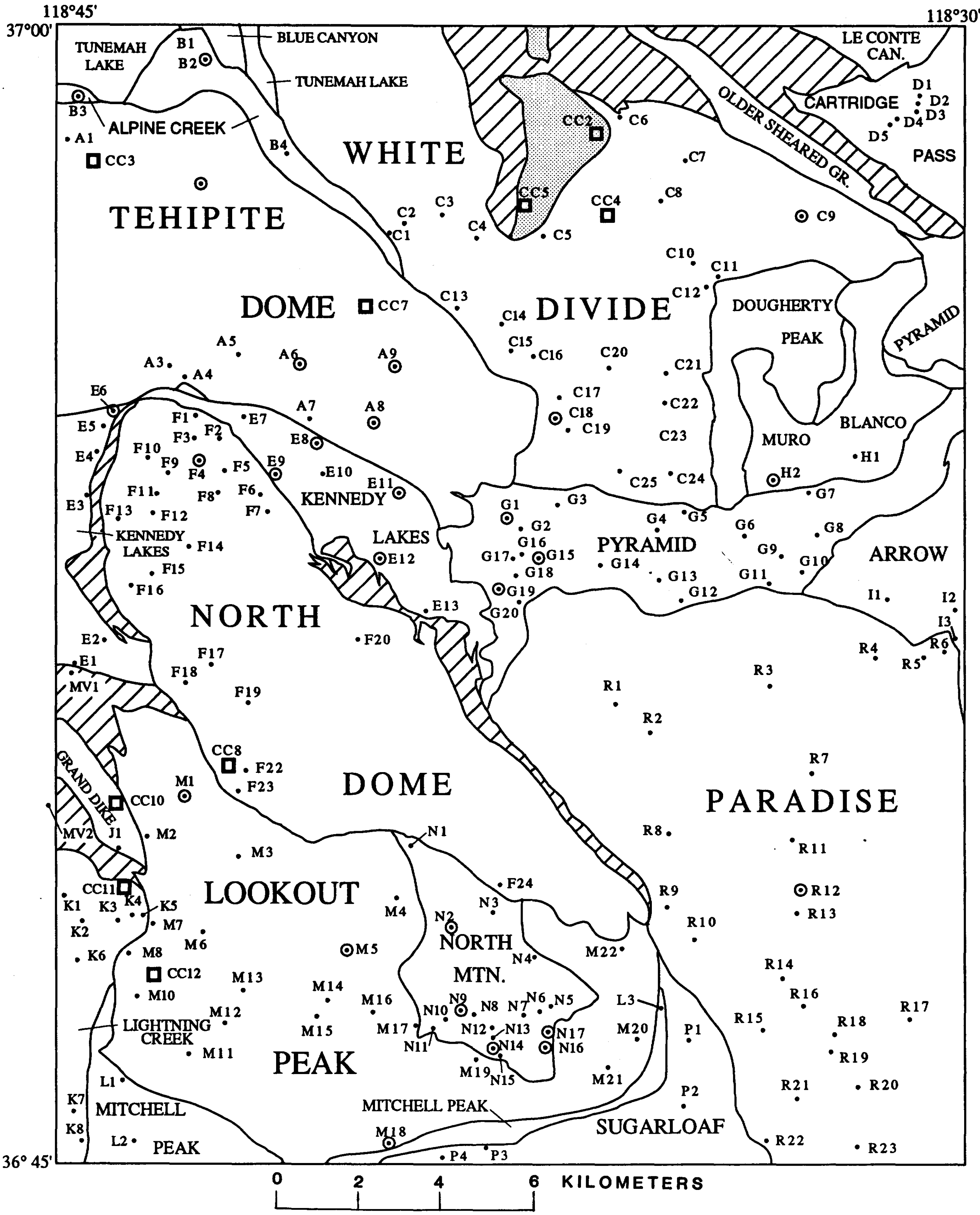


Figure 1. Generalized geologic map of Marion Peak quadrangle (Moore, 1978) showing locations of analyzed samples. Plutonic rocks shown by circles (chemically analyzed, table 1) and dots (modally analyzed, table 2). Chemically analyzed Cenozoic volcanic rocks shown by squares. Mesozoic granitic rocks are unpatterned, Cenozoic volcanic rocks have a shaded pattern, and metamorphic rocks have a lined pattern. Names of plutonic rock units shown.

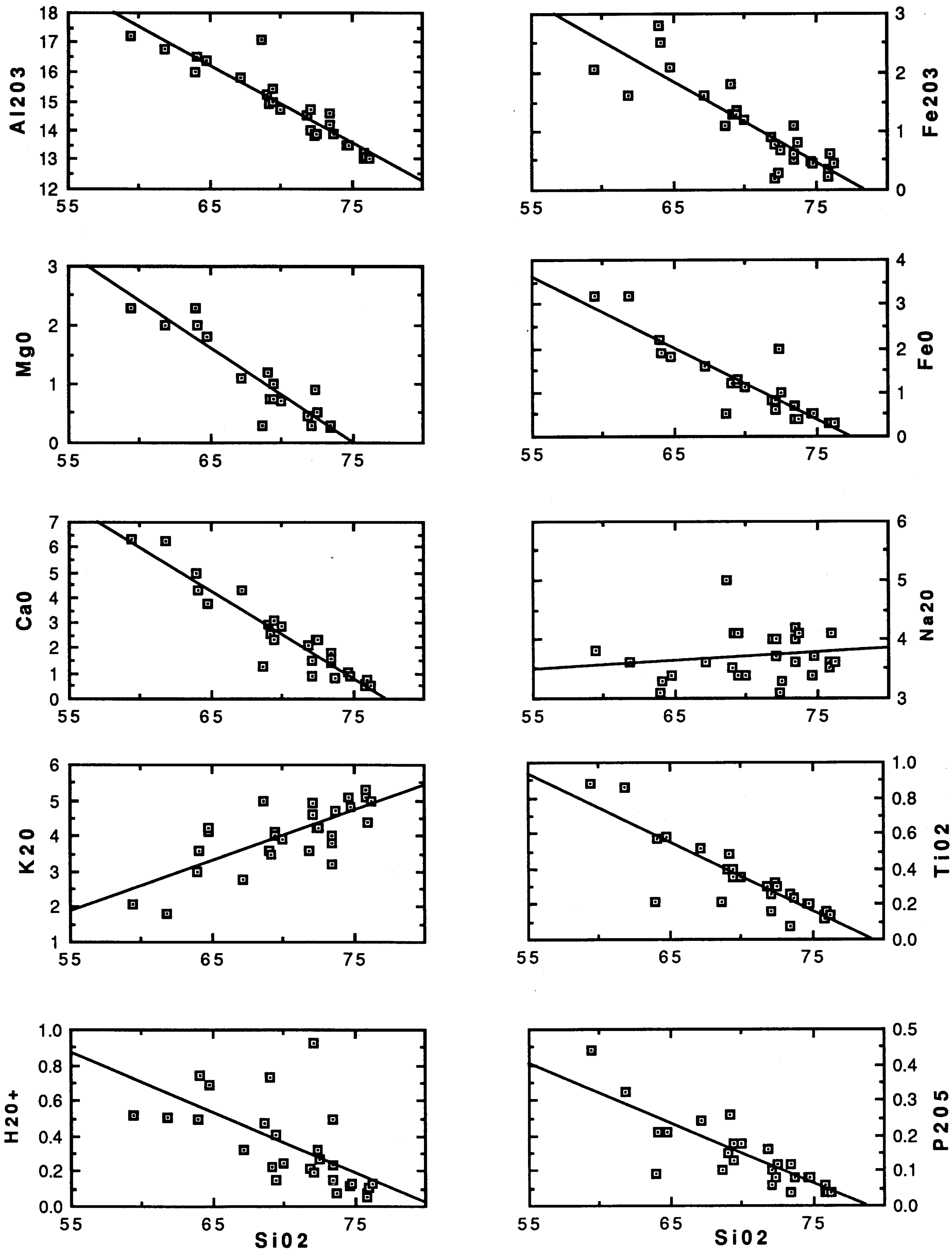


Figure 2. SiO_2 variation diagrams for analyzed granitic rocks from the Marion Peak quadrangle. Least squares regression lines through data were used to estimate the average major elements based on the SiO_2 average of 69.2 weight percent (table 5).

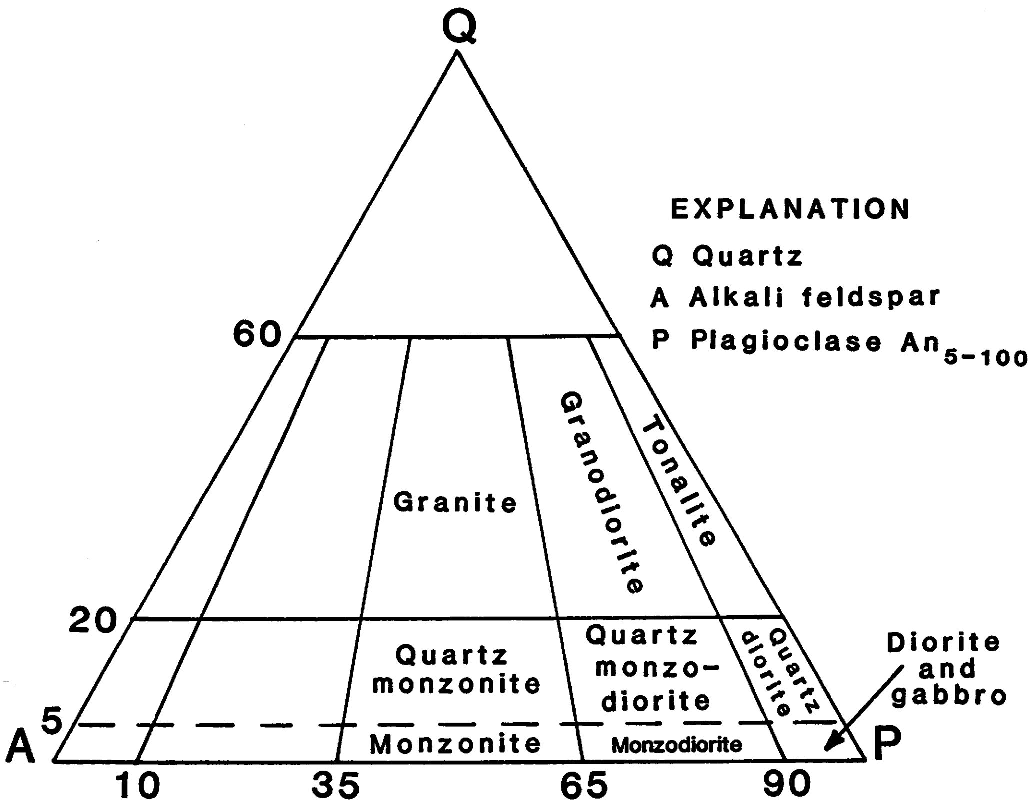


Figure 3. Classification scheme for granitic rocks from Streckeisen (1973).

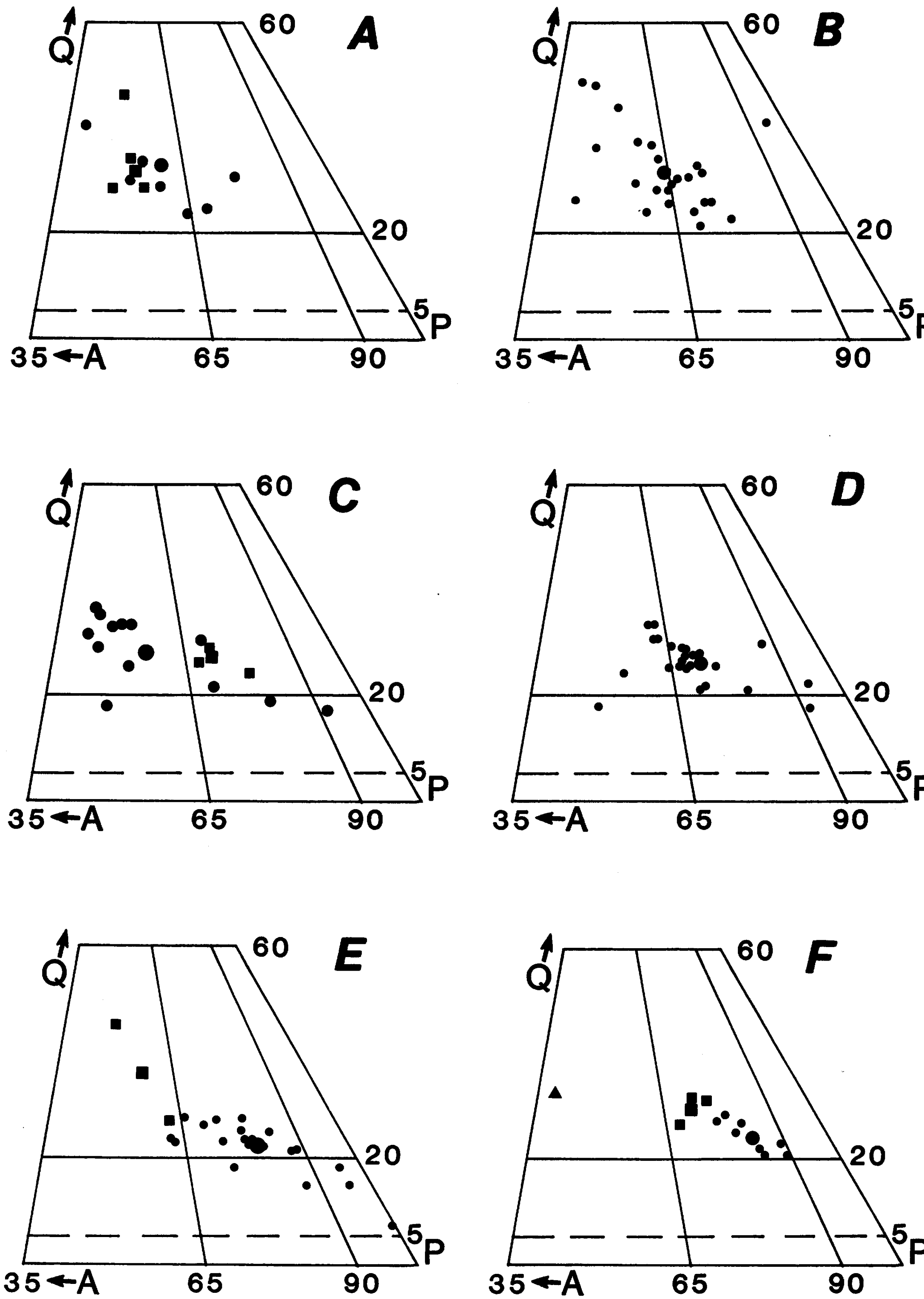
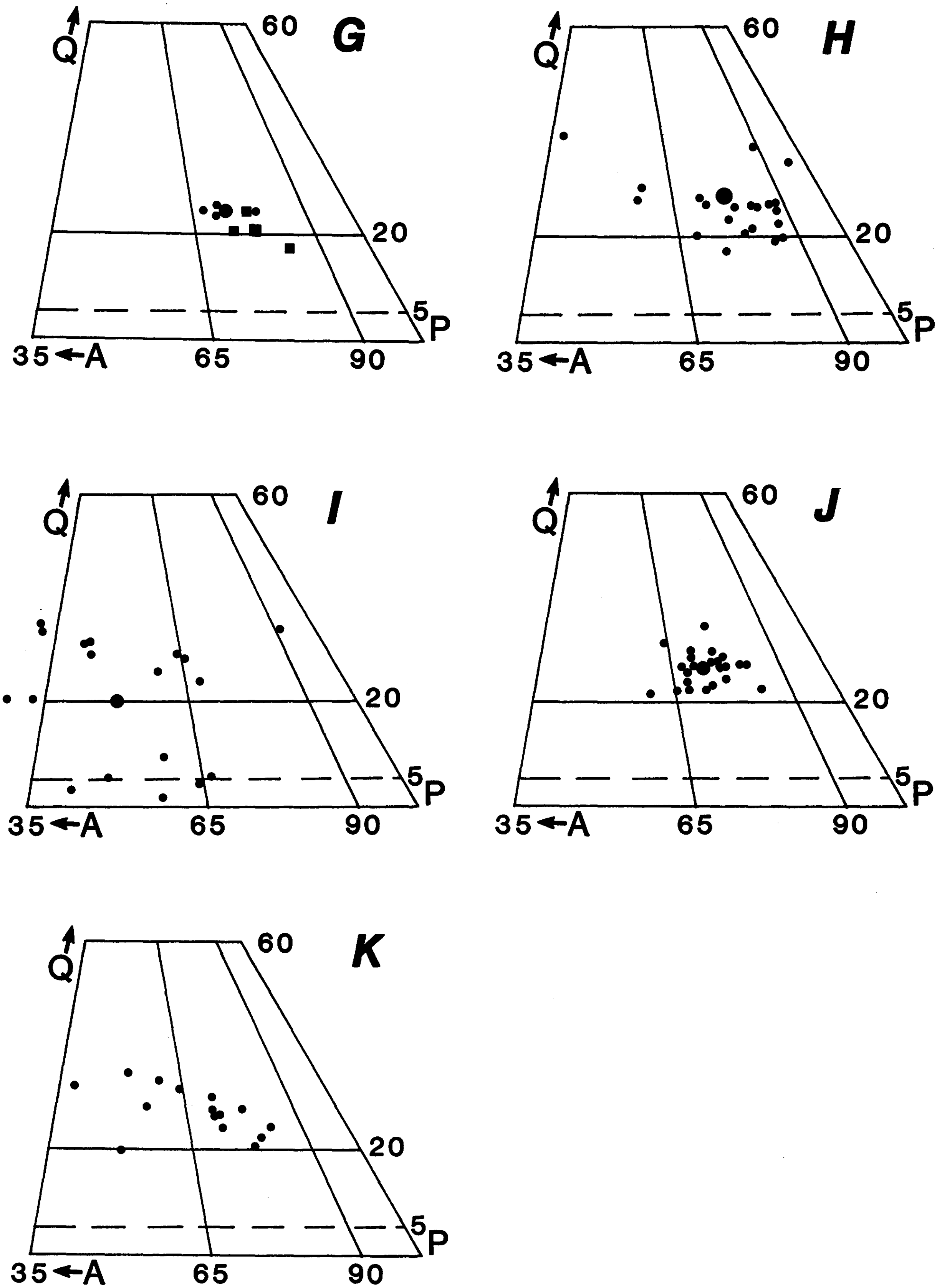


Figure 4. Modal plots of samples from 15 of 22 granitic masses in the Marion Peak quadrangle; large symbols White Divide. *C*, Granite of Kennedy Lakes (circles) and Cartridge Pass pluton (squares). *D*, Granodiorite of North (circles), Arrow pluton (squares), and Granite of Grand dike (triangle). *G*, Granodiorite of Mitchell Peak (circles) pluton. *K*, Averages of analyzed granitic masses. See figure 3 for classification scheme.



are averages. *A*, Granite of Tehipite Dome (circles) and Granite of Alpine Creek (squares). *B*, Granodiorite of Dome. *E*, Pyramid pluton (circles) and Granodiorite of Muro Blanco (squares). *F*, Granodiorite of Lightning Creek and Granodiorite of Sugarloaf (squares). *H*, Granodiorite of Lookout Peak. *I*, Granite of North Mountain. *J*, Paradise

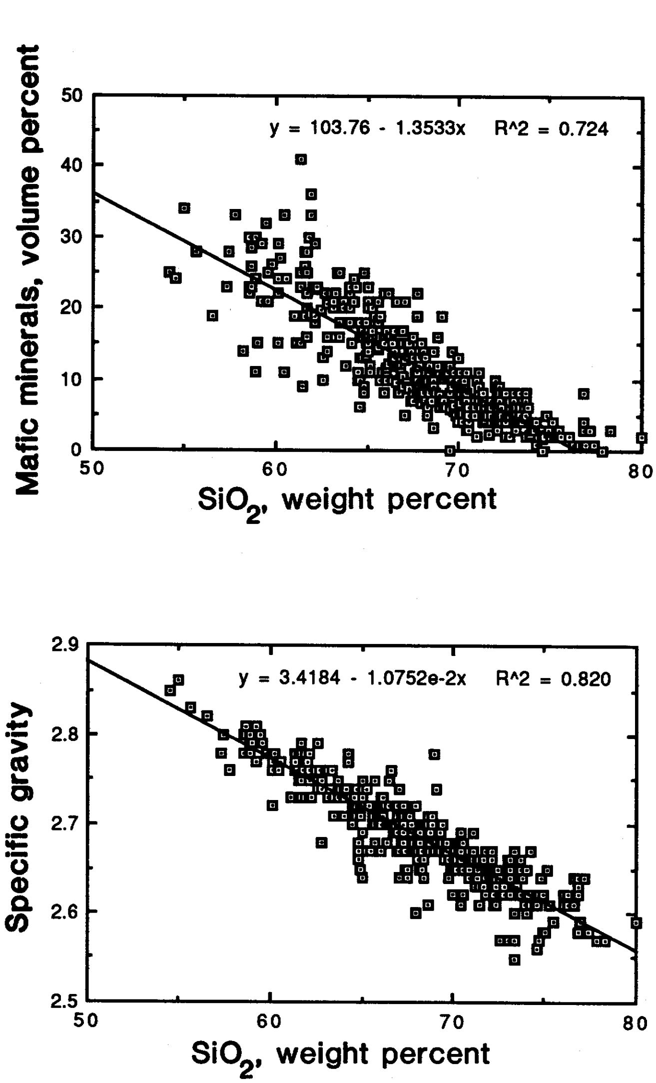


Figure 5. Relation of SiO_2 content to volume percent mafic minerals and to specific gravity for about 200 analyzed granitic rocks in the Sierra Nevada between 37° and 38° N. latitude (Bateman and others, 1984). Equations for least squares regression lines through data are shown.

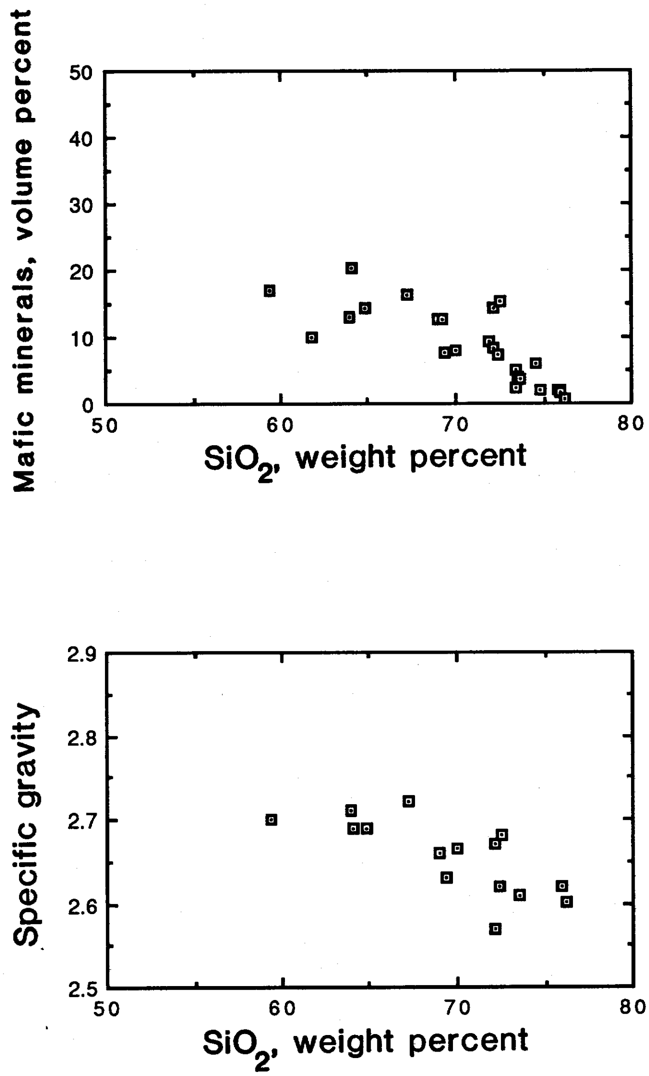
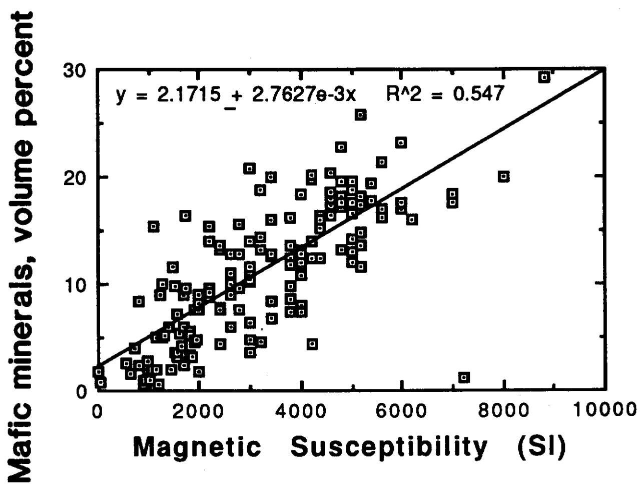


Figure 6. Relation of SiO_2 content to volume percent mafic minerals and to specific gravity for 15 analyzed granitic rocks in the Marion Peak quadrangle.



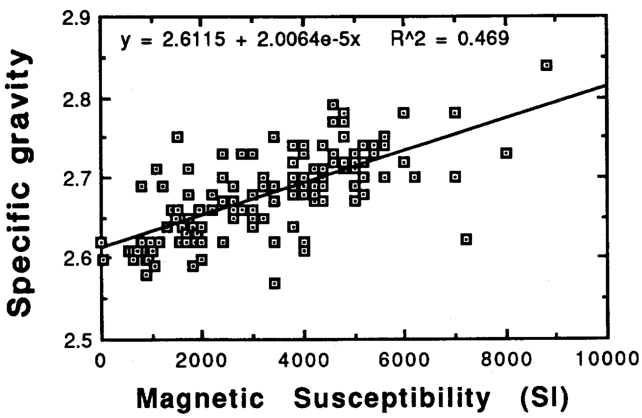


Figure 7. Relation of magnetic susceptibility to volume percent of mafic minerals and to specific gravity for most of the 178 modally analyzed granitic rocks in the Marion Peak quadrangle (table 2). Magnetic susceptibility is reported in dimensionless SI units $X10^{-5}$. Equations for least squares regression lines through data are shown.

Table 1. Chemical analyses and norms of granitic rocks

[†, Analysis performed in the rapid rock analysis laboratory under the supervision of Leonard Shapiro; analysts: P. Elmore, S. Botts, G. Chloe, H. Smith, J. Kelsey, L. Artis and J. Glenn. *, Analysis by X-ray spectroscopy; analysts D. Vivit, M. Dyslin. Analysis of FeO, H_2O, and CO_2 by chemical methods; analyst, N. Elsheimer. -, no data]

	Granite of Tehipite Dome			Granite of Alpine Creek		Granodiorite of White Divide				Granite of Kennedy Lakes		
Field No.	67M24†	68M50*	68M51*	M735*	M742*	64M20*	64M37*	64M9†	64M10*	67M40*	67M43†	67M46*
Map No.	A6	A8	A9 (dior.)	B2	B3	C9	C18	C23	C25	E6	E9	E8
Chemical analyses (weight percent)												
SiO_2	72.4	72.5	61.8	73.4	74.6	69.2	73.4	69.5	71.9	72.1	68.7	76.0
Al_2O_3	13.8	13.9	16.8	14.2	13.5	14.9	14.2	15.4	14.5	14.0	17.1	13.1
Fe_2O_3	0.30	0.67	1.60	0.51	0.48	1.28	0.62	1.30	0.92	0.20	1.10	0.60
FeO	2.00	0.97	3.20	0.70	0.49	1.60	0.70	1.30	0.83	0.78	0.48	0.26
MgO	0.90	0.50	2.00	0.25	<0.2	0.75	0.25	1.00	0.45	<0.2	0.28	<0.2
CaO	2.30	2.34	6.24	1.42	1.06	2.54	1.80	2.30	2.08	0.90	1.30	0.72
Na_2O	3.10	3.30	3.60	4.00	3.40	4.10	4.20	4.10	4.00	3.70	5.00	4.10
K_2O	4.20	4.16	1.82	4.04	5.06	3.50	3.22	4.00	3.62	4.88	5.00	4.38
H_2O^+	0.32	0.27	0.51	0.15	0.12	0.23	0.24	0.41	0.22	0.92	0.47	0.11
H_2O^-	0.14	0.11	0.12	0.10	0.05	0.06	0.11	0.10	0.03	0.20	0.09	0.04
TiO_2	0.32	0.30	0.86	1.20	0.20	0.48	0.26	0.36	0.30	0.16	0.22	0.16
P_2O_5	0.08	0.12	0.32	0.15	0.08	0.26	0.12	0.13	0.16	0.06	0.10	0.04
MnO	0.08	0.07	0.10	1.40	0.04	0.09	0.05	0.12	0.07	0.04	0.09	0.04
LOI	-	0.42	0.43	-	0.26	0.22	0.37	-	0.22	2.14	-	0.17
CO_2	<.05	-	-	<.05	-	-	-	<.05	-	-	<.05	-
Total	99.9	99.6	99.4	99.9	99.5	99.2	99.5	100.0	99.3	100.3	99.9	99.9
Trace elements (parts per million)												
Ba	700	630	900	1750	770	1250	720	1500	990	950	3000	510
Ce	-	60	72	112	98	94	78	-	82	90	-	70
La	30	54	68	98	82	72	66	30	74	78	70	64
Nb	15	18	18	18	12	26	16	20	16	14	10	22
Rb	-	148	54	102	126	80	94	-	82	76	-	166
Sr	200	198	450	220	76	380	280	500	315	84	200	54
Zr	100	96	172	154	210	250	128	150	158	176	200	134
Y	20	14	20	18	16	34	16	20	18	14	15	16
Cu	2	<20	<20	<20	<20	<20	<20	3	<20	<20	2	<20
Ni	-	<20	<20	<20	<20	<20	<20	1.5	<20	<20	-	<20
Zn	-	26	60	24	26	44	26	-	32	20	-	<20
Cr	5	<20	<20	<20	<20	<20	<20	5	<20	<20	-	<20
CIPW norms (weight percent)												
Q	31.17	31.93	18.23	31.68	33.28	25.90	32.94	24.09	30.26	30.26	17.78	33.78
or	24.94	24.88	10.93	24.11	30.2	20.98	19.27	23.76	21.63	29.73	29.73	26.00
ab	26.32	28.26	30.97	34.19	29.0	35.12	35.96	34.86	34.27	32.24	42.56	34.86
an	10.62	10.94	24.71	6.31	4.79	11.05	8.25	10.29	9.37	4.22	5.53	3.31
C	0.29	-	-	0.98	0.69	0.38	0.83	0.57	0.61	1.17	1.45	0.40
ne	-	-	-	-	-	-	-	-	-	-	-	-
di	-	0.03	3.78	-	-	-	-	-	-	-	-	-
ol	-	-	-	-	-	-	-	-	-	-	-	-
hy	5.30	2.13	6.58	1.20	0.75	3.15	1.07	3.44	1.55	1.63	0.70	0.50
mt	0.43	0.99	2.36	0.75	0.70	1.88	0.91	1.90	1.35	0.30	1.20	0.50
il	0.61	0.57	1.65	0.49	0.38	0.93	0.49	0.68	0.57	0.30	0.42	0.30
hem	-	-	-	-	-	-	-	-	-	-	0.28	0.25
ap	0.19	0.28	0.76	0.28	0.19	0.60	0.28	0.30	0.37	0.14	0.23	0.09
cc	0.11	-	-	-	-	-	-	0.11	-	-	0.11	-
Total	99.98	100.01	99.97	99.99	100.00	99.99	100.00	100.00	99.98	99.99	99.99	99.99

Table 1. Chemical analyses and norms of granitic rocks—Continued

[†, Analysis performed in the rapid rock analysis laboratory under the supervision of Leonard Shapiro; analysts: P. Elmore, S. Botts, G. Chloe, H. Smith, J. Kelsey, L. Artis and J. Glenn. *, Analysis by X-ray spectroscopy; analysts D. Vivit, M. Dyslin. Analysis of FeO, H_2O, and CO_2 by chemical methods; analyst, N. Elsheimer. -, no data]

	Granite of Kennedy Lakes—Con.		Granodiorite of North Dome	Pyramid pluton			Granodiorite of Muro Blanco	Granodiorite of Lookout Peak	
Field No.	68M39*	68M40*	67M26†	68M35b†	68M41†	68M42†	68M80*	67M76*	67M1†
Map No.	E12	E11	F4	G1(gabbro)	G15	G19 (diorite)	H2	M1	M5
Chemical analyses (weight percent)									
SiO_2	72.1	73.7	69.0	45.7	63.9	51.5	70.0	67.2	64.1
Al_2O_3	14.7	13.9	15.2	18.0	16.0	18.7	14.7	15.8	16.5
Fe_2O_3	0.77	0.82	1.80	4.40	2.80	4.80	1.18	1.62	2.50
FeO	0.59	0.42	1.20	7.10	2.20	4.20	1.07	1.59	1.90
MgO	0.30	<0.2	1.20	6.70	2.30	4.90	0.70	1.10	2.00
CaO	1.50	0.86	2.90	11.00	5.00	8.80	2.86	4.30	4.30
Na_2O	4.00	4.10	3.50	2.20	3.10	3.60	3.40	3.60	3.30
K_2O	4.58	4.74	3.60	0.78	3.00	0.78	3.94	2.84	3.60
H_2O^+	0.19	0.07	0.73	1.40	0.49	0.63	0.25	0.32	0.74
H_2O^-	0.09	0.11	0.15	0.11	0.09	0.14	0.10	0.07	0.17
TiO_2	0.26	0.24	0.40	0.53	0.21	0.42	0.36	0.52	0.57
P_2O_5	0.10	0.08	0.15	0.16	0.09	0.16	0.18	0.24	0.21
MnO	0.06	0.07	0.07	1.50	0.66	1.20	0.05	0.06	0.09
LOI	0.32	0.19	-	-	-	-	0.40	0.32	-
CO_2	-	-	<.05	<.05	0.05	<.05	-	-	<.05
Total	99.6	99.5	99.9	99.6	99.9	99.9	99.2	99.6	100.0
Trace elements (parts per million)									
Ba	1600	990	1000	300	700	2000	890	920	1500
Ce	102	104	-	-	-	-	66	92	-
La	86	92	-	-	30	-	56	70	30
Nb	10	16	10	-	15	7	14	18	10
Rb	90	98	-	-	-	-	88	70	-
Sr	230	88	700	1500	1000	1500	325	520	1000
Zr	180	275	100	50	200	70	152	210	150
Y	10	14	15	50	30	20	14	20	20
Cu	<20	<20	10	50	30	100	20	<20	15
Ni	<20	<20	5	50	15	50	20	<20	10
Zn	24	30	-	-	-	-	28	38	-
Cr	<20	<20	5	50	20	50	<20	<20	7
CIPW norms (weight percent)									
Q	28.15	30.04	27.62	-	20.24	1.71	28.72	25.40	19.54
or	27.36	28.25	21.45	4.67	17.85	4.67	23.64	16.96	21.45
ab	34.19	35.03	29.87	18.95	26.40	30.72	29.19	30.80	28,18
an	6.89	3.79	13.24	37.66	21.04	32.86	13.26	18.79	19.76
C	0.67	0.65	0.75	-	-	-	0.07	-	-
ne	-	-	-	-	-	-	-	-	-
di	-	-	-	13.56	2.43	7.93	-	0.98	0.06
ol	-	-	-	12.86		-	-	-	-
hy	0.89	0.50	3.20	4.31	7.23	13.82	2.26	3.13	5.65
mt	1.13	0.89	2.64	6.50	4.09	7.02	1.74	2.38	3.65
il	0.49	0.46	0.76	1.03	0.40	0.80	0.70	1.01	1.10
hem	-	0.22	-	-	-	-	-	-	-
ap	0.23	0.19	0.35	0.37	0.21	0.37	0.42	0.56	0.49
cc	-	-	0.11	0.11	0.11	0.11	-	-	0.11
Total	100.00	100.02	99.99	100.02	100.00	100.00	100.00	100.01	99.99

Table 1. Chemical analyses and norms of granitic rocks—Continued

[†, Analysis performed in the rapid rock analysis laboratory under the supervision of Leonard Shapiro; analysts: P. Elmore, S. Botts, G. Chloe, H. Smith, J. Kelsey, L. Artis and J. Glenn. *, Analysis by X-ray spectroscopy; analysts D. Vivit, M. Dyslin. Analysis of FeO, H_2O, and CO_2 by chemical methods; analyst, N. Elsheimer. -, no data]

	Granodiorite of Lookout Peak—Con.		Granite of North Mountain					Paradise pluton	Metavolcanic	
Field No.	68M121*	68M100*	67M97†	M794*	67M93*	68M1*	68M2*	67M86†	M183†	68M114†
Map No.	M18	M21(diorite)	N2	N9	N14	N17	N16	R12	MV1	MV2
Chemical analyses (weight percent)										
SiO_2	69.4	59.4	73.5	75.8	76.2	74.8	75.9	64.8	73.8	63.3
Al_2O_3	15.0	17.2	14.6	13.2	13.0	13.5	13.0	16.4	14.2	16.7
Fe_2O_3	1.35	2.05	1.10	0.36	0.44	0.45	0.23	2.1	0.60	2.10
FeO	1.22	3.24	0.44	0.28	0.29	0.47	0.33	1.8	0.64	3.40
MgO	0.75	2.30	0.30	<0.2	<0.2	<0.2	<0.2	1.8	0.34	2.20
CaO	3.08	6.30	1.60	0.62	0.52	0.90	0.50	3.8	4.00	4.90
Na_2O	3.40	3.80	3.60	3.60	3.60	3.70	3.50	3.4	0.23	3.00
K_2O	4.08	2.06	3.80	5.10	5.04	4.76	5.30	4.1	5.00	2.60
H_2O^+	0.15	0.52	0.50	0.07	0.13	0.13	0.05	0.7	0.46	0.63
H_2O^-	0.06	0.08	0.14	0.05	0.04	0.05	0.03	0.1	0.17	0.09
TiO_2	0.40	0.88	0.08	0.14	0.14	0.20	0.12	0.6	0.37	0.15
P_2O_5	0.18	0.44	0.04	0.06	0.04	0.08	0.04	0.2	0.06	0.12
MnO	0.05	0.10	0.11	0.03	0.04	0.05	0.04	0.1	0.08	0.67
LOI	0.18	0.39	0.17	0.25	0.23	0.10	-	-	-	-
CO_2	-	-	<.05	-	-	-	-	<.05	0.05	<.05
Total	99.3	98.8	99.9	99.7	99.9	99.5	99.3	99.9	100.0	99.9
Trace elements (parts per million)										
Ba	700	840	-	330	205	930	184	-	2000	1500
Ce	98	90	-	90	78	80	66	-	-	-
La	82	74	-	76	60	70	52	-	-	30
Nb	14	18	-	18	24	34	16	-	15	15
Rb	110	82	-	162	172	220	186	-	-	-
Sr	345	660	-	48	30	170	30	-	100	700
Zr	162	240	-	126	88	164	84	-	200	100
Y	14	18	-	14	20	28	16	-	50	20
Cu	<20	22	-	<20	<20	<20	<20	-	5	15
Ni	<20	<20	-	<20	<20	<20	<20	-	-	2
Zn	28	76	-	<20	<20	<20	<20	-	-	-
Cr	<20	<20	-	<20	<20	<20	<20	-	5	15
CIPW norms (weight percent)										
Q	26.93	13.6	34.66	34.10	34.85	51.76	34.18	19.02	44.74	20.27
or	24.35	12.47	22.63	30.32	29.90	3.01	31.56	24.47	29.73	15.48
ab	29.11	32.92	30.72	30.63	30.63	33.25	29.87	29.02	1.95	25.55
an	13.79	24.31	7.41	2.68	2.32	4.24	2.22	17.31	19.29	23.41
C	-	-	1.88	0.79	0.78	5.66	0.71	0.07	1.40	0.46
ne	-	-	-	-	-	-	-	-	-	-
di	0.37	3.81	-	-	-	-	-	-	-	-
ol	-	-	-	-	-	-	-	-	-	-
hy	2.28	7.05	0.75	0.54	0.51	0.80	0.79	5.32	1.06	11.09
mt	1.97	3.04	1.55	0.52	0.64	0.68	0.33	3.07	0.87	3.07
il	0.76	1.71	0.15	0.27	0.27	0.40	0.23	1.12	0.70	0.28
hem	-	-	0.04	-	-	-	-	-	-	-
ap	0.42	1.04	0.09	0.14	0.09	0.19	0.09	0.49	0.14	0.28
cc	-	-	0.11	-	-	-	-	0.11	0.11	0.11
Total	99.98	99.99	99.99	99.99	99.99	99.99	99.98	100.00	99.99	100.00

Table 2. Modal analyses of granitic rocks

[Analyst, Oleg Polovtzoff. S.D., standard deviation. —, no data]

Map No.	Field No.	Quartz	K-feldspar	Plagioclase	Mafic minerals	Specific gravity	Magnetic susceptibility
Granite of Tehipite Dome							
A1	M163	27.4	14.4	47.2	11.1	—	—
A3	67M41	21.0	24.4	42.9	11.7	2.65	1480
A4	67M50	26.0	26.8	37.4	9.8	2.66	1520
A5	67M25	27.9	31.2	33.7	7.2	2.62	1580
A6	67M24	26.2	29.4	36.2	8.2	2.64	2000
A7	67M47	20.8	20.3	43.5	15.4	2.68	2200
A8	68M50	36.2	32.3	21.6	9.9	—	1280
A9	68M51	45.2	11.5	16.4	26.9	—	2600
Average		28.8	23.8	34.9	12.5	2.65	1768
S.D.		8.2	7.2	10.1	5.9	0.02	423
Granite of Alpine Creek							
B1	M736	32.6	29.2	35.9	2.3	—	—
B2	M735	43.3	24.6	26.2	5.9	—	1680
B3	M742	27.5	36.0	33.3	3.2	—	1560
B4	M773	30.6	32.7	36.1	0.6	—	1200
Average		33.5	30.6	32.9	3.0	—	1480
S.D.		5.9	4.2	4.0	1.9	—	204
Granodiorite of White Divide							
C1	M512	24.3	19.0	52.1	4.6	2.63	1900
C2	M511	26.2	41.1	31.1	1.6	2.61	640
C3	M94	30.0	20.5	47.0	2.5	2.62	980
C4	M536	28.9	22.8	44.8	3.5	2.75	1500
C5	M112	27.5	21.2	46.7	4.6	2.65	3200
C6	M116	22.7	22.7	50.1	4.5	2.67	4200
C7	64M8	35.8	25.6	35.4	3.2	2.62	1860
C8	M110	27.6	23.6	44.3	4.7	2.66	1920
C9	64M20	42.7	25.9	18.8	12.6	—	3400
C10	M111	24.0	25.5	44.5	6.0	2.66	—
C11	M528	37.4	2.7	51.4	8.5	2.69	800
C12	64M6	28.3	28.8	38.5	4.4	—	2400
C13	68M31	35.6	33.4	30.0	1.0	2.58	900
C14	M534	19.0	21.6	49.4	10.0	2.67	2600
C15	M533	26.5	15.8	41.4	16.3	2.71	1720
C16	M532	24.0	19.1	51.6	5.3	2.64	1300
C17	M526	33.0	23.8	39.8	3.4	2.64	1820
C18	64M37	45.5	26.4	23.1	5.0	—	1260
C19	M74	35.4	23.4	37.6	3.6	2.65	3000
C20	M531	30.4	17.9	45.2	6.5	2.66	—
C21	M530	20.9	16.5	53.8	8.8	2.66	2200
C22	64M3	22.3	28.8	41.4	7.5	—	2800
C23	64M9	26.4	26.4	42.3	4.9	—	3000
C24	64M4	26.5	23.7	43.4	6.4	2.64	3000
C25	64M10	39.8	23.5	27.2	9.5	—	2200
Average		29.6	23.1	41.2	6.0	2.65	2113
S.D.		6.8	6.7	9.1	3.4	0.04	913
Cartridge Pass Pluton							
D1	M60	24.9	21.7	47.5	5.9	2.67	—
D2	M58	24.3	21.6	45.4	8.7	2.68	—

Table 2. Modal analyses of granitic rocks—Continued

[Analyst, Oleg Polovtzoff. S.D., standard deviation. —, no data]

Map No.	Field No.	Quartz	K-feldspar	Plagioclase	Mafic minerals	Specific gravity	Magnetic susceptibility
				Cartridge Pass Pluton—Continued			
D3	M57	27.2	19.2	46.9	6.7	2.67	—
D4	M63	22.6	14.7	53.9	8.8	2.67	—
D5	M61	28.4	19.4	45.0	7.2	2.66	—
Average		25.6	19.3	47.2	7.9	2.67	—
S.D.		1.9	2.3	3.2	1.4	0.01	—
				Granite of Kennedy Lakes			
E1	M184	34.2	34.5	28.7	2.6	2.61	540
E2	67M71	32.8	31.7	33.0	2.5	2.62	1700
E3	67M34	24.1	33.6	36.7	5.6	2.59	1800
E4	67M36	30.8	38.3	29.0	1.9	2.59	1060
E5	67M63	27.1	35.2	29.4	8.3	2.57	3400
E6	67M40	14.4	5.7	61.9	18.0	2.73	—
E7	67M23	23.4	32.0	35.6	9.0	2.60	2000
E8	67M46	32.5	33.8	31.5	2.2	2.61	1160
E9	67M43	17.9	42.0	38.3	1.8	2.62	2000
E10	67M45	18.9	19.9	47.0	14.2	2.67	5000
E11	68M40	35.4	34.2	26.7	3.6	—	1580
E12	68M39	31.9	29.9	34.0	4.2	—	1660
E13	67M68	17.0	13.4	57.1	12.5	2.69	4400
Average		26.2	29.6	37.6	6.6	2.63	2192
S.D.		7.0	9.9	10.7	5.1	0.05	1305
				Granodiorite of North Dome			
F1	67M49	18.3	13.8	54.4	13.5	2.70	2400
F2	67M51	18.2	4.6	60.0	17.2	2.76	—
F3	67M48	19.5	20.2	50.1	10.2	2.68	3000
F4	67M26	24.3	19.9	43.1	12.7	2.66	2600
F5	67M21	24.1	21.0	45.9	9.0	2.67	2600
F6	67M22	22.3	21.2	45.7	10.8	2.61	4000
F7	67M61	18.4	20.5	48.4	12.7	2.66	2800
F8	67M27	21.9	21.2	43.0	13.9	2.65	3000
F9	67M38	30.9	23.8	37.5	7.8	2.62	2400
F10	67M39	23.1	23.7	43.5	9.7	2.65	1740
F11	67M37	23.7	21.1	46.1	9.1	2.63	1700
F12	67M28	28.2	24.6	39.7	7.5	2.62	2000
F13	67M29	24.4	19.4	45.4	10.8	2.65	3000
F14	67M52	26.4	20.8	46.7	6.1	2.61	—
F15	67M53	23.1	20.7	45.7	10.5	2.65	3000
F16	67M54	21.9	16.3	47.6	14.2	2.67	—
F17	M822	27.7	23.4	43.8	5.1	—	1820
F18	67M81	24.3	19.1	40.6	16.0	2.69	3400
F19	M824	24.9	21.2	44.9	9.0	2.69	1240
F20	67M67	32.0	23.7	39.3	5.0	2.62	1140
F22	M825	25.1	18.2	46.5	10.2	2.69	2600
F23	M826	15.1	6.4	65.3	13.2	2.73	2400
F24	67M100	25.3	7.8	51.4	15.5	2.73	2800
Average		23.6	18.8	46.7	10.9	2.67	2425
S.D.		4.0	5.4	6.2	3.3	0.04	725

Table 2. Modal analyses of granitic rocks—Continued

[Analyst, Oleg Polovtzoff. S.D., standard deviation. —, no data]

Map No.	Field No.	Quartz	K-feldspar	Plagioclase	Mafic minerals	Specific gravity	Magnetic susceptibility
				Pyramid pluton			
G1	68M35b	—	—	—	—	—	14800
G2	68M56	12.3	3.3	66.7	17.7	2.78	7000
G3	68M57	11.7	8.7	58.2	21.4	2.75	5600
G4	64M11	18.1	8.0	57.6	16.3	2.77	4600
G5	64M15	19.8	13.0	51.1	16.1	2.74	4400
G6	64M14	16.0	18.2	52.3	13.5	2.72	5200
G7	68M79	18.3	13.7	49.3	18.7	2.72	4600
G8	64M16	20.2	9.6	50.6	19.5	2.73	5400
G9	68M76	19.2	13.7	48.3	18.8	2.72	5000
G10	68M75	20.8	13.8	47.9	17.5	2.73	5000
G11	68M77	24.9	20.3	42.7	12.1	2.69	3800
G12	68M9	22.7	16.7	44.5	16.1	2.70	6200
G13	68M10	22.5	18.8	43.8	14.9	2.68	5200
G14	68M74	20.6	25.0	41.3	13.1	2.71	4800
G15	68M41	22.6	13.0	47.6	16.8	2.73	5000
G16	68M60	19.2	12.7	54.8	13.3	2.70	3200
G17	68M59	18.3	8.9	59.2	13.6	2.74	3800
G18	68M58	19.5	16.8	46.4	17.3	2.73	4600
G19	68M42	—	—	—	—	—	13000
G20	64M33	24.5	22.1	42.4	11.0	2.69	4000
Average		18.6	13.0	51.6	16.8	2.73	5855
S.D.		4.6	6.3	7.5	3.9	0.04	2800
				Granodiorite of Muro Blanco			
H1	B794	22.7	23.8	39.6	13.9	—	2200
H2	68M80	41.6	25.4	25.0	8.0	—	4000
Average		32.2	22.4	25.9	6.7	—	2000
S.D.		9.5	13.3	15.4	4.0	—	900
				Arrow pluton			
I1	B792	25.4	22.0	46.2	6.4	—	3000
I2	B785	27.0	14.8	44.5	13.6	2.69	—
I3	B787	27.9	16.6	42.8	12.7	2.69	—
Average		26.8	17.8	44.5	10.9	2.69	3000
S.D.		1.0	3.1	1.4	3.2	—	—
				Granite of Grand Dike			
J1	68M117	32.1	40.8	25.9	1.2	2.62	7200
				Granodiorite of Lightning Creek			
K1	B860	20.7	10.4	45.6	23.3	—	—
K2	M809	23.4	12.3	45.5	18.8	—	3200
K3	M807	19.0	7.3	55.7	18.0	2.79	4600
K4	M806	17.9	10.2	52.1	19.8	—	4200
K5	M805	17.1	9.8	53.5	19.6	—	5000
K6	M193	23.4	14.5	46.7	15.4	2.71	1100
K7	2/37	16.4	6.4	54.0	23.2	2.78	6000
K8	68M123	21.3	12.5	49.2	17.0	2.72	6000
Average		19.9	10.4	50.3	19.4	2.75	4300
S.D.		2.5	2.5	3.8	2.6	0.04	1596

Table 2. Modal analyses of granitic rocks—Continued

[Analyst, Oleg Polovtzoff. S.D., standard deviation. —, no data]

Map No.	Field No.	Quartz	K-feldspar	Plagioclase	Mafic minerals	Specific gravity	Magnetic susceptibility
				Granodiorite of Mitchell Peak			
L1	M167	16.9	17.4	47.2	18.5	2.74	4000
L2	2/36	14.3	10.7	55.0	20.0	2.75	3400
L3	68M98	21.4	15.0	51.7	11.9	2.71	5000
Average		17.5	14.4	51.3	16.8	2.73	4133
S.D.		2.9	2.8	3.2	3.5	0.02	660
				Granodiorite of Lookout Peak			
M1	67M76	22.1	16.7	45.0	16.2	2.72	3800
M2	M186	27.2	2.0	50.0	20.8	2.73	3000
M3	68M92	25.7	28.5	38.9	6.9	2.62	3400
M4	68M88	18.2	12.2	52.9	16.7	2.69	5000
M5	67M1	20.8	12.3	46.7	20.2	2.69	4200
M6	67M10	21.9	7.1	52.7	18.3	2.70	7000
M7	68M102	17.4	7.8	51.9	22.9	2.72	4800
M8	M195	19.5	14.6	48.7	17.2	2.75	4800
M10	67M83	22.8	16.5	42.5	18.2	2.70	5200
M11	M168	27.5	26.8	38.3	7.4	2.64	3800
M12	67M8	22.0	7.6	52.8	17.6	2.72	6000
M13	67M9	20.9	10.1	49.0	20.0	2.73	8000
M14	67M3	21.8	9.8	52.2	16.2	—	5600
M15	M170	17.3	13.3	52.0	17.4	2.74	5200
M16	67M4	20.6	7.2	53.7	18.5	2.73	4000
M17	67M5	16.4	19.2	56.7	7.7	2.63	1900
M18	68M121	36.1	33.4	21.2	9.3		2200
M19	67M91	16.0	9.7	56.1	18.2	2.77	4800
M20	68M97	16.7	8.6	57.7	17.0	2.70	5600
M21	68M100	55.2	8.0	11.0	25.8	—	5200
M22	68M89	29.6	5.5	44.6	20.3	—	4600
Average		23.1	13.2	46.4	16.8	2.70	4605
S.D.		9.2	7.8	11.2	4.9	0.04	1405
				Granodiorite of North Mountain			
N1	67M96	23.2	27.3	39.9	9.6	2.66	2800
N2	67M97	28.0	24.2	43.9	3.9	2.61	700
N3	67M99	5.0	30.3	59.3	5.4	2.64	1600
N4	67M98	4.6	33.3	60.3	1.8	2.62	—
N5	M83	32.7	5.8	58.1	3.4	2.68	1740
N6	M82	33.8	44.4	20.1	1.7	2.60	640
N7	M81	33.2	44.9	20.9	1.0	2.60	920
N8	M175	27.9	38.9	30.4	2.8	2.61	980
N9	M794	30.3	39.3	28.5	1.9	—	960
N10	M176	20.4	57.6	21.4	0.6	2.60	880
N11	67M90	22.5	22.8	48.5	6.1	2.65	2600
N12	67M95	5.0	47.5	45.1	2.4	2.62	820
N13	67M94	1.9	40.9	56.4	0.8	2.60	44
N14	67M93	3.4	55.1	40.5	1.0	2.61	1020
N15	67M92	9.0	35.1	50.0	5.9	2.66	1400
N16	68M2	20.4	52.3	25.4	1.9	—	1160
N17	68M1	30.4	39.1	28.6	1.9	—	1420
Average		19.5	38.8	39.8	3.1	2.63	1230
S.D.		11.6	13.3	13.9	2.4	0.03	681

Table 2. Modal analyses of granitic rocks—Continued

[Analyst, Oleg Polovtzoff. S.D., standard deviation. —, no data]

Map No.	Field No.	Quartz	K-feldspar	Plagioclase	Mafic minerals	Specific gravity	Magnetic susceptibility
				Granodiorite of Sugarloaf			
P1	2/33	20.0	13.1	49.1	17.8	2.74	5400
P2	68M95	21.7	17.8	44.4	16.1	2.70	4400
P3	68M201	22.1	21.9	46.2	9.8	2.69	3800
P4	68M19	19.7	18.4	44.2	17.7	2.71	4800
Average		20.9	17.8	46.0	15.4	2.71	4600
S.D.		1.0	3.2	2.0	3.3	0.02	583
				Paradise pluton			
R1	M70	24.3	16.1	47.3	12.3	2.72	3800
R2	M69	24.2	15.8	51.4	8.6	2.70	3800
R3	68M6	22.0	22.6	48.0	7.4	2.68	4000
R4	B-798	19.3	16.8	46.5	17.4	2.68	—
R5	B-799	23.8	19.3	45.4	11.4	2.70	—
R6	B-950	19.3	18.7	47.3	14.7	2.69	—
R7	67M88	19.9	22.1	46.0	12.0	2.62	4000
R8	M68	27.5	16.0	48.9	7.6	2.67	2400
R9	M67	24.1	15.8	47.7	12.4	2.70	4000
R10	67M7	28.7	13.6	41.2	16.5	2.67	4400
R11	67M87	23.2	14.7	48.2	13.9	2.71	4200
R12	67M86	23.4	12.1	50.2	14.3	2.69	3200
R13	67M85	19.0	10.8	54.9	15.3	2.71	4400
R14	67M89	23.5	15.7	47.8	13.0	2.67	5000
R15	2/31	29.0	23.0	41.6	6.4	2.66	3000
R16	67M20	25.2	19.0	44.3	11.5	2.68	5200
R17	67M19	23.6	20.8	43.8	11.8	2.68	3800
R18	67M11	24.6	13.9	48.2	13.3	2.69	4000
R19	67M18	18.9	27.5	41.2	12.4	2.68	4200
R20	67M17	23.1	20.9	45.0	11.0	2.67	2600
R21	67M14	19.2	23.2	44.9	12.7	2.67	3400
R22	67M15	21.3	15.4	50.5	12.8	2.69	4000
R23	67M12	26.2	18.6	43.6	11.5	2.66	3000
Average		23.2	17.9	46.7	12.2	2.68	3820
S.D.		2.9	4.0	3.3	2.7	0.02	701

Table 3. Chemical analyses and norms of Cenozoic volcanic rocks

Field No.	M117	M-778	69M9	M-113	68M32	67M74	67M78	67M66	67M84
Map No.	CC-2	CC-3	CC-4	CC-5	CC-7	CC-8	CC-10	CC-11	CC-12
Chemical analyses (weight percent)									
SiO_2	63.0	47.9	48.92	63.3	53.7	47.9	48.13	57.17	49.5
Al_2O_3	17.5	13.6	13.39	17.3	13.9	11.8	13.78	14.94	13.3
Fe_2O_3	2.1	4.5	4.51	2.6	5.7	6.2	4.27	2.79	5.7
FeO	1.7	4.6	3.52	1.2	1.4	2.8	4.00	2.83	3.4
MgO	1.6	11.7	7.44	2.1	6.4	11.1	11.61	5.94	10.2
CaO	3.6	9.7	9.12	4.2	6.8	8.4	9.36	5.73	9.4
Na_2O	4.7	2.8	3.48	5.0	2.7	2.8	3.00	3.70	2.8
K_2O	2.8	2.1	3.75	2.7	6.0	5.1	2.50	4.00	2.7
H_2O^+	1.3	0.51	1.76	0.54	0.49	0.33	0.39	0.26	0.60
H_2O^-	0.34	0.15	0.34	0.27	0.10	0.30	0.15	0.13	0.26
TiO_2	0.52	1.0	1.38	0.49	1.2	1.2	0.99	1.04	1.1
P_2O_5	0.26	0.96	1.14	0.30	1.4	1.6	0.84	0.72	0.81
MnO	0.07	0.18	0.135	0.08	0.15	0.16	0.14	0.084	0.16
CO_2	0.52	<.05	0.28	<.05	<.05	<.05	0.15	0.16	<.05
Total	100.0	99.7	99.17	100.1	99.9	99.7	99.31	99.49	99.9
CIPW norms (weight percent)									
Q	15.53	0.00	0.00	12.74	0.00	0.00	0.00	2.84	0.00
or	16.91	12.53	22.90	16.07	35.69	30.42	14.98	23.89	16.10
ab	40.64	18.23	17.79	42.62	22.99	5.47	16.51	31.64	20.47
an	16.52	18.52	10.17	16.91	8.14	4.61	16.99	12.48	15.90
C	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ne	0.00	3.08	6.84	0.00	0.00	10.00	5.00	0.00	1.87
di	0.00	18.96	23.02	1.67	13.20	21.44	19.52	9.07	20.66
ol	0.00	20.66	9.37	0.00	8.03	17.72	19.28	0.00	16.89
hy	4.95	0.00	0.00	5.40	2.15	0.00	0.00	12.65	0.00
mt	2.99	3.66	4.32	2.91	3.94	3.95	3.66	3.72	3.81
il	1.01	1.92	2.71	0.94	2.29	2.30	1.91	2.00	2.11
hem	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ap	0.63	2.30	2.79	0.72	3.34	3.83	2.02	1.72	1.72
Total	100.01	99.86	99.91	99.98	99.77	99.74	99.87	100.01	99.75

Table 4. Some features of mapped and sampled granitic units

[—, no data]

Pluton or mass	Area, (km^2)	Average specific gravity	Average magnetic susceptibility
Granite of Tehipite Dome	72.4	2.65	1768
Granite of Alpine Creek	5.6	2.65	1480
Granodiorite of White Divide	89.7	2.65	2113
Cartridge Pass pluton	9.6	2.67	—
Granite of Kennedy Lakes	19.6	2.63	2192
Granodiorite of North Dome	70.6	2.67	2425
Pyramid pluton	32.1	2.73	5855
Granodiorite of Muro Blanco	13.0	2.69	3100
Arrow pluton	10.5	2.69	3000
Granite of Grand Dike	2.4	2.62	7200
Granodiorite of Lightning Creek	8.6	2.75	4300
Granoodiorite of Mitchell Peak	9.7	2.73	4133
Granodiorite of Lookout Peak	76.4	2.70	4605
Granite of North Mountain	14.4	2.63	1230
Granodiorite of Sugarloaf	11.8	2.71	4600
Paradise Granodiorite	117.0	2.68	3820
Granite of Dougherty Peak	10.5	2.62	—
Granite of Tunemah Lake	4.5	2.62	—
Granite of LeConte Canyon	2.5	2.61	—
Granodiorite of Upper Blue Canyon	0.7	2.67	—
Older sheared granodiorite	4.5	2.69	—
Mafic plutonic rock	2.8	2.80	—
Total granitic rock	589.0		
Average granitic rock (by area)		2.674	
Metamorphic rock	24.7		
Tertiary dacite	5.6		
Tertiary basalt	0.7		
Total quadrangle	620.0		

Table 5. Average chemical composition, in weight percent, of granitic rocks in the Marion Peak quadrangle

SiO_2	69.2
Al_2O_3	15.1
Fe_2O_3	1.2
FeO	1.3
MgO	0.95
CaO	2.8
Na_2O	3.7
K_2O	3.9
H_2O^+	0.38
H_2O^-	0.90
TiO_2	0.38
P_2O_5	0.16
MnO	0.1
Total	100.1

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