Tuolumne Meadows Quadrangle, California—Analytic Data

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Tuolumne Meadows Quadrangle, California—Analytic Data

By PAUL C. BATEMAN, BRUCE W. CHAPPELL,
RONALD W. KISTLER, DALLAS L. PECK, and ALAN BUSACCA

Modal, chemical, and isotopic data
for the granitic rocks of the
Tuolumne Meadows quadrangle

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By Paul C. Bateman, Bruce W. Chappell, Ronald W. Kistler, Dallas L. Peck, *and* Alan Busacca

Abstract

This report presents modal, chemical, and isotopic data for the intrusive rocks of the Tuolumne Meadows quadrangle in the high central Sierra Nevada, California, and supplements the previously published geologic map of the quadrangle. Most of the quadrangle is underlain by plutonic rocks of the compositionally and texturally zoned early Late Cretaceous Tuolumne Intrusive Suite. The data show that both compositions and initial $^{87}Sr/^{86}Sr$ change systematically inward from the margins of the Tuolumne Intrusive Suite as the rocks become more felsic. The greatest changes are within 1 to 2 km of the margins. Metamorphic rocks and late Early Cretaceous plutonic rocks border the Tuolumne Intrusive Suite in the northwestern, northeastern, and southeastern parts of the quadrangle.

INTRODUCTION

The Tuolumne Meadows quadrangle (fig. 1) is in the glaciated high Sierra Nevada, largely in the northeastern part of Yosemite National Park, but a small area of about 30 km^2 in the northeast corner lies east of the Sierran crest in the Inyo National Forest. The Tioga Road (California State Highway 120), a main thoroughfare across the Sierra Nevada, crosses the quadrangle, and numerous trails lead from the Tioga Road into the back country.

This report is designed to supplement the geologic map of the Tuolumne Meadows quadrangle (Bateman and others, 1983) by bringing together the analytic data currently available on the rocks of the quadrangle. The Tuolumne Intrusive Suite, which occupies most of the quadrangle, is of special interest because it is an excellent example of a typical intrusive suite (as cited in the North American stratigraphic code, North American Commission on Stratigraphic Nomenclature, 1983), and because easy access, excellent exposures, clearly established units, and relatively abundant high-grade analytic data already available make the suite an attractive subject for further study.

Much of the chemical data on the Tuolumne Intrusive Suite included herein have been published in an earlier report by Bateman and Chappell (1979), and all of the available isotopic data were previously published by Kistler and others (1986). However, some chemical data and most of the modal data in this report have not been published previously. Not included here are rare-earth element data published by Frey and others (1978) and U-Pb ages of zircon from rocks of the Tuolumne Intrusive Suite published by Stern and others (1981). However, a map showing the distribution of joints within the quadrangle is included.

The data are presented in tables and in diagrams that relate the locations of samples to the mapped geologic units. The accompanying text contains brief descriptions of the rocks and other geologic features of the quadrangle. Models for the origin of the zonation in the Tuolumne Intrusive Suite have been published by Frey and others (1978), Bateman and Chappell (1979), Reid and others (1983), and Kistler and others (1986).

GEOLOGIC SUMMARY

The Late Cretaceous Tuolumne Intrusive Suite, a nested suite of plutonic rocks, occupies most of the Tuolumne Meadows quadrangle (fig. 2). Somewhat older, mostly late Early Cretaceous, granitic rocks flank the Tuolumne Intrusive Suite in the northwestern and southern parts of the quadrangle, and metamorphosed sedimentary and volcanic rocks bound it in the northeastern part. Metasedimentary septa are present locally along contacts between the Tuolumne Intrusive Suite and the older granitoids in the northwestern and southeastern parts.

The Tuolumne Intrusive Suite comprises several concentrically arranged units that are progressively younger and more felsic inward. Within the Tuolumne Meadows quadrangle, the tonalite of Glen Aulin is the outermost unit on the west, and the granodiorite of Kuna Crest is the outermost unit on the east. Successively inward from these rocks are the equigranular facies of the Half Dome Granodiorite, the megacrystic facies of the Half Dome Granodiorite, the Cathedral Peak Granodiorite, and the Johnson Granite Porphyry. Generally, contacts between units are sharp and intrusive, but the equigranular facies of the Half Dome Granodiorite grades to the megacrystic facies in most places.

The rocks of the Tuolumne Intrusive Suite intruded all of the rocks with which they are in contact and are among the youngest granitic rocks in the central Sierra

Nevada. U-Pb isotopic ages range from 86 to 91 m.y. (million years) (Stern and others, 1981). Compositional and textural changes within the suite have been described in detail by Bateman and Chappell (1979), and only a few pertinent relations are summarized here. In general, the marginal rocks are fine grained and dark colored, and the rocks become coarser grained and lighter colored inward within the suite. However, the Johnson Granite Porphyry in the core of the suite is fine grained. Exceptions to the general inward increase of grain size are inward decreases in the sizes of biotite and hornblende crystals within the megacrystic facies of the Half Dome Granodiorite and the Cathedral Peak Granodiorite and of alkali-feldspar megacrysts within the Cathedral Peak Granodiorite.

Compositional and textural changes are greatest in the outer part of the intrusive suite, within 1 to 2 km of the outer contact. Changes take place both within units and at contacts between units. Each of the units represents a magmatic surge. Where a surge has removed little of the adjacent older unit, changes are very nearly gradational across the contact, but where the magmatic surge was transgressive and removed a significant part of an earlier unit, abrupt compositional and textural changes can occur at the contact. Traverses A–B and C–D (fig. 2) are located where little material was removed at contacts. Along these traverses, textural and compositional changes are almost entirely within units; abrupt compositional and textural changes occur only at the contact of the Johnson Granite Porphyry with the Cathedral Peak Granodiorite, which is sharp everywhere.

The plutonic rocks that predate the Tuolumne Intrusive Suite in the northwestern part of the quadrangle are mostly biotite granites (table 7; fig. 16). Kistler and others (1986) interpreted the Yosemite Creek Granodiorite of Rose (1957) to be an early member of the Tuolumne Intrusive Suite. Compositional and textural similarities and Rb-Sr whole-rock dating (R.W. Kistler, unpub. data) indicate that the granodiorite of Double Rock and the granodiorite of Mount Hoffman are correlative with the El Capitan Granite, and that the leucogranite of Ten Lakes is correlative with the Taft Granite. All of these units crop out to the west and southwest in the Hetch Hetchy Reservoir and Yosemite quadrangles (fig. 1). The El Capitan Granite and the Taft Granite are cogenetic and have isotopic ages of about 102 m.y. (Stern and others, 1981).

In the southeast corner of the quadrangle, the granites of Turner Lake and Ireland Lake and the leucogranite of Gallison Lake are small bodies of felsic rocks, whereas the more extensive granodiorite of Red Devil Lake contains 5 to 10 percent mafic minerals (table 7; fig. 17). The granites of Ireland Lake and Turner Lake and the granodiorite of Red Devil Lake are intruded by units of the Tuolumne Intrusive Suite. The granodiorite of Red Devil Lake, which has a U-Pb age of 98 m.y. (Stern and others, 1981), intruded the granite of Gallison Lake and was intruded by the granite of Turner Lake.

A small mass of dark-colored quartz diorite lies along the western edge of the Tuolumne Intrusive Suite in the northwest quadrant, and two masses intrude metamorphic rocks in the southeast quadrant. In addition to these masses of quartz diorite, two masses of melagranite intrude metamorphic rocks in the northeast quadrant. The melagranite masses are probably hypabyssal equivalents of nearby metavolcanic rocks.

SAMPLING AND ANALYTIC METHODS

About 350 samples of representative, unaltered, plutonic rocks were collected from within the quadrangle (fig. 2). All of the samples were analyzed modally and their specific gravities determined (tables 4 to 7), 64 samples were analyzed chemically (tables 1 to 3), 52 samples were analyzed isotopically (tables 8 and 9), and the compositions of plagioclase in 45 samples were determined with a microprobe.

Sizes of samples were largest and modal determinations were carried out with the greatest care on the samples (underlined on figure 2) projected on traverses A–B and C–D (fig. 2). Samples projected on these traverses range in size from about 5 kg for the Johnson Granite Porphyry to 20 kg for the coarse-grained Cathedral Peak Granodiorite. Modes were determined by counting at least 2,000 equally spaced points on each of two slabs on which plagioclase was selectively stained red and alkali feldspar yellow. The areas of the slabs, except those of the fine-grained Johnson Granite Porphyry, exceed 150 cm^2. Amounts of biotite, hornblende, and accessory minerals, which cannot be distinguished on stained slabs, were determined from thin sections (at least two for each sample) and apportioned to the total mafic mineral content measured on slabs (tables 4 and 5). The percentages of alkali-feldspar megacrysts in the Cathedral Peak Granodiorite were determined on the adjacent outcrops for all samples projected on traverses A–B and C–D and about half of the other samples by counting 2,000 points spaced 2.54 cm (1 inch) apart on a square grid on a transparent overlay sheet.

Modal analyses of the samples not projected on traverses A–B and C–D were carried out in a similar way but with fewer counts on smaller slabs, and the proportions of biotite, hornblende, and accessory minerals generally were determined on single thin sections. For these samples, at least 1,000 regularly spaced points were counted on slabs having areas of 70 cm^2 or more to determine the volume percent of quartz, alkali feldspar, plagioclase, and total mafic minerals (color index) (tables 6 and 7).

Chemical analyses of the samples along traverses A–B and C–D and four other samples were determined at the Australian National University, chiefly by X-ray spectrometry under the direction of B.W. Chappell (tables 1 and 2). Eight samples from the Tuolumne Intrusive Suite were analyzed in the laboratories of the U.S. Geological Survey by X-ray spectrometry or the rapid rock method. No samples of pre-Tuolumne intrusive rocks were analyzed chemically. Plagioclase compositions of most samples projected on traverses A–B and C–D were determined with an electron microprobe by making 20 to 40 measurements on each sample to determine the range of zoning (fig. 13). Rb-Sr isotopic data for the samples along traverses A–B and C–D (tables 8 and 9; fig. 14) were determined by R.W. Kistler. Analytical methods for determining the isotopic data are described in detail in Kistler and others (1986).

MODAL DATA AND SPECIFIC GRAVITY

Modes and specific gravities for samples from the Tuolumne Intrusive Suite are listed in tables 4 to 6 and presented graphically on simplified geologic maps in figures 3 to 9. Modes are also plotted on Q–A–P diagrams in figure 15. The modes of samples projected on traverse A–B are also shown in profiles in figure 10. With the exception of hornblende, which is present in small amounts and distributed somewhat erratically, the modal percentages of minerals are contoured on the maps at 5-percent intervals. Specific gravity is contoured on figure 9 at intervals of 0.05. The maps (figs. 3–9) show that quartz and alkali feldspar increase inward in the suite, that hornblende, biotite, and specific gravity decrease, and that plagioclase is distributed irregularly. In most places, contours lie within the units rather than on contacts between them, but they follow contacts where magmatic surges have eliminated significant amounts of material.

Modal plots of samples from the Tuolumne Intrusive Suite (fig. 15) show that each of the units has its own field and that a composite field for the suite would be slightly curved, extending from the upper part of the quartz diorite field across the lower part of the granodiorite field and into the granite field. Most samples of the older granitoids in the northwestern and southeastern parts of the quadrangle plot in the granite field (fig. 16), but the granodiorite of Red Devil Lake plots in the granodiorite field.

Details of the modal changes within the Tuolumne Intrusive Suite are best shown by the samples along traverse A–B (fig. 10). The greatest changes occur within the outermost units, the tonalite of Glen Aulin and the granodiorite of Kuna Crest and the outer part of the equigranular facies of the Half Dome Granodiorite. Farther inward to the Johnson Granite Porphyry, modal changes are small. The amounts of quartz and alkali feldspar increase inward, and the amounts of plagioclase, biotite, and hornblende decrease. Specific gravity also decreases. Continued inward decrease of biotite and alkali feldspar across the megacrystic facies of the Half Dome Granodiorite differ somewhat from the pattern for other minerals.

Smaller amounts of quartz and alkali feldspar and larger amounts of plagioclase and hornblende in the outer part of the tonalite of Glen Aulin than in the granodiorite of Kuna Crest indicate that the west side of the suite began to solidify somewhat earlier than the east side.

MAJOR ELEMENTS

The major elements also show the greatest variations in the outer parts of the Tuolumne Intrusive Suite (fig. 11). SiO_2 and K_2O increase into the equigranular facies of the Half Dome Granodiorite, Al_2O_3 and CaO show a reciprocal relation to SiO_2 and K_2O, decreasing inward into the equigranular facies of the Half Dome Granodiorite, and remaining fairly constant inward to the Johnson Granite Porphyry, where they decrease abruptly. Fe_2O_3, FeO, and MgO also decrease into the equigranular facies of the Half Dome Granodiorite, but continue to decrease by smaller amounts into the Johnson Granite Porphyry. Na_2O behaves differently than any of the other major elements. In the west flank, it increases erratically inward to the megacrystic Half Dome Granodiorite, jumps to 4 weight percent or greater through the inner part of the Cathedral Peak Granodiorite, then decreases sharply into the Johnson Granite Porphyry. In the east flank, it increases inward into the outer part of the Cathedral Peak Granodiorite, remains constant across the Cathedral Peak Granodiorite, then decreases in the Johnson Granite Porphyry.

CIPW NORMS

CIPW norms are given in tables 1 to 3 and are plotted on a triangular quartz-plagioclase (albite + anorthite)-orthoclase diagram in figure 18. As with the modes, the different units plot in overlapping but discrete fields. The composite plot of norms in figure 18 forms an elongate field that shows no curvature, unlike the composite field of modes.

TRACE ELEMENTS

Trace-element abundances of samples projected on traverses A–B and C–D are given in tables 1 and 2, and those projected on traverse A–B are shown graphically in figure 12. The transition metals all decrease inward from the margins into the equigranular facies of the Half Dome Granodiorite, remain relatively constant across the megacrystic facies of the Half Dome and the Cathedral Peak Granodiorite, and decrease further in the Johnson Granite Porphyry. Lanthanum, rubidium, zirconium, lead, uranium, and thorium all increase inward near the margins of the suite but follow different patterns inward in the suite. Lanthanum rises inward into the equigranular facies of the Half Dome Granodiorite, but farther inward varies with cerium, remaining more or less constant into the Johnson Granite Porphyry, where the abundance of both elements is erratic. Rubidium, zirconium, and lead increase by small amounts inward in the tonalite of Glen Aulin, remain constant across the Half Dome and Cathedral Peak Granodiorites, and increase in the Johnson Granite Porphyry. Uranium and thorium increase inward in the tonalite of Glen Aulin, decrease across the Half Dome Granodiorite, remain constant across the Cathedral Peak Granodiorite, and decrease in the Johnson Granite Porphyry. The amounts of barium, strontium, and niobium, although variable, are grossly constant across the suite.

PLAGIOCLASE COMPOSITIONS

The anorthite content of plagioclase generally varies within crystals by about 15 to 20 percent, and both the maximum and the minimum anorthite contents decrease inward in the suite. The greatest decreases are in the outermost units, but decreases continue by lesser amounts inward into the Johnson Granite Porphyry (fig. 13). Along the west half of traverse A–B, the general compositional range decreases from An_{42} to An_{22}, in sample 1 in the outer part of the tonalite of Glen Aulin, to An_{21} to An_8, in sample 20 in the Johnson Granite Porphyry, and similar change occurs across the east flank. Determinations along traverse C–D, which crosses contacts between units at a small angle, show that compositions are nearly constant across both the equigranular and megacrystic facies of the Half Dome Granodiorite and decrease at the contact with the Cathedral Peak Granodiorite. Scattered determinations of larger amounts of anorthite than the general range within crystals denote lag in the separation of crystals formed at higher temperatures and (or) with smaller amounts of H_2O in the melt phase of the magma. Anorthite contents less than the general range probably represent late crystallization from interstitial melt except for plagioclase less than about An_8, which probably represents reequilibration to subsolidus temperatures.

STRONTIUM ISOTOPES

Strontium isotopic data for the samples projected on traverses A–B and C–D across the Tuolumne Intrusive Suite are given in tables 8 and 9 and shown graphically in figure 14. The data for samples along traverse A–B show that initial $^{87}Sr/^{86}Sr$ increases inward from the margin of the suite into the equigranular facies of the Half Dome Granodiorite. Farther inward, values remain approximately constant to the Johnson Granite Porphyry, where they may rise slightly. The total range of initial $^{87}Sr/^{86}Sr$ is 0.0009, from 0.7057 to 0.7066. Although the range of replicate analyses of individual samples is as much as 0.0003, the plot in figure 14 clearly shows that initial $^{87}Sr/^{86}Sr$ increases from about 0.7057 in the outer part of the tonalite of Glen Aulin to about 0.7064 in the middle of the equigranular facies of the Half Dome Granodiorite, that no significant changes take place farther inward to the Johnson Granite Porphyry, and that it probably rises to 0.7066 in the Johnson Granite Porphyry (the value obtained on three samples), even though this change is less than the range of replicate analyses.

JOINTS

The distribution of joints visible on aerial photographs is shown in figure 19. The most prominent set trends N. 20°–30° W. on the average, but many joints strike in other directions. The joints are continuous across contacts between different rocks. They reflect both regional stresses and stresses that accompanied cooling of the batholith during uplift and erosion.

REFERENCES CITED

Bateman, P.C., and Chappell, B.W., 1979, Crystallization, fractionation, and solidification of the Tuolumne Intrusive Series, Yosemite National Park, California: Geological Society of America Bulletin, Part I, v. 90, p. 465–482.

Bateman, P.C., Kistler, R.W., Peck, D.L., and Busacca, Alan, 1983, Geologic map of the Tuolumne Meadows quadrangle, Yosemite National Park, California: U.S. Geological Survey Geologic Quadrangle Map GQ–1570, scale 1:62,500.

Frey, F.A., Chappell, B.W., and Roy, S.D., 1978, Fractionation of rare-earth elements in the Tuolumne Intrusive Series, Sierra Nevada batholith, California: Geology, v. 6, p. 239–242.

Kistler, R.W., Chappell, B.W., Peck, D.L., and Bateman, P.C., 1986, Isotopic variations in the Tuolumne Intrusive Suite, central Sierra Nevada, California: Contributions to Mineralogy and Petrology, v. 94, p. 205–220.

North American Commission on Stratigraphic Nomenclature, 1983, North American stratigraphic code: The American Association of Petroleum Geologists Bulletin, v. 67, no. 5, p. 841–875.

Reid, J.B., Evans, O.C., and Fates, D.G., 1983, Magma mixing in granitic rocks of the Sierra Nevada, California: Earth and Planetary Science Letters, v. 66, p. 243–261.

Rose, R.L., 1957, Andalusite- and corundum-bearing pegmatites in Yosemite National Park, California: The American Mineralogist, v. 42, p. 635–647.

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., 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 1–19; TABLES 1–9

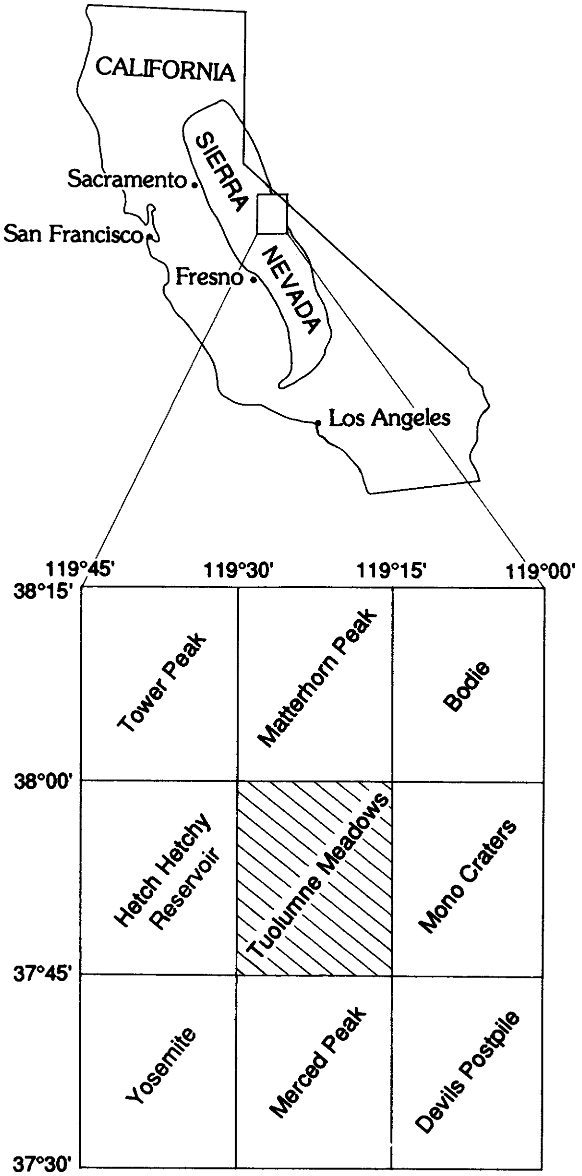


Figure 1. Index map showing locations of Tuolumne Meadows 15-minute quadrangle, California, and of contiguous 15-minute quadrangles.

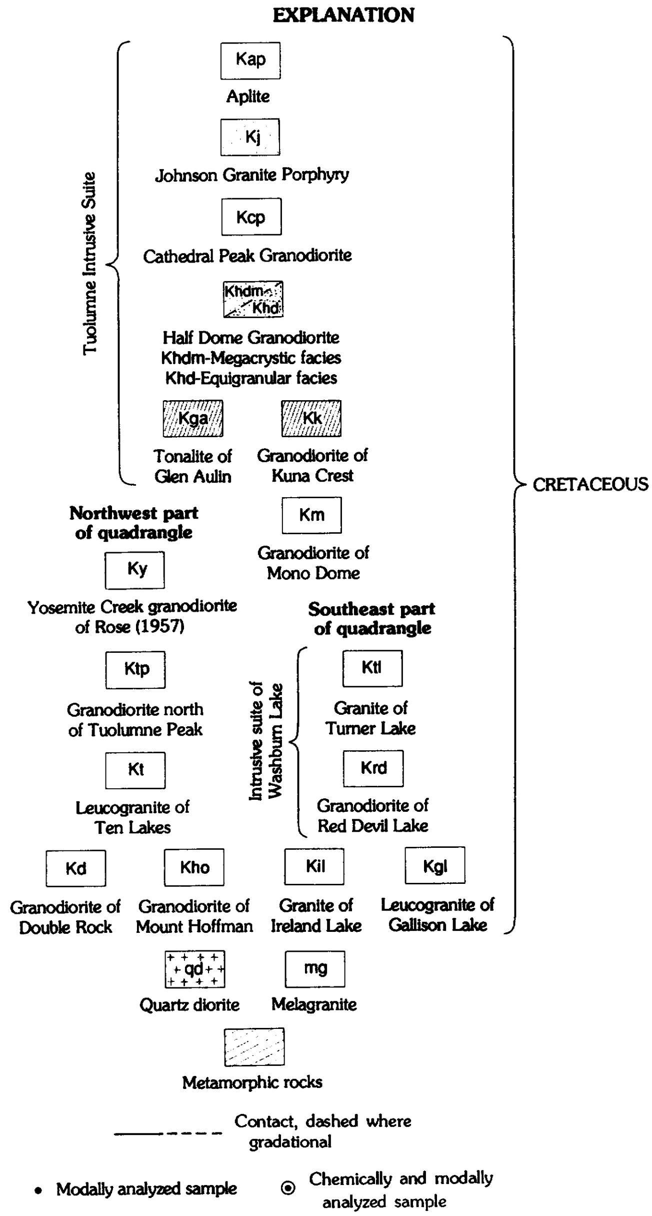
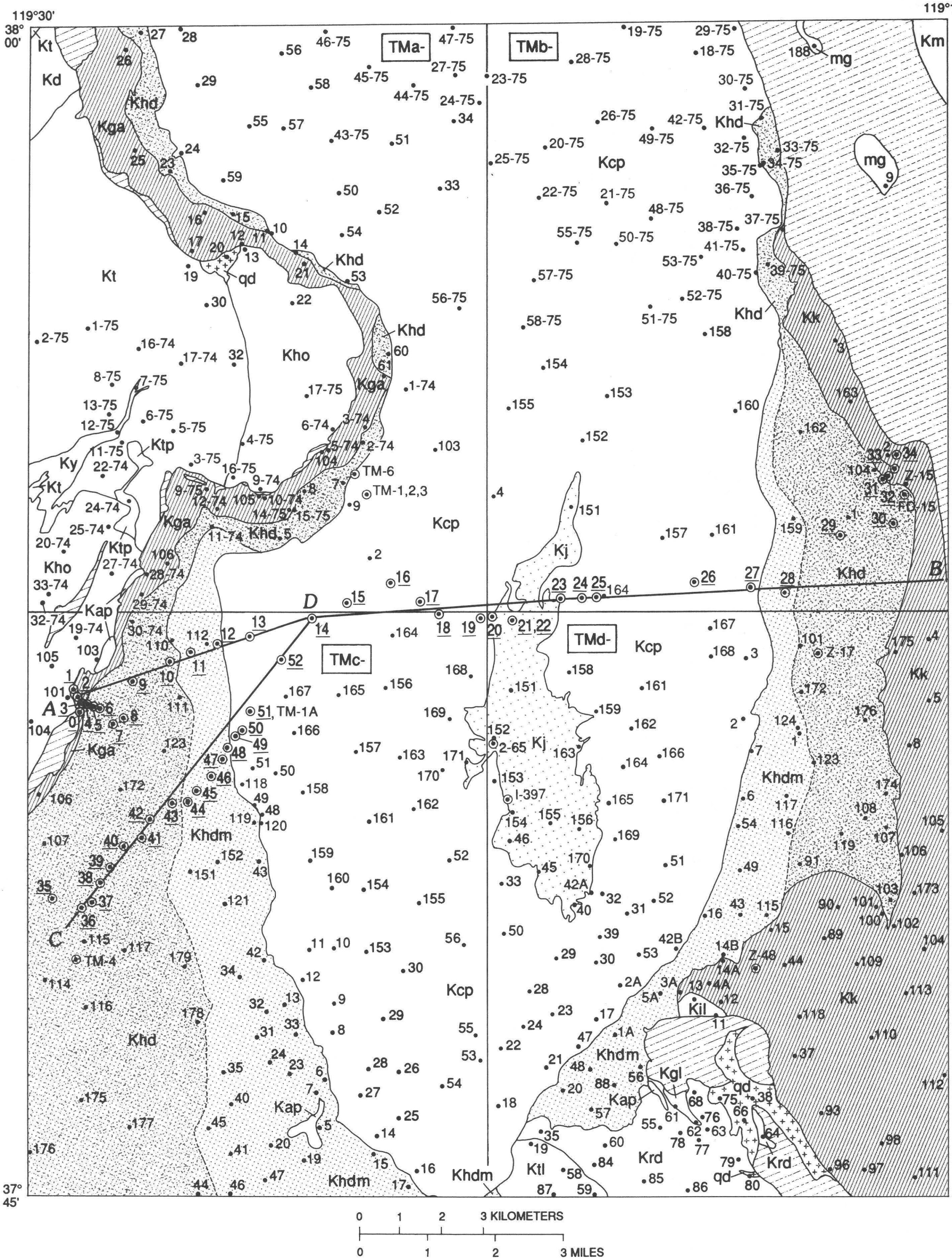


Figure 2. Generalized geologic map of the Tuolumne Meadows quadrangle showing locations of chemically and modally analyzed samples. Underlined numbers denote samples that are projected on traverses A–B and C–D (field numbers are prefixed with Z- in tables). Hyphenated sample numbers are prefixed with K- in tables. Letters shown in rectangular boxes at top of each quadrant (TMa-, for example) prefix other sample numbers within the quadrants.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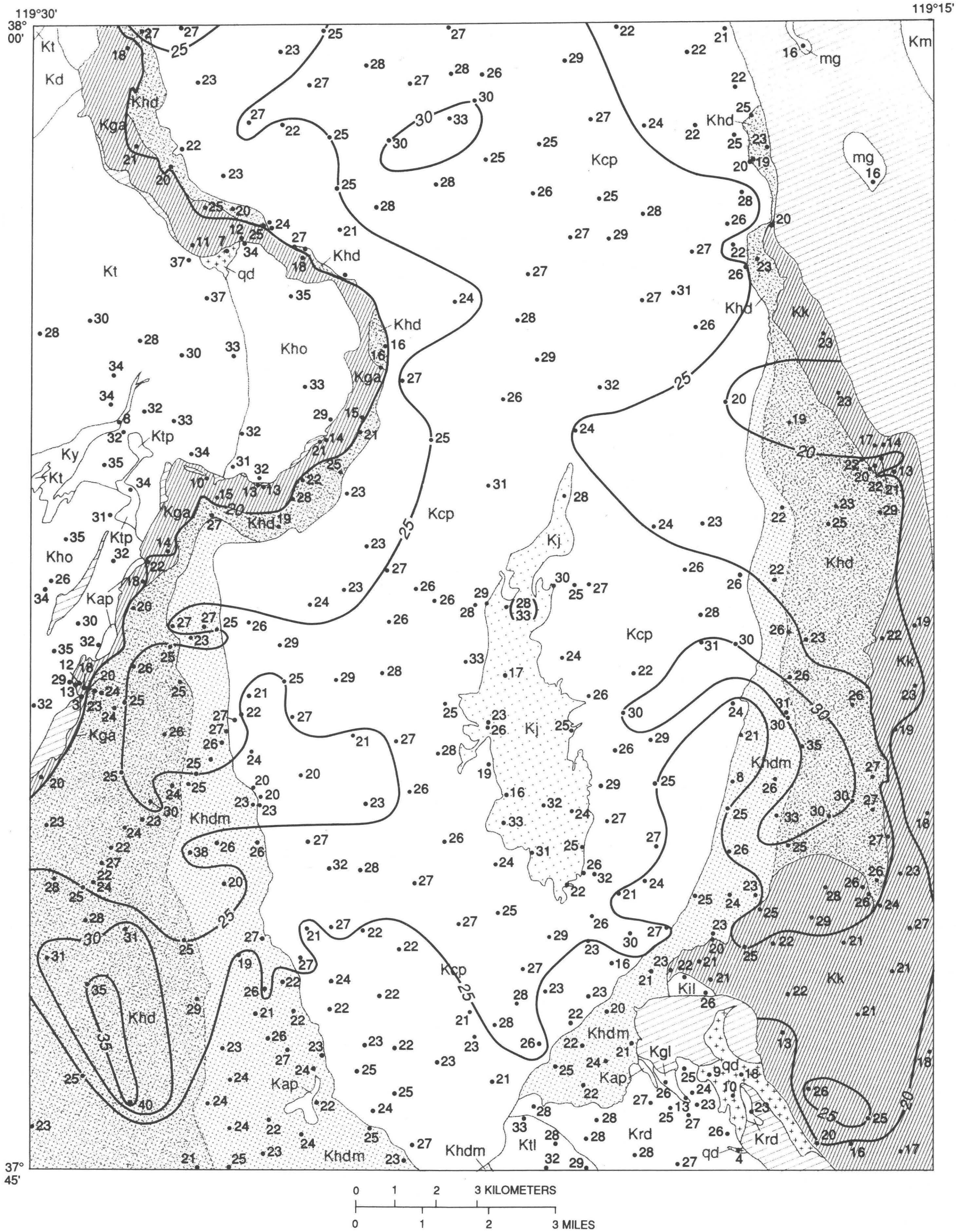


Figure 3. Generalized geologic map of Tuolumne Meadows 15-minute quadrangle showing volume-percent quartz at sample localities (dots). Isopleths (heavy lines) for Tuolumne Intrusive Suite at intervals of 5 percent. See figure 2 for explanation of geology.

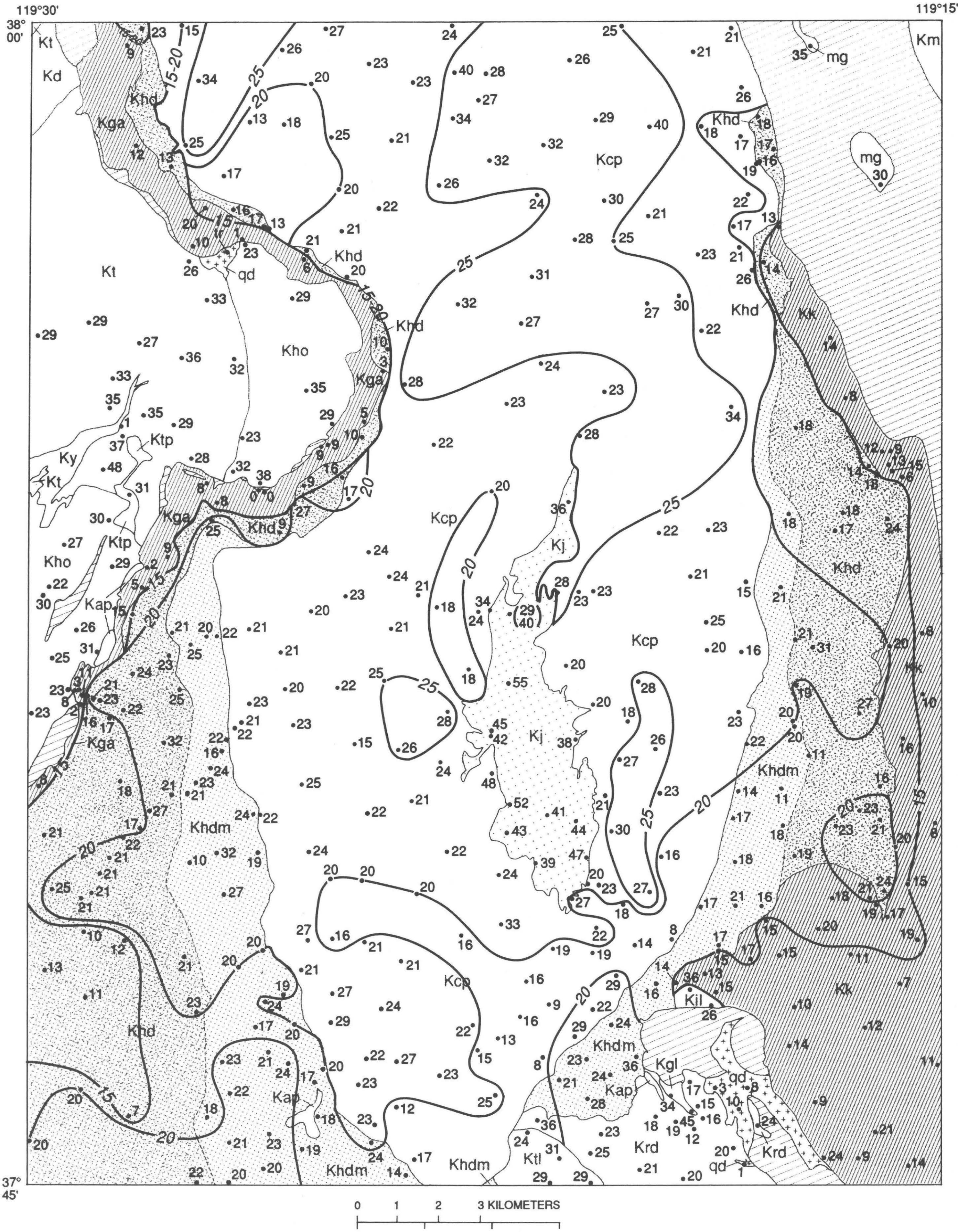


Figure 4. Generalized geologic map of Tuolumne Meadows quadrangle showing volume-percent alkali feldspar at sample localities (dots). Isopleths (heavy lines) for Tuolumne Intrusive Suite at intervals of 5 percent. See figure 2 for explanation of geology.

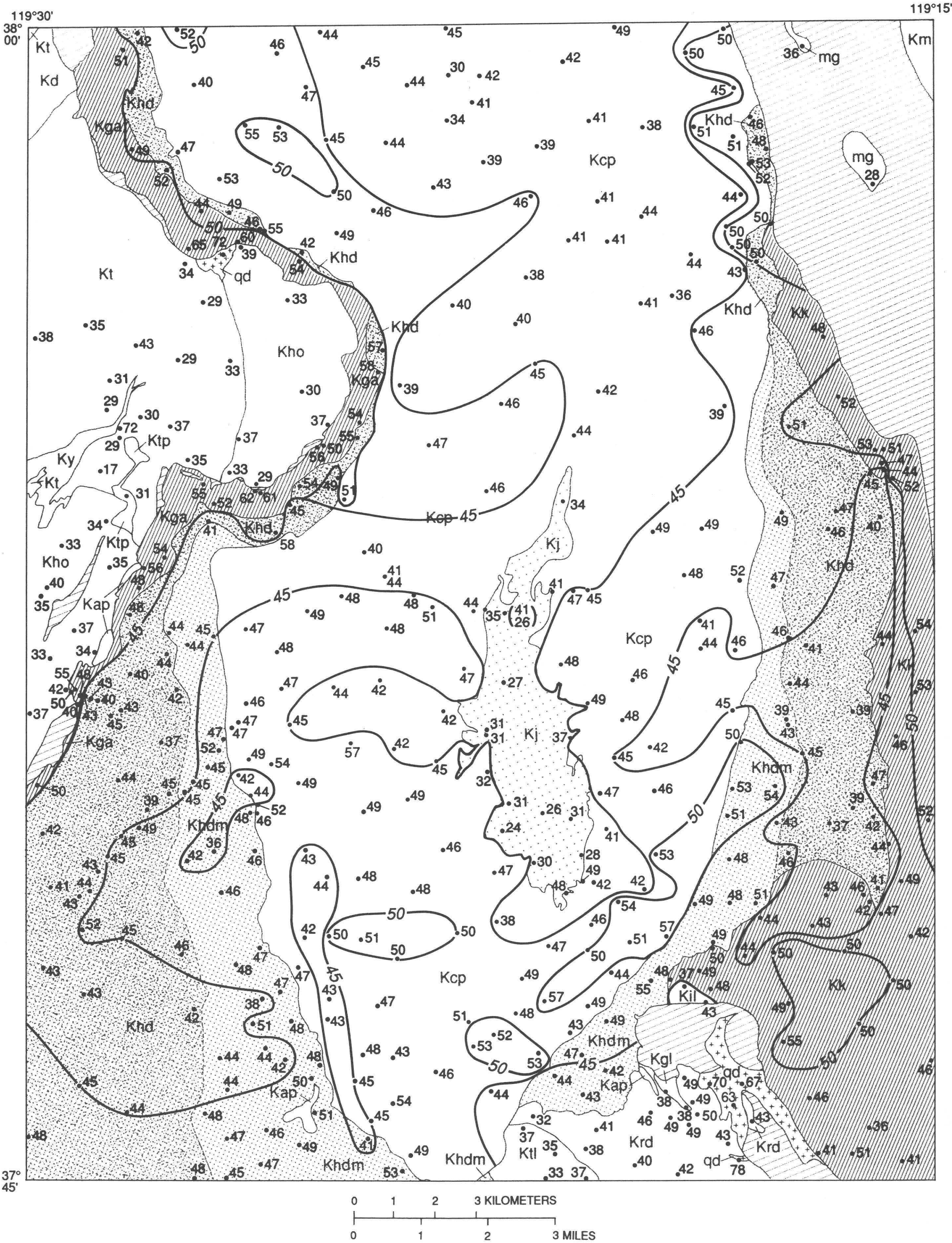


Figure 5. Generalized geologic map of Tuolumne Meadows quadrangle showing volume-percent plagioclase at sample localities (dots). Isopleths (heavy lines) for Tuolumne Intrusive Suite at intervals of 5 percent. See figure 2 for explanation of geology.

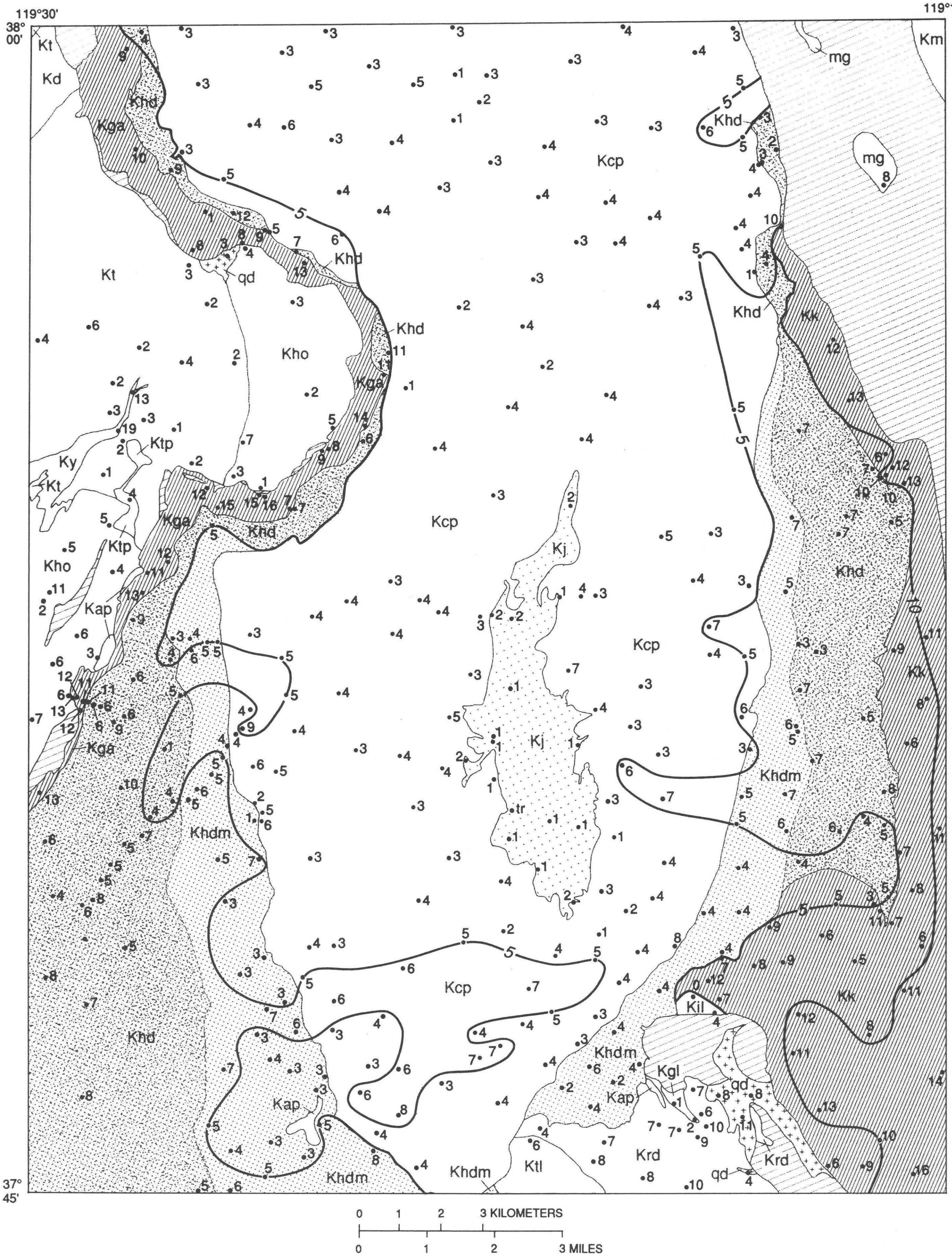


Figure 6. Generalized geologic map of Tuolumne Meadows quadrangle showing volume-percent biotite at sample localities (dots). Isopleths (heavy lines) for Tuolumne Intrusive Suite at intervals of 5 percent. See figure 2 for explanation of geology.

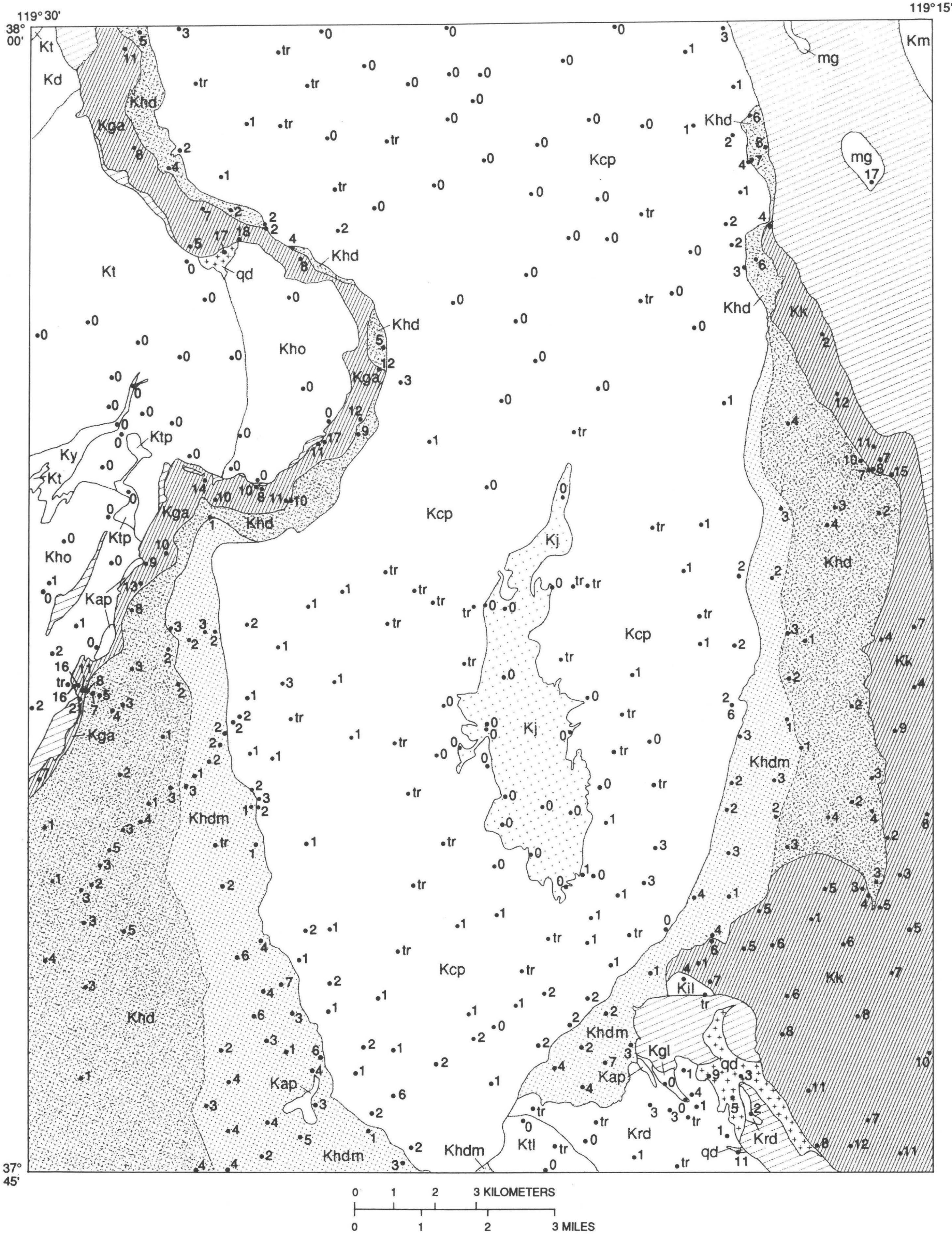


Figure 7. Generalized geologic map of the Tuolumne Meadows quadrangle showing volume-percent hornblende (tr, trace) at sample localities (dots). See figure 2 for explanation of geology.

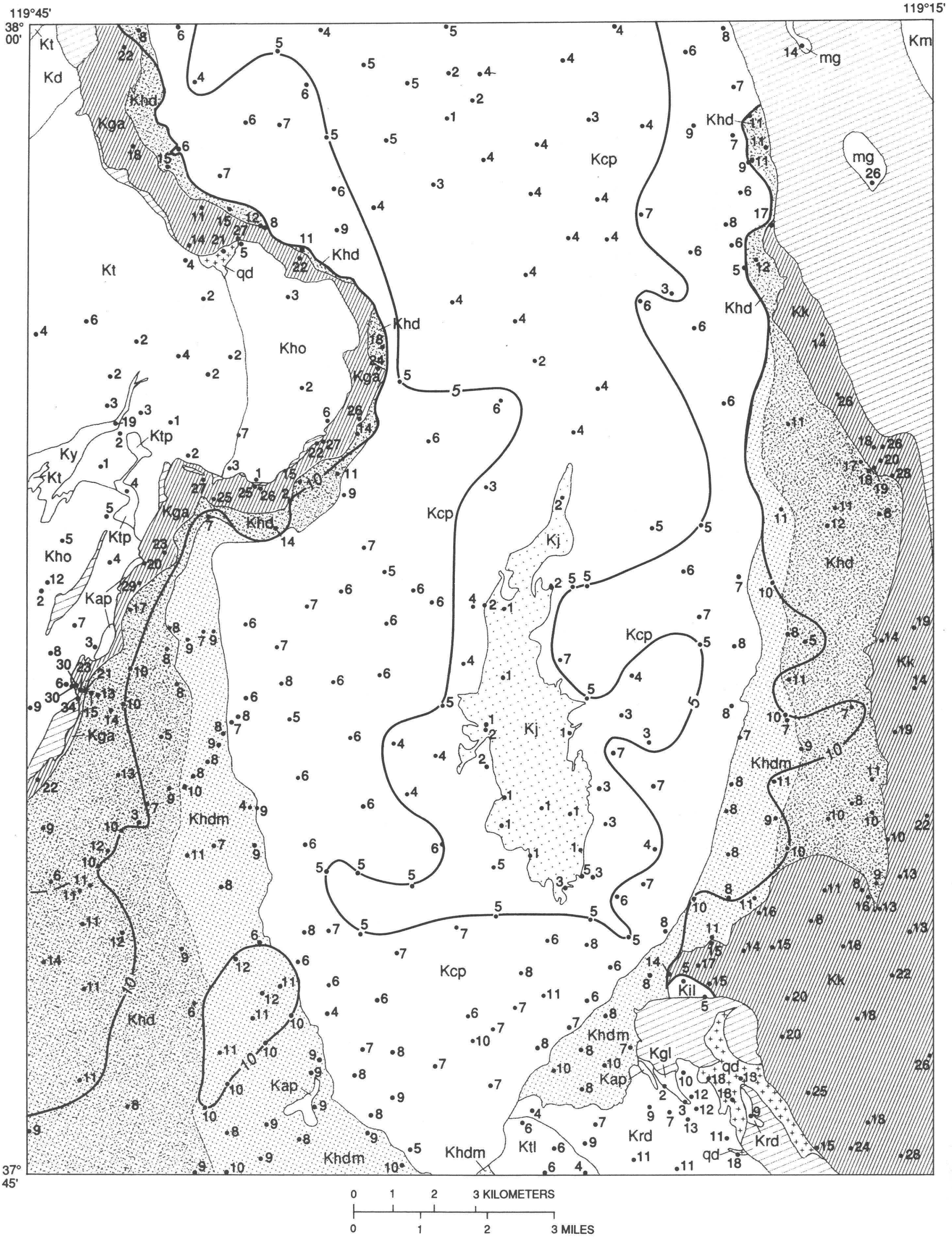


Figure 8. Generalized geologic map of the Tuolumne Meadows quadrangle showing volume-percent mafic and accessory minerals at sample localities (dots). Isopleths (heavy lines) for Tuolumne Intrusive Suite at intervals of 5 percent. See figure 2 for explanation of geology.

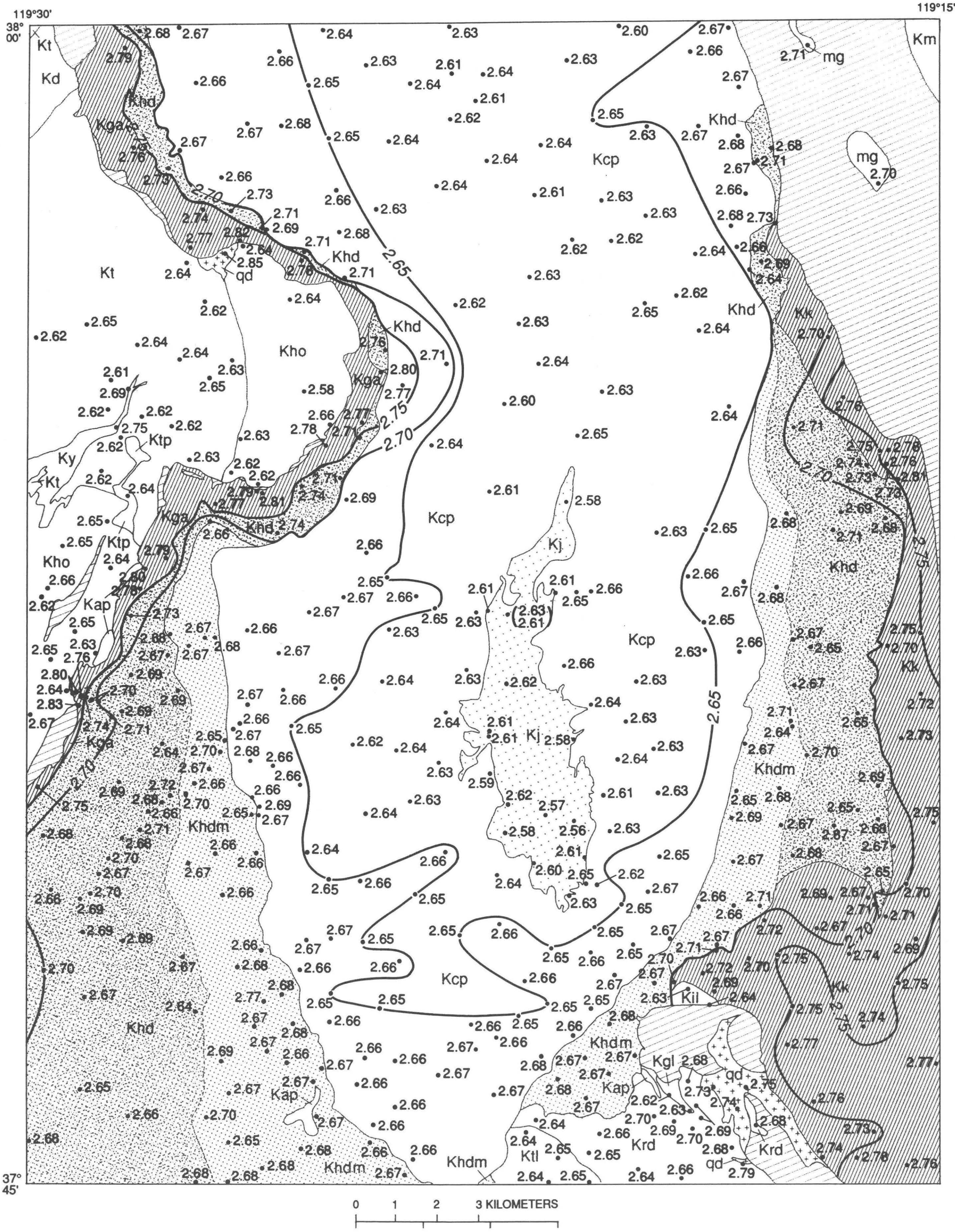


Figure 9. Generalized geologic map of Tuolumne Meadows quadrangle showing bulk specific gravity at sample localities (dots). Isopleths for Tuolumne Intrusive Suite (heavy lines) at intervals of 0.05. See figure 2 for explanation of geology.

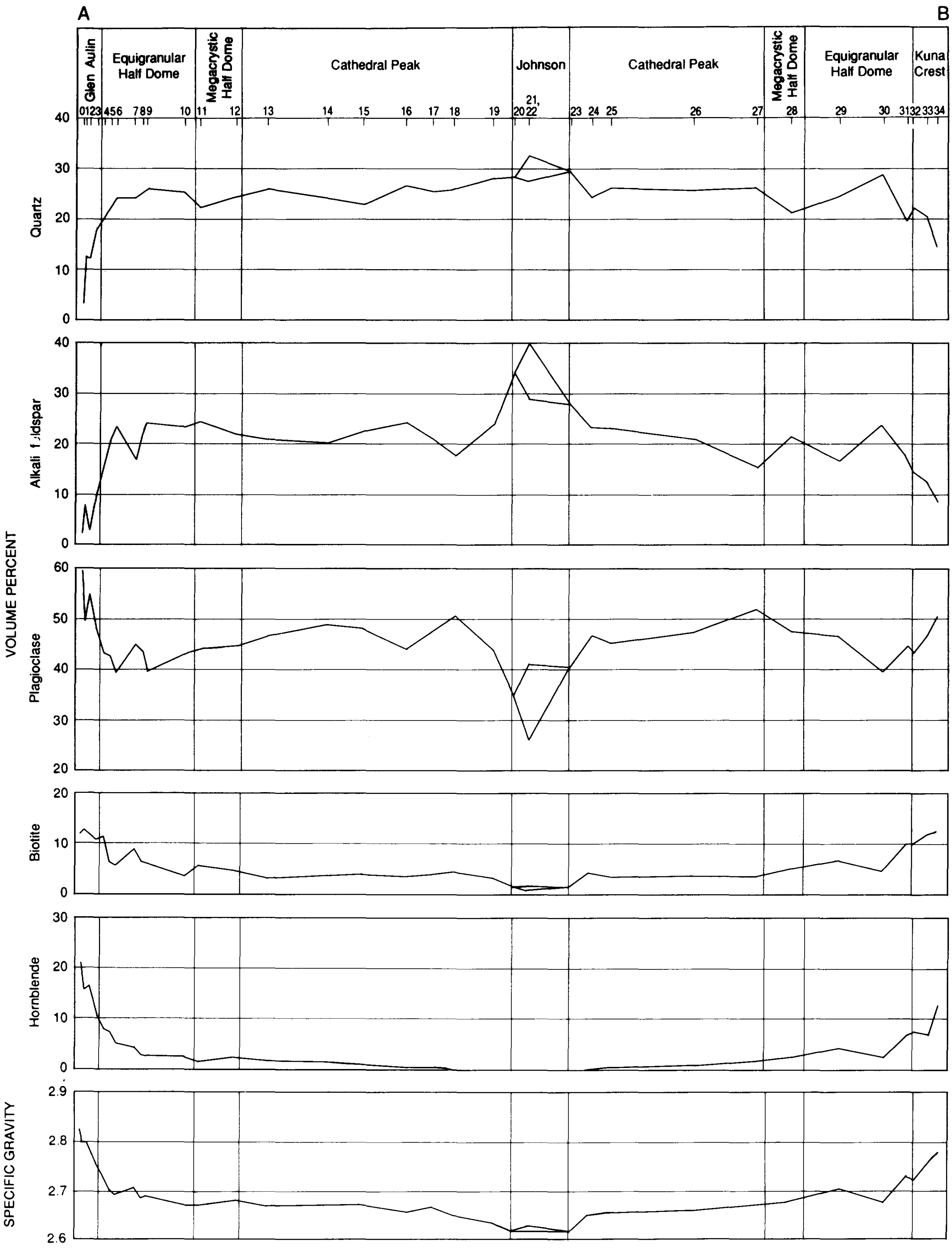


Figure 10. Variations of modes and specific gravities along traverse A–B (fig. 2). Data from table 4.

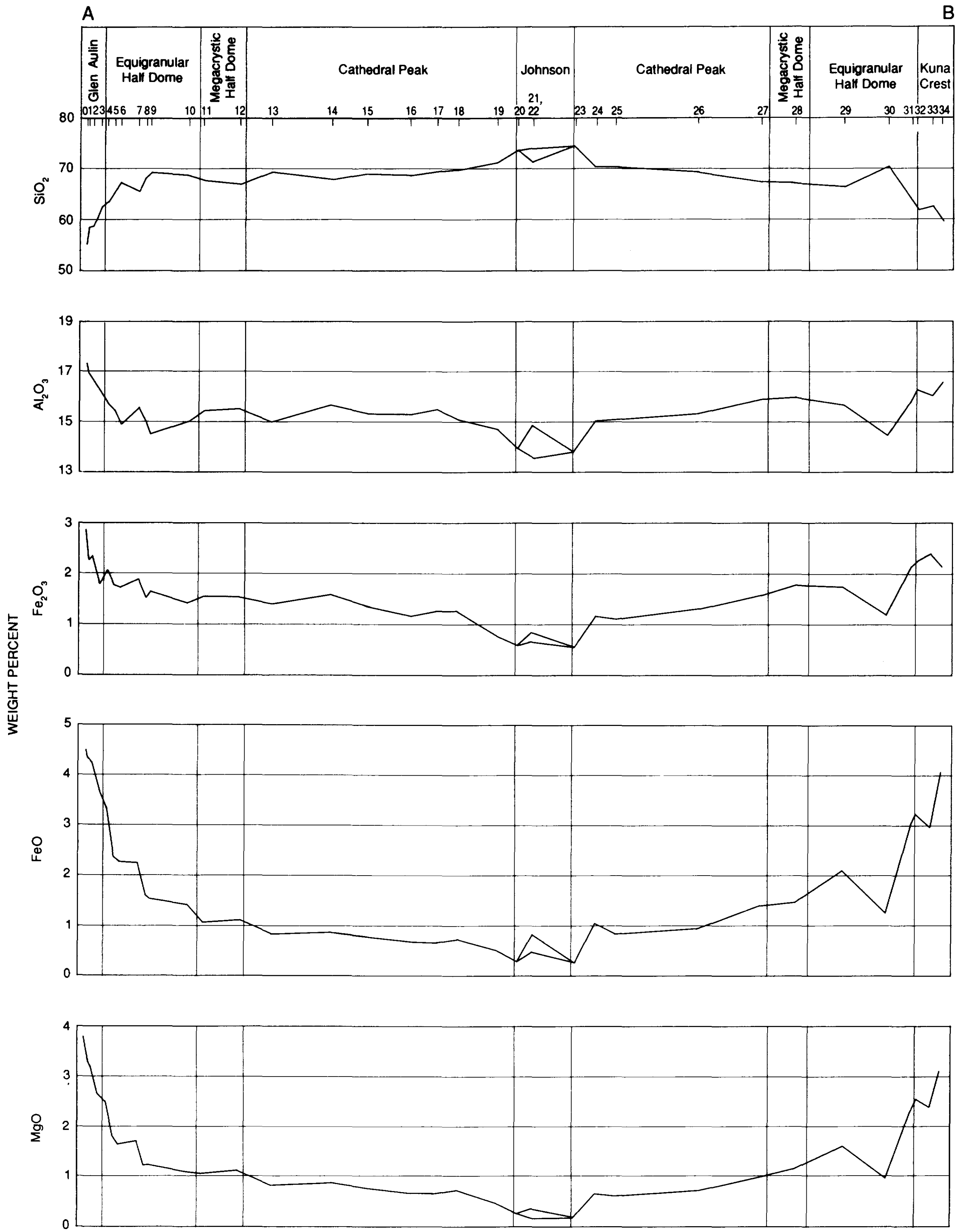


Figure 11. Variations of major oxides in samples 0–34 projected on traverse A–B (fig. 2). Data from table 1.

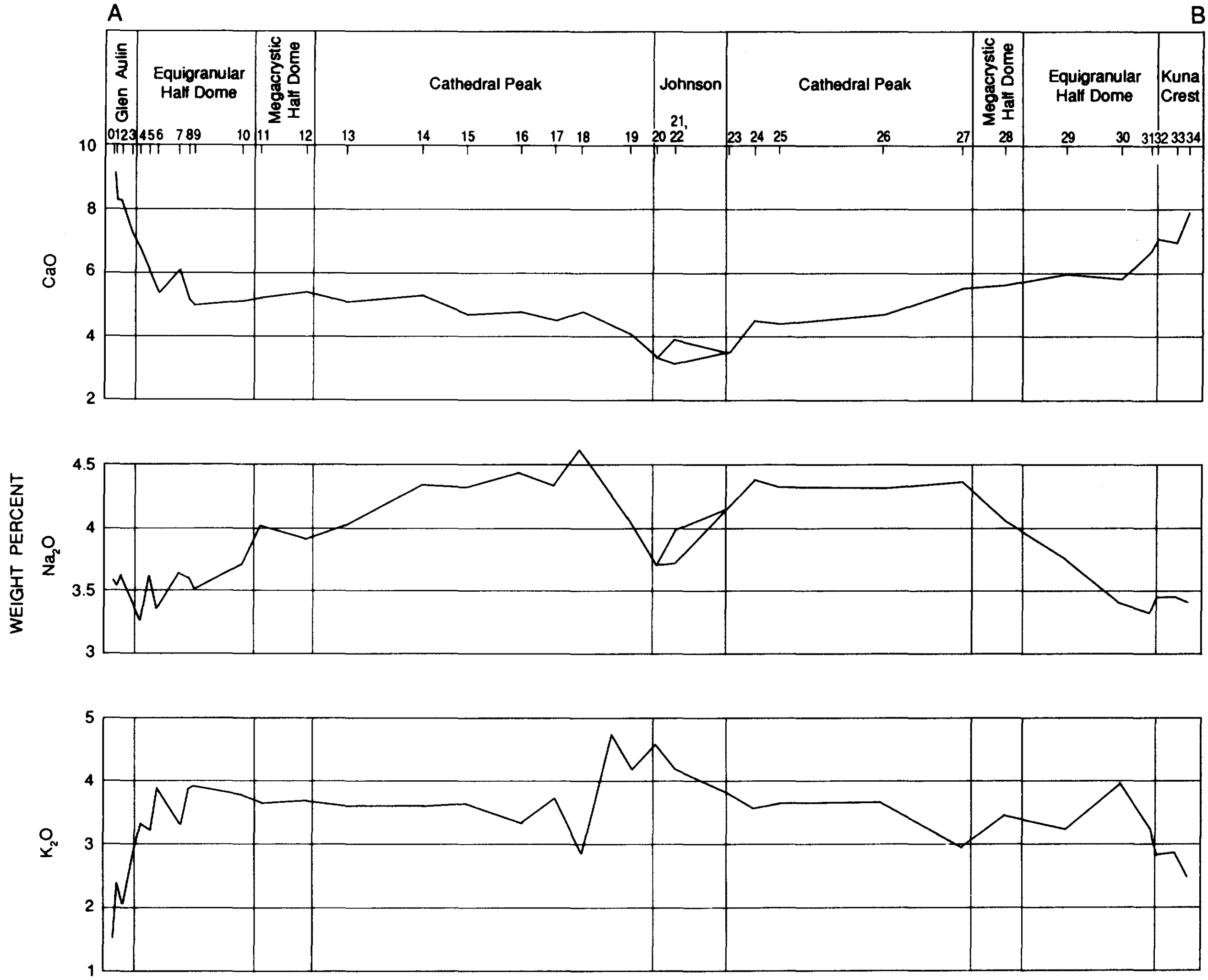


Figure 11. Continued.

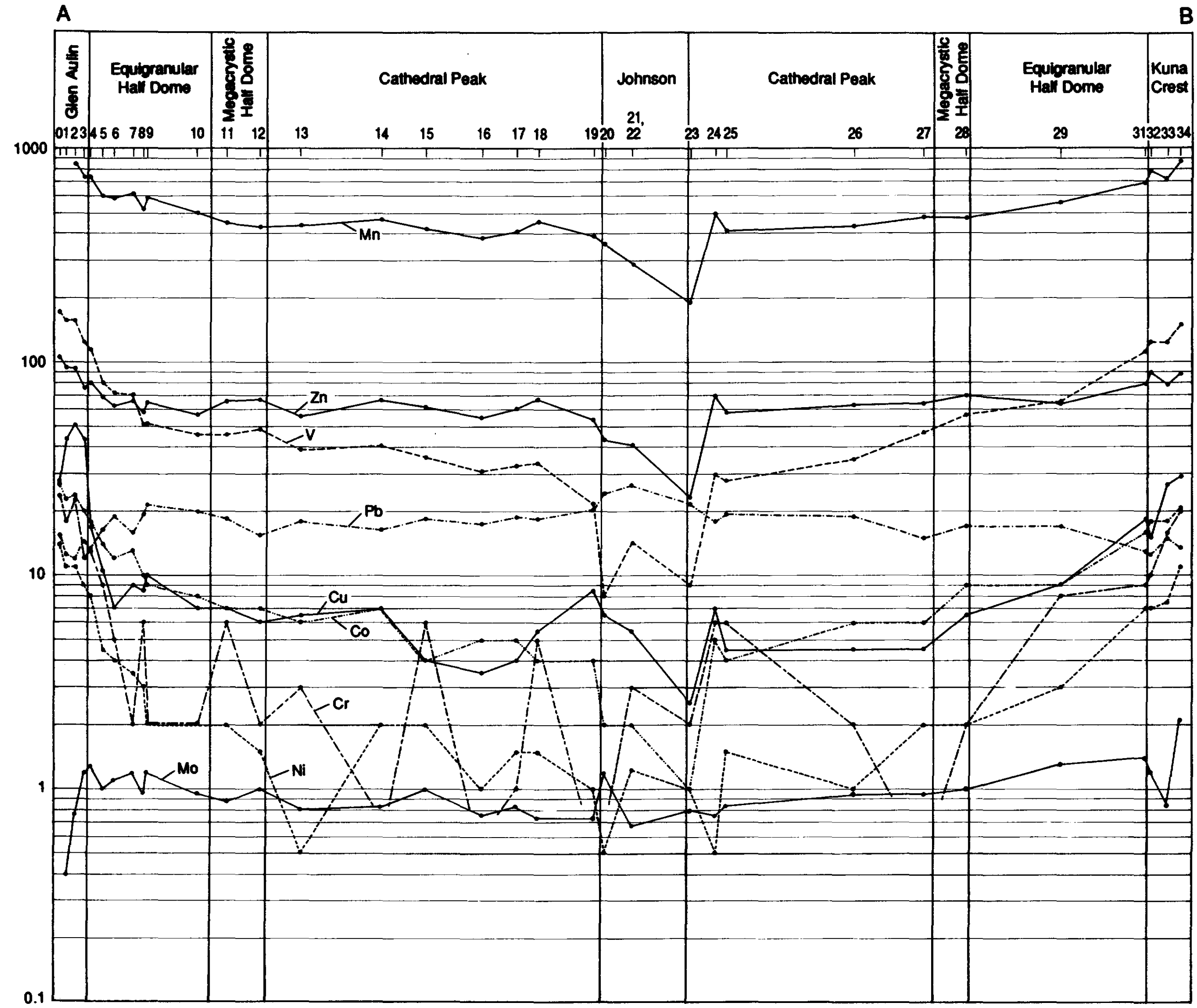


Figure 12. Variations of trace elements in samples 0–34 projected on traverse A–B (fig. 2). Data from table 1. Vertical scale is logarithmic.

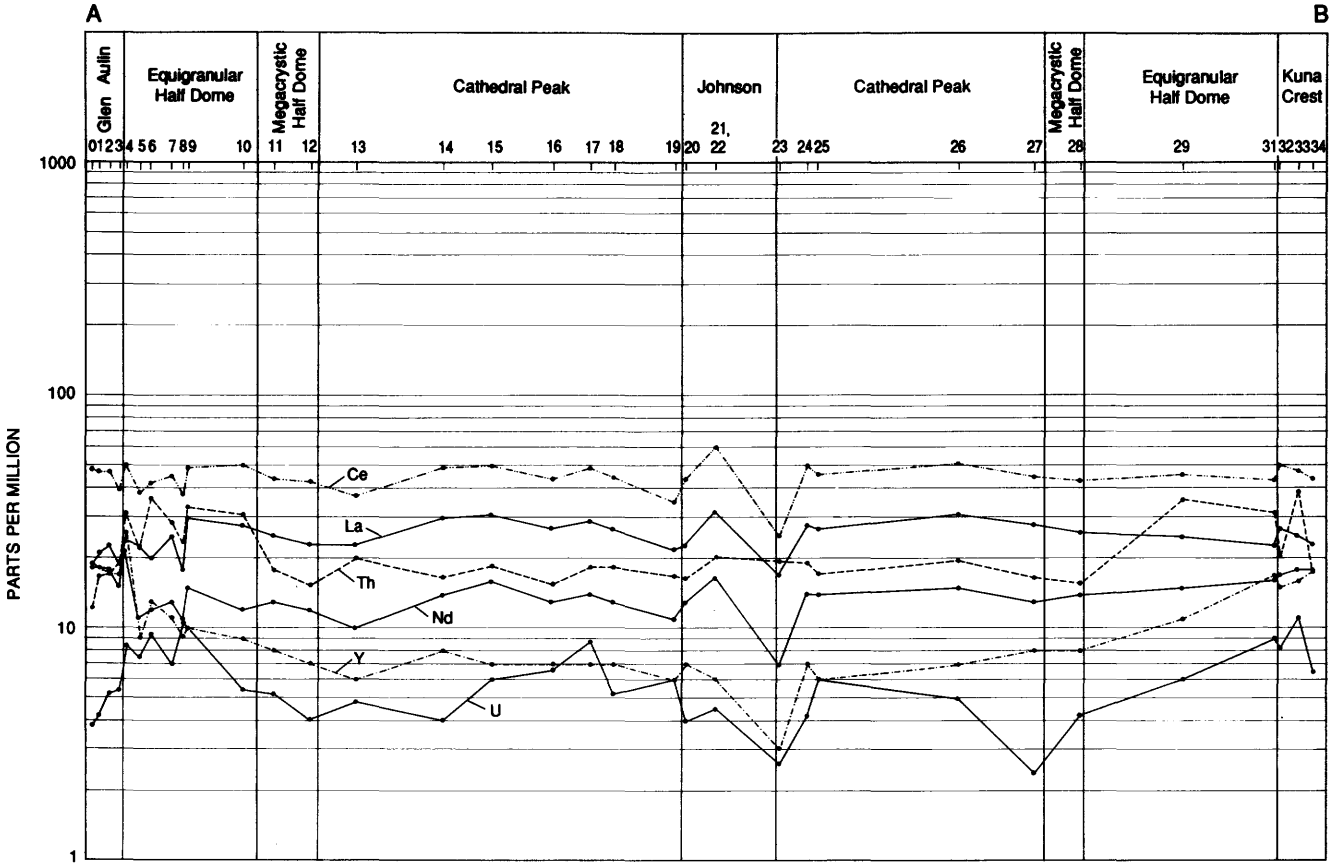
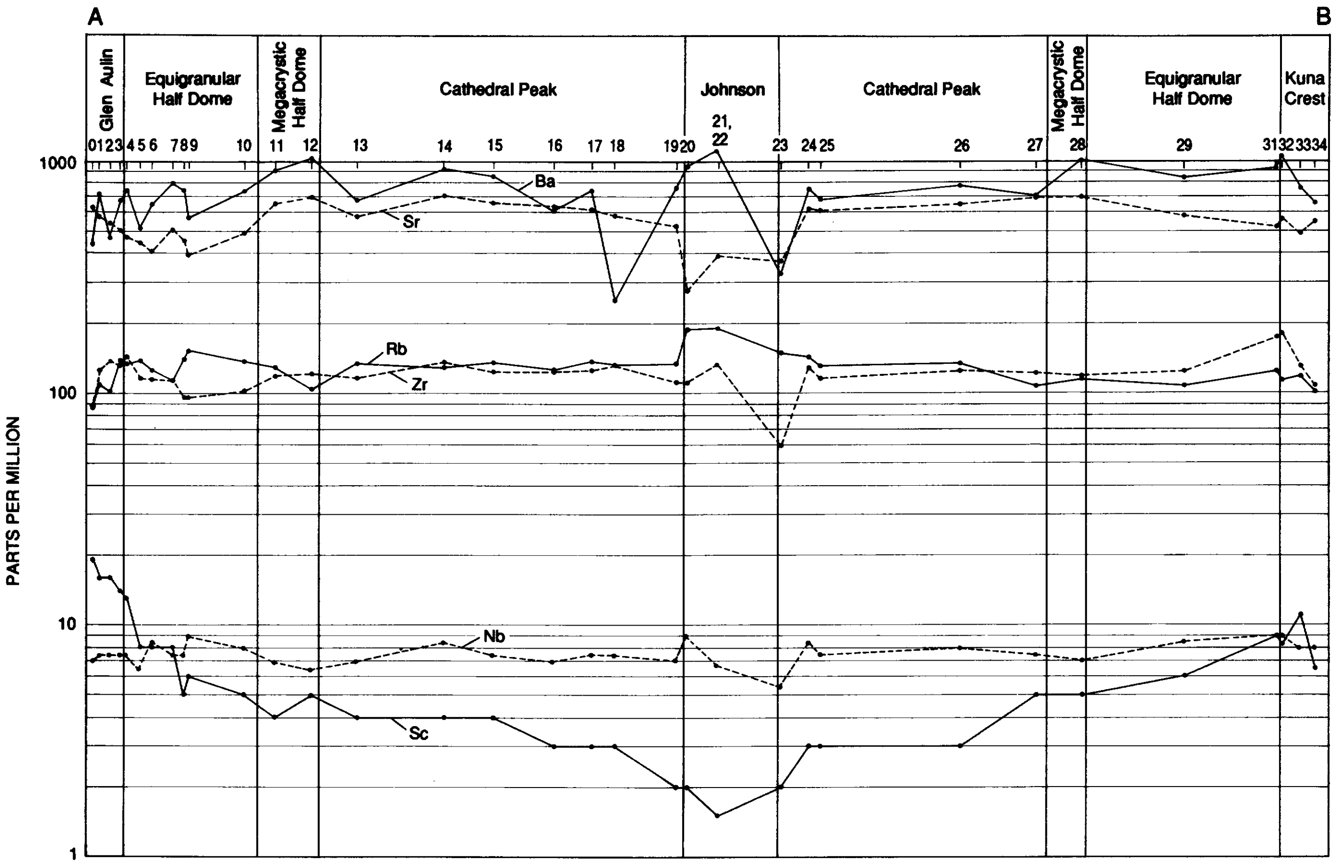


Figure 12. Continued.



A
B
Glen Aulin
Equigranular Half Dome
Megacrystic Half Dome
Cathedral Peak
Johnson
Cathedral Peak
Megacrystic Half Dome
Equigranular Half Dome
Kuna Crest
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21, 22 23 24 25 26 27 28 29 31 32 33 34
PARTS PER MILLION
1000
100
10
1
Ba
Sr
Rb
Zr
Nb
Sc

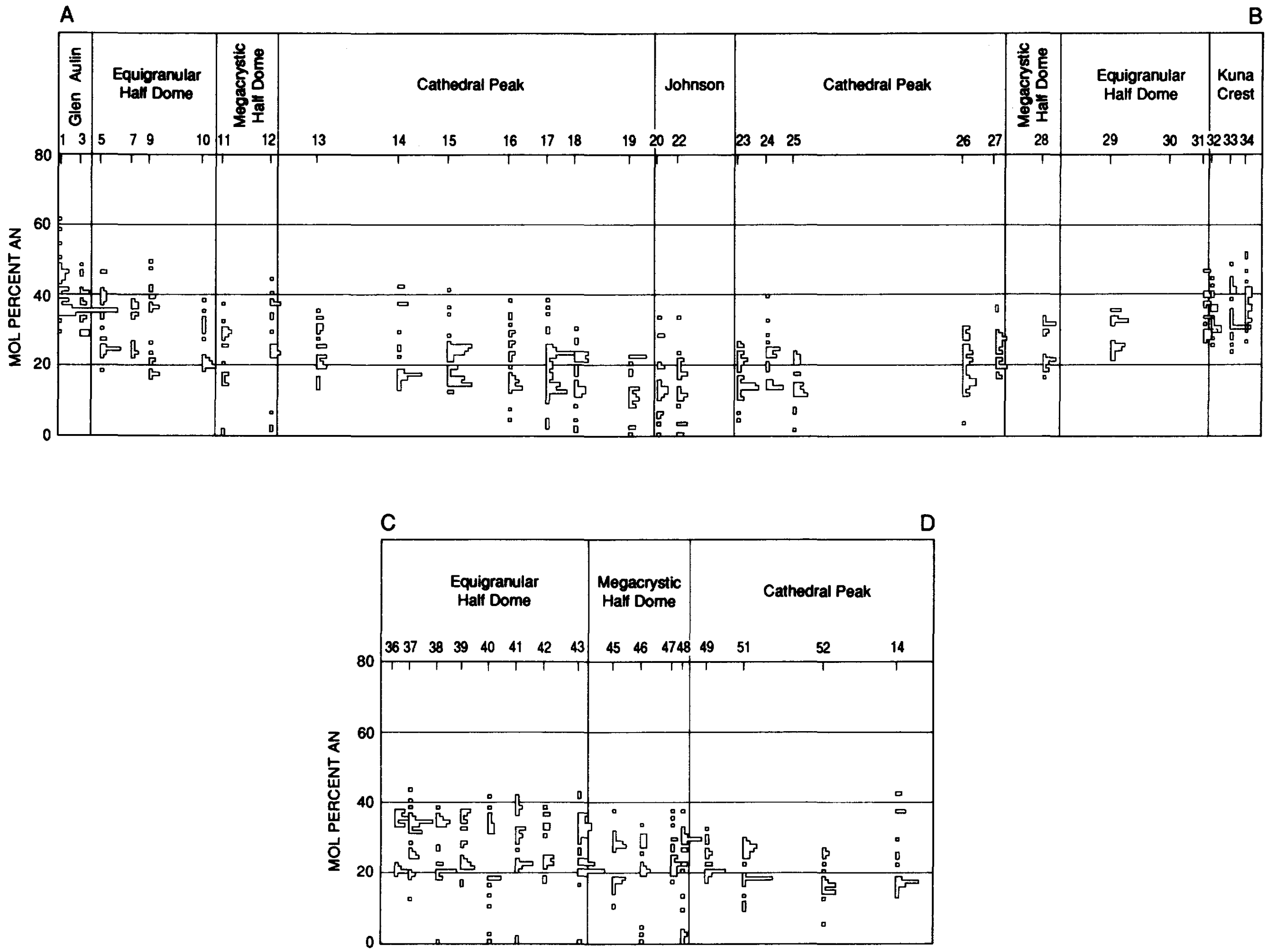


Figure 13. Variations of plagioclase compositions in selected samples (numbered) projected onto traverses A–B and C–D (fig. 2).

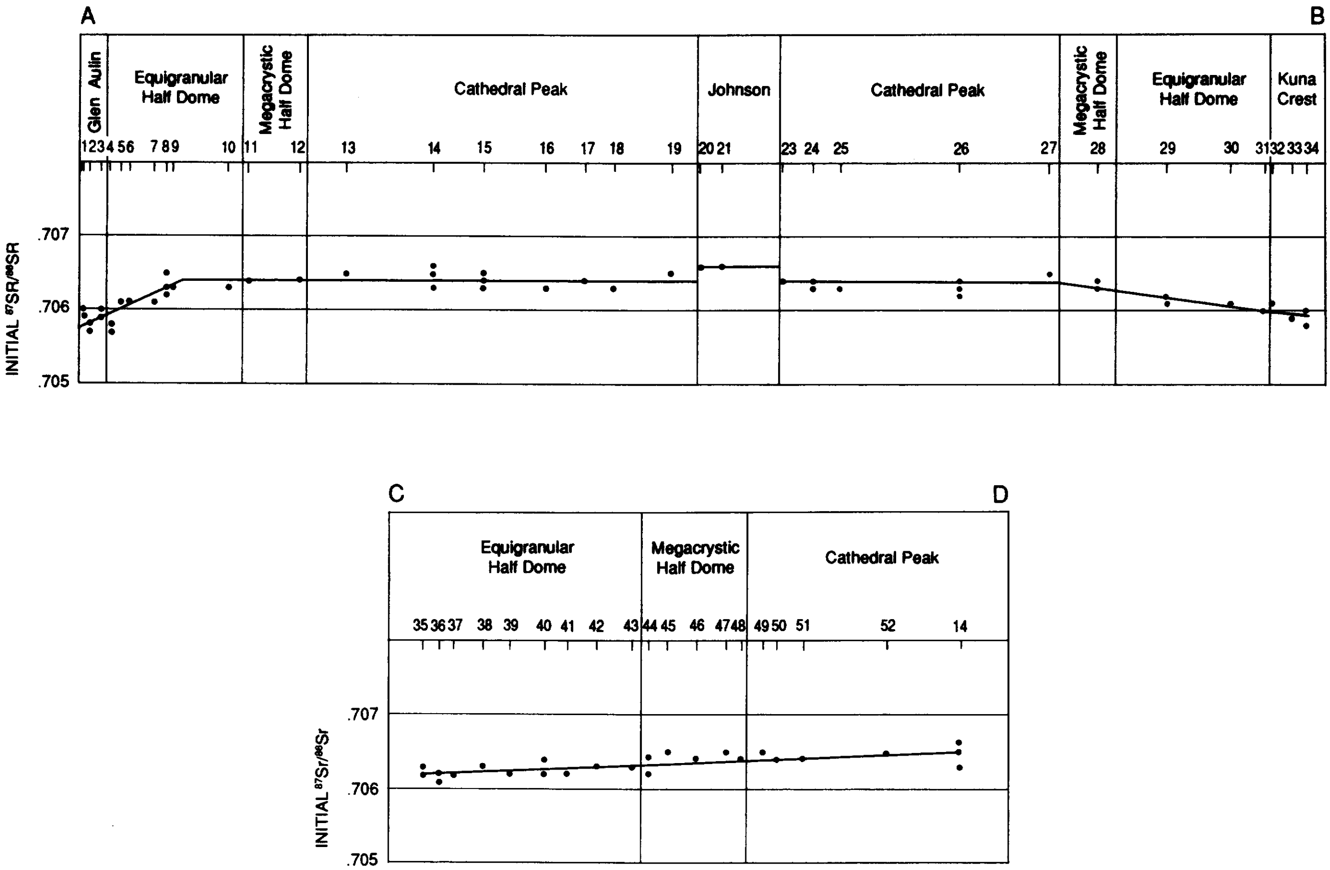


Figure 14. Variations of initial $^{87}Sr/^{86}Sr$ in selected samples (numbered) projected onto traverses A–B and C–D (fig. 2). Data from tables 8 and 9.

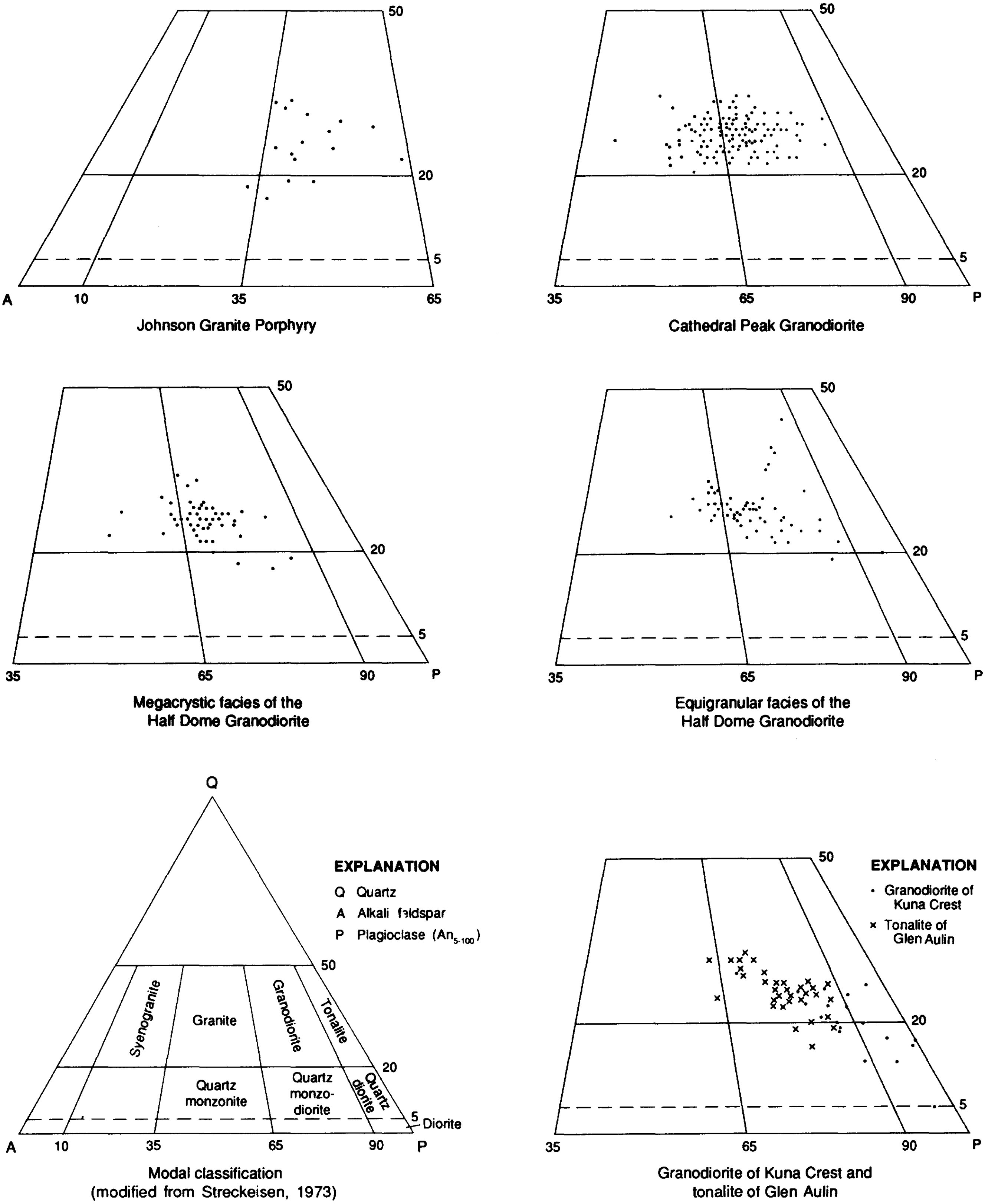


Figure 15. Modal plots on Q–A–P diagrams of Tuolumne Intrusive Suite granitoids. Data from table 6.

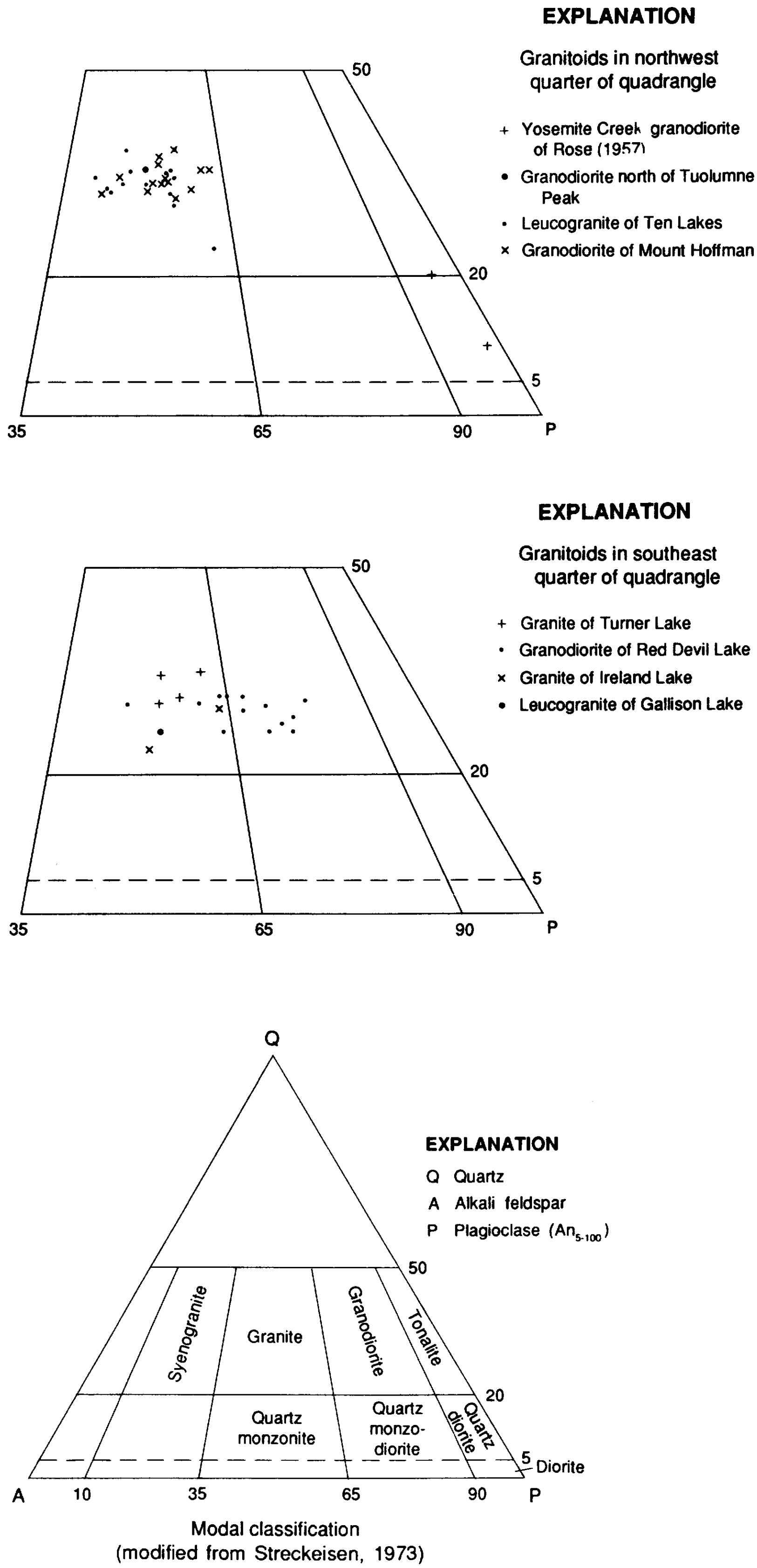


Figure 16. Modal plots on Q–A–P diagrams of granitoids predating the Tuolumne Intrusive Suite. Data from table 7.

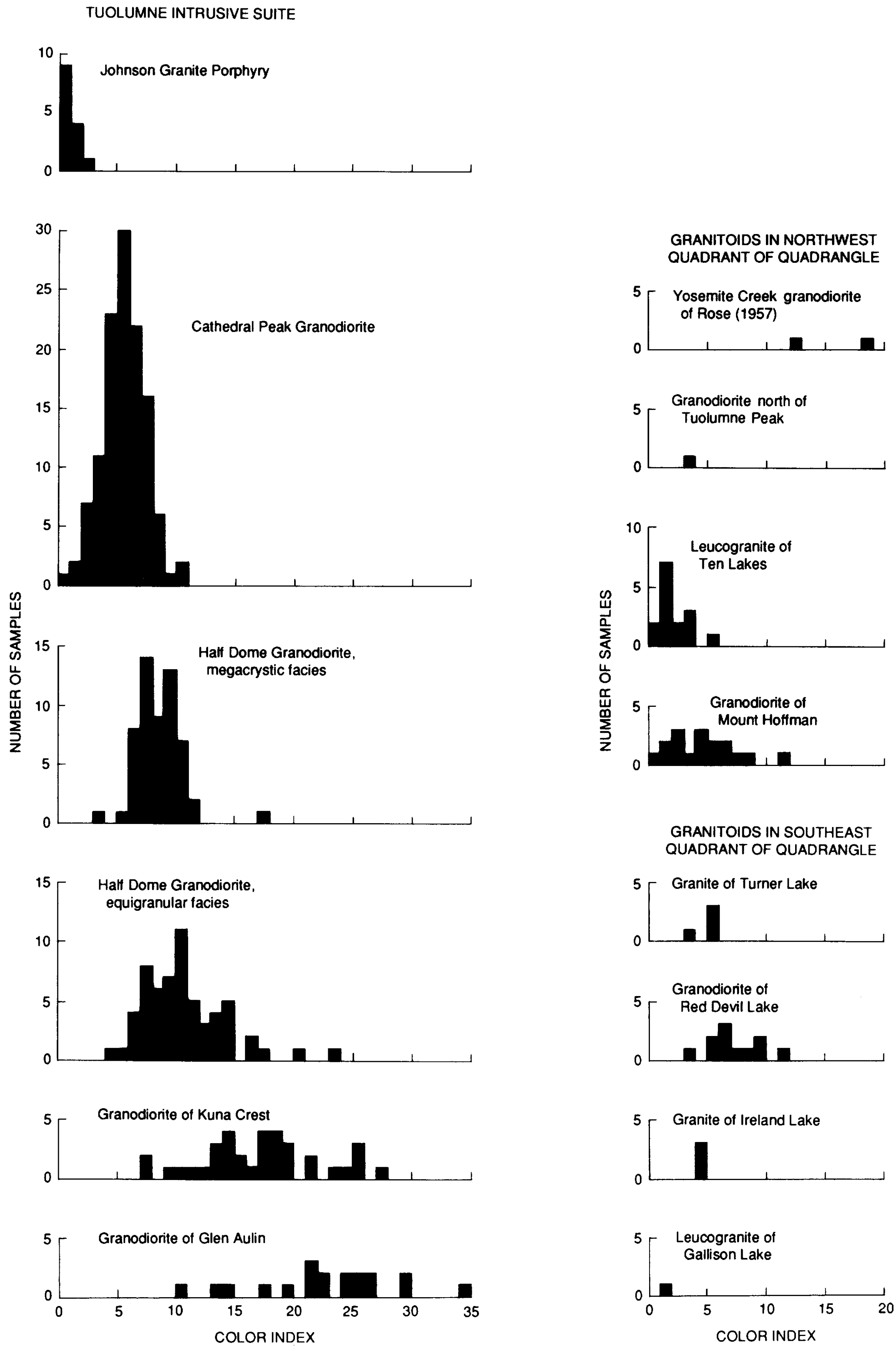
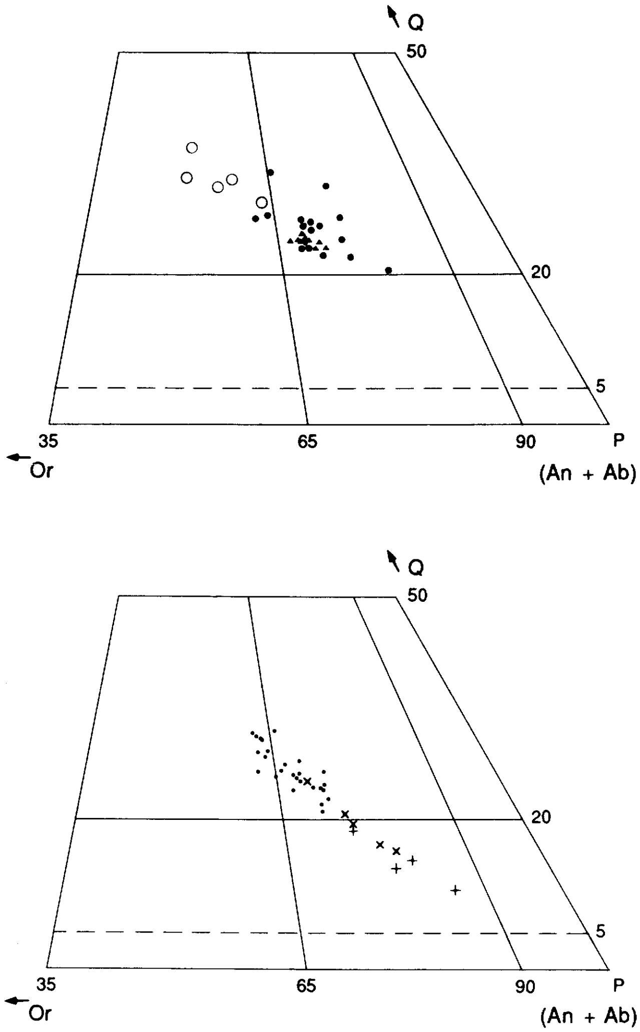


Figure 17. Histograms showing color indexes (volume-percent mafic minerals) of granitoids. Data from tables 4 to 7.



EXPLANATION

- ○ Johnson Granite Porphyry
- • Cathedral Peak Granodiorite
- ▴ Megacrystic facies of the Half Dome Granodiorite
- · Equigranular facies of the Half Dome Granodiorite
- × Granodiorite of Kuna Crest
- + Tonalite of Glen Aulin

Q Quartz
Or Orthoclase
P Plagioclase
An Anorthite
Ab Albite

Figure 18. Normative plots of Tuolumne Intrusive Suite granitoids. Data from tables 1 to 3.

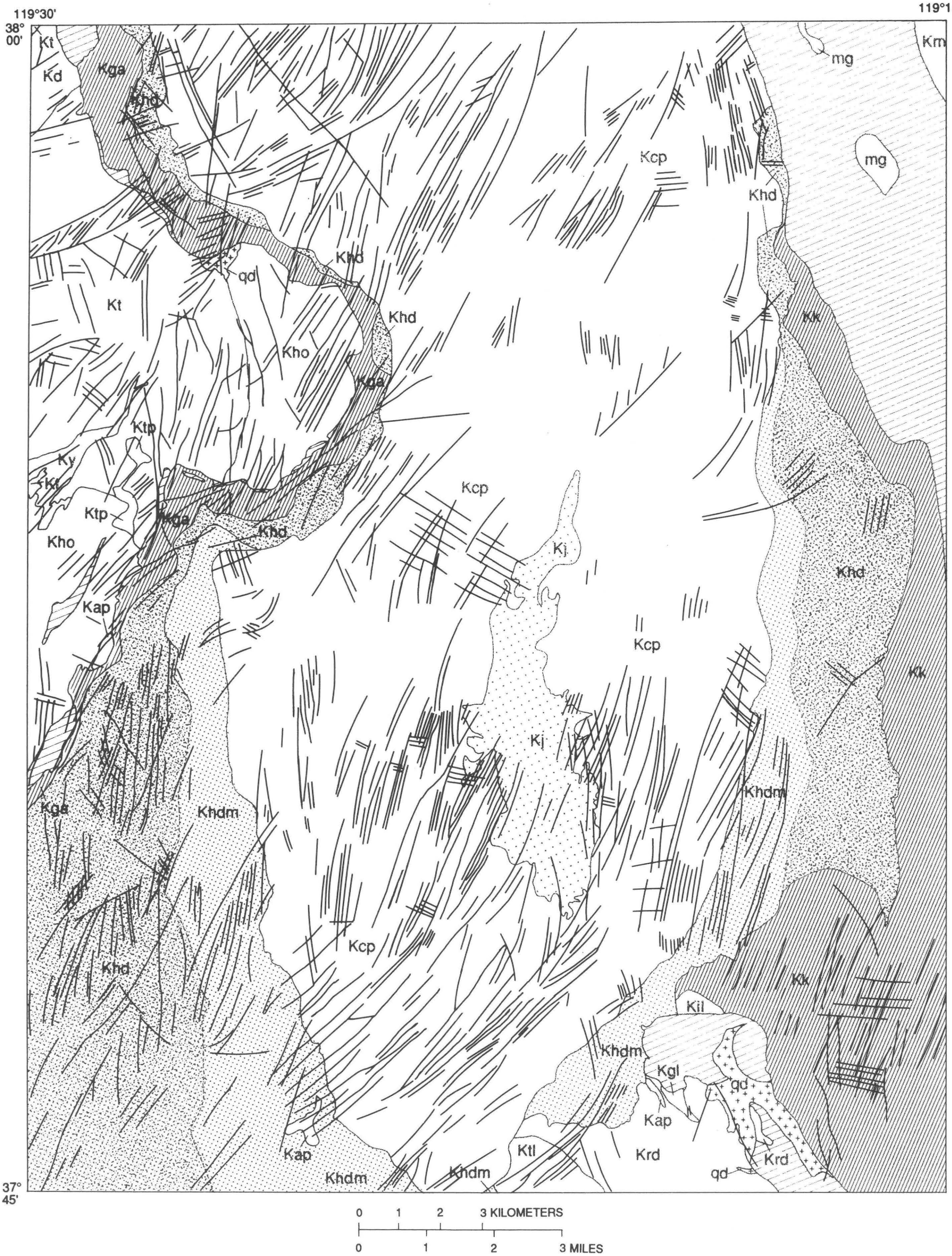


Figure 19. Generalized geologic map of Tuolumne Meadows quadrangle showing joints visible on aerial photographs. See figure 2 for explanation of geology.

Table 1. Chemical analyses of major and trace elements and CIPW norms of samples along traverse A–B (fig. 2) across the Tuolumne Intrusive Suite

[Most elements determined by X-ray fluorescence under the direction of B.W. Chappell at the Australian National University. FeO, H_2O, and CO_2 determined by wet chemical methods in the laboratories of the U.S. Geological Survey]

	Tonalite of Glen Aulin				Half Dome Granodiorite								
					Equigranular							Megacrystic	
Map No.	0	1	2	3	4	5	6	7	8	9	10	11	12
Field No.	Z-64	Z-51	Z-52	Z-53	Z-54	Z-55	Z-56	Z-57	Z-58	Z-59	Z-60	Z-61	Z-62
	Chemical analyses (weight percent)												
SiO_2...	55.27	58.59	58.91	62.18	62.78	65.61	67.06	65.57	68.20	69.23	68.99	67.83	67.70
Al_2O_3..	17.39	16.93	16.87	16.12	15.74	15.44	14.91	15.57	15.19	14.55	15.01	15.44	15.56
Fe_2O_3..	2.84	2.26	2.31	1.78	2.07	1.76	1.71	1.87	1.50	1.67	1.40	1.55	1.52
FeO....	4.48	4.31	4.25	3.65	3.22	2.38	2.27	2.24	1.60	1.53	1.40	1.44	1.41
MgO....	3.80	3.26	3.19	2.65	2.50	1.80	1.64	1.70	1.21	1.22	1.08	1.03	1.10
CaO....	7.13	6.25	6.22	5.21	4.80	4.10	3.60	4.14	3.17	3.00	3.15	3.22	3.41
Na_2O...	3.59	3.53	3.62	3.45	3.25	3.62	3.35	3.63	3.60	3.51	3.72	4.02	3.91
K_2O....	1.51	2.38	2.04	2.83	3.22	3.11	3.89	3.20	3.88	4.02	3.79	3.65	3.70
H_2O^+...	1.82	1.01	1.16	.84	1.06	.78	.68	.74	.62	.48	.50	.61	.54
H_2O^-...	.33	.14	.13	.11	.25	.14	.07	.13	.11	.11	.08	.10	.14
TiO_2...	.94	.90	.89	.77	.70	.54	.54	.54	.42	.44	.42	.49	.48
P_2O_5...	.24	.22	.21	.18	.17	.16	.15	.17	.15	.14	.15	.17	.17
MnO....	.14	.11	.11	.09	.09	.08	.08	.08	.07	.08	.06	.06	.06
CO_2....	.13	.07	.07	.07	.11	.09	.12	.16	.09	.11	.09	.13	.15
Other..	.22	.25	.22	.23	.24	.19	.20	.22	.21	.18	.21	.25	.26
Total	99.83	100.21	100.20	100.16	100.20	99.80	100.27	99.96	100.02	100.27	100.05	99.99	100.11
	Trace elements (ppm)												
Ba.....	440	720	475	660	745	515	645	800	745	565	735	905	1015
Rb.....	88	108	102	140	134	138	127	114	141	153	138	129	104
Sr.....	616	574	551	507	478	451	412	509	462	397	491	658	701
Pb.....	15.5	12.5	12.0	14.5	13.5	16.5	19.0	16.0	19.5	21.5	20.0	18.5	15.5
Th.....	12.2	16.6	17.0	19.4	31.8	21.8	36.4	28.6	23.0	33.2	30.8	18.0	15.4
U......	3.8	4.2	5.2	5.4	8.4	7.4	9.4	6.8	10.4	10.0	5.4	5.2	4.0
Zr.....	86	126	139	132	143	116	115	114	96	96	102	119	122
Nb.....	7.0	7.5	7.5	7.5	7.5	6.5	8.5	7.5	7.5	9.0	8.0	7.0	6.5
Y......	18	18	17	17	26	9	13	11	9	10	9	8	7
La.....	19	21	23	19	24	23	20	25	18	30	28	25	23
Ce.....	48	47	47	39	50	38	42	45	37	49	50	44	43
Nd.....	19	18	18	15	22	11	12	13	11	15	12	13	12
Sc.....	19	16	16	14	13	8	8	8	5	6	5	4	5
V......	172	157	158	126	117	81	72	71	51	52	46	46	49
Cr.....	24	17	23	12	13	9	5	2	6	2	2	6	2
Mn.....	1090	855	850	735	735	595	585	615	515	585	495	445	430
Co.....	27	23	24	20	18	14	12	13	10	9	8	7	7
Ni.....	14.0	10.5	10.5	8.5	8.0	4.5	4.0	3.5	3.0	2.0	2.0	2.0	1.5
Cu.....	28.0	44.0	51	43.5	17.0	11.0	7.0	9.0	8.5	10.0	7.0	7.0	6.0
Zn.....	106	95	94	76	81	69	63	66	58	65	57	66	67
Ga.....	20.4	19.0	19.4	18.2	17.6	18.0	16.4	17.2	17.0	17.2	16.4	18.8	18.4
	CIPW norms (weight percent)												
Q......	8.0	10.6	11.8	15.9	17.6	21.5	22.8	21.3	24.2	25.7	25.1	22.8	22.6
C......	-	-	-	-	-	-	-	-	-	-	-	-	-
or.....	9.2	14.2	12.2	16.9	19.3	18.6	23.2	19.2	23.2	23.9	22.6	21.8	22.1
ab.....	31.2	30.3	31.1	29.5	27.9	31.1	28.6	31.1	30.8	29.9	31.7	34.4	33.4
an.....	27.6	23.6	24.1	20.4	19.1	16.9	14.3	17.0	14.0	12.1	13.2	13.5	14.1
di.....	5.8	5.1	4.7	3.7	3.2	2.1	2.2	2.2	.7	1.5	1.3	1.3	1.5
hy.....	11.7	10.5	10.5	9.0	8.0	5.7	5.1	5.1	3.8	3.2	2.9	2.7	2.7
mt.....	4.2	3.3	3.4	2.6	3.0	2.6	2.5	2.7	2.2	2.4	2.0	2.3	2.2
il.....	1.8	1.7	1.7	1.5	1.3	1.0	1.0	1.0	.8	.8	.8	.9	.9
ap.....	.6	.5	.5	.4	.4	.4	.4	.4	.4	.3	.4	.4	.4
Total	100.1	99.8	100.0	99.9	99.8	99.9	100.1	100.0	100.1	99.8	100.0	100.1	99.9

Table 1. Chemical analyses of major and trace elements and CIPW norms of samples along traverse A–B (fig. 2) across the Tuolumne Intrusive Suite—*Continued*

	Cathedral Peak Granodiorite							Johnson Granite Porphyry			Cathedral Peak Granodiorite				
Sample no.	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Field no.	Z-63	Z-35	Z-10	Z-36	Z-11	Z-37	Z-38	Z-39	Z-18	Z-19	Z-12	Z-40	Z-13	Z-14	Z-41
							Chemical analyses (weight percent)								
SiO_2..	69.72	68.02	69.22	69.89	69.76	70.08	71.51	73.95	71.65	74.24	74.66	70.24	70.49	69.60	67.98
Al_2O_3..	15.02	15.73	15.38	15.32	15.49	15.14	14.75	13.75	14.87	13.55	13.80	15.03	15.06	15.34	15.89
Fe_2O_3..	1.39	1.59	1.36	1.14	1.24	1.26	.78	.59	.84	.66	.56	1.16	1.11	1.30	1.59
FeO....	1.18	1.28	1.00	1.05	.95	1.08	.89	.60	.81	.48	.28	1.07	.83	.95	1.40
MgO....	.81	.87	.77	.67	.66	.71	.49	.28	.38	.18	.19	.63	.61	.70	.98
CaO....	2.90	3.10	2.73	2.78	2.52	2.79	2.07	1.36	1.87	1.15	1.52	2.47	2.41	2.68	3.57
Na_2O...	4.03	4.34	4.31	4.43	4.33	4.62	4.07	3.71	3.98	3.22	4.17	4.39	4.33	4.31	4.37
K_2O....	3.59	3.59	3.63	3.30	3.72	2.84	4.19	4.58	4.19	5.47	3.80	3.55	3.62	3.64	2.96
H_2O^+...	.59	.56	.49	.49	.45	.55	.50	.56	.58	.43	.38	.49	.60	.58	.45
H_2O^-...	.08	.12	.14	.07	.09	.14	.17	.18	.17	.09	.16	.10	.19	.23	.08
TiO_2...	.42	.47	.40	.38	.37	.39	.28	.16	.24	.14	.13	.38	.33	.38	.50
P_2O_5...	.15	.18	.14	.14	.13	.15	.10	.04	.08	.03	.03	.13	.12	.14	.19
MnO....	.06	.06	.05	.05	.05	.06	.05	.05	.04	.03	.02	.06	.05	.06	.06
CO_2....	.11	.04	.05	.04	.05	.11	.07	.03	.13	.08	.06	.05	.09	.08	.02
Other..	.21	.26	.24	.21	.22	.17	.21	.20	.26	.23	.12	.23	.21	.23	.23
Total	100.26	100.21	99.91	99.96	100.03	100.09	100.13	100.04	100.09	99.98	99.88	99.98	100.05	100.22	100.27
							Trace elements (ppm)								
Ba....	670	915	860	610	740	250	760	940	1170	1085	325	755	680	785	705
Rb....	135	129	134	127	137	132	165	189	158	207	150	143	131	133	107
Sr....	582	710	663	641	621	585	525	277	484	301	369	628	609	648	695
Pb....	18.0	16.5	18.5	17.5	19.0	18.5	20.5	24.5	23.5	29.5	22.0	18.0	19.5	19.0	15.0
Th....	20.0	16.6	18.6	15.6	18.4	18.4	16.8	16.4	16.8	24.2	19.4	19.2	17.2	19.6	16.4
U.....	4.8	4.0	6.0	6.6	8.8	5.2	6.0	4.0	3.8	5.2	2.6	4.2	6.0	5.0	2.8
Zr....	117	136	123	123	126	131	112	111	138	130	59	130	116	125	122
Nb....	7.0	8.5	7.5	7.0	7.5	7.5	7.0	9.0	9.0	4.5	5.5	8.5	7.5	8.0	7.5
Y.....	6	8	7	7	7	7	6	7	8	4	3	7	6	7	8
La....	23	30	31	27	29	27	22	23	31	34	17	28	27	31	28
Ce....	37	49	50	44	49	45	35	44	58	65	25	50	46	51	45
Nd....	10	14	16	13	14	13	11	13	15	18	7	14	14	15	13
Sc....	4	4	4	3	3	3	2	2	2	1	2	3	3	3	5
V.....	39	41	36	31	33	34	22	8	18	11	9	30	28	35	47
Cr....	3	<1	6	<1	1	5	<1	<1	<1	6	2	6	6	2	<1
Mn....	435	465	420	380	405	455	390	355	335	250	190	495	410	430	480
Co....	6	7	4	5	5	4	4	2	2	2	1	5	4	6	6
Ni....	.5	2.0	2.0	1.0	1.5	1.5	1.0	.5	2.0	1.5	1.0	.5	1.5	1.0	2.0
Cu....	6.5	7.0	4.0	3.5	4.0	5.5	8.5	6.5	7.5	3.5	2.5	7.0	4.5	4.5	4.5
Zn....	56	67	62	55	60	67	54	43	54	28	23	69	58	63	64
Ga....	18.8	19.2	19.8	19.8	19.6	21.0	19.2	17.2	18.4	16.6	18.0	20.2	19.4	19.4	20
							CIPW norms (weight percent)								
Q.....	25.8	21.9	24.0	25.1	24.4	25.9	26.9	31.7	28.2	32.1	32.7	25.4	26.0	24.5	22.8
C.....	-	-	-	-	.1	-	-	.3	.6	.3	.1	-	-	-	-
or....	21.4	21.4	21.7	19.7	22.2	16.9	25.0	27.3	25.0	32.6	22.7	21.2	21.6	21.7	17.6
ab....	34.4	37	36.8	37.8	36.9	39.4	34.7	31.7	34.0	27.5	35.6	37.5	37.0	36.8	37.2
an....	12.4	12.9	12.0	12.3	11.7	12.3	9.7	6.5	8.8	5.6	7.4	10.9	11.1	11.9	15.1
di....	.9	1.1	.6	.6	-	.5	<.05	-	-	-	.5	.5	.2	.5	1.2
hy....	2.0	2.0	1.8	1.9	1.9	1.9	1.9	1.2	1.4	.6	.6	1.9	1.6	1.7	2.4
mt....	2.0	2.3	2.0	1.7	1.8	1.8	1.1	.9	1.2	1.0	.2	1.7	1.6	1.9	2.3
il....	.8	.9	.8	.7	.7	.7	.5	.3	.5	.3	.2	.7	.6	.7	1.0
ap....	.4	.4	.3	.3	.3	.4	.2	.2	.1	<.05	.1	.3	.3	.3	.5
Total	100.1	99.9	100.0	100.1	100.0	99.8	100.0	100.0	99.9	100.1	100.1	100.1	100.0	100.0	100.1

Table 1. Chemical analyses of major and trace elements and CIPW norms of samples along traverse A–B (fig. 2) across the Tuolumne Intrusive Suite—*Continued*

	Half Dome Granodiorite				Granodiorite of Kuna Crest		
	Megacr.	Equigranular					
Sample no.	28	29	30	31	32	33	34
Field no.	Z-42	Z-43	Z-16	Z-44	Z-45	Z-46	Z-47
	Chemical analyses (weight percent)						
SiO_2...	67.17	66.18	70.35	63.47	61.87	62.48	59.74
Al_2O_3..	15.97	15.71	14.48	15.81	16.25	16.03	16.58
Fe_2O_3..	1.79	1.74	1.20	2.14	2.26	2.39	2.15
FeO....	1.47	2.10	1.27	3.03	3.23	2.98	4.10
MgO....	1.15	1.60	.96	2.28	2.56	2.40	3.12
CaO....	3.62	3.97	2.80	4.72	5.11	4.98	5.91
Na_2O...	4.07	3.77	3.41	3.32	3.46	3.46	3.41
K_2O....	3.49	3.24	3.96	3.22	2.84	2.89	2.45
H_2O^+...	.53	.62	.56	.88	.91	.90	1.12
H_2O^-...	.10	.09	.19	.15	.18	.15	.14
TiO_2...	.53	.55	.33	.72	.77	.74	.85
P_2O_5...	.19	.18	.10	.17	.19	.17	.20
MnO....	.06	.07	.06	.09	.10	.09	.11
CO_2....	.02	.05	.18	.03	.07	.06	.07
Other..	.26	.24	.18	.26	.28	.24	.23
Total	100.42	100.11	100.03	100.29	100.08	99.96	100.18
	Trace elements (ppm)						
Ba.....	1015	840	560	905	1040	745	655
Rb.....	114	107	163	123	113	119	102
Sr.....	699	579	380	515	563	482	545
Pb.....	17.0	17.0	24.0	13.0	12.5	15.0	13.5
Th.....	15.6	35.8	34.4	31.4	19.6	38.4	16.4
U......	4.2	6.0	11.6	9.0	8.2	11.0	6.4
Zr.....	118	123	97	174	182	130	107
Nb.....	7.0	8.5	7.5	9.0	9.0	8.0	8.0
Y......	8	11	8	17	15	16	18
La.....	26	25	26	23	27	25	23
Ce.....	43	46	39	44	50	48	44
Nd.....	14	15	11	16	17	18	18
Sc.....	5	6	4	12	13	14	18
V......	57	66	40	113	123	123	150
Cr.....	2	8	8	9	10	16	20
Mn.....	475	565	475	680	780	725	865
Co.....	9	9	9	16	18	18	21
Ni.....	2.0	3.0	3.0	7.0	7.0	7.5	11.0
Cu.....	6.5	9.0	5.5	18.5	15.0	26.5	29.0
Zn.....	70	64	46	78	89	78	88
Ga.....	18.6	17.4	15.4	18.0	18.8	16.8	18.0
	CIPW norms (weight percent)						
Q......	21.5	21.4	28.3	18.5	16.3	17.5	13.1
C......	-	-	-	-	-	-	-
or.....	20.7	19.3	23.7	19.2	17.0	17.3	14.7
ab.....	34.6	32.2	29.2	28.4	29.7	29.7	29.3
an.....	15.1	16.5	12.6	18.9	20.7	19.9	22.8
di.....	1.4	1.7	0.6	2.9	3.0	3.2	4.6
hy.....	2.7	4.8	3.0	7.1	8.0	7.0	10.3
mt.....	2.6	2.5	1.8	3.1	3.3	3.5	3.2
il.....	1.0	1.1	0.6	1.4	1.5	1.4	1.6
ap.....	0.5	0.4	0.2	0.4	0.5	0.4	0.5
Total	100.1	99.9	100.0	100.0	100.0	99.9	100.0

Table 2. Chemical analyses of major and trace elements and CIPW norms of samples along traverse C–D (fig. 2) across the Tuolumne Intrusive Suite

[Most elements determined by X-ray fluorescence under the direction of B.W. Chappell at the Australian National University. FeO, H_2O, and CO_2 determined by wet chemical methods in the laboratories of the U.S. Geological Survey]

	Half Dome Granodiorite Equigranular								
Map No.	35	36	37	38	39	40	41	42	43
Field No.	Z-5	Z-23	Z-6	Z-24	Z-25	Z-26	Z-7	Z-27	Z-28
Chemical analyses (weight percent)									
SiO_2...	69.79	66.93	65.86	68.04	66.12	68.08	64.96	70.07	67.76
Al_2O_3..	14.75	15.44	15.68	15.56	15.62	15.33	15.97	14.45	15.61
Fe_2O_3..	1.47	1.82	2.13	1.46	1.85	1.56	2.34	1.28	1.64
FeO....	1.07	1.79	1.65	1.37	1.93	1.48	1.62	1.23	1.48
MgO....	.95	1.39	1.50	1.10	1.61	1.09	1.51	.90	1.14
CaO....	2.90	3.65	3.92	3.42	3.80	3.35	4.16	2.70	3.51
Na_2O...	3.55	3.67	3.70	3.75	3.52	3.84	3.87	3.53	3.83
K_2O....	3.96	3.63	3.41	3.61	3.75	3.69	3.21	4.20	3.66
H_2O^+...	.63	.65	.81	.51	.58	.53	.76	.43	.32
H_2O^-...	.15	.08	.17	.11	.19	.05	.18	.12	.07
TiO_2...	.34	.50	.52	.40	.55	.45	.60	.37	.46
P_2O_5...	.11	.17	.18	.13	.17	.15	.21	.12	.17
MnO....	.06	.07	.08	.05	.07	.06	.07	.05	.07
CO_2....	.16	.10	.10	.11	.04	.06	.12	.15	.09
Other..	.19	.22	.25	.22	.24	.20	.27	.15	.24
Total	100.08	100.11	99.96	99.84	100.04	99.92	99.85	99.78	100.05
Trace elements (ppm)									
Ba.....	625	795	930	830	925	685	985	625	900
Rb.....	146	130	114	121	114	136	110	149	127
Sr.....	436	526	578	555	568	510	688	413	572
Pb.....	23.0	18.5	18.5	17.0	17.0	21.0	17.0	19.0	20.0
Th.....	32.8	28.4	36.0	28.8	9.8	24.2	18.4	24.6	25.4
U......	6.0	8.0	9.4	6.4	4.2	6.6	4.6	7.0	5.8
Zr.....	98	117	117	105	114	87	132	86	105
Nb.....	7.5	8.5	9.0	8.0	8.0	6.5	8.5	6.5	7.5
Y......	7	11	13	8	11	8	11	6	9
La.....	27	25	33	23	25	22	29	17	28
Ce.....	39	43	58	36	48	37	53	33	42
Nd.....	10	14	19	10	16	11	19	9	13
Sc.....	4	6	6	4	6	5	6	4	5
V......	40	61	67	46	67	50	77	42	53
Cr.....	2	2	3	1	6	5	9	2	8
Mn.....	465	545	590	420	575	460	570	425	505
Co.....	6	10	11	7	10	8	14	7	9
Ni.....	2.5	2.5	4.5	2.5	3.5	2.5	4.5	2.0	2.5
Cu.....	7.0	10.0	7.0	7.0	9.0	7.5	10.5	8.0	6.0
Zn.....	50	64	72	49	72	58	76	52	60
Ga.....	15.4	17.0	17.0	16.8	17.0	17.4	18.8	16.8	18.2
CIPW norms (weight percent)									
Q......	27.0	22.4	21.7	24.0	21.3	23.5	20.4	27.0	22.9
C......	-	-	-	-	-	-	-	-	-
or.....	23.7	21.7	20.4	21.6	22.4	22.0	19.3	25.1	21.8
ab.....	30.4	31.3	31.7	32.1	30.1	32.8	33.2	30.2	32.6
an.....	12.7	15.1	16.3	15.1	15.9	13.8	17.0	11.3	14.7
di.....	.8	1.7	1.7	.9	1.6	1.6	2.0	1.2	1.4
hy.....	2.3	3.8	3.5	3.1	4.5	2.8	3.1	2.4	2.9
mt.....	2.2	2.7	3.1	2.1	2.7	2.3	3.4	1.9	2.4
il.....	.7	1.0	1.0	.8	1.1	.9	1.2	.7	.9
ap.....	.3	.4	.4	.3	.4	.4	.5	.3	.4
Total	100.1	100.1	99.8	100.0	100.0	100.1	100.1	100.1	100.0

Table 2. Chemical analyses of major and trace elements and CIPW norms of samples along traverse C–D (fig. 2) across the Tuolumne Intrusive Suite—*Continued*

	Half Dome Granodiorite Megacrystic					Cathedral Peak Granodiorite			
Sample No.	44	45	46	47	48	49	50	51	52
Field No.	Z-8	Z-29	Z-30	Z-31	Z-32	Z-33	Z-9	Z-34	Z-20
				Chemical analyses (weight percent)					
SiO_2...	66.65	68.12	67.89	67.32	67.48	67.40	68.06	69.33	69.26
Al_2O_3..	15.73	15.54	15.55	15.66	15.58	15.80	15.59	15.22	15.47
Fe_2O_3..	1.93	1.55	1.52	1.69	1.64	1.77	1.19	1.40	1.40
FeO....	1.47	1.36	1.40	1.58	1.43	1.36	1.21	1.29	.97
MgO....	1.23	1.03	.98	1.10	1.09	1.02	.90	.85	.73
CaO....	3.62	3.15	3.19	3.59	3.27	3.45	3.28	3.12	2.91
Na_2O...	4.14	3.99	4.02	4.17	3.86	4.08	4.11	4.12	4.26
K_2O....	3.27	3.75	3.73	3.22	3.89	3.63	3.56	3.40	3.48
H_2O^+...	.66	.36	.50	.42	.45	.35	.64	.30	.55
H_2O^-...	.12	.20	.10	.08	.15	.11	.15	.10	.18
TiO_2...	.53	.47	.48	.55	.50	.53	.46	.45	.39
P_2O_5...	.19	.18	.17	.19	.19	.20	.18	.17	.16
MnO....	.07	.06	.06	.06	.06	.06	.06	.06	.05
CO_2....	.09	.04	.14	.04	.10	.03	.09	.10	.07
Other..	.26	.24	.24	.25	.27	.27	.25	.21	.24
Total	99.96	100.04	99.97	99.94	99.96	100.06	99.73	100.12	100.12
				Trace elements (parts per million)					
Ba.....	960	895	905	895	1150	1015	915	615	825
Rb.....	117	128	118	100	106	113	127	126	126
Sr.....	633	631	641	709	689	715	668	618	667
Pb.....	19.0	19.0	17.0	16.0	17.5	16.5	19.0	18.0	18.5
Th.....	16.6	12.2	18.2	12.8	16.0	15.4	17.4	20.0	17.2
U......	5.4	3.2	7.2	3.6	3.2	5.2	5.2	5.2	4.2
Zr.....	126	116	109	121	112	127	127	116	113
Nb.....	8.0	7.0	7.0	8.0	7.0	8.0	7.0	6.5	7.0
Y......	9	8	8	8	7	8	8	7	7
La.....	27	23	28	26	24	29	29	22	29
Ce.....	49	42	46	46	41	49	47	38	45
Nd.....	15	14	14	15	13	15	16	14	14
Sc.....	5	4	4	5	5	5	4	4	3
V......	61	50	48	56	51	54	49	44	36
Cr.....	4	1	2	7	1	1	1	5	<1
Mn.....	540	450	445	475	470	490	470	470	425
Co.....	10	7	6	8	8	8	7	7	6
Ni.....	3.5	2.5	1.5	1.5	2.0	2.0	2.5	2.0	1.0
Cu.....	7.5	6.0	5.5	7.5	6.0	6.5	5.0	6.0	6.0
Zn.....	72	67	62	69	64	69	65	62	60
Ga.....	20.0	18.6	18.6	19.8	18.8	19.4	20.0	18.8	18.8
				CIPW norms (weight percent)					
Q......	21.5	22.9	22.6	22.2	22.3	21.8	23.0	25.1	24.6
C......	-	-	-	-	-	-	-	-	-
or.....	19.6	22.3	22.3	19.2	23.2	21.6	21.3	20.2	20.8
ab.....	35.4	34.0	34.4	35.6	33.0	34.8	35.3	35.1	36.4
an.....	14.9	13.5	13.5	14.7	13.8	14.2	13.8	13.1	12.9
di.....	1.6	.8	1.1	1.6	1.0	1.4	1.2	1.1	.5
hy.....	2.7	2.7	2.6	2.7	2.8	2.2	2.3	2.2	1.7
mt.....	2.8	2.3	2.2	2.5	2.4	2.6	1.8	2.0	2.0
il.....	1.0	.9	.9	1.1	1.0	1.0	.9	.9	.7
ap.....	.5	.4	.4	.5	.5	.5	.4	.4	.4
Total	100.0	99.8	100.0	100.1	100.0	100.1	100.0	100.1	100.0

Table 3. Chemical analyses of major and trace elements and CIPW norms of miscellaneous samples from the Tuolumne Intrusive Suite not along traverses A–B and C–D

[Samples having field numbers prefixed by Z- were analyzed by X-ray fluorescence under the direction of B.W. Chappell at the Australian National University. Other samples were analyzed in the laboratories of the U.S. Geological Survey by rapid-rock methods or by X-ray fluorescence. FeO, H_2O, and CO_2 were determined for all samples in the laboratories of the U.S. Geological Survey by wet chemical methods]

	Granodiorite of Kuna Crest		Half Dome Granodiorite Equigranular			Cathedral Peak Granodiorite					Johnson Granite Porphyry	
Map/Field No.	Z-15	Z-48	TM-4	Z-17	FD-15	TM-1A	TM-1	TM-2	TM-3	TM-6	I-397	Z-65
Lab. No.			D-100207		162505	D-100208	D-102873	D-102874	D-102875	D-102876	162495	
					Chemical analyses (weight percent)							
SiO_2...	58.66	66.57	67.18	71.31	71.2	68.46	67.05	66.60	65.89	64.91	74.7	73.39
Al_2O_3..	16.84	15.41	15.51	14.31	14.8	15.77	15.98	16.44	16.39	16.96	13.8	13.83
Fe_2O_3..	2.97	1.75	1.64	1.17	1.3	1.35	1.62	1.69	2.15	2.00	.93	.70
FeO....	3.61	2.15	1.93	.84	.92	1.31	1.01	1.37	1.53	1.82	.52	.48
MgO....	3.30	1.70	1.42	.74	.48	.90	.60	.96	1.12	1.29	.28	.24
CaO....	6.27	3.83	2.88	2.25	2.5	3.22	3.71	3.46	3.85	4.41	.92	1.26
Na_2O...	3.45	3.55	3.68	3.64	3.4	4.15	3.80	4.12	4.32	4.59	3.1	3.68
K_2O....	2.25	3.48	3.34	4.10	4.2	3.69	4.16	3.51	2.91	2.36	5.0	4.90
H_2O^+...	1.11	.62	.46	.67	.46	.37	.28	.45	.40	.45	.55	.71
H_2O^-...	.20	.12	.04	.27	.29	.05	.09	.12	.10	.05	.04	.20
TiO_2...	.87	.51	.58	.28	.27	.44	.66	.52	.61	.63	.14	.16
P_2O_5...	.22	.16	.17	.09	.10	.17	.33	.20	.23	.26	.02	.05
MnO....	.11	.07	.07	.06	.04	.06	.06	.06	.08	.09	.05	.04
CO_2....	.05	.06	.03	.01	<.05	.02	.01	.01	.02	.01	<.05	.27
Other..	.24	.22	-	.17	-	-	-	-	-	-	-	.19
Cl.....	-	-	.01	-	-	.00	.00	.00	.01	.00	-	-
F......	-	-	.04	-	-	.05	.05	.05	.06	.07	-	-
Less O.	-	-	.02	-	-	.02	.02	.02	.03	.02	-	-
Total	100.15	100.20	99.96	99.91	100.0	99.99	99.29	99.54	99.64	99.87	100.1	100.10
					Trace elements (parts per million)							
Ba.....	615	840	-	520	-	-	-	-	-	-	-	800
Rb.....	101	122	-	178	-	-	-	-	-	-	-	229
Sr.....	592	487	-	360	-	-	-	-	-	-	-	249
Pb.....	14.0	15.0	-	26.5	-	-	-	-	-	-	-	31.0
Th.....	17.6	27.2	-	28.4	-	-	-	-	-	-	-	21.8
U......	5.2	6.2	-	7.4	-	-	-	-	-	-	-	6.4
Zr.....	110	99	-	91	-	-	-	-	-	-	-	118
Nb.....	7.0	8.5	-	8.5	-	-	-	-	-	-	-	10.5
Y......	17	12	-	8	-	-	-	-	-	-	-	14
La.....	28	29	-	21	-	-	-	-	-	-	-	29
Ce.....	51	48	-	34	-	-	-	-	-	-	-	60
Nd.....	19	15	-	9	-	-	-	-	-	-	-	17
Sc.....	17	8	-	3	-	-	-	-	-	-	-	3
V......	161	64	-	32	-	-	-	-	-	-	-	6
Cr.....	20	2	-	2	-	-	-	-	-	-	-	<1
Mn.....	885	565	-	475	-	-	-	-	-	-	-	310
Co.....	23	11	-	5	-	-	-	-	-	-	-	1
Ni.....	12.5	2.5	-	2.5	-	-	-	-	-	-	-	<.5
Cu.....	43.5	8.0	-	4.0	-	-	-	-	-	-	-	2.0
Zn.....	98	60	-	50	-	-	-	-	-	-	-	32
Ga.....	19.4	17.4	-	17.2	-	-	-	-	-	-	-	17.2
					CIPW norms (weight percent)							
Q......	12.3	22.1	25.0	29.0	29.7	22.5	21.8	21.0	20.6	18.6	35.4	30.6
C......	-	-	1.0	-	.4	-	-	.1	-	-	1.7	.3
or.....	13.5	20.7	20.1	24.5	25.0	21.9	24.8	21.0	17.4	14.0	29.7	29.3
ab.....	29.6	30.3	31.6	31.2	29.0	35.3	32.2	35.2	36.9	39.1	26.4	31.5
an.....	24.2	16.0	13.4	10.7	11.8	13.6	14.4	16.0	16.9	18.8	4.5	6.0
di.....	4.8	1.7	-	-	-	1.1	1.6	-	.7	1.2	-	-
hy.....	9.0	5.2	5.0	2.0	1.5	2.4	.8	2.8	2.7	3.5	.8	.7
mt.....	4.4	2.6	2.4	1.7	1.9	2.0	1.6	2.5	3.1	2.9	1.4	1.0
il.....	1.7	1.0	1.1	.5	.5	.8	1.3	1.0	1.2	1.2	.3	.3
ap.....	.5	.4	.4	.2	.2	.4	.8	.5	.6	.1	.4	.1
hm.....	-	-	-	-	-	-	.6	-	-	-	-	-
Total	100.0	100.0	100.0	99.9	100.0	100.0	100.2	100.1	100.1	99.9	100.2	99.8

Table 4. Mode, color index, and specific gravity of plutonic rocks along traverse A–B (fig. 2) across the Tuolumne Intrusive Suite

Map number	Field number	Modes (volume percent)					Color index	Specific gravity
		Quartz	Plagio-clase	Alkali feldspar	Biotite	Horn-blende		
		Tonalite of Glen Aulin						
0	Z-64	3	60	2	12	21	35	2.83
1	Z-51	13	50	8	13	16	30	2.80
2	Z-52	12	55	3	12	16	30	2.80
3	Z-53	18	48	11	11	11	23	2.76
		Equigranular Half Dome Granodiorite (west)						
4	Z-54	20	43	16	11	8	21	2.74
5	Z-55	23	43	21	6	7	15	2.70
6	Z-56	24	40	23	6	5	13	2.70
7	Z-57	24	45	17	9	4	14	2.71
8	Z-58	25	43	22	6	3	10	2.69
9	Z-59	26	40	24	6	3	10	2.69
10	Z-60	25	44	23	4	2	8	2.67
		Megacrystic Half Dome Granodiorite (west)						
11	Z-61	23	44	25	6	2	9	2.67
12	Z-62	25	45	22	5	2	9	2.68
		Cathedral Peak Granodiorite (west)						
13	Z-63	26	47	21	3	2	6	2.66
14	Z-35	24	49	20	4	1	7	2.67
15	Z-10	23	48	23	4	1	6	2.67
16	Z-36	27	44	24	3	tr	5	2.65
17	Z-11	26	48	21	4	tr	6	2.66
18	Z-37	26	51	18	4	tr	6	2.65
19	Z-38	28	44	24	3	tr	4	2.63
		Johnson Granite Porphyry						
20	Z-39	29	35	34	2	0	2	2.61
21	Z-18	28	41	29	2	0	2	2.63
22	Z-19	33	26	40	1	0	1	2.61
		Cathedral Peak Granodiorite (east)						
23	Z-12	30	41	28	1	0	2	2.61
24	Z-40	25	47	23	4	tr	5	2.65
25	Z-13	27	45	23	3	tr	5	2.66
26	Z-14	26	48	21	4	1	6	2.66
27	Z-41	26	52	15	3	2	7	2.67
		Megacrystic Half Dome Granodiorite (east)						
28	Z-42	22	47	21	5	3	10	2.68
		Equigranular Half Dome Granodiorite (east)						
29	Z-43	25	46	17	7	4	12	2.71
30	Z-16	29	40	24	5	2	8	2.68
31	Z-44	20	45	18	10	7	18	2.73
		Granodiorite of Kuna Crest						
32	Z-45	22	44	15	10	8	19	2.73
33	Z-46	21	47	13	12	7	20	2.76
34	Z-47	14	51	9	12	13	26	2.78

Table 5. Mode, color index, and specific gravity of plutonic rocks along traverse C–D (fig. 2) across part of the western flank of the Tuolumne Intrusive Suite

Map number	Field number	Modes (volume percent)					Color index	Specific gravity
		Quartz	Plagio-clase	Alkali feldspar	Biotite	Horn-blende		
				Equigranular Half Dome Granodiorite				
35	Z-5	27	41	25	4	1	7	2.66
36	Z-23	25	43	21	6	3	11	2.69
37	Z-6	24	44	21	8	2	11	2.71
38	Z-24	26	43	22	5	3	10	2.67
39	Z-25	22	45	21	5	5	12	2.70
40	Z-26	23	45	22	3	1	10	2.68
41	Z-7	20	49	17	7	4	13	2.71
42	Z-27	28	39	27	4	1	7	2.66
43	Z-28	25	45	21	4	3	9	2.68
				Megacrystic Half Dome Granodiorite				
44	Z-8	24	45	21	5	3	10	2.70
45	Z-29	24	45	23	6	1	8	2.66
46	Z-30	24	45	24	5	2	7	2.67
47	Z-31	23	51	16	5	2	9	2.70
48	Z-32	23	47	22	4	2	8	2.65
				Cathedral Peak Granodiorite				
49	Z-33	25	47	22	4	2	7	2.67
50	Z-9	24	47	21	4	2	8	2.66
51	Z-34	25	46	23	4	1	6	2.67
52	Z-20	24	48	21	5	1	7	2.67

Table 6. Mode, color index, and specific gravity of plutonic rocks of the Tuolumne Intrusive Suite not along traverses A–B or C–D

Field/map number	Modes (volume percent)					Color index	Specific gravity
	Quartz	Plagio-clase	Alkali feldspar	Biotite	Horn-blende		
Equigranular Half Dome Granodiorite							
Z-17	23	41	31	3	1	5	2.65
K-2-74	21	55	10	6	9	14	2.71
K-11-74	27	41	25	5	1	7	2.66
K-30-74	20	48	15	9	8	17	2.73
K-15-75	15	55	10	10	7	20	2.75
K-31-75	25	46	18	6	3	11	2.55
K-33-75	23	48	18	8	2	11	2.68
K-34-75	19	53	16	7	3	11	2.71
K-39-75	23	50	14	6	4	12	2.69
TMa-5	19	58	9	-	-	15	2.74
TMa-7	25	49	16	-	-	11	2.71
TMa-8	22	54	9	-	-	15	2.74
TMa-11	25	46	18	9	2	12	2.71
TMa-14	27	42	21	7	4	11	2.71
TMa-15	20	49	16	12	2	15	2.73
TMa-23	20	52	13	9	4	15	2.73
TMa-27	27	42	23	4	5	8	2.68
TMa-60	16	57	10	11	5	18	2.76
TMb-1	23	47	18	7	3	11	2.69
TMb-104	22	48	14	7	10	17	2.74
TMb-162	19	51	18	7	4	11	2.71
TMc-44	21	48	22	5	4	11	2.68
TMc-107	23	43	26	6	1	9	2.67
TMc-111	25	42	25	5	2	8	2.69
TMc-114	31	43	13	8	4	14	2.70
TMc-115	28	52	10	5	3	11	2.69
TMc-116	35	43	11	7	3	11	2.67
TMc-117	31	45	12	5	5	12	2.69
TMc-123	26	37	32	1	1	5	2.64
TMc-172	25	44	18	10	2	13	2.69
TMc-175	25	45	19	8	1	11	2.65
TMc-176	23	48	20	-	-	9	2.68
TMc-177	40	44	7	-	-	8	2.66
TMc-178	29	42	23	-	-	6	2.64
TMc-179	25	46	21	-	-	9	2.67
TMd-91	25	46	19	4	3	10	2.68
TMd-101	26	46	21	3	3	8	2.67
TMd-103	26	41	24	5	3	9	2.65
TMd-107	27	42	21	5	4	10	2.68
TMd-108	30	39	23	4	2	8	2.65
TMd-119	30	37	23	6	4	10	2.67
TMd-123	35	45	11	7	0	9	2.70
TMd-172	26	44	19	7	2	11	2.67
TMd-174	27	47	16	8	3	11	2.69
TMd-176	26	39	27	5	3	7	2.65
Megacrystic Half Dome Granodiorite							
TMb-159	22	49	18	7	3	11	2.68
TMc-5	22	51	18	5	3	9	2.67
TMc-6	23	48	20	3	6	10	2.67
TMc-7	24	50	17	9	3	4	2.67
TMc-13	22	47	19	3	7	11	2.68
TMc-15	24	41	24	8	1	9	2.66
TMc-17	23	53	14	3	3	10	2.67
TMc-19	24	49	19	3	5	8	2.68
TMc-20	28	46	18	3	4	9	2.68
TMc-23	27	42	24	3	1	7	2.66
TMc-24	26	44	21	4	3	10	2.67
TMc-31	21	51	17	3	6	11	2.67
TMc-32	26	38	24	7	4	12	2.67
TMc-33	22	43	20	6	3	10	2.68
TMc-34	19	48	20	3	6	12	2.68
TMc-35	23	44	23	6	4	11	2.69
TMc-40	24	44	22	6	4	10	2.67
TMc-41	24	47	21	4	4	8	2.65
TMc-42	27	47	20	3	4	6	2.66
TMc-43	26	46	19	7	1	9	2.66
TMc-45	24	48	18	5	3	10	2.70
TMc-46	25	45	20	6	4	10	2.68
TMc-47	23	46	21	5	2	9	2.68

Table 6. Mode, color index, and specific gravity of plutonic rocks of the Tuolumne Intrusive Suite not along traverses A–B or C–D—*Continued*

Field/map number	Modes (volume percent)					Color index	Specific gravity
	Quartz	Plagio-clase	Alkali feldspar	Biotite	Horn-blende		
			Megacrystic Half Dome Granodiorite (continued)				
TMc-110	28	47	18	3	3	8	2.68
TMc-112	27	20	46	4	2	7	2.67
TMc-119	23	48	24	1	1	4	2.65
TMc-121	20	46	27	3	2	8	2.66
TMc-151	38	42	10	-	-	11	2.67
TMc-152	26	36	33	5	tr	7	2.66
TMd-1	30	43	20	5	1	7	2.64
TMd-1A	20	47	24	4	2	8	2.68
TMd-5A	21	55	16	4	1	8	2.67
TMd-6	25	53	14	5	2	8	2.65
TMd-7	21	50	22	3	3	7	2.67
TMd-14B	23	48	18	4	4	10	2.67
TMd-16	24	49	17	4	4	10	2.66
TMd-20	25	44	21	2	4	10	2.68
TMd-43	23	47	22	4	1	8	2.66
TMd-48	23	51	25	6	2	8	2.67
TMd-49	26	48	18	4	3	8	2.67
TMd-54	25	51	17	5	2	8	2.69
TMd-56	22	35	36	4	3	7	2.66
TMd-57	22	43	28	4	4	8	2.67
TMd-88	24	42	34	2	7	10	2.67
TMd-115	23	51	16	-	-	11	2.71
TMd-116	30	43	18	6	2	9	2.67
TMd-117	23	54	11	7	3	11	2.68
TMd-124	31	39	20	6	2	10	2.71
			Cathedral Peak Granodiorite				
K-1-74	27	39	28	3	1	5	2.65
K-18-75	22	51	21	4	1	6	2.66
K-19-75	22	49	25	4	0	4	2.60
K-20-75	25	39	32	4	0	4	2.64
K-21-75	26	44	26	4	0	5	2.63
K-22-75	27	47	22	4	0	4	2.61
K-23-75	27	43	26	3	0	4	2.64
K-24-75	30	42	26	2	0	2	2.61
K-25-75	26	41	29	3	0	4	2.64
K-26-75	29	42	26	3	0	3	2.65
K-27-75	30	32	37	1	0	2	2.61
K-28-75	29	42	26	3	0	4	2.63
K-29-75	22	51	18	3	3	8	2.67
K-30-75	23	46	25	5	1	7	2.67
K-32-75	27	55	10	5	2	8	2.68
K-35-75	21	53	17	4	4	9	2.67
K-36-75	29	46	16	4	1	6	2.66
K-38-75	25	49	18	4	2	8	2.68
K-40-75	24	39	33	1	3	5	2.64
K-41-75	21	48	25	4	2	6	2.66
K-42-75	21	48	24	6	1	8	2.67
K-43-75	27	48	21	3	0	5	2.63
K-44-75	28	47	20	5	0	6	2.64
K-45-75	28	45	23	3	0	4	2.63
K-46-75	26	47	22	3	0	4	2.64
K-47-75	27	46	22	3	0	5	2.63
K-48-75	26	41	24	4	tr	6	2.63
K-49-75	27	43	25	3	0	4	2.63
K-50-75	29	40	27	4	0	4	2.62
K-51-75	26	40	29	4	tr	5	2.65
K-52-75	28	33	36	3	0	3	2.62
K-53-75	27	43	25	5	0	6	2.64
K-55-75	27	42	26	3	0	4	2.62
K-56-75	26	43	26	2	0	4	2.62
K-57-75	27	39	29	3	0	4	2.63
K-58-75	29	42	25	4	0	4	2.63
TMa-2	21	40	31	-	-	7	2.66
TMa-9	23	51	17	-	-	9	2.69
TMa-10	26	60	14	5	1	8	2.69
Tma-24	23	47	25	3	2	6	2.67
TMa-28	29	55	16	3	3	6	2.67
TMa-29	23	40	34	3	tr	4	2.66

Table 6. Mode, color index, and specific gravity of plutonic rocks of the Tuolumne Intrusive Suite not along traverses A–B or C–D—*Continued*

Field/map number	Modes (volume percent)					Color index	Specific gravity
	Quartz	Plagio-clase	Alkali feldspar	Biotite	Horn-blende		
Cathedral Peak Granodiorite (continued)							
TMa-33	28	43	26	3	0	3	2.64
TMa-34	33	34	32	1	0	1	2.62
TMa-50	25	50	29	4	tr	6	2.66
TMa-51	30	44	21	4	tr	5	2.64
TMa-52	28	46	22	4	0	4	2.63
TMa-54	21	49	21	6	2	9	2.68
TMa-55	27	55	13	4	1	6	2.67
TMa-56	23	46	26	3	tr	5	2.66
TMa-57	22	53	18	6	tr	7	2.68
TMa-58	27	47	20	5	tr	6	2.65
TMa-59	23	53	17	5	1	7	2.66
TMa-103	25	47	22	4	1	6	2.64
TMb-4	31	46	20	3	0	3	2.62
TMb-152	24	44	29	3	tr	4	2.65
TMb-153	32	42	22	3	0	4	2.63
TMb-154	29	45	24	2	0	2	2.64
TMb-155	26	46	23	3	tr	4	2.64
TMb-157	24	49	22	4	tr	5	2.63
TMb-158	26	46	22	5	tr	6	2.64
TMb-160	20	39	35	5	1	6	2.64
TMb-161	23	49	23	3	1	5	2.65
TMb-164	19	43	31	–	–	8	2.65
TMc-8	22	43	29	3	1	5	2.66
TMc-9	24	43	27	2	2	6	2.66
TMc-10	27	50	17	3	1	7	2.67
TMc-11	21	45	27	4	2	8	2.67
TMc-12	27	47	20	5	1	6	2.66
TMc-14	24	45	23	4	2	8	2.66
TMc-16	27	49	17	4	2	7	2.66
TMc-25	25	54	12	4	3	9	2.66
TMc-26	22	43	27	6	1	8	2.66
TMc-27	25	45	23	6	1	8	2.66
TMc-28	23	48	22	3	2	7	2.66
TMc-29	22	47	25	4	1	6	2.65
TMc-30	22	50	21	6	tr	8	2.66
TMc-48	21	52	17	5	3	11	2.69
TMc-49	20	44	29	2	2	7	2.66
TMc-50	26	54	11	5	1	9	2.66
TMc-51	24	49	18	5	3	9	2.68
TMc-52	26	46	22	3	tr	4	2.66
TMc-53	21	53	16	7	2	10	2.67
TMc-54	24	46	23	3	2	7	2.67
TMc-55	21	51	22	4	1	6	2.66
TMc-56	27	50	16	5	1	7	2.65
TMc-118	30	42	20	–	–	8	2.66
TMc-120	23	46	23	6	2	9	2.67
TMc-153	22	51	21	–	–	5	2.65
TMc-154	29	48	19	–	–	5	2.66
TMc-155	27	48	20	4	tr	5	2.65
TMc-156	30	45	26	–	–	6	2.64
TMc-157	21	57	16	3	1	6	2.65
TMc-158	21	49	25	–	–	6	2.66
TMc-159	27	43	25	3	1	6	2.64
TMc-150	32	44	19	–	–	5	2.65
TMc-161	23	49	22	–	–	6	2.65
TMc-162	26	49	21	3	tr	4	2.63
TMc-163	27	42	27	4	tr	4	2.64
TMc-164	26	48	21	4	tr	6	2.63
TMc-165	29	44	22	4	1	6	2.66
TMc-166	27	45	23	4	tr	5	2.65
TMc-167	25	47	20	5	3	8	2.66
TMc-168	33	47	17	3	tr	4	2.63
TMc-169	25	43	28	5	0	5	2.64
TMc-170	27	45	24	4	0	4	2.64

Table 6. Mode, color index, and specific gravity of plutonic rocks of the Tuolumne Intrusive Suite not along traverses A–B or C–D—*Continued*

Field/map number	Modes (volume percent)					Color Index	Specific Gravity
	Quartz	Plagio-clase	Alkali feldspar	Biotite	Horn-blende		
			Cathedral Peak Granodiorite (continued)				
TMd-2	26	48	18	6	2	8	2.66
TMd-3	30	46	16	5	2	8	2.66
TMd-2A	21	44	29	4	1	6	2.68
TMd-17	24	49	21	3	2	6	2.66
TMd-18	21	44	28	4	1	7	2.67
TMd-21	25	53	14	4	2	8	2.68
TMd-22	29	52	12	6	tr	7	2.66
TMd-23	23	57	9	5	2	11	2.65
TMd-24	28	48	17	4	1	7	2.66
TMd-28	27	49	17	6	tr	8	2.66
TMd-29	29	47	19	4	tr	6	2.65
TMd-30	23	50	19	5	1	8	2.66
TMd-31	21	54	18	2	1	6	2.66
TMd-32	32	42	23	3	tr	3	2.62
TMd-33	24	47	24	4	tr	5	2.64
TMd-39	26	46	23	3	1	5	2.66
TMd-42A	26	49	20	3	1	5	2.65
TMd-42B	27	57	8	6	0	8	2.67
TMd-47	22	43	29	3	2	7	2.66
TMd-50	23	38	33	2	1	5	2.66
TMd-51	27	53	16	3	tr	4	2.65
TMd-52	24	42	27	4	3	7	2.67
TMd-53	30	51	14	4	0	5	2.65
TMd-158	24	48	21	5	tr	7	2.66
TMd-159	26	49	20	3	0	5	2.64
TMd-161	22	46	28	3	1	5	2.63
TMd-162	30	48	18	2	tr	3	2.63
TMd-164	26	45	22	5	0	7	2.64
TMd-165	29	47	21	3	0	3	2.61
TMd-166	27	42	26	3	0	3	2.63
TMd-167	28	41	24	5	tr	7	2.65
TMd-168	31	44	20	4	1	5	2.63
TMd-169	27	41	29	1	1	3	2.63
TMd-169	25	46	23	5	tr	7	2.63
TMd-171	25	46	23	6	tr	7	2.63
			Johnson Granite Porphyry				
Z-65	22	34	42	1	0	2	2.60
TMb-151	28	34	36	–	–	2	2.58
TMc-171	18	37	43	–	–	2	2.61
TMd-40	22	48	27	–	–	3	2.63
TMd-45	31	30	38	–	–	1	2.60
TMd-46	33	24	43	–	–	1	2.58
TMd-151	17	27	55	–	–	1	2.62
TMd-152	23	31	45	–	–	1	2.61
TMd-153	19	32	48	–	–	2	2.59
TMd-154	16	31	53	–	–	1	2.62
TMd-155	32	26	41	–	–	1	2.57
TMd-156	24	31	44	–	–	1	2.56
TMd-163	25	37	38	–	–	1	2.58

Table 7. Mode, color index, and specific gravity of plutonic rock samples predating the Tuolumne Intrusive Suite

Field/map number	Modes (volume percent) Quartz	Plagio-clase	Alkali feldspar	Biotite	Horn-blende	Color index	Specific gravity
			Granodiorite of Yosemite Creek				
K-7-75	17	66	4	-	-	13	2.69
K-12-75	8	72	1	-	-	19	2.75
			Granodiorite north of Tuolumne Peak				
K-24-74	35	31	31	4	0	4	2.64
			Leucogranite of Ten Lakes				
TMa-19	37	34	27	3	0	4	2.64
TMa-30	37	29	33	1	0	2	2.62
TMa-31	18	51	17	-	-	14	2.71
TMa-32	33	33	32	1	0	2	2.63
K-16-74	28	43	27	2	0	2	2.64
K-17-74	30	29	36	4	0	4	2.64
K-22-74	35	17	48	1	0	1	2.62
K-1-75	30	35	29	6	0	6	2.65
K-2-75	29	38	30	4	0	4	2.62
K-3-75	34	35	29	2	0	2	2.63
K-5-75	33	37	29	1	0	1	2.62
K-6-75	32	30	35	3	0	3	2.62
K-8-75	34	31	33	2	0	2	2.61
K-11-75	32	29	37	2	0	2	2.62
K-13-75	33	28	34	3	0	3	2.62
			Granodiorite of Mount Hoffman				
TMa-13	34	39	23	4	0	5	2.64
TMa-22	35	33	29	3	0	3	2.64
TMc-101	29	42	23	6	tr	6	2.64
TMc-103	32	34	31	3	0	3	2.63
TMc-104	32	37	23	7	2	9	2.67
TMc-105	35	33	25	6	2	8	2.65
K-6-74	29	37	29	5	0	6	2.66
K-9-74	32	29	38	1	0	1	2.62
K-20-74	35	33	27	4	0	5	2.65
K-25-74	31	34	30	4	0	5	2.65
K-27-74	32	34	29	4	0	4	2.64
K-32-74	34	35	30	2	0	2	2.62
K-33-74	26	40	22	11	1	12	2.66
K-4-75	32	38	23	7	0	7	2.63
K-16-75	31	33	32	3	0	3	2.62
K-17-75	33	30	35	2	0	2	2.58
			Granite of Turner Lake				
TMd-19	33	37	24	6	0	7	2.64
TMd-58	28	35	31	5	1	6	2.65
TMd-59	29	37	29	-	-	4	2.65
TMd-87	32	33	29	6	0	6	2.64

Table 7. Mode, color index, and specific gravity of plutonic rock samples predating the Tuolumne Intrusive Suite—*Continued*

Map Number	Modes (volume percent)					Color Index	Specific Gravity
	Quartz	Plagio-clase	Alkali-feldspar	Biotite	Horn-blende		
Granodiorite of Red Devil Lake							
TMd-35	28	32	36	4	tr	4	2.64
TMd-55	27	46	18	6	3	9	2.70
TMd-60	28	41	23	7	tr	7	2.66
TMd-63	23	50	16	10	1	12	2.69
TMd-64	23	43	24	6	2	9	2.68
TMd-68	25	49	17	7	1	10	2.68
TMd-76	24	49	15	6	4	12	2.69
TMd-77	27	49	12	12	tr	13	2.70
TMd-78	25	49	19	5	2	7	2.69
TMd-79	26	43	20	8	1	11	2.68
TMd-84	28	38	25	8	0	9	2.65
TMd-85	28	40	21	8	1	11	2.64
TMd-86	27	42	20	10	tr	11	2.66
Granite of Ireland Lake							
TMd-11	26	43	26	4	tr	5	2.64
TMd-13	22	37	36	0	4	5	2.63
Leucogranite of Gallison Lake							
TMd-61	26	38	34	1	0	2	2.62
TMd-62	13	38	45	2	0	3	2.63
Quartz diorite							
TMa-20	7	72	tr	3	17	21	2.85
TMd-38	13	67	8	8	3	13	2.75
TMd-66	10	63	10	11	5	18	2.74
TMd-75	9	70	3	8	9	18	2.73
TMd-80	4	78	1	4	11	18	2.79
Melagranite							
TMb-9	16	28	30	8	17	26	2.70
TMb-188	16	36	35	-	-	14	2.71

Table 8. Isotopic data for oxygen, rubidium, and strontium from samples projected on traverse A–B (fig. 2) across the Tuolumne Intrusive Suite

Map number	Field number	Rb (ppm)	Sr (ppm)	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	$^{87}Sr/^{86}Sr$ 87 Ma	$\delta^{18}O$
0	Z-64	88	616	0.143	0.413	0.70650	0.7060	
1	Z-51	108	574	.188	.544	.70656	.7059	
2	Z-52	102	551	.185	.535	.70635	.7057	
						.70645	.7058	
						.70642	.7058	
3	Z-53	140	507	.276	.799	.70693	.7059	7.7
						.70695	.7060	
						.70687	.7059	
4	Z-54	134	478	.280	.811	.70678	.7058	7.7
						.70680	.7058	
						.70667	.7057	
5	Z-55	138	451	.306	.885	.70723	.7061	7.9
6	Z-56	127	412	.308	.892	.70719	.7061	
7	Z-57	114	509	.224	.648	.70692	.7061	8.0
8	Z-58	141	462	.305	.883	.70744	.7063	8.3
						.70759	.7065	
						.70728	.7062	
9	Z-59	153	397	.485	1.115	.70769	.7063	
10	Z-60	138	491	.281	.813	.70733	.7063	
11	Z-61	129	658	.196	.567	.70707	.7064	
						.70713	.7064	
						.70717	.7064	
12	Z-62	104	701	.148	.429	.70695	.7064	
13	Z-63	135	582	.232	.671	.70729	.7065	
14	Z-35	129	710	.182	.526	.70690	.7063	
						.70725	.7066	
						.70710	.7065	
15	Z-10	134	663	.202	.585	.70700	.7063	8.3
						.70709	.7064	
						.70717	.7065	
16	Z-36	127	641	.198	.573	.70701	.7063	
17	Z-11	137	621	.221	.638	.70716	.7064	
18	Z-37	132	585	.226	.653	.70712	.7063	
19	Z-38	165	525	.314	.909	.70765	.7065	
20	Z-39	189	277	.682	1.975	.70907	.7066	
21	Z-18	158	484	.326	.944	.70776	.7066	
22	Z-19	207	301	.688	1.990	.70906	.7066	
23	Z-12	150	369	.407	1.176	.70786	.7064	
						.70791	.7064	
24	Z-40	143	628	.228	.659	.70718	.7064	
						.70707	.7063	
25	Z-13	131	609	.215	.622	.70710	.7063	
26	Z-14	133	648	.205	.594	.70717	.7064	
						.70694	.7062	
						.70707	.7063	
27	Z-41	107	695	.154	.445	.70704	.7065	
28	Z-42	114	699	.163	.472	.70691	.7063	
						.70703	.7064	
						.70697	.7064	
29	Z-43	107	579	.185	.535	.70673	.7061	
						.70685	.7062	
						.70679	.7061	
30	Z-16	163	380	.429	1.241	.70760	.7061	
31	Z-44	123	515	.239	.691	.70683	.7060	8.1
32	Z-45	113	563	.201	.581	.70678	.7061	
33	Z-46	119	482	.247	.714	.70679	.7059	
34	Z-47	102	545	.187	.541	.70663	.7060	
						.70646	.7058	

Table 9. Isotopic data for oxygen, rubidium, and strontium from samples along traverse C–D (fig. 2) across part of the western flank of the Tuolumne Intrusive Suite

Map number	Field number	Rb (ppm)	Sr (ppm)	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	$^{87}Sr/^{86}Sr$ 87 Ma	$\delta^{18}O$
35	Z-5	146	436	0.335	0.969	0.70749	0.7063	8.2
						.70740	.7062	
36	Z-23	30	526	.247	.715	.70701	.7061	7.9
						.70713	.7062	
37	Z-6	114	578	.197	.571	.706920	.7062	--
38	Z-24	121	555	.218	.631	.707070	.7063	--
39	Z-25	114	568	.201	.581	.706960	.7062	--
40	Z-26	136	510	.267	.771	.70736	.7064	--
						.70712	.7062	
						.70717	.7062	
41	Z-7	110	688	.160	.463	.70682	.7062	--
42	Z-27	149	413	.361	.044	.70757	.7063	--
43	Z-28	127	572	.222	.642	.70714	.7063	--
44	Z-8	117	633	.185	.535	.70704	.7064	--
						.70688	.7062	
45	Z-29	28	631	.203	.587	.70726	.7065	--
46	Z-30	18	641	.184	.533	.70709	.7064	--
47	Z-31	100	709	.141	.408	.70698	.7065	--
48	Z-32	106	689	.154	.445	.70699	.7064	--
49	Z-23	113	712	.158	.457	.70709	.7065	--
50	Z-9	127	668	.190	.550	.70710	.7064	--
51	Z-34	128	618	.207	.599	.70713	.7064	--
52	Z-20	126	667	.189	.547	.70714	.7065	--

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