Shaver Lake Quadrangle, Central Sierra Nevada, California—Analytic Data

GEOLOGICAL SURVEY PROFESSIONAL PAPER 774-D

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By PAUL C. BATEMAN *and* JOHN P. LOCKWOOD

SHORTER CONTRIBUTIONS TO GENERAL GEOLOGY

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Chemical, semiquantitative spectrographic, and modal analyses and potassium-argon and uranium-lead age determinations on granitic and volcanic rocks supplement Geologic Quadrangle Map (GQ-1271)

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1976

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress Cataloging in Publication Data

Bateman, Paul Charles, 1910–
Shaver Lake quadrangle, central Sierra Nevada, California–analytic data. (Shorter contributions to general geology)

(Geological Survey Professional Paper 774–D)
Bibliography: p. 3.
Supt. of Doc. No.: I 19.16:774–D.
1. Granite–California–Shaver Lake region–Analysis. 2. Volcanic ash, tuff, etc.–California–Shaver Lake region–Analysis. 3. Radioactive dating. I. Lockwood, John P., joint author. II. Title. III. Series: United States. Geological Survey. Shorter contributions to general geology. IV. Series: United States. Geological Survey Professional Paper 774–D.
QE462.G7B39 552'.3 75–619335

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402
Stock Number 024–001–02755–1

CONTENTS

ILLUSTRATIONS

TABLES

SHAVER LAKE QUADRANGLE, CENTRAL SIERRA NEVADA, CALIFORNIA— ANALYTIC DATA

By PAUL C. BATEMAN and JOHN P. LOCKWOOD

ABSTRACT

More than 400 samples of plutonic rocks were collected during the geologic mapping of the Shaver Lake quadrangle. Of these, 368 samples were modally analyzed, and the volume percentages of quartz, potassium feldspar, plagioclase, and mafic minerals and the bulk specific gravities are plotted, and partly contoured where the data permit, separately on a simplified geologic base map. Quartz, potassium feldspar, and plagioclase, calculated to 100 percent, are plotted on triangular diagrams. Chemical and spectrographic analyses of 32 plutonic rocks and 3 volcanic rocks are tabulated, and normative quartz, orthoclase, and plagioclase (albite plus anorthite) are plotted on a triangular diagram. Data on the ages determined by the potassium-argon and uranium-lead methods for some plutonic and volcanic rocks are tabulated. A map of conspicuous, steeply dipping joints is included.

INTRODUCTION

The Shaver Lake quadrangle is northeast of Fresno on the west slope of the central Sierra Nevada. Shaver Lake, a lumbering and recreational community in the east-central part of the quadrangle, is about 72 kilometres (45 mi) from Fresno by road. Numerous roads, the principal ones paved but many minor ones unpaved, provide access to all parts of the quadrangle. Altitudes within the quadrangle range from about 1,000 feet where the San Joaquin River exits the west side of the quadrangle to 8,111 feet at Black Point in the northeast corner of the quadrangle.

This report supplements the geologic map of the Shaver Lake quadrangle (Lockwood and Bateman, 1975) by providing chemical, spectrographic, and modal data on some of the plutonic volcanic rocks. In addition, it lists ages determined by the potassium-argon and uranium-lead methods for some of the volcanic and plutonic rocks. The analytic data are tabulated. These maps, diagrams, and tables are the most significant parts of the report; the text deals only with factors that bear on the interpretation of the analytic data. A nontechnical summary of some of the many interesting geologic features accompanies the geologic map.

In this report we follow the classification of plutonic rocks recommended by the International Union of Geological Sciences (Streckeisen and others, 1973) which was developed to eliminate some of the communication problems that beset petrologists as a result of different usages of rock names. The part of the classification scheme that affects the names of rocks in the Shaver Lake quadrangle is given in figure 8. In fact, only two rock names are different from ones used in reports on the central Sierra Nevada published during the past 15 years. Rocks here called tonalite were included with quartz diorite in earlier reports, and rocks here called granite include both quartz monzonite and granite of earlier reports.

GENERAL GEOLOGY

The quadrangle is underlain chiefly by plutonic rocks ranging in composition from gabbro to leucogranite. Metamorphosed sedimentary and volcanic rocks crop out at only a few places; volcanic rocks overlie the granitic rocks locally. The granitic rocks constitute many different plutons that are in sharp contact with one another. Most of these bodies vary internally in composition and texture, but abrupt changes generally are confined to contacts between different bodies. The plutons range in size from less than 1 square kilometre to several hundred square kilometres. The largest plutons extend beyond the quadrangle boundaries. The tonalite of Blue Canyon, called the quartz diorite of Blue Canyon in reports on the adjoining Huntington Lake quadrangle (Bateman and Wones, 1972a, b), is the most extensive rock unit within the quadrangle, occupying more than half the quadrangle. Because potassium increases in the plutonic rocks eastward across the Sierra Nevada, tonalite predominates west of the Shaver Lake quadrangle but is sparsely represented east of the quadrangle. The larger plutons to the east within the Sierra Nevada are granodiorite and granite; farther east in the

White Mountains they are monzonite, quartz monzonite, and granite.

The second most extensive rock unit within the quadrangle is the granodiorite of Dinkey Creek. This rock unit is widespread in the Huntington Lake quadrangle to the east; the part that lies within the Shaver Lake quadrangle is a southwestward-trending protrusion. Among the other bodies of plutonic rocks, the granite of Shuteye Peak and the leucogranite of Big Sandy Bluffs are the most extensive. The granodiorite of Whiskey Ridge forms a large pluton in the Shuteye Peak quadrangle to the north (Huber, 1968), but only the southern part lies within the Shaver Lake quadrangle. The other plutonic rocks all form small bodies; none underlies more than 26 square kilometres (10 mi^2) within the quadrangle.

ANALYTIC DATA

In collecting samples of plutonic rocks, our objective was to collect one sample per square mile, but because exposures are discontinuous and because our principal purpose was geologic mapping, our sample localities do not show a regularly spaced pattern. More than 400 samples of plutonic rocks were collected. Of these, 368 were analyzed modally, and 32 were also analyzed chemically and spectrographically (fig. 1). In addition, three samples of Tertiary basalt flows and intrusive rocks were analyzed chemically and spectrographically, and the ages of several samples of both plutonic and volcanic rocks were determined by the potassium-argon and uranium-lead methods.

Modes were determined by counting 1,000–2,000 regularly spaced points on rocks slabs of not less than 40 square centimetres (6 $in.^2$) on which potassium feldspar had been selectively stained yellow and plagioclase red (Norman, 1974). Four constituents were counted: quartz, potassium feldspar, plagioclase, and mafic minerals. Biotite, hornblende, and opaque minerals cannot be counted separately on stained slabs, and so their separate amounts were not determined. The tonalites and granodiorites contain both hornblende and biotite, whereas granite contains biotite but commonly no more than a trace of hornblende. In the granodiorites, biotite generally is more abundant than hornblende, whereas in the tonalite hornblende commonly exceeds biotite.

The percentages of modal constituents and the specific gravities of samples of plutonic rocks are plotted on simplified geologic maps in figures 2–6. Isopleths have been drawn where the data permit, but no attempt was made to contour systematically all the data. Conspicuous joints, readily visible on aerial photographs, are plotted in figure 7, together with a few observations made in the field.

The percentage contents of quartz, potassium feldspar, and plagioclase were recalculated to 100 and plotted on ternary diagrams (fig. 8). The percentage contents of normative quartz, orthoclase, and plagioclase (Ab + An) are similarly plotted in figure 9. Chemical and spectrographic analyses are listed in table 1 together with the CIPW norms and the modes of the analyzed samples. The radiometric age data are given in tables 2 and 3.

TONALITE OF BLUE CANYON

The tonalite of Blue Canyon is divided into four facies: a principal facies of biotite-hornblende tonalite and granodiorite, a hornblende-biotite facies, a finer grained biotite-hornblende tonalite and granodiorite facies, and a sheared facies. The principal facies grades to the other facies through changes in composition, grain size, and the amount of postconsolidation deformation. The finer grained facies differs from the principal facies only in average grain size, but locally it has sharp contacts with the principal facies, and part may be slightly younger. Perhaps because of the smaller grain size and consequent statistical superiority of the samples, the modes of the finer grained facies show less scatter than those of the other facies (fig. 8). In contrast, the sheared facies exhibits the greatest scatter on the modal plot, perhaps indicating postconsolidation movement of silica and alkalis.

The principal facies and the hornblende-biotite facies grade into each other. The hornblende-biotite facies, however, is readily distinguished by the presence of conspicuous biotite books. Of 15 modes of the hornblende-biotite facies, all but 2 plot close to or on the Q–P side line of the modal plot, showing that potassium feldspar is even less abundant in the hornblende-biotite facies than in the principal facies. The distribution of the hornblende-biotite facies, in a curving strip peripheral to the younger leucogranite of Big Sandy Bluffs, suggests that the hornblende-biotite facies may have formed from the principal facies as a result of thermal metamorphism, with or without metasomatism, as a result of the emplacement of the leucogranite of Big Sandy Bluffs. The required conversion of hornblende to biotite would necessarily involve other minerals in the rocks. Mehnert (1968, p. 264) suggested the following reaction: biotite+plagioclase (45 percent An) + quartz $\leftrightharpoons$ hornblende + sphene + plagioclase (35 percent An) + orthoclase. Using analyses of biotite (Dodge and others, 1968, table 2, p. 398) and hornblende (Dodge and others, 1969, table 1, p. 256) extracted from sample SL–32, we attempted to complete such a reaction. Our calculations show that a simple reaction with no loss or gain of constituents is not possible because of the low content of Al_2O_3 in the hornblende. When all other constituents are balanced, Al_2O_3 is greatly in excess on the biotite side of the equation.

Further investigations must be made before the relations between the two facies can be understood, but at least two alternate explanations are possible: (1) contamination of the magma that crystallized the biotite-hornblende tonalite by aluminous sedimentary material and (2) crystal fractionation of anorthite from the biotite-hornblende tonalite magma. Either process could yield a magma that would crystallize hornblende-biotite tonalite.

GRANODIORITE OF DINKEY CREEK

Most of the rock in the protrusion of granodiorite of Dinkey Creek, which extends into the east side of the quadrangle, is equigranular granodiorite and tonalite. A porphyritic facies generally less than a few hundred metres wide rims the protrusion and in the northeastern part of the quadrangle underlies an extensive area that continues into the adjoining Kaiser Peak (Bateman and others, 1971) and Huntington Lake quadrangles (Bateman and Wones, 1972a). In composition, the porphyritic facies ranges from granodiorite to granite. In many plutons, the most mafic rock is marginal; inward the rock becomes more felsic and is composed of less refractory mineral assemblages. Although few were mapped, felsic generally porphyritic margins have been observed in several plutons.

As the contact between the porphyritic and the equigranular facies is completely gradational, the relative ages of the facies cannot be determined from field relations. The porphyritic facies clearly represents lower temperature mineral assemblages than the equigranular facies: the color index is lower, plagioclase has a lower An content, and the modal plot (fig. 8) shows that the rocks from the porphyritic facies extend into a lower temperature region. Although additional studies are required to settle the problem conclusively, these relations suggest that the porphyritic facies is the younger of the two facies and that it spread along the marginal contact of the equigranular facies before the equigranular facies was completely crystallized.

REFERENCES CITED

Bateman, P.C., Lockwood, J. P., and Lydon, P. A., 1971, Geologic map of the Kaiser Peak quadrangle, central Sierra Nevada, California: U.S. Geol. Survey Geol. Quad. Map GO–894, scale 1:62,500.

Bateman, P.C., and Wones, D. R., 1972a, Geologic map of the Huntington Lake quadrangle, central Sierra Nevada, California: U.S. Geol. Survey Geol. Quad. Map GQ–987, scale 1:62,500.

———1972b, Huntington Lake quadrangle, central Sierra Nevada, California—analytic data: U.S. Geol. Survey Prof. Paper 724–A, 18 p.

Dalrymple, G. B., 1963, Potassium-argon dates of some Cenozoic volcanic rocks of the Sierra Nevada, California: Geol. Soc. America Bull., v. 74, no. 4, p. 379–390.

Dodge, F.C.W., Papike, J.J., and Mays, R.E., 1968, Hornblendes from granitic rocks of the central Sierra Nevada batholith, California: Jour. Petrology, v. 9, no. 3, p. 378–410.

Dodge, F.C.W., Smith, V.C., and Mays, R.E., 1969, Biotites from granitic rocks of the central Sierra Nevada batholith, California: Jour. Petrology, v. 10, no. 2, p. 250–271.

Hamilton, W.B., and Neuerburg, G.J., 1956, Olivine-sanidine trachy-basalt from the Sierra Nevada, California: Am. Mineralogist, v. 41, p. 851–873.

Huber, N.K., 1968, Geologic map of the Shuteye Peak quadrangle, Sierra Nevada, California: U.S. Geol. Survey Geol. Quad. Map GQ–728, scale 1:62,500.

Kistler, R.W., Bateman, P.C., and Brannock, W.W., 1965, Isotopic ages of minerals from granitic rocks of the central Sierra Nevada and Inyo Mountains, California: Geol. Soc. America Bull., v. 76, no. 2, p. 155–164.

Lockwood, J.P. and Bateman, P.C., 1975, Geologic map of the Shaver Lake quadrangle, central Sierra Nevada, California: U.S. Geol. Survey Geol. Quad. Map GQ–1271, scale 1:62,500 (in press).

Mehnert, K.R., 1968, Migmatites and the origin of granitic rocks: Amsterdam, Elsevier, 393 p.

Norman, M.B., 1974, Improved techniques for selective staining of feldspar and other minerals using amaranth: U.S. Geol. Survey Jour. Research, v. 2, no. 1, p. 73–79.

Streckeisen, A.L., and others, 1973, Plutonic rocks; Classification and nomenclature recommended by the IUGS Subcommission on the Systematics of Igneous Rocks: Geotimes, v. 18, no. 10, p. 26–30.

FIGURES 1–9; TABLES 1–3

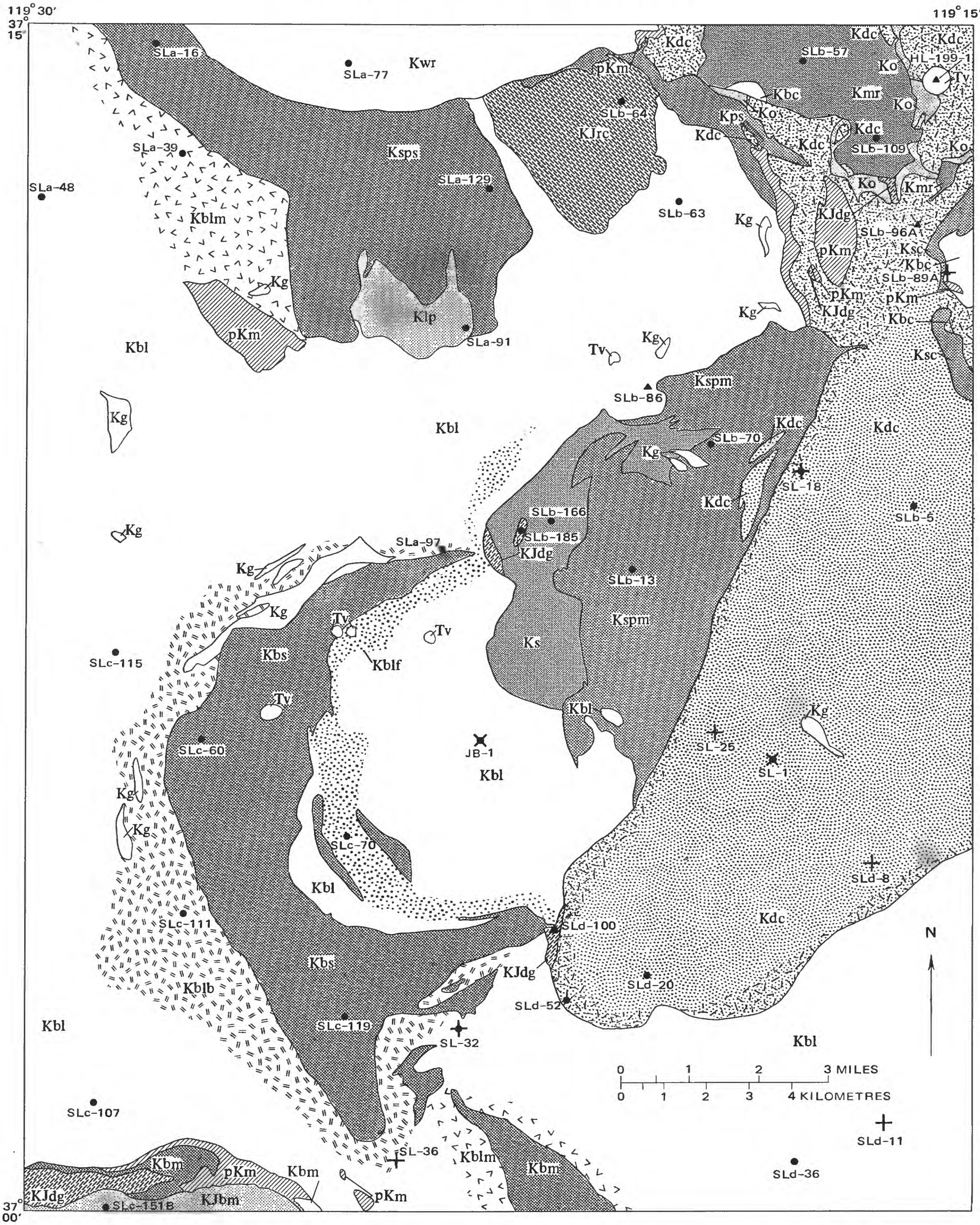

FIGURE 1.—Shaver Lake quadrangle showing the locations of chemically analyzed and isotopically dated rock samples. Numbers refer to sample numbers in tables 1–3.

EXPLANATION

TERTIARY — Miocene

- Tv — Volcanic rocks

CRETACEOUS — Upper

- Kg — Fine-grained felsic rocks
- Klp — Leucogranite of Lion Point
- Ks — Granodiorite of Stevenson Creek
- Kwr — Granodiorite of Whiskey Ridge
- Kbc — Granodiorite of Big Creek

CRETACEOUS — Lower

- Kmr — Granite of Mushroom Rock
- Ko — Granite of Ordinance Creek
- Kbm — Leucogranite of Burrough and Black Mountains
- Kbs — Leucogranite of Big Sandy Bluffs
- Ksps, Kspm — Granite of Shuteye Peak
  - Ksps, *Shuteye Peak pluton*
  - Kspm, *Mussick Mountain pluton*
- Kps — Granodiorite of Pick and Shovel mine area
- Ksc — Granite of Sheepthief Creek
- Kdc — Granodiorite of Dinkey Creek
  - *Porphyritic facies shown by overprint*
- Kbl, Kblb, Kblf, Kblm — Tonalite of Blue Canyon
  - Kbl, *biotite-hornblende facies*
  - Kblb, *hornblende-biotite facies*
  - Kblf, *finer grained facies*
  - Kblm, *sheared facies*

JURASSIC OR CRETACEOUS

- KJbm — Tonalite south of Black Mountain
- KJdg — Gabbro, diorite, quartz diorite, and tonalite
- KJrc — Tonalite of Ross Creek

PRE-CRETACEOUS

- pKm — Metasedimentary rocks

Contact

● Plutonic rock ▲ Other
Location of chemically analyzed sample

× U–Pb + K–Ar
Location of radiometrically dated sample

Vertical Inclined
Strike and dip of joints
Arrow indicates sense of lateral movement. Shown only in figure 7

FIGURE 1.—Continued.

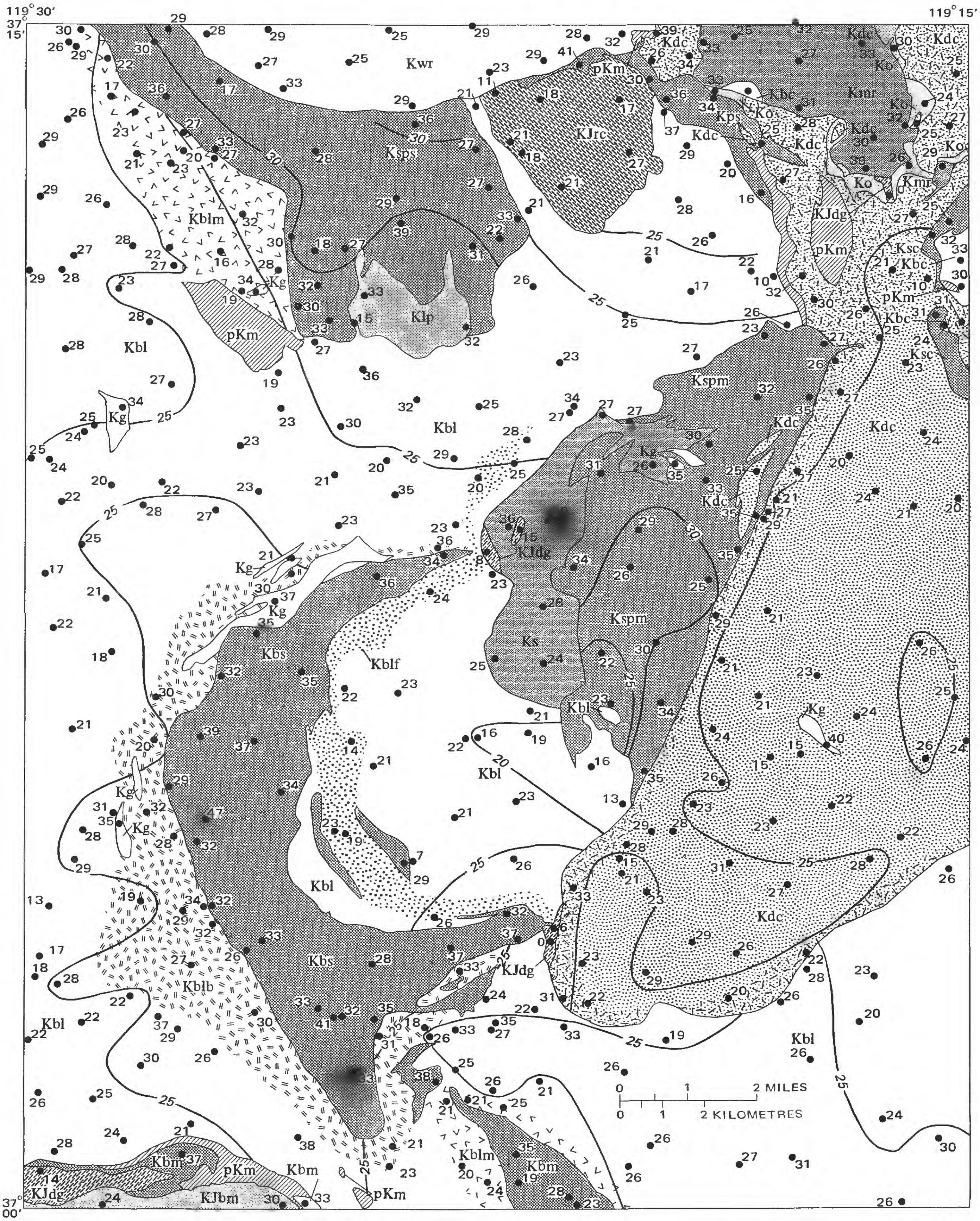

FIGURE 2.—Shaver Lake quadrangle showing quartz, in volume percent. Explanation in figure 1.

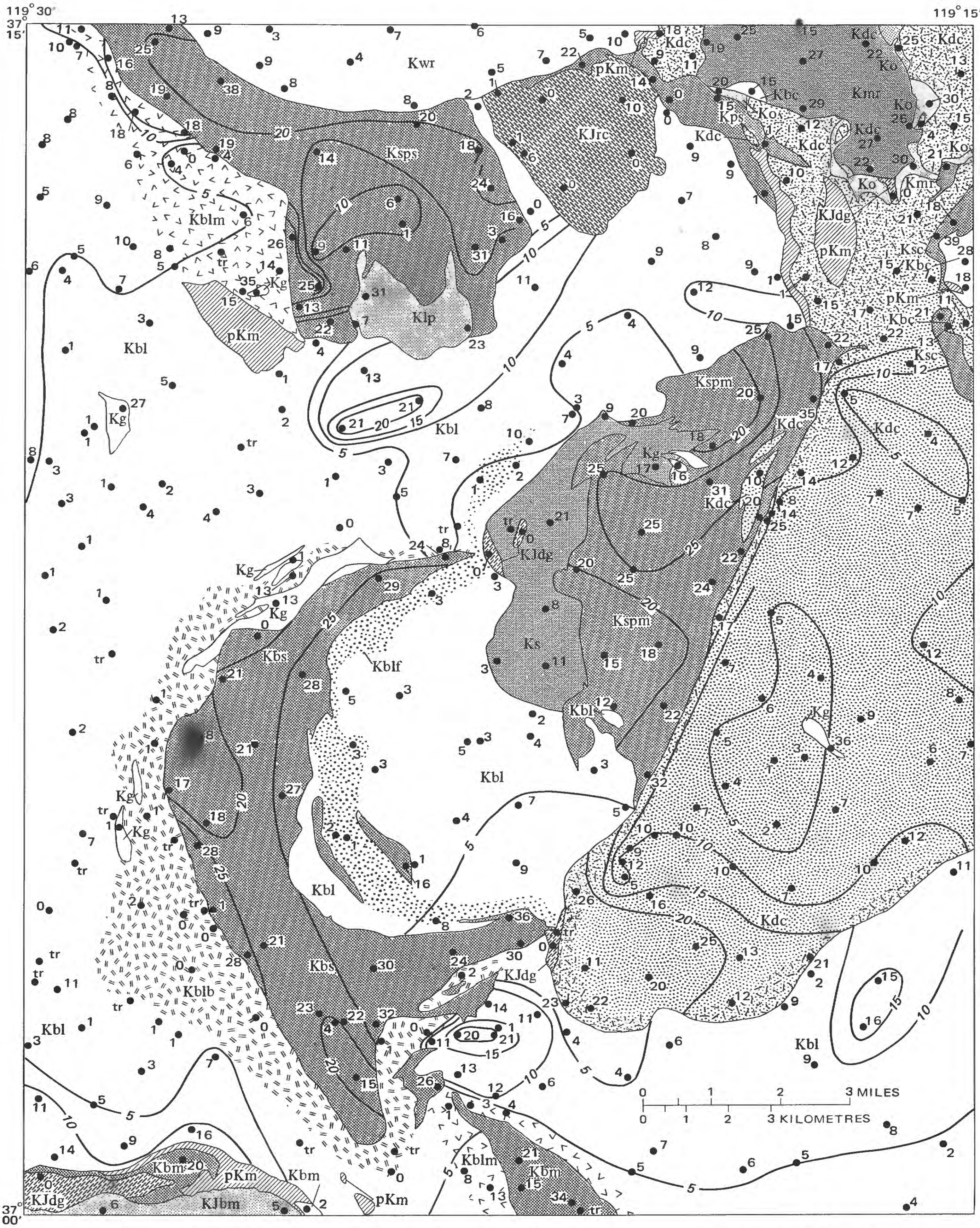

FIGURE 3.—Shaver Lake quadrangle showing potassium feldspar, in volume percent. Explanation in figure 1.

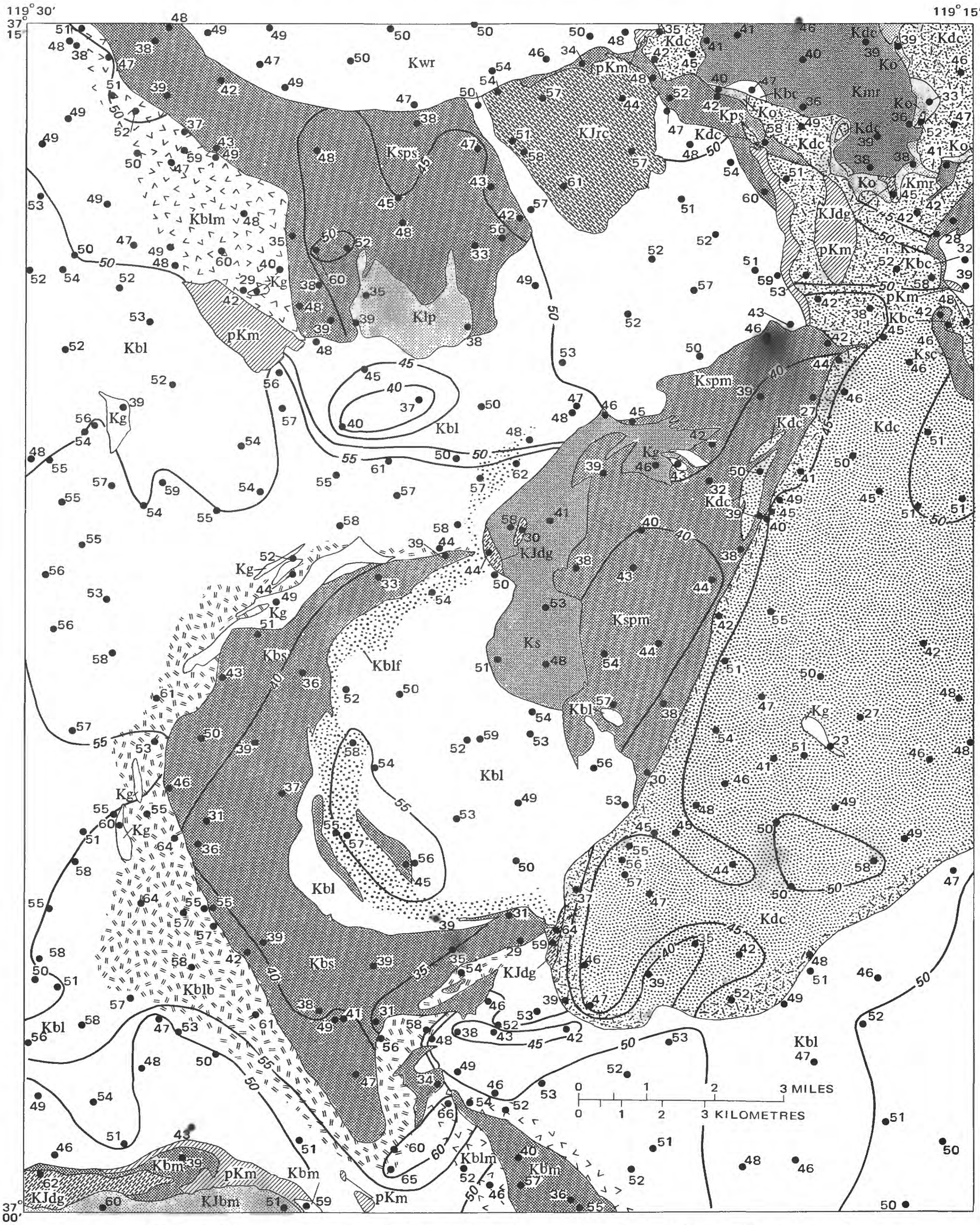

FIGURE 4.—Shaver Lake quadrangle showing plagioclase in volume percent. Explanation in figure 1.

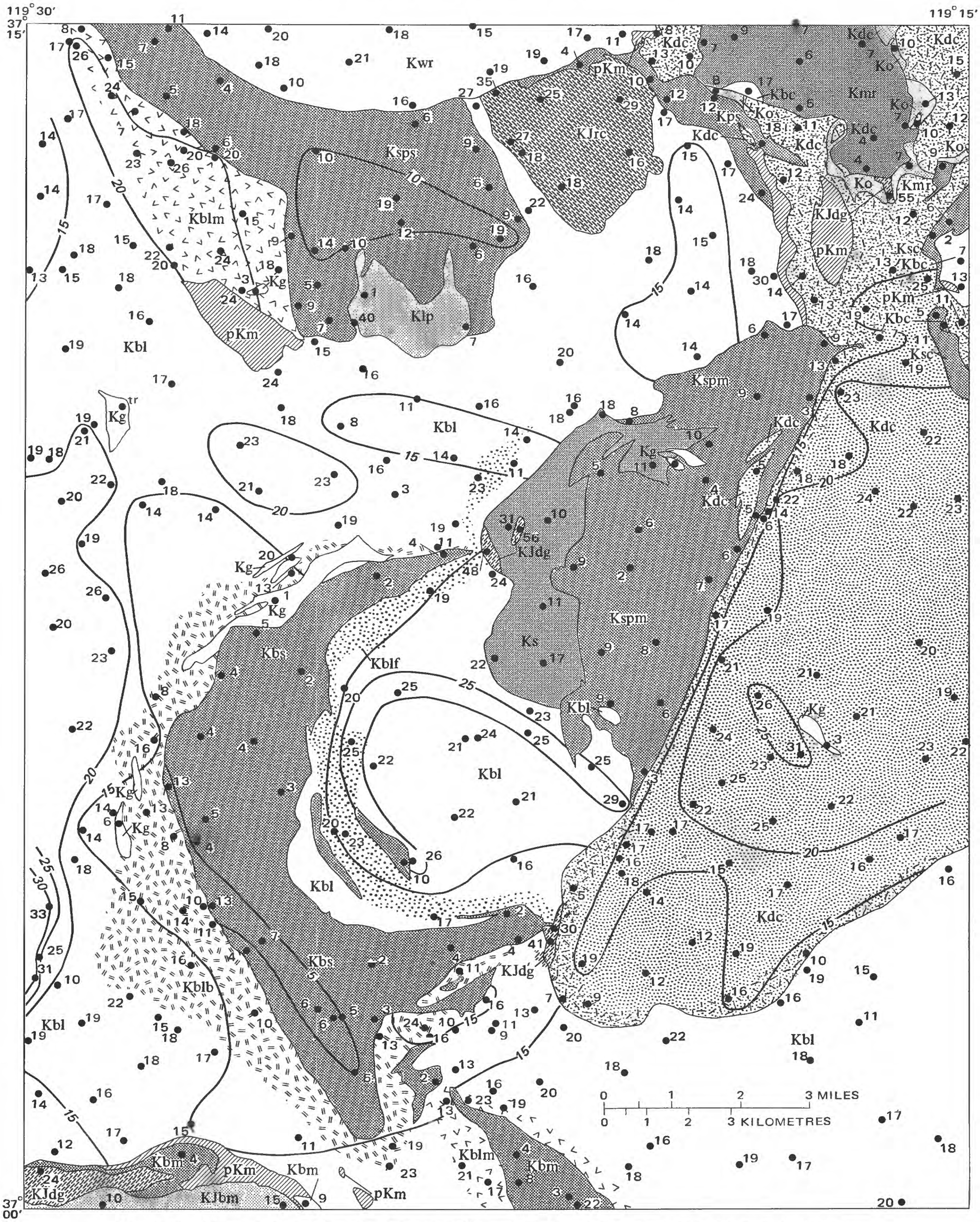

FIGURE 5.—Shaver Lake quadrangle showing mafic minerals in volume percent. Explanation in figure 1.

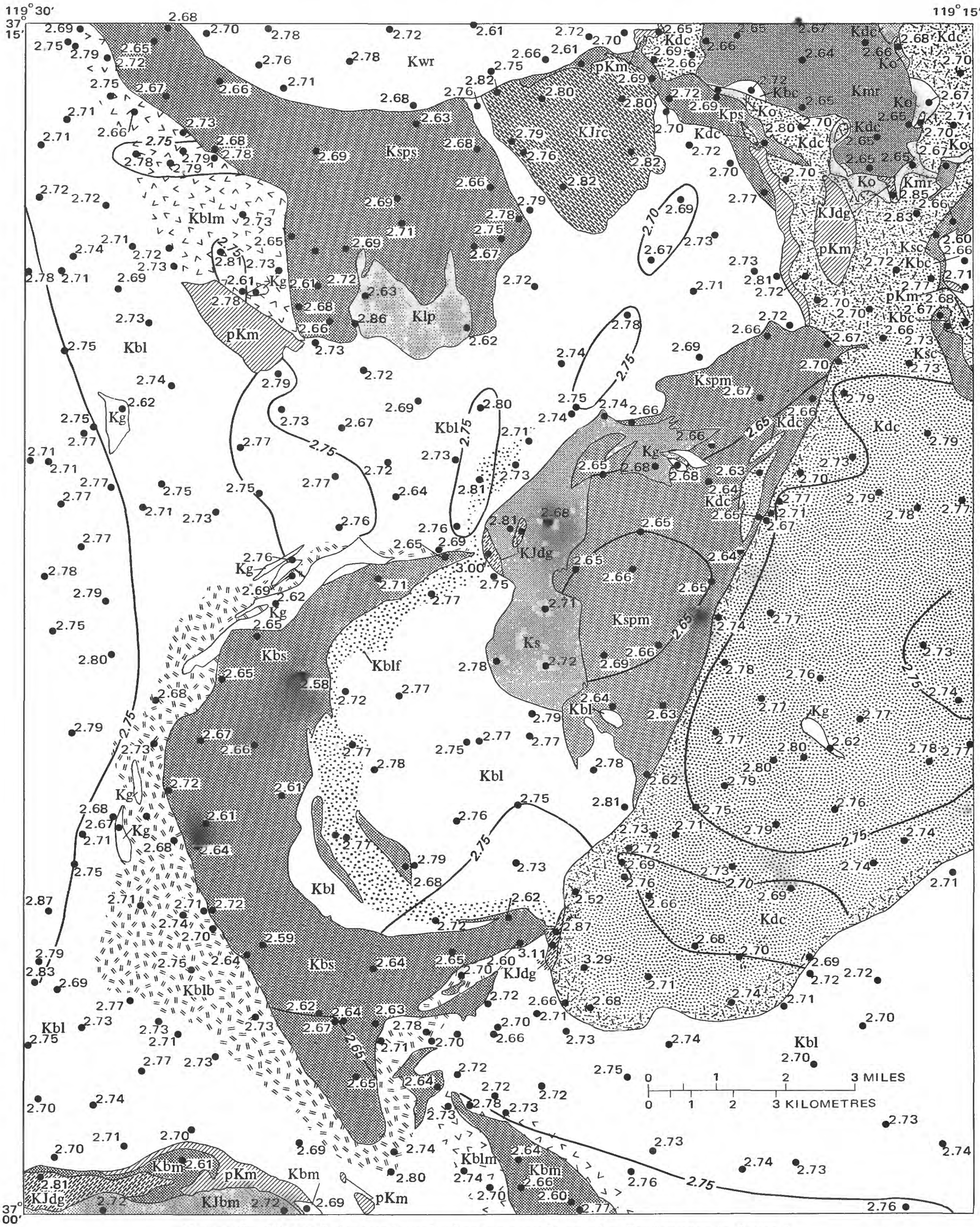

FIGURE 6.—Shaver Lake quadrangle showing specific gravity. Explanation in figure 1.

FIGURE 7.—Shaver Lake quadrangle showing steeply inclined regional joints (heavy lines), as observed on aerial photographs, and the attitude of joints, as observed on the ground. See figure 1 for explanation.

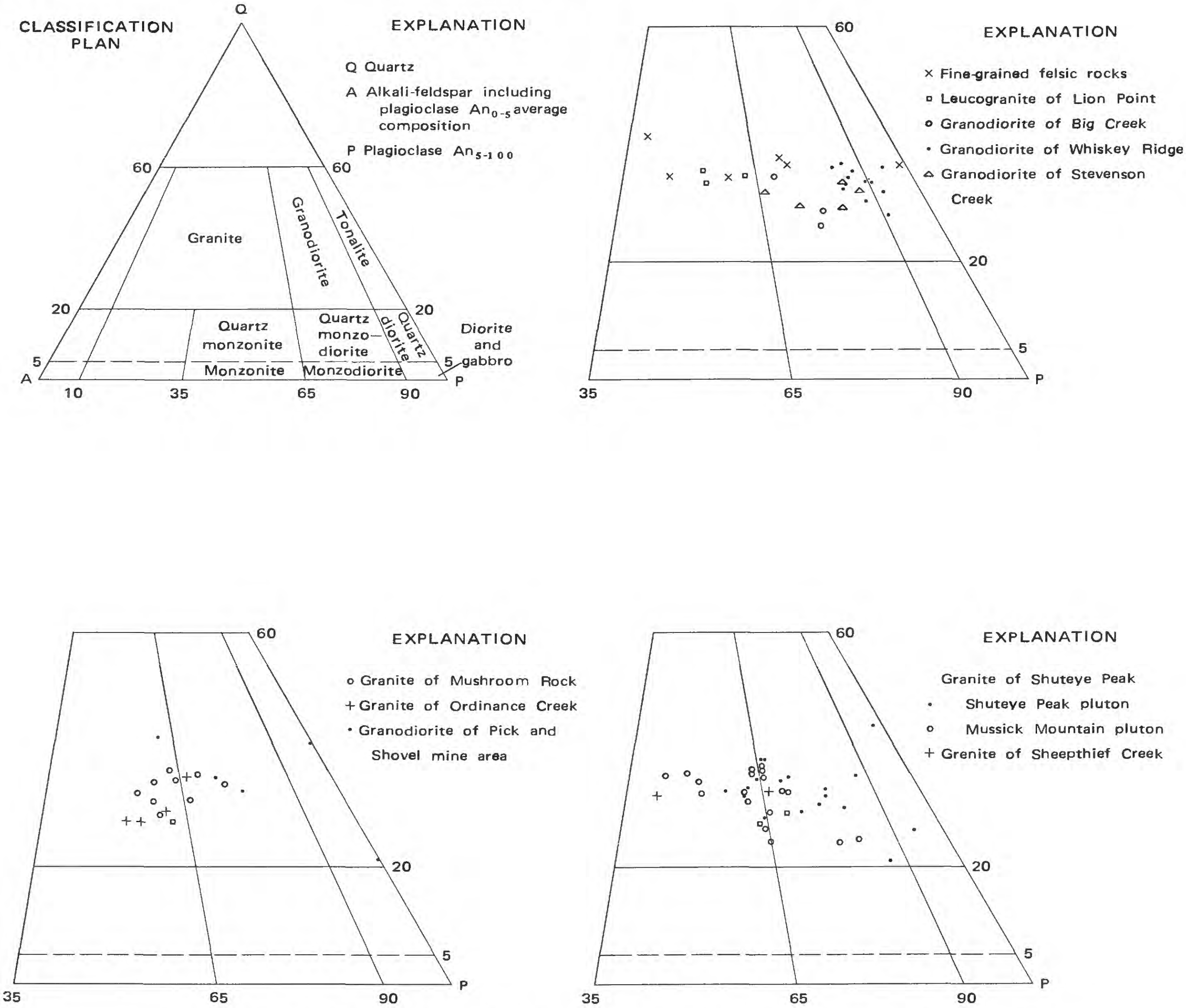

FIGURE 8.—Plots of modes of granitic rocks. Classification plan by Streckeisen and others (1973).

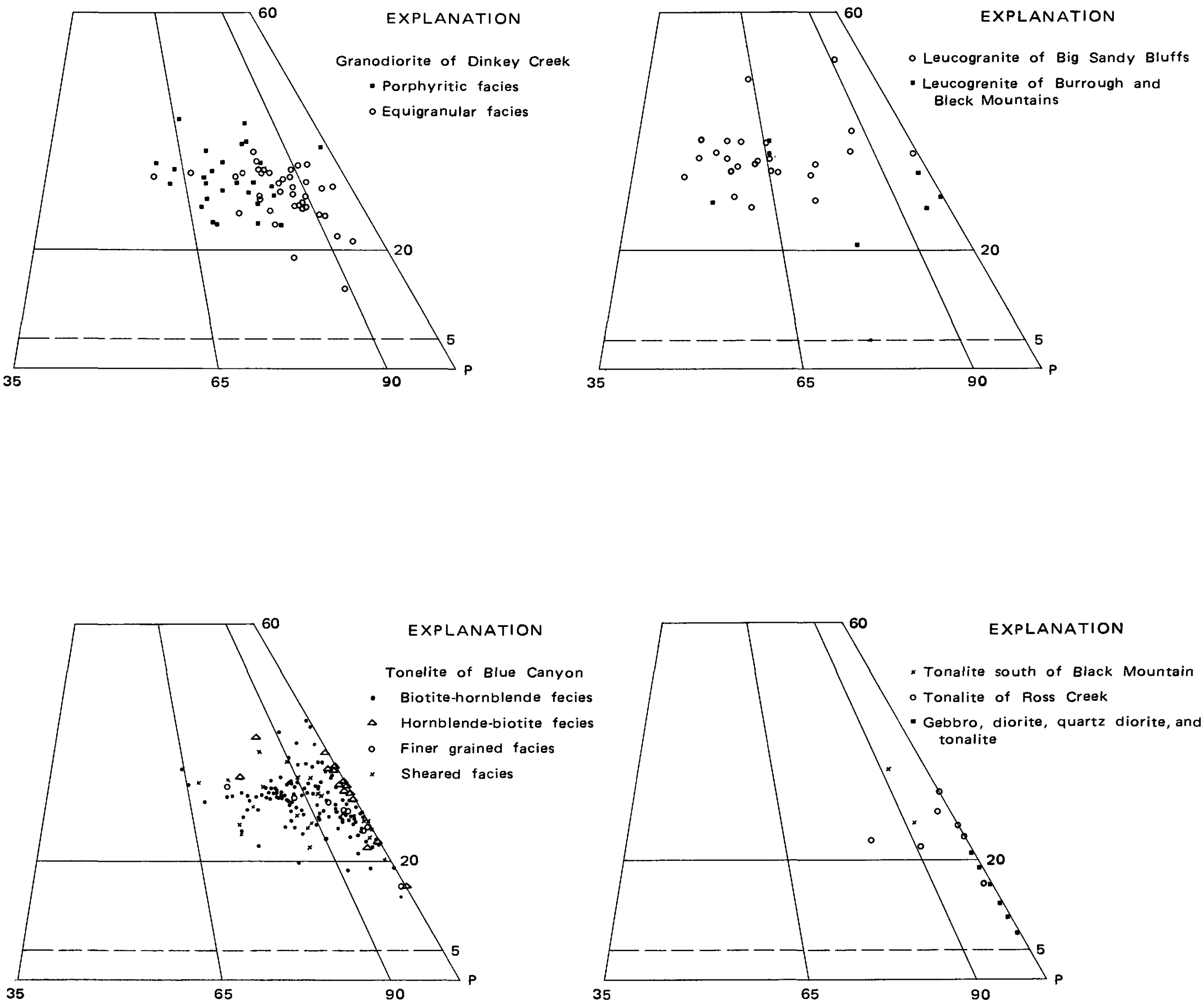

FIGURE 8.—Continued.

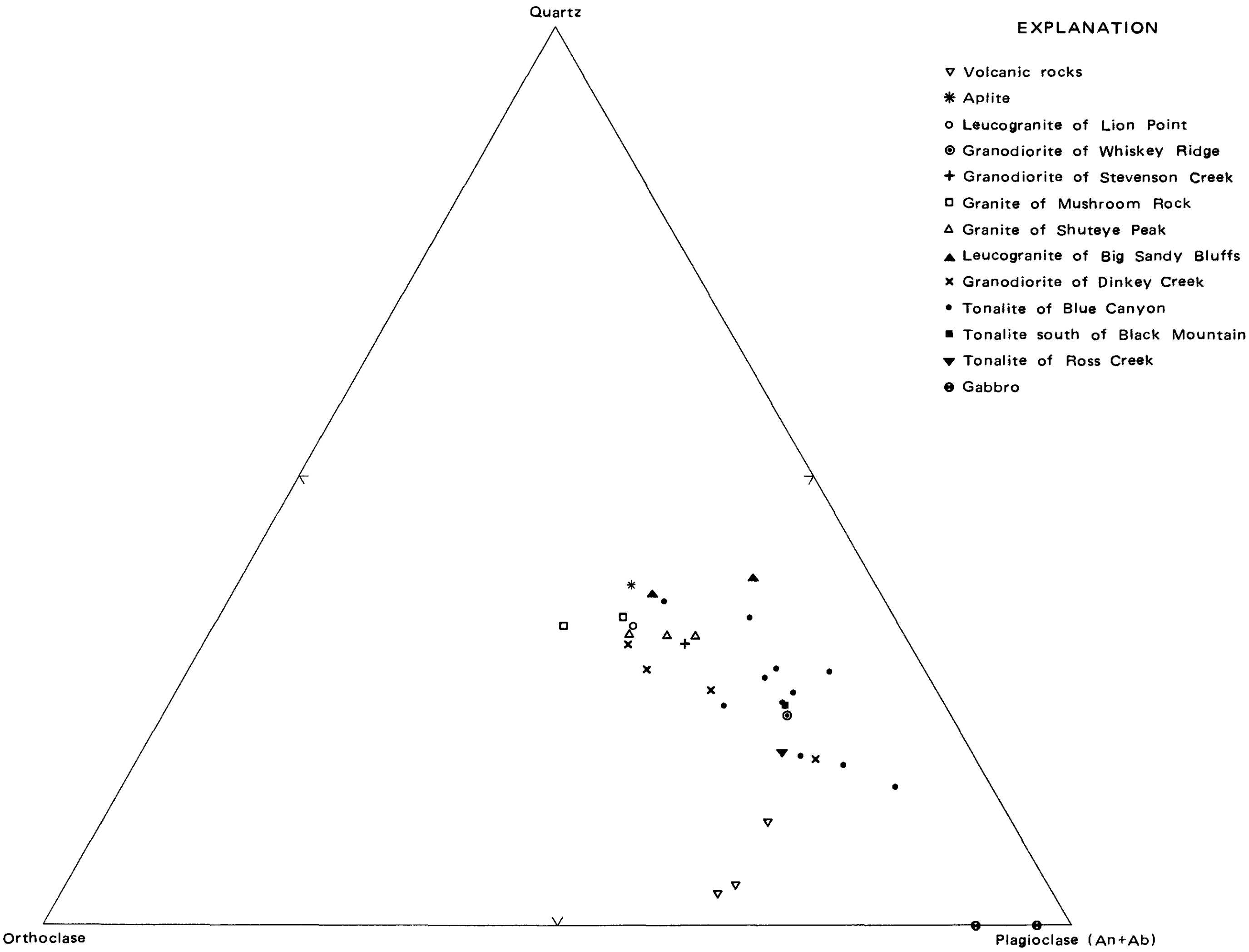

FIGURE 9.—Plot of norms of igneous rocks.

TABLE 1.—*Chemical and spectrographic analyses, norms, and modes of representative igneous rocks*

[Chemical analyses: Standard rock analysis of SL–18 by D. F. Powers; rapid-rock analysis of HL–199–1 by W. Blake; analyses of all others performed under the supervision of Leonard Shapiro. Semiquantitative spectrographic analysis of SL–18 by P. R. Barnett, of HL–199–1 by A. A. Chodas, of JB–1 and SL–1 by R. E. Mays, and of all others by Chris Heropoulos. Values reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, etc., which represent midpoints on a geometric scale; the precision of a value is approximately plus or minus one bracket of 68 percent confidence or two brackets at 95 percent. N = not detected; detection limits given in parentheses after element symbols. The following chemical analyses have been published previously: HL–199–1, by Hamilton and Neuerburg (1965, p. 868, table 4); SL–18, by Dodge, Papike, and Mays (1968, p 382, table 1). Modal analyses by Oleg Polovtzoff: 1,000- to 2,000-point counts on a slab of at least 70 cm²]

	Gabbro		Tonalite of Ross Creek	Tonalite south of Black Mountain	Tonalite of Blue Canyon						
					Biotite-hornblende facies						
	SLb–185	SLd–100	SLb–64	SLc–151B–1	JB–1	SL–32	SLa–48	SLb–63	SLc–107	SLc–115	SLd–36
Chemical analyses (weight percent)											
SiO_2	51.0	45.8	61.6	64.5	60.8	71.70	67.3	65.1	65.1	58.5	66.1
Al_2O_3	9.7	24.0	16.8	17.3	16.9	14.90	16.6	16.4	16.6	18.8	16.5
Fe_2O_3	1.9	2.5	2.1	1.6	1.7	.88	1.8	1.8	2.1	2.8	2.0
FeO	10.0	3.8	4.3	3.2	4.3	1.25	2.2	1.9	2.4	3.8	2.6
MgO	16.5	5.3	3.3	2.2	2.8	.82	1.6	1.6	2.0	2.9	1.9
CaO	6.4	13.2	5.6	4.4	5.6	2.60	4.6	3.8	4.7	6.5	4.8
Na_2O	1.6	1.7	3.1	3.6	3.3	3.15	3.5	3.5	3.6	3.7	3.2
K_2O	.48	.42	2.5	2.2	2.3	3.40	2.2	3.2	2.3	1.3	2.4
H_2O+	.51	1.1	.70	.53	.95	.66	.64	.58	.74	.88	.82
H_2O-	.14	.22	.06	.12	.05	.11	.07	.05	.13	.10	.10
TiO_2	.57	1.2	.81	.60	.94	.33	.61	.61	.65	.83	.72
P_2O_5	.10	.04	.14	.13	.21	.07	.14	.10	.16	.18	.13
MnO	.15	.07	.08	.06	.09	.05	.05	.03	.05	.08	.05
CO_2	.10	.01	.06	.04	<.05	<.05	.04	.01	.02	.03	.02
Less O	------	------	------	------	------	------	------	------	------	------	------
Sum	99	99	101	100	99.9	99.9	101	99	101	100	101
Powder density (gm/cm^3)	------	------	------	------	------	------	------	------	------	------	------
Semiquantitative spectrographic analyses (parts per million)											
B(7)	N	N	20	N	N	15	N	N	N	N	N
Ba(2)	1,000	100	700	700	700	700	700	700	700	500	700
Be(1)	N	N	N	N	N	1.5	N	1	N	N	N
Ce (70)	N	N	N	N	N	N	N	N	N	N	100
Co (2)	3	20	15	10	15	30	7	7	10	15	10
Cr (1)	3	150	50	15	15	7	7	10	10	7	10
Cu (0.7)	1.5	7	30	5	10	3	10	1.5	5	15	7
Ga (2)	10	15	15	15	15	10	15	20	20	20	20
La (30)	50	N	N	N	N	N	N	N	N	N	70
Nb (7)	N	N	7	N	N	7	N	7	N	N	10
Ni (2)	500	15	15	5	7	N	1.5	1	3	3	3
Pb (7)	20	N	10	7	N	30	15	20	15	N	30
Sc (2)	5	70	20	15	15	3	10	7	10	20	10
Sr (5)	300	700	500	300	700	500	500	700	700	700	700
V (3)	15	300	100	50	150	50	50	50	50	70	70
Y (7)	15	15	30	15	20	7	10	10	10	20	15
Yb (0.7)	1.5	2	3	1.5	2	1	.7	1.5	.7	1.5	1
Zr (10)	200	15	150	100	150	150	150	100	100	100	150
CIPW norms (weight percent)											
Q	------	------	15.71	21.13	15.4	33.3	25.93	21.77	21.99	12.74	24.63
C	------	------	------	1.31	.05	1.49	.43	.51	.03	------	.22
or	2.84	2.48	14.77	13.00	13.5	20.0	13.00	18.91	13.59	7.68	14.18
ab	13.54	14.38	26.23	30.46	27.8	26.7	29.62	29.62	30.46	31.31	27.08
an	17.87	56.61	24.54	20.98	24.5	12.5	21.91	18.20	22.27	30.85	22.96
wo	5.52	3.59	.97	------	.80	------	------	------	------	.09	------
en	34.25	9.50	8.22	5.48	6.95	2.05	3.99	3.99	4.98	7.22	4.73
fs	13.44	2.20	4.97	3.68	5.23	1.10	1.64	1.05	1.69	3.44	2.03
fo	4.80	2.60	------	------	------	------	------	------	------	------	------
fa	2.08	.66	------	------	------	------	------	------	------	------	------
mt	2.75	3.62	3.04	2.32	2.40	1.28	2.61	2.61	3.04	4.06	2.90
il	1.08	2.28	1.54	1.14	1.78	.63	1.16	1.16	1.23	1.58	1.37
ap	.23	.09	.33	.30	.50	.18	.33	.23	.37	.42	.30
hm	------	------	------	------	------	------	------	------	------	------	------
Other	------	------	------	------	.01	------	------	------	------	------	------
Total	98.40	98.01	100.32	99.80	98.92	99.23	100.62	98.05	99.65	99.39	100.40
Modes (volume percent)											
Quartz	------	------	------	24	15	33	29	28	25	18	31
Potassium feldspar	------	------	------	6	3	20	5	7	5	<.5	5
Plagioclase	------	------	------	60	59	38	53	51	54	58	46
Mafic minerals	------	------	------	10	24	10	14	14	16	23	17
Total	------	------	------	100	101	101	101	100	100	101	99
Bulk specific gravity	------	2.87	------	2.72	2.77	------	2.72	2.69	2.74	2.80	2.73

TABLE 1.—*Chemical and spectrographic analyses, norms, and modes of representative igneous rocks* —Continued

	Tonalite of Blue Canyon—Continued				Granodiorite of Dinkey Creek						
	Hornblende-biotite facies		Finer grained facies	Sheared facies	Equigranular facies			Porphyritic facies		Leucogranite of Big Sandy Bluffs	
	SLa–97	SLc–111	SLc–70	SLa–39	SL–1	SLb–5	SLd–20	SL–18	SLd–52	SLc–60	SLc–119
Chemical analyses (weight percent) — Continued											
SiO_2	71.1	65.1	62.0	59.5	58.7	61.7	68.9	65.60	71.1	74.3	74.8
Al_2O_3	15.8	17.4	17.2	18.0	16.6	16.5	14.8	15.37	14.9	14.9	14.1
Fe_2O_3	1.2	1.8	2.4	2.7	2.0	2.1	1.7	1.16	1.3	1.1	.79
FeO	1.9	2.5	3.5	4.6	5.1	4.2	2.3	3.60	1.2	.76	.80
MgO	1.0	1.6	2.5	3.0	3.2	2.7	1.6	1.91	.66	.40	.45
CaO	3.2	4.9	5.5	6.0	6.4	5.2	3.3	4.39	2.0	2.4	1.6
Na_2O	3.8	3.7	3.5	3.2	2.9	2.7	3.0	3.03	3.4	4.2	3.7
K_2O	2.2	1.4	2.0	1.8	2.0	2.5	4.1	3.17	4.3	1.9	3.6
H_2O+	.47	.72	.63	.88	1.3	.89	.70	.47	.57	.36	.50
H_2O-	.07	.21	.12	.07	.19	.21	.07	.05	.10	.04	.06
TiO_2	.44	.53	.91	.68	.95	.90	.52	.67	.27	.17	.14
P_2O_5	.08	.13	.14	.11	.21	.20	.08	.13	.04	.03	.03
MnO	.02	.06	.07	.16	.12	.13	.05	.09	.02	.01	.01
CO_2	.03	.07	.03	.03	<.09	<.05	.03	.02	.04	.03	.06
Less O	------	------	------	------	.06	------	------	------	------	------	------
Sum	101	100	101	101	99.7	101.01	101	99.7	100	101	101
------	------	------	------	------	------	------	------	2.76			
Semiquantitative spectrographic analyses (parts per million) —Continued											
B (7)	N	N	N	N	N	N	N	15	N	N	N
Ba (2)	1,500	700	700	500	700	700	700	200	700	3,000	1,000
Be (1)	N	N	N	2	N	N	N	N	1.5	N	1.5
Ce (70)	N	N	N	N	N	N	100	N	N	70	N
Co (2)	3	7	15	15	20	15	10	7	2	N	N
Cr (1)	2	3	10	10	20	15	10	7	2	2	1.5
Cu (0.7)	2	3	5	20	20	10	5	3	1	1	1.5
Ga (2)	15	20	20	20	20	20	15	7	15	15	15
La (30)	N	N	N	N	N	70	70	70	N	50	N
Nb (7)	N	N	N	N	N	N	N	7	7	N	N
Ni (2)	N	N	2	1	7	N	3	3	N	N	N
Pb (7)	10	7	10	10	N	10	20	15	30	N	20
Sc (2)	7	10	15	30	20	15	10	15	5	N	N
Sr (5)	500	700	700	500	1,500	500	300	700	200	300	200
V (3)	20	30	100	100	150	100	50	70	15	7	10
Y (7)	N	N	20	30	20	20	20	15	20	N	N
Yb (0.7)	N	N	1.5	3	2	2	2	1.5	1.5	N	N
Zr (10)	150	150	150	70	100	100	150	30	150	150	50
CIPW norms (weight percent) — Continued											
Q	31.63	24.61	17.70	14.52	14.5	19.67	25.82	22.47	29.38	36.84	35.21
C	1.54	1.20	------	.14	.01	.38	------	------	1.11	1.64	1.28
or	13.00	8.27	11.82	10.64	11.9	14.77	24.23	18.79	25.41	11.23	21.27
ab	32.15	31.31	29.62	27.08	24.3	22.85	25.39	25.58	28.77	35.54	31.31
an	15.35	23.46	25.31	29.05	26.7	24.49	14.81	19.12	9.66	11.71	7.74
wo	------	------	.44	------	1.52	------	.43	.65	------	------	------
en	2.49	3.99	6.23	7.47	7.97	6.73	3.99	4.77	1.64	1.00	1.12
fs	1.81	2.34	3.07	5.39	6.38	4.73	2.05	4.73	.72	.22	.60
fo	------	------	------	------	------	------	------	------	------	------	------
fa	------	------	------	------	------	------	------	------	------	------	------
mt	1.74	2.61	3.48	3.91	2.91	3.04	2.46	1.69	1.88	1.59	1.15
il	.84	1.01	1.73	1.29	1.81	1.71	.99	1.28	.51	.32	.27
ap	.19	.30	.33	.26	.49	.46	.19	.31	.09	.07	.07
hm	------	------	------	------	------	------	------	------	------	------	------
Other	------	------	------	------	.06	------	------	.14	------	------	------
Total	100.74	99.13	99.73	99.75	98.55	98.83	100.36	99.53	99.17	100.16	100.02
Modes (volume percent) — Continued											
Quartz	37	29	19	20	15	21	29	27	31	39	32
Potassium feldspar	8	------	1	------	1	7	20	14	23	8	22
Plagioclase	44	57	57	59	61	51	39	41	39	50	41
Mafic minerals	11	14	23	21	23	22	12	18	7	4	5
Total	100	100	100	100	100	101	100	100	100	101	100
Bulk specific gravity	2.69	2.74	2.77	2.79	2.80	2.78	2.71	2.70	2.66	2.67	2.64

TABLE 1.—*Chemical and spectrographic analyses, norms, and modes of representative igneous rocks*—Continued

Granite of Shuteye Peak				Granite of Mushroom Rock		Granodiorite of Stevenson Creek	Granodiorite of Whiskey Ridge	Leucogranite of Lion Point	Aplite	Volcanic rocks		
SLa-16	SLa-129	SLb-13	SLb-70	SLb-57	SLb-109	SLb-166 -	SLa-77	SLa-91	SLb-86	HL-199-1	SLb-89A	SLb-96A
Chemical analyses (weight percent) — Continued												
73.0	73.6	73.2	71.0	73.8	73.2	70.3	64.3	72.3	76.1	52.1	53.1	57.9
15.0	14.2	14.8	15.4	14.4	14.8	15.5	16.8	15.3	13.3	13.7	14.9	13.5
1.4	.88	1.1	1.4	.99	1.1	1.4	2.0	.90	.47	9.0	3.9	1.4
1.3	1.2	1.1	1.3	.88	.84	1.7	3.3	1.1	.28	1.31	5.9	4.4
.48	.52	.48	.64	.30	.44	.78	2.2	.65	.03	8.5	5.1	8.2
2.0	2.2	1.8	2.0	1.5	1.8	2.6	4.8	2.2	1.4	6.8	7.3	5.0
4.2	3.0	3.6	3.8	3.0	3.4	3.6	3.5	3.3	3.6	2.60	3.0	3.0
3.3	3.7	4.3	3.6	5.3	4.2	3.4	2.3	4.1	3.9	3.06	3.6	2.6
.33	.43	.21	.45	.75	.39	.45	.66	.71	.03	------	2.1	.79
.08	.13	.06	.09	.03	.07	.11	.13	.43	.29	------	.90	2.0
.26	.27	.43	.29	.34	.20	.36	.79	.25	.04	1.38	.93	.63
.06	.06	.05	.08	.03	.04	.09	.16	.06	.00	.71	.56	.52
.01	.06	.02	.02	.00	.00	.02	.06	.03	.00	.24	.10	.10
.02	.05	.03	.08	.08	.01	.05	.07	.02	<.05	------	.42	<.05
------	------	------	------	------	------	------	------	------	------	------	------	------
101	99	101	100	101	100	100	101	101	100	99.40	100	100
------	------	------	------	------	------	------	------	------	------	------	2.68	2.76
Semiquantitative spectrographic analyses (parts per million) — Continued												
N	N	N	N	N	N	N	N	N	15	50	N	30
1,000	1,000	1,500	1,000	1,000	1,000	1,000	700	1,500	200	1,000	1,000	1,000
1	1.5	1.5	1.5	1.5	2	N	N	1.5	2	2	3	2
100	N	N	N	100	N	N	N	N	N	------	N	N
2	2	N	2	N	N	3	10	N	N	50	50	30
N	2	1.5	2	N	1.5	3	10	1.5	N	100	300	500
.7	.7	1.5	1	1.7	1.5	1.5	7	1.5	2	30	100	70
20	15	20	20	20	15	15	20	20	15	20	20	15
70	N	N	70	70	N	50	N	N	N	------	N	N
N	N	N	10	N	N	N	N	N	15	------	N	N
N	N	N	N	N	N	N	2	N	N	200	150	500
15	15	20	20	30	30	20	7	30	50	10	20	30
3	5	5	N	N	N	5	15	3	N	30	30	15
200	200	300	300	300	300	300	500	300	150	1,000	1,000	1,000
7	20	15	15	7	7	15	70	10	N	100	200	150
20	15	20	15	10	10	15	20	10	N	50	20	15
1.5	1.5	1.5	1	1	1	1.5	1.5	1	N	5	1.5	1.5
200	150	100	200	150	150	200	150	150	50	100	150	150
CIPW norms (weight percent) — Continued												
30.74	36.15	31.17	29.75	32.38	32.81	29.23	20.56	31.48	37.16	2.71	2.48	7.50
1.03	1.40	1.07	1.81	1.07	1.48	1.39	.21	1.58	.61	------	------	------
19.50	21.86	25.41	21.27	31.32	24.82	20.09	13.59	24.23	23.05	18.08	21.27	15.36
35.54	25.39	30.46	32.15	25.39	28.77	30.46	29.62	27.92	30.46	22.00	25.39	25.39
9.53	10.52	8.60	9.40	7.25	8.67	12.31	22.77	10.52	6.95	16.67	16.56	16.69
------	------	------	------	------	------	------	------	------	------	5.19	6.68	2.39
1.20	1.30	1.20	1.59	.75	1.10	1.94	5.48	1.62	.07	21.17	12.70	20.42
.82	1.14	.44	.79	.24	.30	1.41	3.21	.92	.06	------	2.59	6.07
------	------	------	------	------	------	------	------	------	------	------	------	------
------	------	------	------	------	------	------	------	------	------	------	------	------
2.03	1.28	1.59	2.03	1.44	1.59	2.03	2.90	1.30	.68	1.01	5.65	2.03
.49	.51	.82	.55	.65	.38	.68	1.50	.47	.08	2.62	1.77	1.20
.14	.14	.12	.19	.07	.09	.21	.37	.14	------	1.65	1.30	1.21
------	------	------	------	------	------	------	------	------	------	8.31	------	------
------	------	------	------	------	------	------	------	------	.32	------	3.42	2.79
101.02	99.69	100.88	99.53	100.56	100.01	99.75	100.21	100.18	99.44	99.41	99.81	100.05
Modes (volume percent) — Continued												
30	27	26	30	27	30	29	25	32	35	------	------	------
25	24	25	18	27	27	21	4	23	26	------	------	------
38	43	43	42	40	39	41	50	38	39	------	------	------
7	6	6	10	6	4	10	21	7	<.5	------	------	------
100	100	100	100	100	100	101	100	100	100	------	------	------
2.65	2.66	2.66	2.66	2.64	2.65	2.68	2.78	2.62	2.64	------	------	------

TABLE 2.—*Potassium-argon age determinations on biotite and hornblende from granitic and volcanic rocks of the Shaver Lake quadrangle*

[Determinations for SL–18, SL–25, SL–32, and SL–36 from Kistler, Bateman, and Brannock (1965, p. 158, table 1). Determinations for KA–998 from Dalrymple (1963, p. 380, table 1). Determinations for SLd–8, SLd–11, and SLb–89A are by R. W. Kistler. K analyses by Lois Schlocker. $\lambda_\beta = 4.72\times10^{-10}$ year^{-1}; $\lambda_\epsilon = 0.584\times10^{-10}$ year^{-1}; 1.19×10^{-4} atoms ^{40}K/atoms K. Estimated uncertainty, owing to analytic uncertainties of potassium and argon, of each age at the 68 percent confidence level is ±30 percent]

Sample No.	Rock unit	Mineral	K (weight percent)	Radiogenic ^{40}Ar (moles/gm $\times10^{-11}$)	Percentage of radiogenic Ar	Age (m.y.)
SL–18	Granodiorite of Dinkey Creek	Biotite	7.58	126.7	88	92
SL–18	do	Hornblende	0.79	13.1	82	91
SL–25	do	Biotite	7.06	115.5	84	90
SLd–8	do	do	9.46	130.76	93	91.5
SLd–8	do	Hornblende	1.038	15.61	90	99.3
SL–32	Tonalite of Blue Canyon	Biotite	7.01	113.1	82	89
SL–32	do	Hornblende	0.62	12.32	69	109
SL–36	do	Biotite	5.99	96.8	84	89
SLd–11	do	do	9.25	126.89	67	90.7
SLd–11	do	Hornblende	0.881	13.54	89	101.6
SLb–89A	Trachybasalt southwest of Big Creek.	Biotite	9.34	15.29	66	11.1
KA–998	Trachybasalt of Sugarloaf Hill.	Whole rock	2.01	5.58	72	9.5

TABLE 3.—*Uranium-lead age determinations on zircon from granitic rocks of the Shaver Lake quadrangle*

[Determinations by T. W. Stern. Constants used: 238U/235U = 137.88; 238λ = 0.155×10^{-9} years. Analytic uncertainties ~±3 percent]

Sample		SL–1	JB–1
Rock unit		Granodiorite of Dinkey Creek	Tonalite of Blue Canyon
Parts per million.	Pb	21.94	14.41
	U	725.0	569.3
Atomic percentage.	^{204}Pb	0.631	0.232
	^{206}Pb	58.08	65.98
	^{207}Pb	11.85	8.157
	^{208}Pb	29.44	25.63
Age (m.y.)	^{200}Pb/^{238}U	104	116

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