Millerton Lake Quadrangle, West-Central Sierra Nevada, California—Analytic Data

GEOLOGICAL SURVEY PROFESSIONAL PAPER 1261

Millerton Lake Quadrangle, West-Central Sierra Nevada, California—Analytic Data

By PAUL C. BATEMAN *and* ALAN J. BUSACCA

GEOLOGICAL SURVEY PROFESSIONAL PAPER 1261

Modal and chemical data on and isotopic ages of the plutonic rocks of the Millerton Lake quadrangle

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1983

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *Secretary*

GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

Library of Congress Cataloging in Publication Data

Bateman, Paul Charles, 1910–
Millerton Lake quadrangle, west-central Sierra Nevada, California—analytic data.

(Geological Survey professional paper 1261)
Bibliography
Supt. of Docs. no.: I 19.16:1261
1. Rocks, igneous. 2. Geological time. 3. Geology—California—Madera County. I. Busacca, Alan J. II. Title.
III. Series: United States. Geological Survey. Professional Paper 1261.
QE461.B42 1983 552.3'0979481 82–600354

For sale by the Distribution Branch, U.S. Geological Survey,
604 South Pickett Street, Alexandria, VA 22304

CONTENTS

ILLUSTRATIONS

TABLES

MILLERTON LAKE QUADRANGLE, WEST-CENTRAL SIERRA NEVADA, CALIFORNIA—ANALYTIC DATA

By PAUL C. BATEMAN and ALAN J. BUSACCA

ABSTRACT

More than 300 samples of plutonic rocks were collected from the Millerton Lake quadrangle; 249 of these were analyzed modally, 13 were analyzed chemically, and zircon from 6 samples was dated isotopically by the U-Pb method. The results are given in tables and diagrams, and the brief text provides a background for understanding and interpreting the data. The U-Pb zircon ages of the most widespread granitoids are about 114 m.y.

Except for scattered small bodies of granite and aplitic leucogranite, all the granitoids are poor in potassium and include tonalite, leucotonalite, and biotite granodiorite. In these low-potassium rocks, potassium feldspar (K-feldspar) generally is in thin stringers interstitial to plagioclase, quartz, and the mafic minerals. This texture is interpreted to indicate that, when the magmas were emplaced and began to solidify, they contained crystals of plagioclase, quartz, and mafic minerals, but not K-feldspar. K-feldspar crystallized from interstitial melt. The presence locally of subequant crystals of K-feldspar indicates that, with continued crystallization and falling temperature, the melt phase of the magma became saturated with K-feldspar and precipitated crystals.

INTRODUCTION

The Millerton Lake quadrangle is in the western foothills of the central Sierra Nevada, and the southwest corner extends into the Central Valley of California. California State Highway 41 from Fresno to Yosemite National Park passes through the east side of the quadrangle, and branching roads provide access to all parts of the quadrangle.

This report supplements the geologic map of the Millerton Lake quadrangle (Bateman and Busaca, 1982) by providing modal and chemical data and isotopic uranium-lead ages for the plutonic rocks. These data are contained in the maps, diagrams, and tables; the brief text provides a background for understanding and interpreting these data. A nontechnical summary of some of the more interesting aspects of the geology of the quadrangle accompanies the geologic map.

GENERAL GEOLOGY

The quadrangle is underlain chiefly by granitoids and by small bodies of diorite and gabbro and remnants of metamorphosed sedimentary and volcanic rocks. The tonalite of Blue Canyon is the most extensive granitoid, and it encloses the metamorphic remnants and is intruded by most of the other, less extensive, granitoids. Cenozoic volcanic and sedimentary rocks locally rest on the plutonic and metamorphic rocks, especially in the south-central and southwestern parts of the quadrangle, but only the sedimentary deposits of the Central Valley in the southwest corner of the quadrangle are shown on the simplified geologic maps accompanying this report (figs. 1-9).

The analytic data pertain only to the granitoids. These rocks occur in separate plutons, which generally are either in sharp contact with one another or are separated by thin, discontinuous septa (screens) of metamorphic rock. However, in several places, hybrid zones occur between different granitoids and between granitoids and metamorphic rocks. These hybrid zones consist of intricately branching dikes of the younger rocks into the older and of fragments of varying size of the older rocks in the younger.

The granitoids of the Millerton Lake quadrangle differ from granitoids farther east in the Sierra Nevada in that they generally contain little potassium feldspar (K-feldspar), having a low potassium content, and almost no magnetite. Comparison of the compositions of the Millerton Lake granitoids with granitoids farther east in the Sierra Nevada can be made by referring to reports of analytic data for the Kaiser Peak (Bateman and Lockwood, 1970), Huntington Lake (Bateman and Wones, 1972), Mount Abbot (Lockwood, 1975), and Shaver Lake quadrangles (Bateman and Lockwood, 1976).

SAMPLING AND ANALYTICAL METHODS

Samples were collected in the course of geologic mapping, and although we made no effort to follow a rigid sampling pattern, we did try to collect samples about 1.6 km apart of the freshest and most representative rocks. More than 300 samples of plutonic rocks were collected; 249 of these were analyzed modally to determine their mineral content (figs. 2-7), 13 were analyzed chemically for their major elements (table 1), and zircon from 6 samples was analyzed to determine isotopic uranium-lead ages (table 2). Samples collected for modal and chemical analyses averaged about one kilogram, and samples collected for age dating averaged about 50 kg. The chemical analyses were made in the rapid rock analysis laboratory of the Geological Survey, and the isotopic U-Pb ages were determined in the laboratory of T. W. Stern, both in Reston, Virginia. Modal analyses were made by point counting on sawed slabs of at least 70 cm^2 on which plagioclase was stained red and K-feldspar yellow (Norman, 1974).

The number of counts on most slabs of the tonalite of Blue Canyon ranged from 1,120 to 1,330 and averaged about 1,200, whereas the counts on the other granitoids were fewer, ranging from 1,040 to 1,140 and averaging about 1,100. Fewer counts were made on the less extensive granitoids because they are more deeply weathered than the tonalite of Blue Canyon, making it difficult to collect large fresh samples. The percentages of hornblende and biotite on the tonalite of Blue Canyon were determined by point counting on thin sections and apportioning the counts to the total mafic content determined on stained slabs. The number of counts on the slabs would be sufficient to permit assigning limits of error of less than ±3 percent at the 95-percent confidence level, the limits diminishing with the decreasing abundance of minerals, except for the fact that the points were counted at spacings of 1.75 to 1.81 mm, whereas the grain size of the rocks ranges up to 5 mm or more. To place limits of error on the counts, the points counted should be at least as far apart as the distance across the largest grains (Van der Plas and Tobi, 1965). Nevertheless, counts on samples collected within a few meters of one another at different times and for different purposes show good agreement and indicate that both the counting errors on individual samples and the variations among closely spaced samples are small. Modes of two groups of closely spaced samples from the tonalite of Blue Canyon are illustrative:

	Group 1			*Group 2*	
	MLc-19	*MLc-23*	*MLc-154*	*MLb-55*	*MLb-69*
Quartz	24	23	25	23	24
K-feldspar	2	3	1	4	tr.
Plagioclase	55	51	56	52	51
Biotite	13	15	13	18	20
Hornblende	6	8	6	4	5
Total	100	100	101	101	100+

TONALITE SOUTH OF BLACK MOUNTAIN

The tonalite south of Black Mountain underlies a small area in the southeast corner of the quadrangle. The rock is medium-grained hornblende-biotite tonalite and closely resembles the tonalite of Blue Canyon both compositionally and texturally. Because primary foliation in the tonalite of Blue Canyon truncates strong, probably cataclastic, foliation in the tonalite south of Black Mountain, the tonalite south of Black Mountain is considered to be the older rock. Sample MLd-17, the only sample collected from the tonalite south of Black Mountain, is strongly foliated and typical.

TONALITE OF BLUE CANYON

The tonalite of Blue Canyon occurs in two facies, a widespread facies that is characterized by conspicuous blocky hornblende prisms and a much less extensive facies that lacks conspicuous hornblende prisms. Despite the apparent abundance of hornblende in the blocky hornblende facies, biotite is more abundant than hornblende in most samples of both facies, and the boundary value of $\frac{100\ \text{hornblende}}{\text{biotite}+\text{hornblende}}$ is about 25 (fig. 8). The color index of the blocky hornblende facies ranges from 10 to 30, wheras the color index of few samples from the biotite facies exceeds 20. The normative composition of plagioclase ranges from An_{44} to An_{49} in samples of the blocky hornblende facies and from An_{37} to An_{41} in the biotite-rich facies (table 1). Another difference in the two facies is that many samples from the blocky hornblende facies contain more plagioclase than samples from the biotite-rich facies. In both facies, K-feldspar is interstitial in all but a few samples where it occurs in subequant grains. Extensive cataclasis reduced the grain size of many samples and doubtless destroyed some subequant K-feldspar grains, but the fact that K-feldspar is mostly interstitial in undeformed samples indicates that subsequent K-feldspar grains were never abundant.

We interpret these relations to indicate that the biotite-rich facies crystallized at a somewhat lower temperature and (or) in the presence of a higher volatile content than the blocky hornblende facies but that the two facies constitute a continuum. The spread of modes along the plagioclase-quartz side of the modal plot (figs. 10, 11) indicates that plagioclase was the first felsic mineral to crystallize and was followed by quartz. At the time the magma began to solidify, it was saturated in both these minerals as well as in hornblende and biotite. Interstitial K-feldspar crystallized from interstitial melt and was not present in the magma as crystals. As the temperature fell and the magma solidified, subequant K-feldspar crystals began to precipitate locally from the melt phase of the magma.

TONALITE SOUTH OF THE EXPERIMENTAL RANGE

The tonalite south of the Experimental Range is a distinctive uniformly fine-grained tonalite that contains biotite but no hornblende. Sparse K-feldspar is interstitial. The pluton intrudes the tonalite of Blue Canyon and is intruded by the leucotonalite of Ward Mountain.

LEUCOTONALITE OF WARD MOUNTAIN

The leucotonalite (trondhjemite) of Ward Mountain forms two plutons in the west half of the quadrangle, the larger and more northerly Ward Mountain pluton and the more southerly Experimental Range pluton (fig. 1). Undeformed rock typically is medium grained, equigranular, and light colored, and deformed rock is fine grained and gneissic. Biotite is the sole mafic mineral and generally constitutes less than 10 percent of the rock, but several samples in a belt that extends across the south-central part of the Ward Mountain pluton contain 12 to 14 percent, and one sample contains 24 percent (fig. 6).

Most samples of the leucotonalite contain less than 5 percent of interstitial K-feldspar, and many samples contain none. However, samples in the northwest and south-central parts of the Ward Mountain pluton contain 6 to 29 percent, and two samples in the west side of the Experimental Range pluton contain 15 and 16 percent. Most of the K-feldspar in samples that contain more than 5 percent is in subequant grains. These relations indicate, as do similar relations in the tonalite of Blue Canyon, that the magma contained no K-feldspar crystals when it was emplaced and began to solidify but that, with continued crystallization and falling temperature, the melt phase became saturated with K-feldspar and subequant crystals precipitated in increasing abundance in the last parts of the leucotonalite to solidify.

BIOTITE GRANODIORITE

Scattered masses of biotite granodiorite are all composed of similar-looking rock except that some have been cataclastically deformed and some have not. Typical undeformed rock is medium-grained biotite granodiorite. The color index ranges from 4 to 8 except in the Great Bend pluton and in the smaller pluton east of the Great Bend pluton in which the biotite content ranges between 5 and 15 percent. The grain size is reduced in strongly foliated cataclastically deformed rocks, and grain boundaries appear diffuse, probably because of granulation.

BIOTITE GRANITE

Biotite granite forms small plutons at and just east of Rock Mountain and a somewhat larger pluton at Corlew Mountain along the eastern part of the south boundary of the quadrangle. The granite in the plutons at and east of Rock Mountain is strongly deformed, whereas that in Corlew Mountain is not. The undeformed granite in Corlew Mountain is fine grained and has a weak primary foliation that is shown by the preferred orientation of biotite. The deformed granite at and east of Rock Mountain appears to have been medium grained before it was deformed, but now consists of clasts as much as 4 mm across in a very fine grained matrix. Although the granites in the two areas are of about the same composition, they may not be consanguineous.

APLITIC LEUCOGRANITE

Scattered small masses of aplitic leucogranite are composed of fine-grained felsic rock that generally contains no more than 2 percent biotite. In a few places, coarse-grained pegmatitic rock of the same composition is present. Their compositions indicate that these rocks crystallized at minimum magmatic temperatures.

U-Pb AGE DATA

Zircon from five samples of the tonalite of Blue Canyon and one sample of the leucotonalite of Ward Mountain were dated by the isotopic U-Pb method as part of a program of dating rocks of the central Sierra Nevada (Stern and others, 1981). Only the $^{206}Pb/^{238}U$ ages are considered reliable. The five ages on samples of the tonalite of Blue Canyon range from 110 to 124 m.y., and the age on sample MLa-12 of the leucotonalite of Ward Mountain is 115 m.y. The leucotonalite of Ward Mountain intrudes the tonalite of Blue Canyon and is therefore younger. If the age of 124 m.y. on sample MLc-10 is omitted, all the other ages on the tonalite of Blue Canyon fall in the narrow range of 110 to 115 m.y. The age on sample MLc-10 can be questioned because earlier determinations on this same sample yielded much older and obviously incorrect ages, which suggests that this determination also is incorrect. An evaluation of all the U-Pb ages on the tonalite of Blue Canyon, including ages from samples collected in adjoining quadrangles, suggests an optimum age of about 114 m.y., approximately the same as the U-Pb age on sample MLa-12 of the leucotonalite of Ward Mountain. For additional information, see the paper by Stern and others (1981).

REFERENCES CITED

Bateman, P. C., and Busacca, A. J., 1982, Geologic map of the Millerton Lake quadrangle, west-central Sierra Nevada, California: U.S. Geological Survey Geologic Quadrangle Map GQ-1548, scale 1:62,500.

Bateman, P. C., and Lockwood, J. P., 1970, Kaiser Peak quadrangle, central Sierra Nevada, California—analytic data: U.S. Geological Survey Professional Paper 644-C, p. C1-C15.

——— 1976, Shaver Lake quadrangle, central Sierra Nevada, California—analytic data: U.S. Geological Survey Professional Paper 774-D, p. D1-D20.

Bateman, P. C., and Wones, D. R., 1972, Huntington Lake quadrangle, central Sierra Nevada, California—analytic data: U.S. Geological Survey Professional Paper 724-A, p. A1-A18.

Lockwood, J. P., 1975, Mount Abbot quadrangle, central Sierra Nevada, California—analytic data: U.S. Geological Survey Professional Paper 774-C, C1-C18.

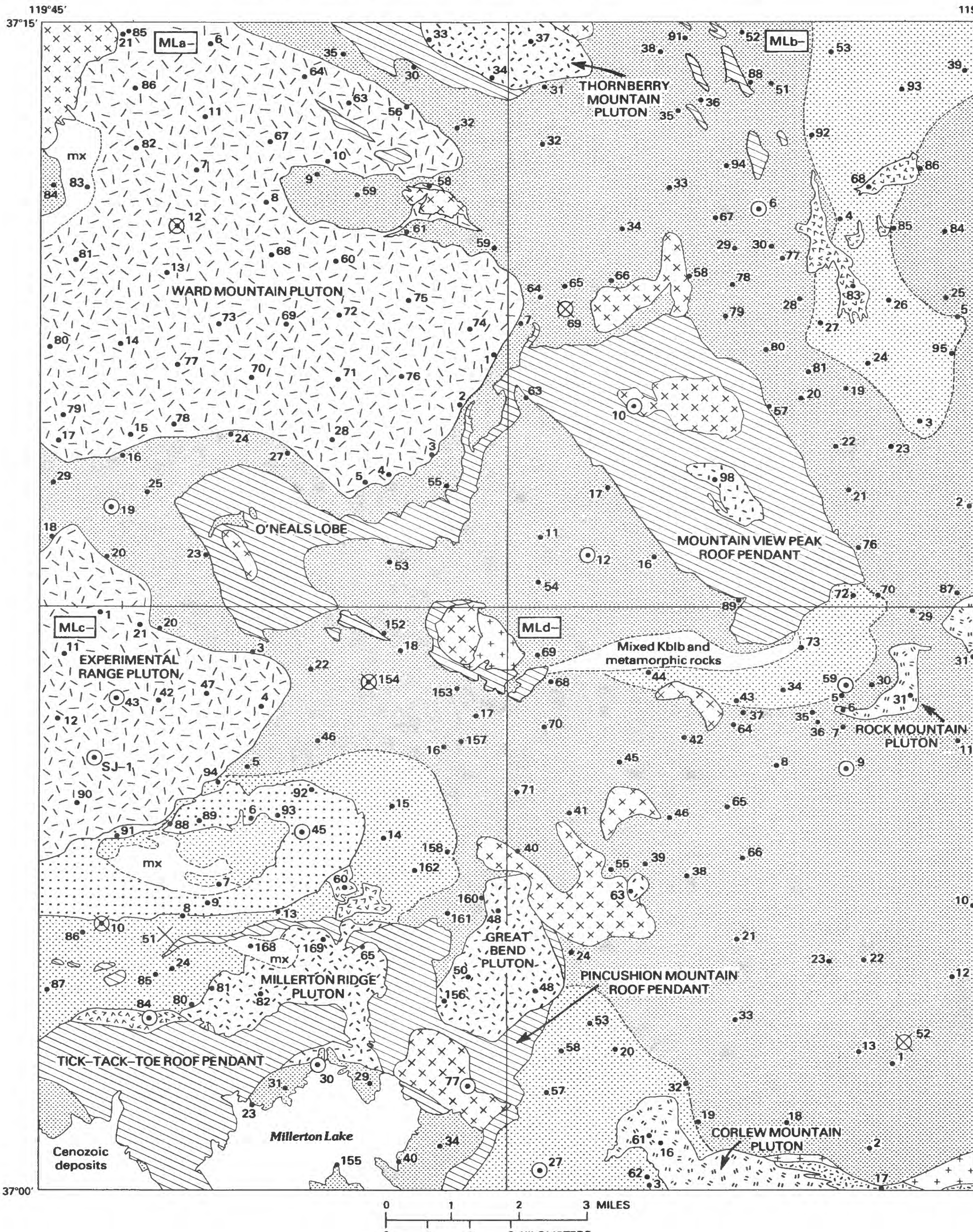
Norman, M. B., II, 1974, Improved techniques for selective staining of feldspar and other minerals using amaranth: U.S. Geological Survey Journal of Research, v. 2, no. 1, p. 73-79.

Stern, T. W., Bateman, P. C., Morgan, B. A., Newell, M. F., and Peck, D. L., 1981, Isotopic U-Pb ages of zircon from the granitoids of the central Sierra Nevada, California: U.S. Geological Survey Professional Paper 1185, 17 p.

Streckeisen, A. L., chairman, 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.

Van der Plas, L., and Tobi, A. C., 1965, A chart for judging the reliability of point counting results: American Journal of Science, v. 263, no. 1, p. 87-90.

FIGURES 1–11; TABLES 1, 2


119°45′
119°30
37°15′
37°00′
MLa–
MLb–
MLc–
MLd–
THORNBERRY MOUNTAIN PLUTON
WARD MOUNTAIN PLUTON
mx
O'NEALS LOBE
MOUNTAIN VIEW PEAK ROOF PENDANT
EXPERIMENTAL RANGE PLUTON
SJ–1
Mixed Kblb and metamorphic rocks
ROCK MOUNTAIN PLUTON
GREAT BEND PLUTON
MILLERTON RIDGE PLUTON
PINCUSHION MOUNTAIN ROOF PENDANT
TICK–TACK–TOE ROOF PENDANT
Millerton Lake
Cenozoic deposits
CORLEW MOUNTAIN PLUTON
0 1 2 3 MILES
0 1 2 3 KILOMETERS

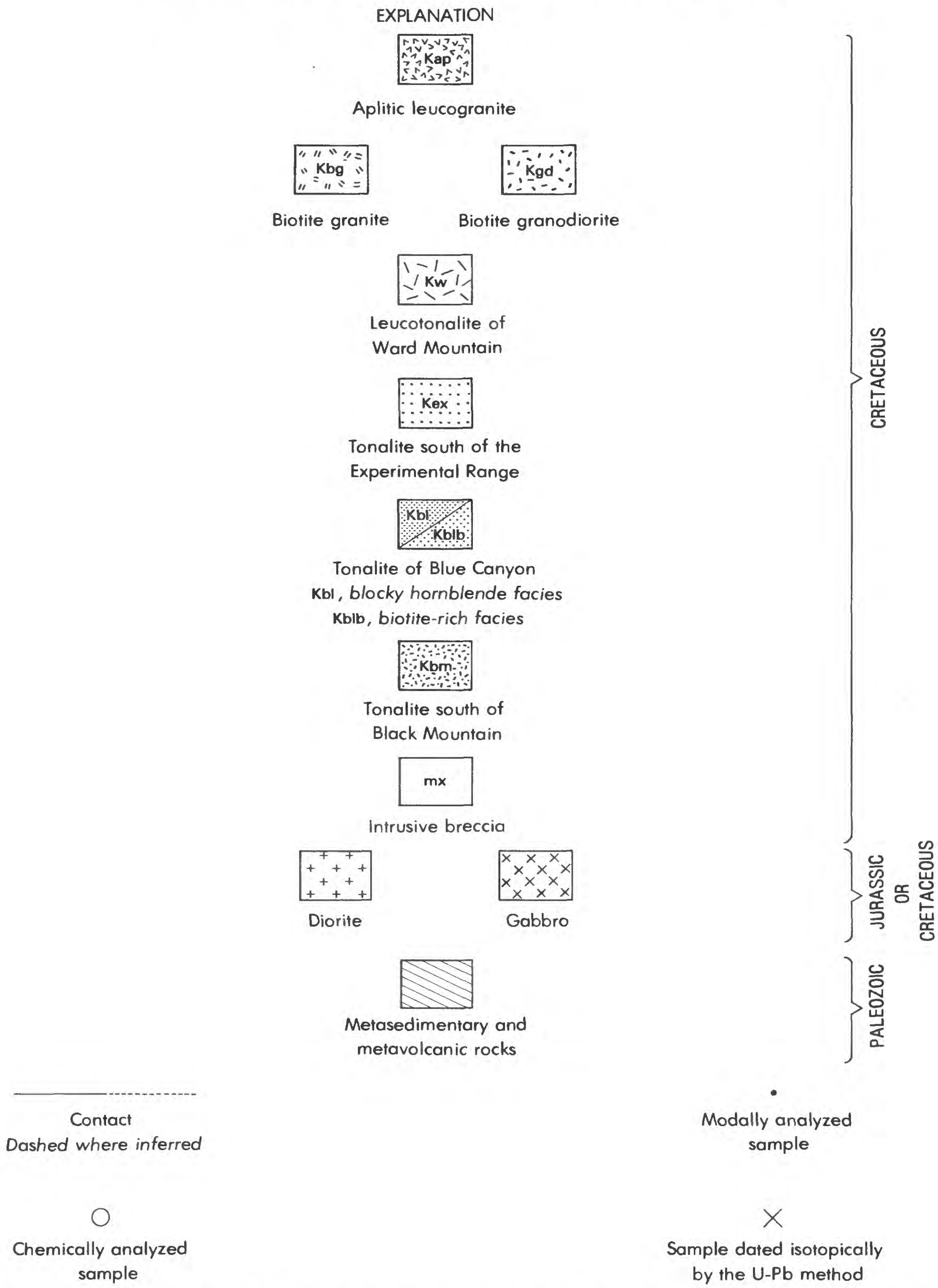


FIGURE 1.—Millerton Lake quadrangle showing the principal geologic units and the locations of modally analyzed, chemically analyzed, and isotopically dated samples. The letters in the upper left of each quadrant (MLa- etc.) prefix the sample numbers within the quadrants. Numbers refer to sample numbers in tables 1–2.

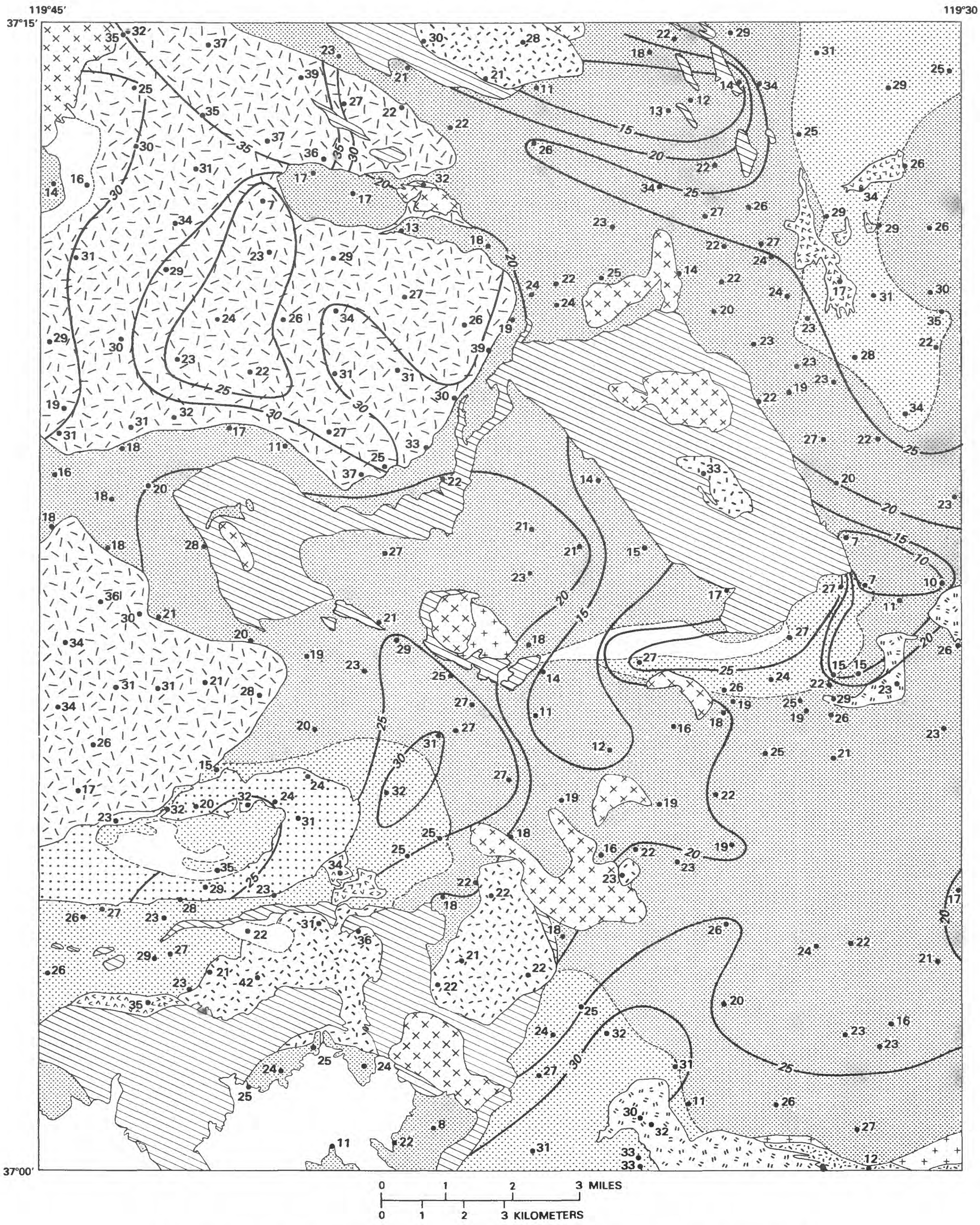


FIGURE 2.—Millerton Lake quadrangle showing volume-percent quartz. Explanation in figure 1.

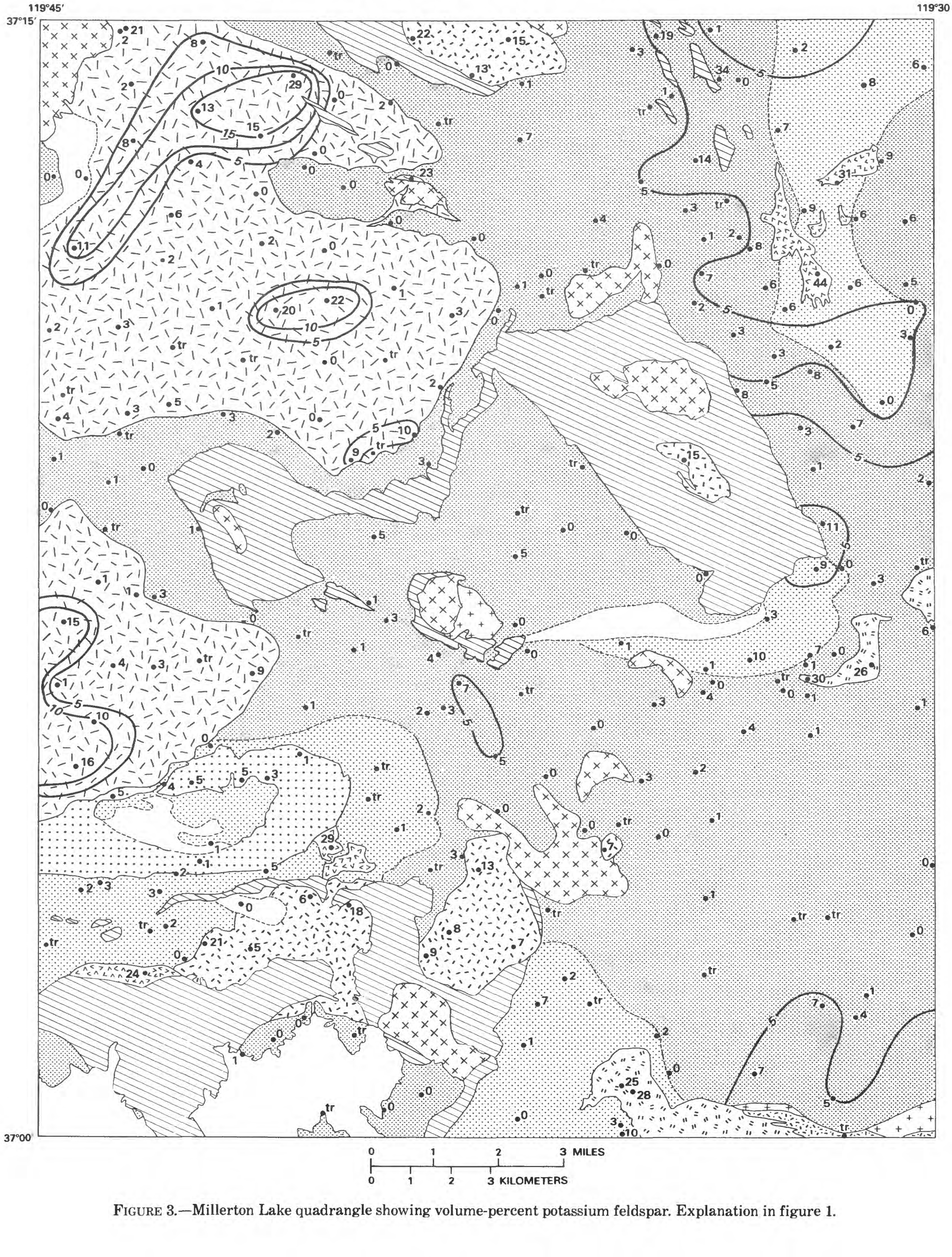


FIGURE 3.—Millerton Lake quadrangle showing volume-percent potassium feldspar. Explanation in figure 1.

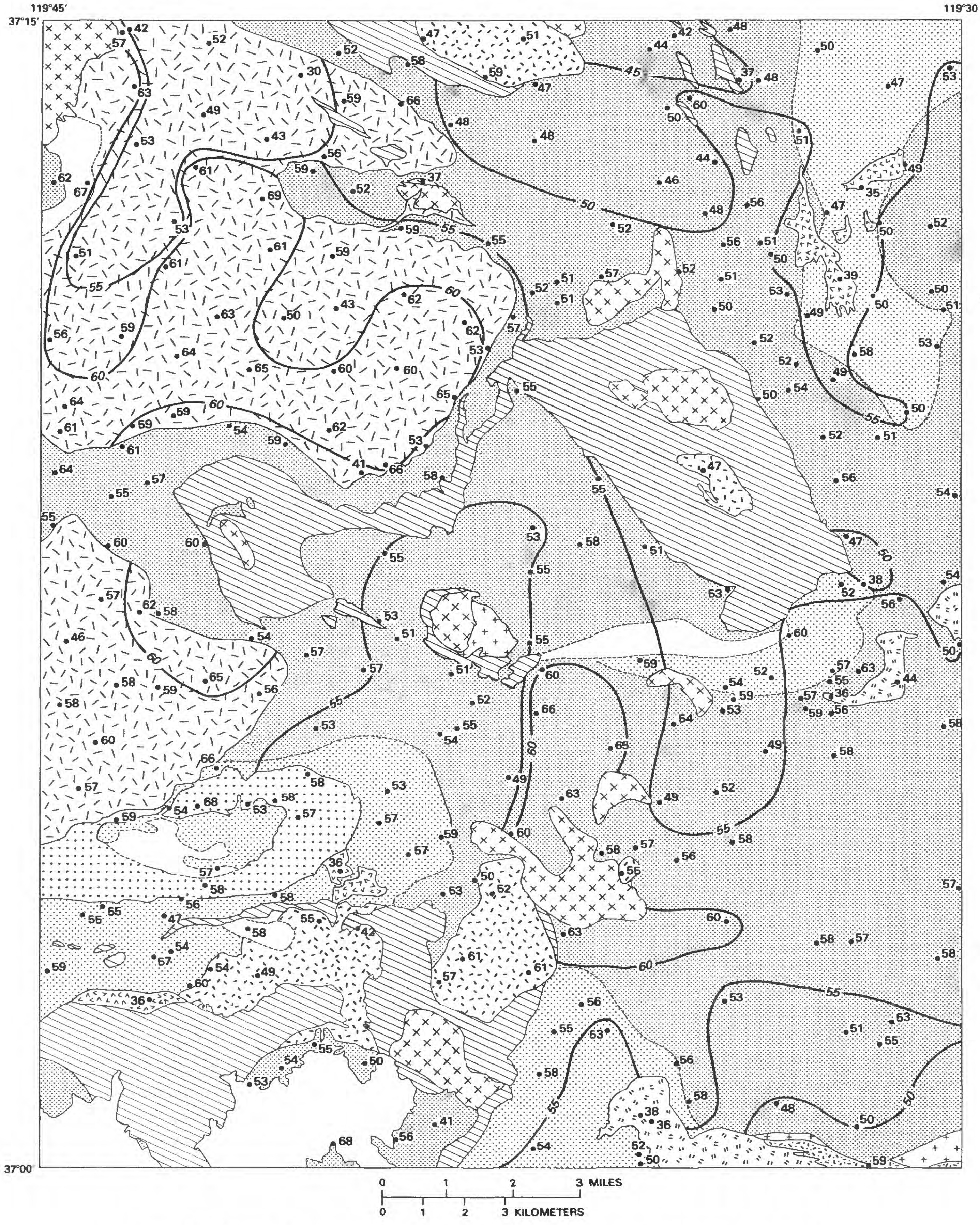


FIGURE 4.—Millerton Lake quadrangle showing volume-percent plagioclase. Explanation in figure 1.

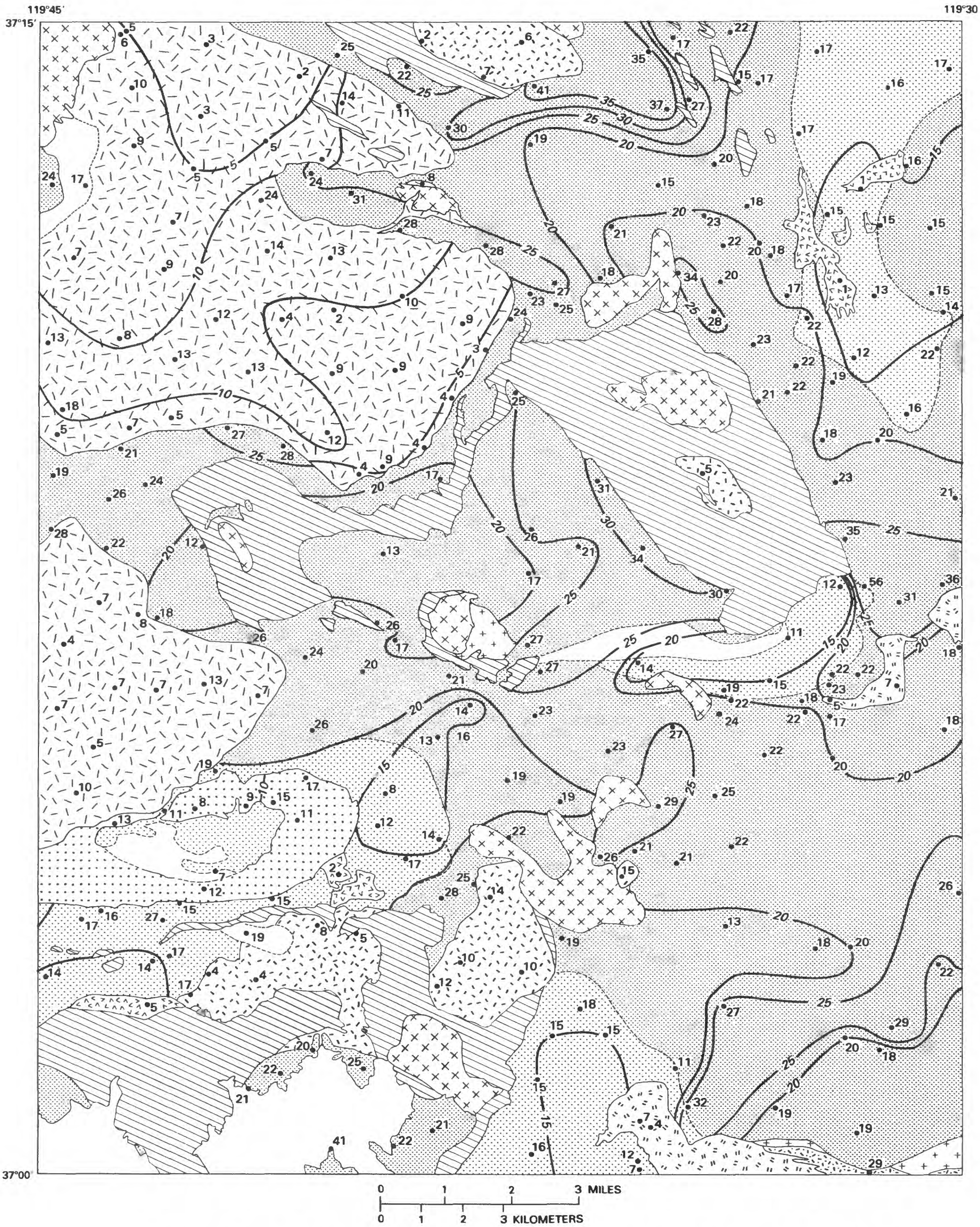


FIGURE 5.—Millerton Lake quadrangle showing volume-percent mafic minerals. Explanation in figure 1.

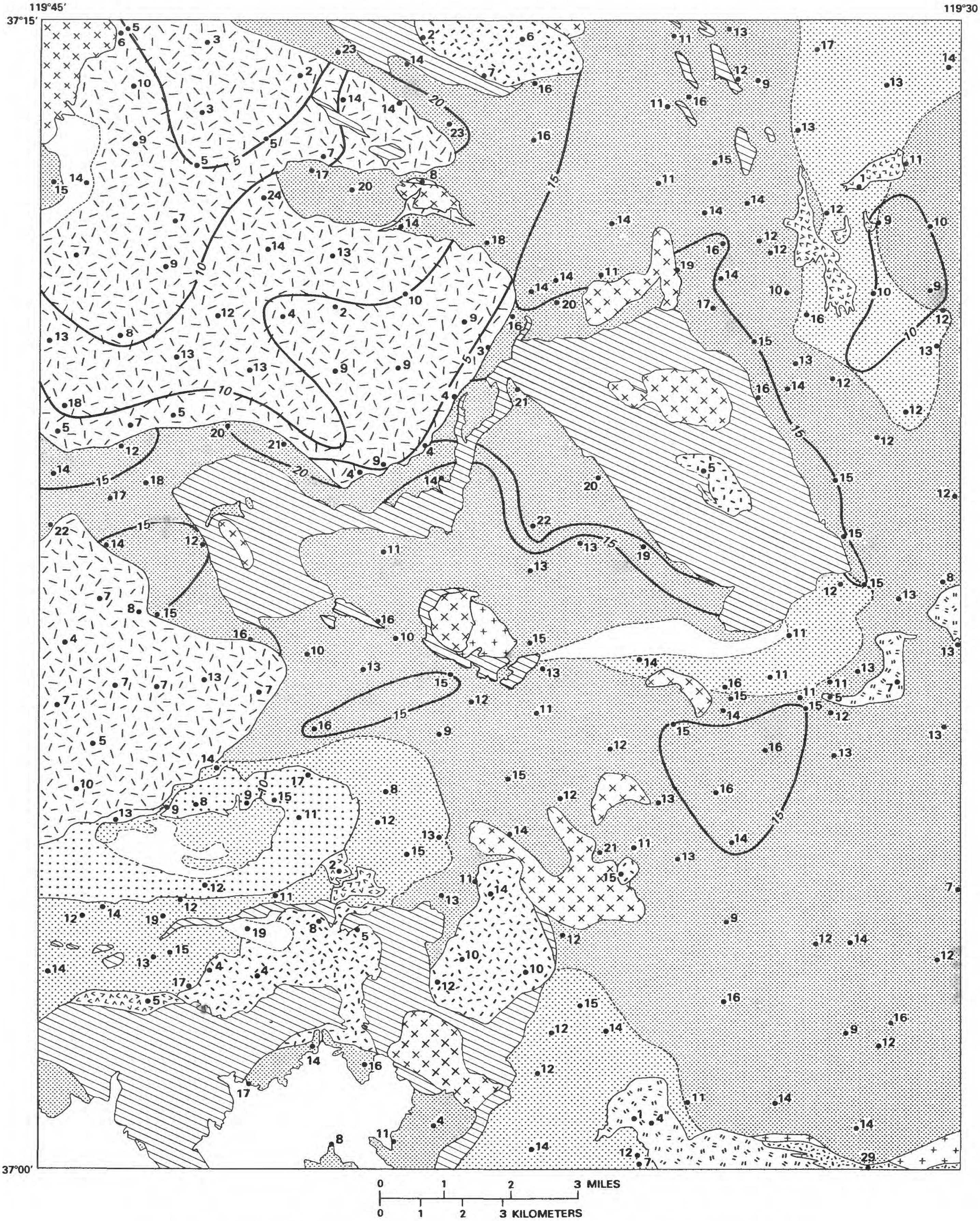


FIGURE 6.—Millerton Lake quadrangle showing volume-percent biotite. Explanation in figure 1.

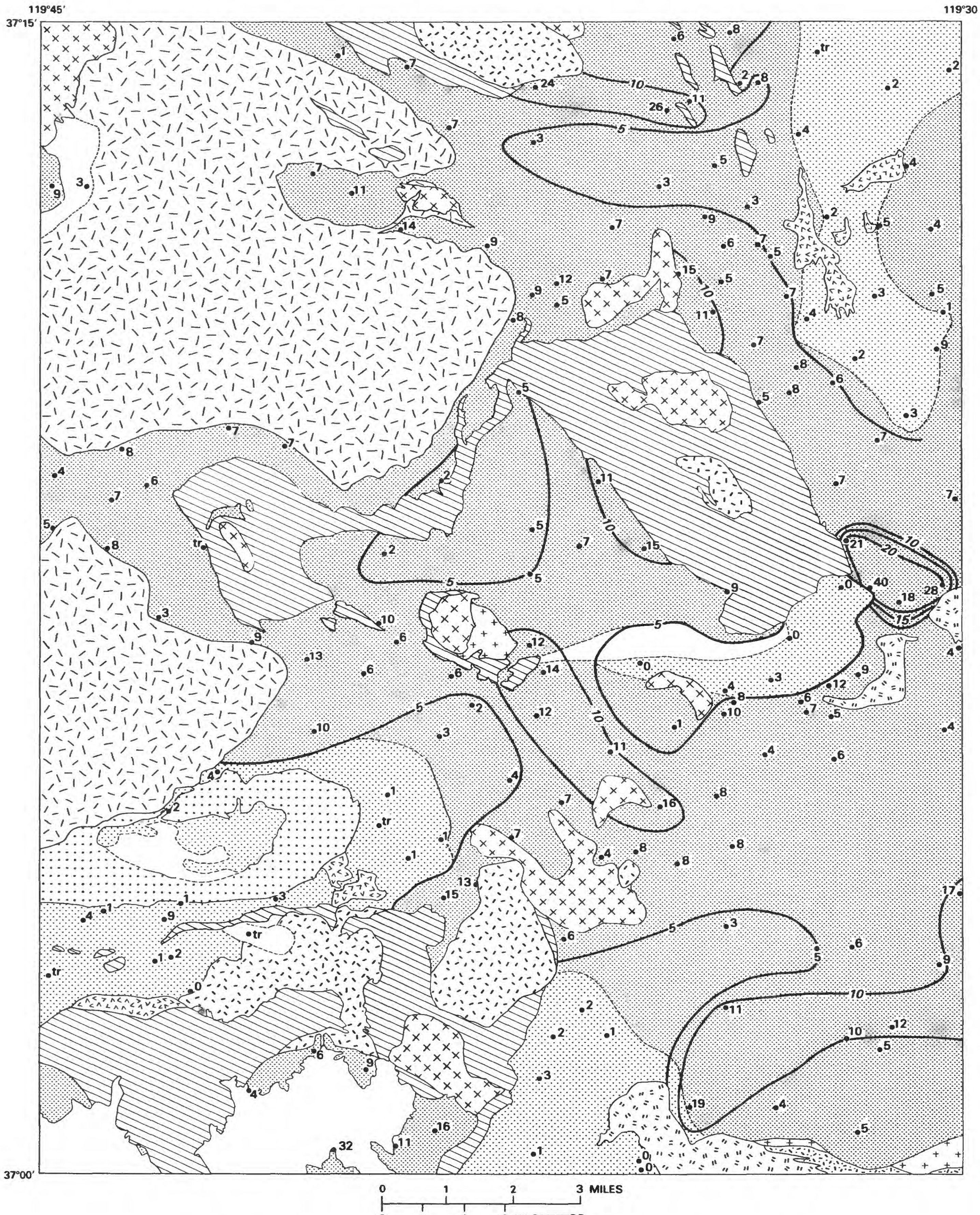


FIGURE 7.—Millerton Lake quadrange showing volume-percent hornblende. Explanation in figure 1.

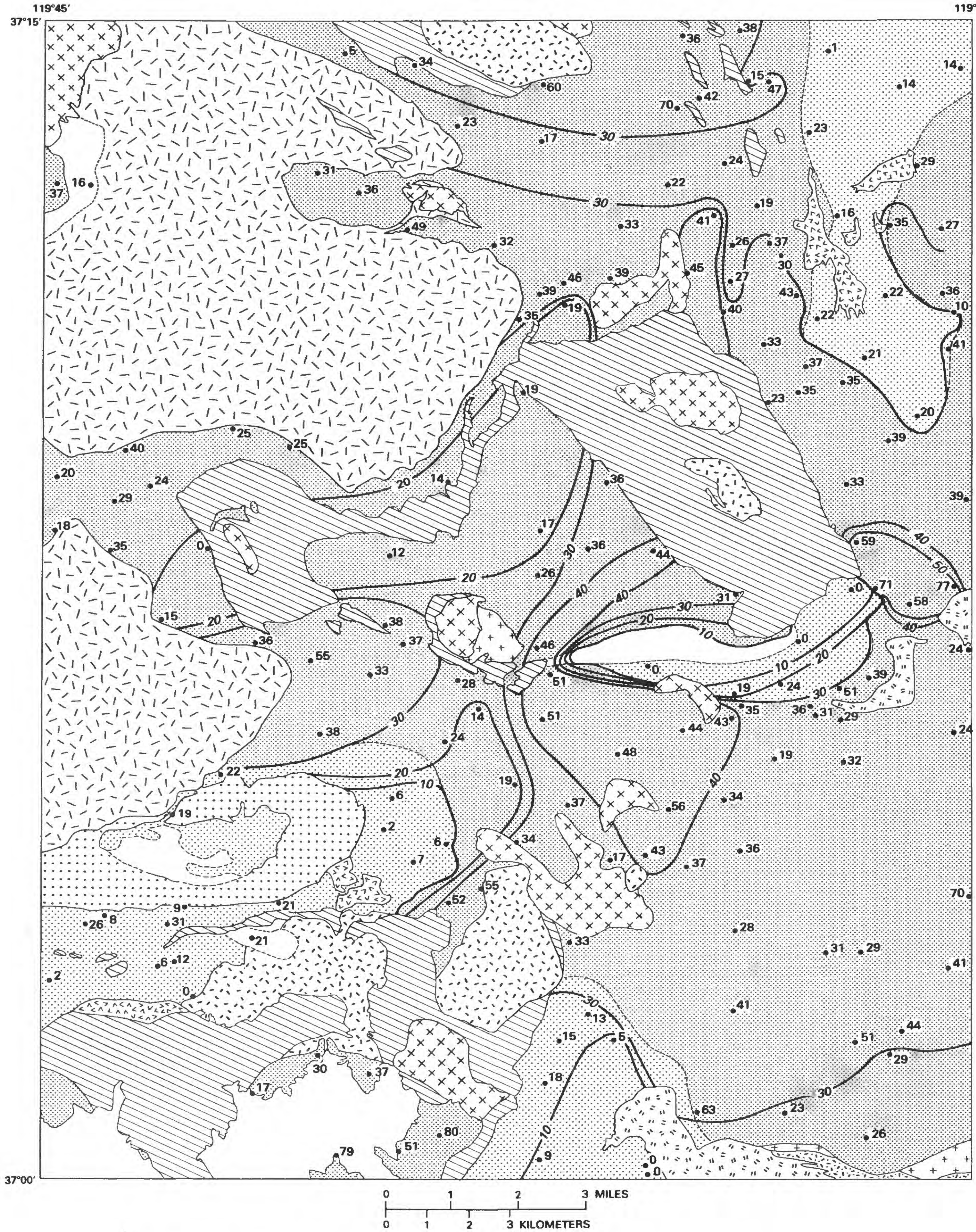


FIGURE 8.—Millerton Lake quadrangle showing $\frac{100 \text{ hornblende}}{\text{biotite} + \text{hornblende}}$. Explanation in figure 1.

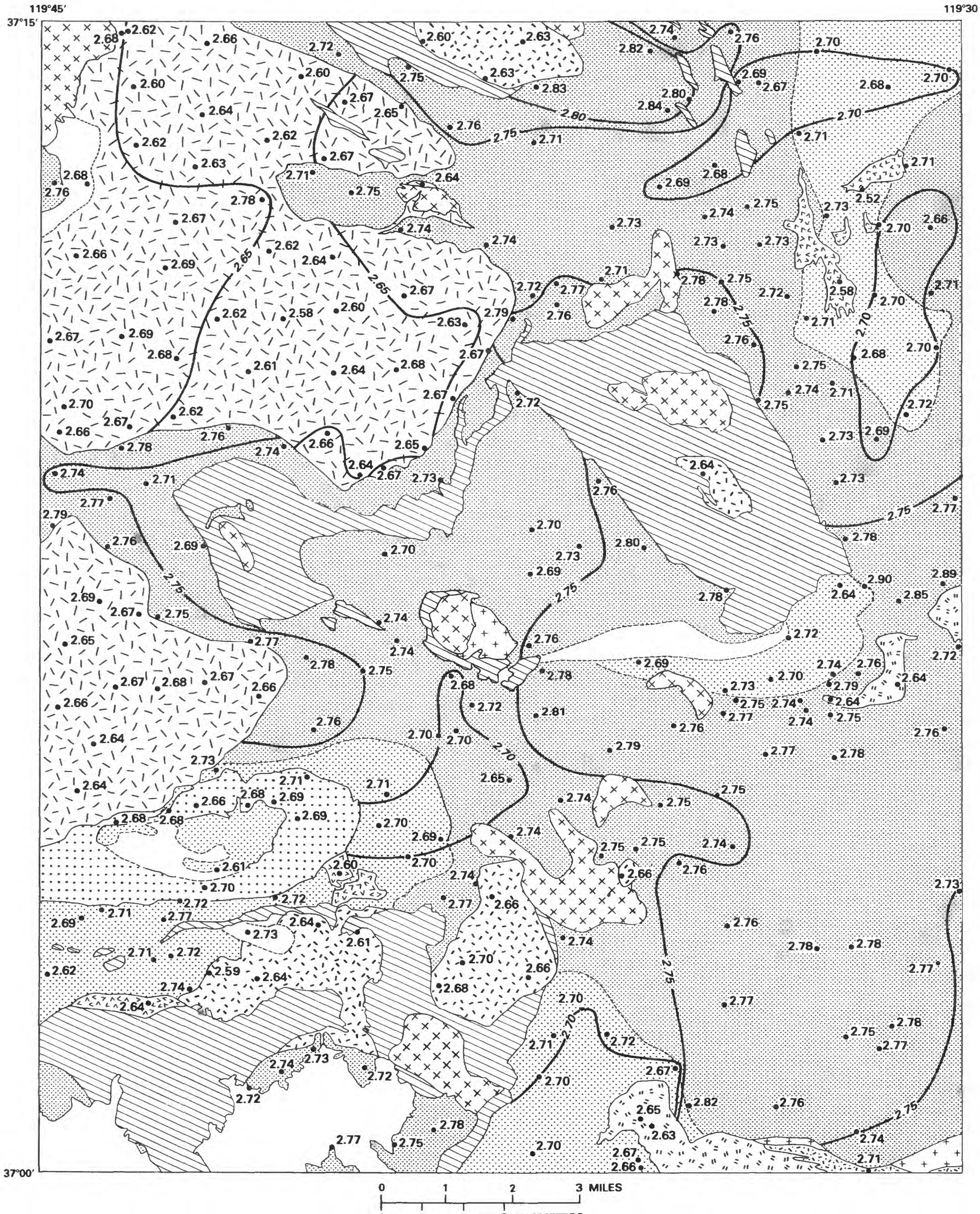


FIGURE 9.—Millerton Lake quadrangle showing bulk specific gravity. Explanation in figure 1.

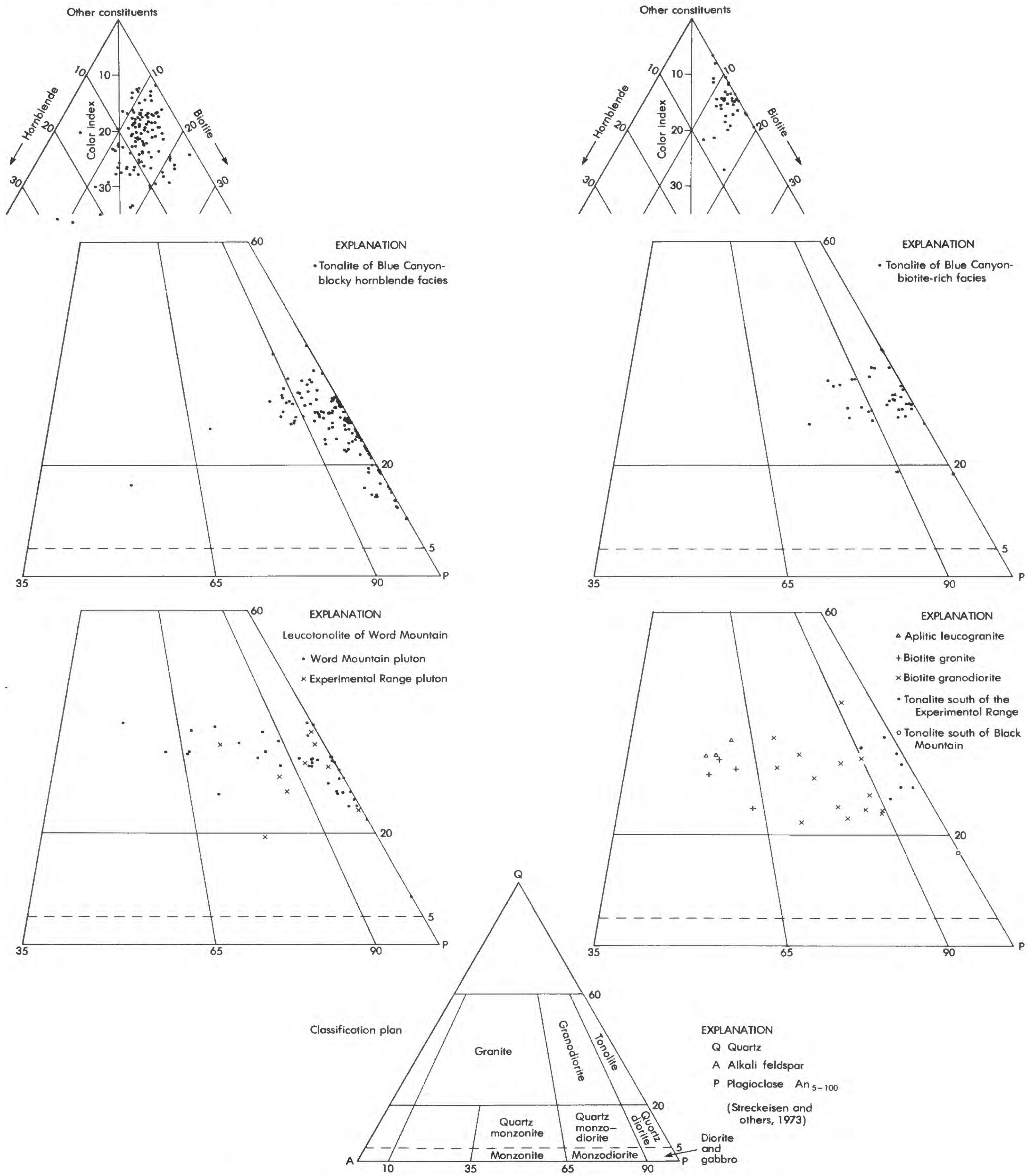


FIGURE 10.—Plots of modes of granitic rocks. Classification plan by Streckeisen (1973).

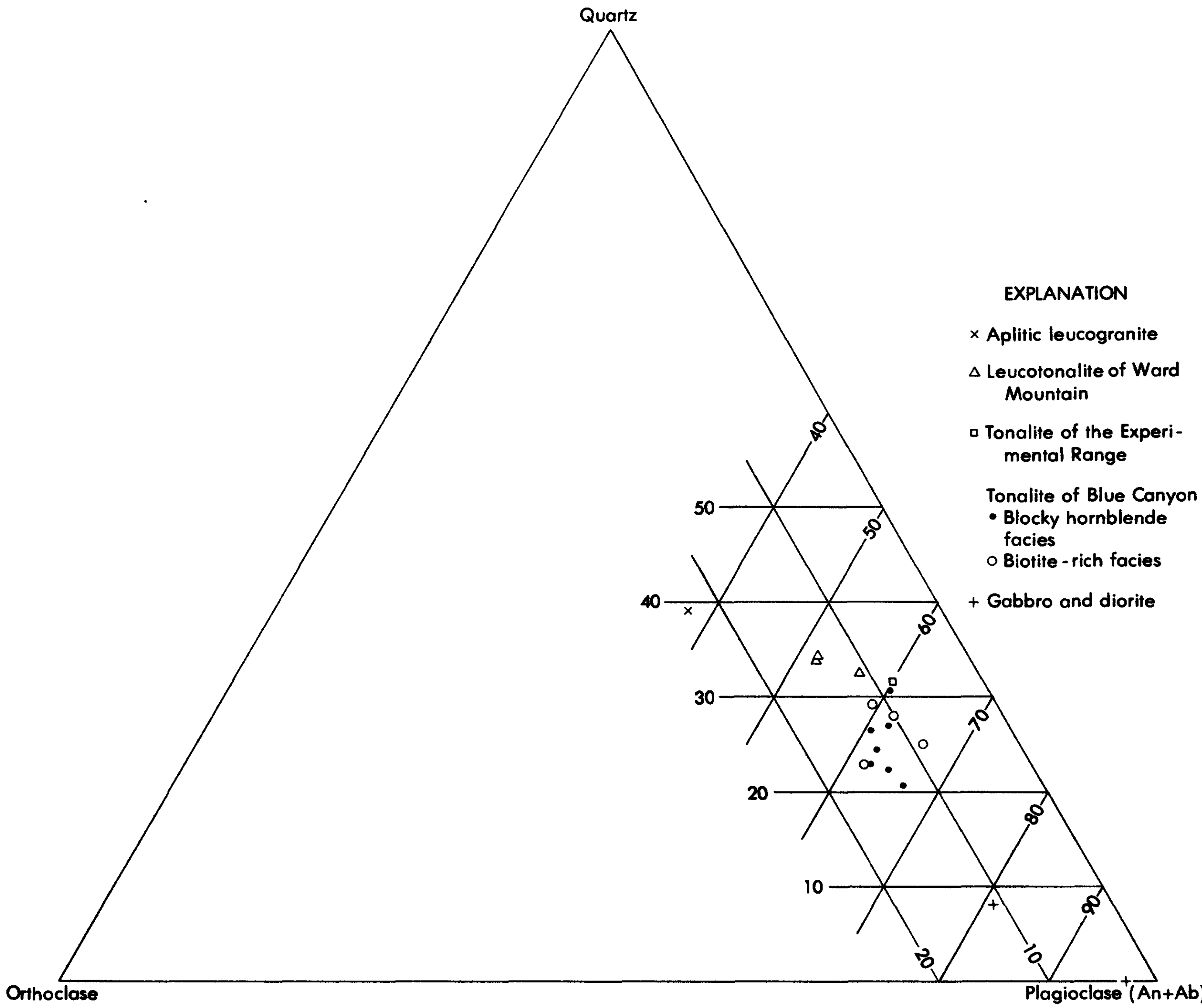


FIGURE 11.—Plot of norms of granitic rocks.

TABLE 1.—*Chemical analyses, norms,*

[Rapid rock chemical analyses in weight percent; analyst, H. Smith, under the supervision of Floyd Brown. CIPW norms in weight percent. Modes in volume percent; felsic minerals and total apportioning counts on thin sections to total mafic

	Tonalite of Blue Canyon											Tonalite of the Experimental Range
	Blocky hornblende facies								Biotite-rich facies			
Sample	MLa-19	MLb-6	MLb-12	MLb-69	MLc-30	MLc-154	MLd-9	MLd-52	MLc-10	MLd-27	MLd-59	MLc-45
						Chemical analyses						
SiO_2	64.3	65.0	46.8	63.6	65.0	65.7	61.6	61.6	67.2	66.4	63.3	68.8
Al_2O_3	16.5	16.7	21.3	16.9	16.6	16.5	17.0	16.9	16.7	16.7	16.3	16.8
Fe_2O_3	.82	1.2	1.0	1.1	.76	.97	1.8	2.0	.79	1.0	1.1	.77
FeO	4.1	3.6	7.2	4.0	2.8	3.0	3.9	3.8	2.6	3.0	3.9	2.2
MgO	2.6	2.1	5.7	2.3	2.5	1.8	2.6	2.6	1.5	1.4	2.0	.93
CaO	5.0	5.0	11.4	5.4	5.2	4.8	5.9	6.0	4.2	4.4	4.5	3.8
Na_2O	3.4	3.5	2.1	3.3	3.1	3.6	3.5	3.2	3.9	4.0	3.7	4.3
K_2O	1.9	1.6	.38	2.1	1.3	1.9	1.8	1.9	1.7	1.5	2.1	1.3
H_2O+	.84	.89	1.6	.81	1.0	.83	.80	.93	.70	.66	.73	.23
H_2O-	.04	.00	.15	.08	.14	.05	.08	.04	.08	.18	.13	.49
TiO_2	.64	.68	1.3	.62	.41	.53	.88	.84	.47	.41	.55	.38
P_2O_5	.17	.17	.15	.15	.12	.15	.21	.21	.16	.18	.20	.15
MnO	.07	.06	.09	.06	.05	.05	.07	.08	.05	.06	.08	.03
CO_2	.01	.02	.08	.06	.02	.02	.02	.01	.02	.04	.00	.01
Sum	100	100	100	100	99	100	100	100	100	100	99	100
						CIPW norms						
Q	20.48	23.11	21.56	19.52	25.73	23.21	17.03	18.22	25.72	24.74	19.62	28.45
C	.19	.57	--	.00	.97	.20	.00	.00	1.24	.94	.24	1.79
or	11.23	9.46	7.76	12.41	7.68	11.23	10.64	11.23	10.05	8.95	12.70	7.68
ab	28.77	29.61	34.18	27.92	26.23	30.46	29.61	27.08	33.00	34.17	32.04	36.38
an	23.63	23.57	23.73	25.10	24.89	22.71	25.36	26.14	19.66	20.85	21.51	17.81
di	.00	.00	.22	.27	.00	.00	1.97	1.79	.00	--	--	.00
hy	12.40	9.84	9.61	11.12	10.16	8.41	9.86	9.69	7.17	7.68	10.72	5.15
ol	--	--	--	--	--	--	--	--	--	--	--	--
mt	1.19	1.74	1.61	1.60	1.10	1.41	2.61	2.90	1.15	1.46	1.63	1.12
il	1.22	1.29	.96	1.18	.78	1.01	1.67	1.60	.89	.79	1.07	.72
ap	.40	.40	.38	.36	.28	.36	.50	.50	.38	.43	.49	.36
cc	.02	.05	--	.14	.05	.05	.05	.02	.05	--	--	.05
Total	99.53	99.64	100.01	99.62	97.87	99.05	99.30	99.17	99.31	100.01	100.02	99.48
						Modes						
Quartz	18	26	21	24	25	23	21	16	27	31	15	31
Potassium feldspar	1	.5	0	.5	0	1	1	1	3	0	7	1
Plagioclase	55	56	58	51	55	57	58	53	55	54	57	57
Biotite	17	14	13	20	14	13	13	16	14	14	[1]22	11
Hornblende	7	3	8	5	6	6	6	12	1	1		0
Total	98	99	100	100	100	100	99	98	100	100	101	100
Bulk specific gravity	2.77	2.75	2.73	2.76	2.73	2.75	2.78	2.78	2.71	2.70	2.74	2.69

[1]Sum of mafic minerals

and modes of representative granitoids

mafic minerals determined by counting 1,000 to 2,000 points on selectively stained slabs of at least 70-cm² area—analyst, Oleg Polovtzoff; hornblende and biotite determined by minerals—analyst, Alan Busacca. nd, not determined]

Leucotonalite of Ward Mountain			Aplitic leuco-granite	Hornblende gabbro		Tonalite of the Experimental Range	Leucotonalite of Ward Mountain			Aplitic leuco-granite	Hornblende gabbro	
MLa-12	MLc-43	SJ-1	MLc-84	MLb-10	MLc-77	MLc-45	MLa-12	MLc-43	SJ-1	MLc-84	MLb-10	MLc-77
						Chemical analyses--Continued						
72.1	70.4	70.9	74.8	46.8	53.9	68.8	72.1	70.4	70.9	74.8	46.8	53.9
15.9	16.1	16.2	14.4	21.3	17.5	16.8	15.9	16.1	16.2	14.4	21.3	17.5
.48	.46	.27	.91	1.0	.8	.77	.48	.46	.27	.91	1.0	.8
1.1	1.4	1.3	.68	7.2	6.6	2.2	1.1	1.4	1.3	.68	7.2	6.6
.58	.61	.73	.32	5.7	4.5	.93	.58	.61	.73	.32	5.7	4.5
2.5	3.0	2.3	1.2	11.4	7.5	3.8	2.5	3.0	2.3	1.2	11.4	7.5
4.4	4.5	4.3	3.6	2.1	3.2	4.3	4.4	4.5	4.3	3.6	2.1	3.2
2.2	1.7	2.2	3.7	.38	1.3	1.3	2.2	1.7	2.2	3.7	.38	1.3
.61	.75	.16	.64	1.6	1.9	.23	.61	.75	.16	.64	1.6	1.9
.05	.05	.75	.05	.15	.19	.49	.05	.05	.75	.05	.15	.19
.24	.27	.22	.15	1.3	1.2	.38	.24	.27	.22	.15	1.3	1.2
.16	.14	.04	.07	.15	.35	.15	.16	.14	.04	.07	.15	.35
.03	.03	.03	.04	.09	.10	.03	.03	.03	.03	.04	.09	.10
.02	.02	.05	.03	.08	.10	.01	.02	.02	.05	.03	.08	.10
100	99	99	101	99	99	100	100	99	99	101	99	99
						CIPW norms--Continued						
31.79	30.02	31.19	36.79	--	5.44	28.45	31.79	30.02	31.19	36.79	--	5.44
2.17	1.78	2.70	2.53	--	--	1.79	2.17	1.78	2.70	2.53	--	--
13.00	10.05	13.20	21.86	2.31	7.93	7.68	13.00	10.05	13.20	21.86	2.31	7.93
37.23	38.08	36.94	30.46	18.24	27.93	36.38	37.23	38.08	36.94	30.46	18.24	27.93
11.23	13.84	11.32	5.31	48.83	30.48	17.81	11.23	13.84	11.32	5.31	48.83	30.48
.00	.00	.00	.00	6.73	4.57	.00	.00	.00	.00	.00	6.73	4.57
2.73	3.32	3.73	1.12	12.85	19.28	5.15	2.73	3.32	3.73	1.12	12.85	19.28
--	--	--	--	6.66	--	--	--	--	--	--	6.66	--
.70	.67	.40	1.32	1.49	1.20	1.12	.70	.67	.40	1.32	1.49	1.20
.46	.51	.42	.29	2.53	2.35	.72	.46	.51	.42	.29	2.53	2.35
.38	.33	.96	.17	.36	.86	.36	.38	.33	.96	.17	.36	.86
.05	.05	.00	.07	--	--	.05	.05	.05	.00	.07	--	--
99.74	98.65	100.86	99.92	100.00	100.04	99.48	99.74	98.65	100.86	99.92	100.00	100.04
						Modes--Continued						
34	31	26	35	nd	nd	31	34	31	26	35	nd	nd
6	4	10	24	nd	nd	1	6	4	10	24	nd	nd
53	58	60	36	nd	nd	57	53	58	60	36	nd	nd
7	7	5	5	nd	nd	11	7	7	5	5	nd	nd
0	0	0	0	nd	nd	0	0	0	0	0	nd	nd
100	100	101	100	nd	nd	100	100	100	101	100	nd	nd
2.67	2.67	2.64	2.64	nd	nd	2.69	2.67	2.67	2.64	2.64	nd	nd

TABLE 2.—*U-Pb age determinations on zircon from granitoids*

[From Stern and others, 1981, table 1]

Sample	Rock Unit	Ages (m.y.)			Parts per million			Atomic ratios		
		$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{208}Pb/^{232}Th$	Pb	U	Th	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
MLa-12	Leucotonalite of Ward Mountain---	114.8	112.6	---	86.97	1556.2	~114.2	0.81137	0.35868	0.02112
MLb-69	Tonalite of Blue Canyon----------	114.3	113.9	76.3	7.12	372.3	138.9	.13709	.070198	.00150
MLc-51	---------------do----------------	110.3	105.2	99.8	4.13	218.2	46.5	.14391	.07768	.00216
MLc-154	---------------do----------------	115.1	120.8	112.0	4.24	222.1	57.2	.13467	.07152	.00141
MLd-52	---------------do----------------	112.3	112.4	117.3	3.80	194.5	47.3	.16131	.07930	.00211
MLc-10	Tonalite of Blue Canyon, biotite-rich facies-------------------	123.6	119.4	120.1	5.06	234.8	57.71	.15999	.07919	.00220