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Petrographic and Chemical Data for the Large Mesozoic and Cenozoic Plutonic Sills East of Juneau, Southeastern Alaska

By JAMES L. DRINKWATER, DAVID A. BREW, and ARTHUR B. FORD

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Petrographic and Chemical Data for the Large Mesozoic and Cenozoic Plutonic Sills East of Juneau, Southeastern Alaska

By James L. Drinkwater, David A. Brew, *and* Arthur B. Ford

Abstract

Petrographic, chemical, and age data are presented for six plutonic sills of Late Cretaceous to early Tertiary age located east of Juneau, Alaska. Five of the sills—the Mount Juneau, Carlson Creek, Lemon Creek Glacier, Mendenhall Glacier, and Taku Cabin plutons—are mostly tonalite but range from quartz diorite to granodiorite; their mean color indexes range from 19 to 32. The more silicic Annex Lakes pluton is mostly granodiorite but has significant quartz monzodiorite and tonalite and a mean color index of 14. Although the six plutons are calc-alkaline and generally similar in average chemical and modal composition, they vary in form, mineralogy, texture, and petrographic and chemical characteristics. The Mount Juneau and Annex Lakes plutons exhibit the greatest internal differences, whereas the Taku Cabin and Mendenhall Glacier plutons are the most homogeneous. Plots on silica-oxide variation and AFM diagrams exhibit coherent trends with some scatter.

INTRODUCTION

This report contains preliminary petrographic and chemical data for a group of six plutonic sills of Late Cretaceous to early Tertiary age located east of Juneau, Alaska (fig.1). The plutons are part of what Brew (1988) termed the "great tonalite sill," which was previously called the Coast Plutonic Complex sill belt by Brew and Morrell (1983). This sill belt is part of a larger unit informally called the Coast plutonic-metamorphic complex (Brew and Ford, 1984a, b). The great tonalite sill is a composite linear batholith that extends for more than 900 kilometers along the length of southeastern Alaska from north of Skagway south into British Columbia (fig. 1). The investigation of the six plutons is important in understanding the emplacement history and petrogenesis of the large composite tonalitic sill belt. The location of the variably deformed and metamorphosed sill bodies in the zone of most intense metamorphism and deformation of a major tectonic welt (Brew and Ford, 1978, 1981, 1985; Monger and others, 1982) makes them a critical element in studying the timing of plutonism, deformation, and regional metamorphism of the region.

Locations of the plutons—herein called the Juneau sills—are shown in figures 1 and 2, and the regional geologic setting is summarized in figure 2. The locations of samples used in modal and chemical analysis are shown on geologic sketch maps of each pluton in the section "Description of Plutons." The Mendenhall Glacier pluton extends much farther northward than the study area, but only the southernmost segment of the pluton is included in this study.

Information presented here includes descriptive summaries, modal analyses, rock-classification diagrams, petrographic data, and major-element chemistry for each pluton. Pluton summary information is presented as plots of average modal and average chemical analyses, tables of petrographic characteristics and mineral occurrences, and frequency distribution charts of color index and estimated anorthite (An) content of plagioclase. Binary and ternary variation diagrams are included to show the petrologic affinity and classification of the rocks.

This report provides information for comparative studies of segments of the great tonalite sill and supports future investigations, synthesis, and related work.

GEOLOGIC SETTING

The Juneau sills form a discontinuous segment of the great tonalite sill (Brew, 1988), a long and narrow belt of sheet-like orthogneiss plutons (Brew and Ford, 1981) of Late Cretaceous to early Tertiary age (fig. 1). The 3- to 25-km-wide belt consists of numerous individual sills of tonalite with minor granodorite and quartz diorite. The sills typically are strongly foliated to gneissic in texture and display other moderate to strong meta-

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morphic characteristics. The sills dip steeply east. They separate metamorphic rocks with Paleozoic and Mesozoic protolith ages on the west from Tertiary granitic rocks and gneisses with Paleozoic protolith ages on the east. The rocks on the east constitute the central part of the (informal) Coast plutonic-metamorphic complex of Brew and Ford (1984a, b). These two separated units were called the western metamorphic and central granitic zones by Brew and Ford (1981), and they roughly coincide with parts of the Taku and Tracy Arm tectonostratigraphic terranes of Berg and others (1978). The significance of this was discussed by Brew and Ford (1978, 1981, 1984b), who believe that the sills were emplaced near a major structural boundary but reject the concept that the Taku and Tracy Arm terranes were separately accreted and are disparate tectonostratigraphic terranes. The relations between ages of intrusion, metamorphism, and deformation are discussed in Brew and Ford (1981), Brew and others (1989a, b) and Gehrels and others (1984).

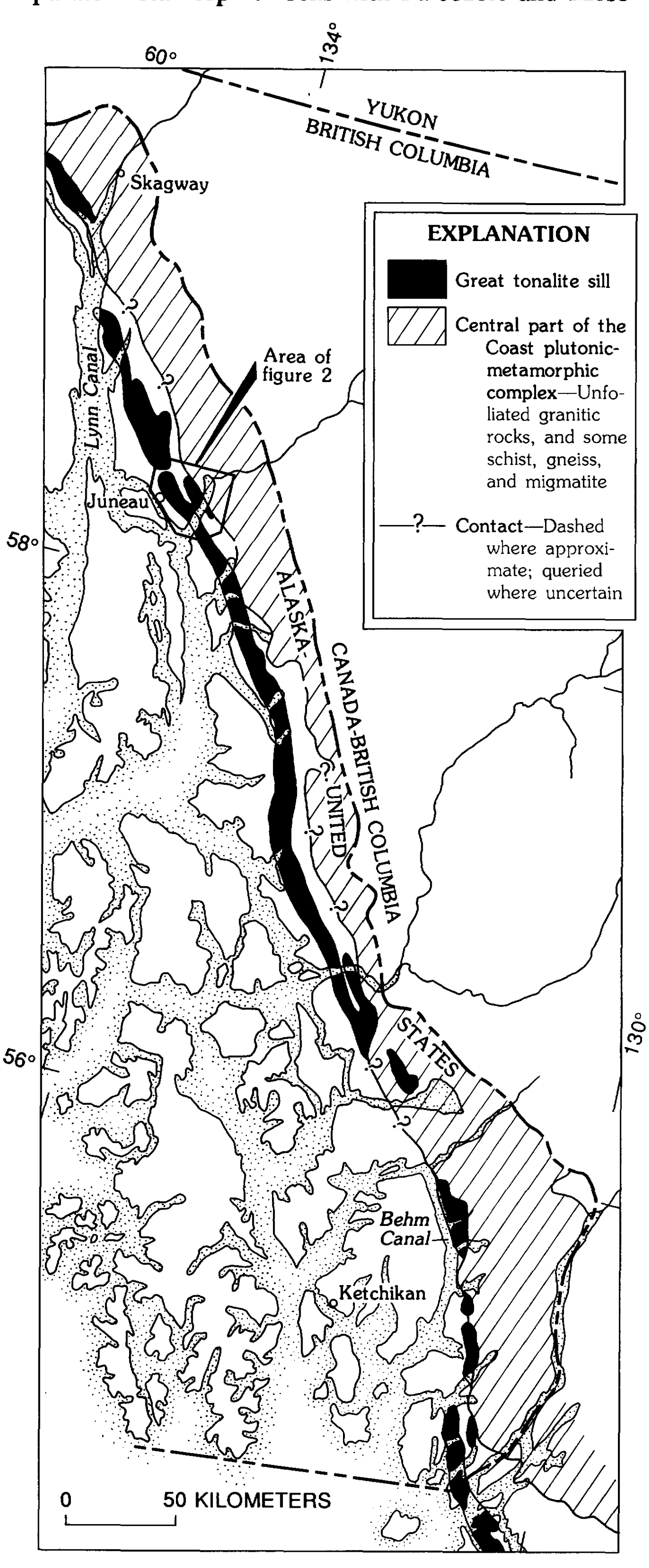

Figure 1. Index map showing location of the great tonalite sill (Brew, 1988) and central granitic part of the (informal) Coast plutonic-metamorphic complex (Brew and Ford, 1984a, b). Eastern contact of the latter in Canada not shown.

The six sills east of Juneau range from 1 to 8 km in width and are separated from each other by screens of migmatitic gneiss and amphibolite-grade schist (fig. 2). Each pluton trends northwest and dips easterly in concordance with the regional structure; the Mount Juneau pluton, however, truncates the regional structure at its northern end. The regional geology of the area is summarized in Brew and Ford (1986), and detailed maps by Ford and Brew (1973) and Brew and Ford (1977) cover most of the area. Earlier geologic descriptions and maps of parts of the area are found in Twenhofel (1952), Sainsbury (1953), and Plafker (1962).

The Juneau sills are composed mostly of tonalite and contain lesser but significant amounts of granodiorite and quartz diorite. Hornblende is the predominant mafic mineral except in the Mount Juneau and Annex Lakes plutons, where biotite is more abundant. All the sills are strongly foliated, but the well-developed gneissic layering displayed by the Mount Juneau, Lemon Creek Glacier, and Carlson Creek plutons is absent in the Taku Cabin and Mendenhall Glacier plutons. The Annex Lakes pluton, which is mostly biotite granodiorite, is only moderately to weakly foliated but locally displays a weak gneissic layering and strong foliation. The foliation and gneissic layering generally parallel the margins of the sills and the foliation in the country rock.

The Annex Lakes pluton is larger and more leucocratic than the other plutons and is the most varied lithologically and texturally; it may be a composite body that is intermediate in character between the sills to the west and the massive homogeneous granodiorite of the Turner Lake pluton to the east. Whether the more massive homogeneous core of the Annex Lakes pluton, which has been separately called the Flat Point pluton by Brew and Ford (1977), is a differentiated phase of the Annex Lakes pluton or a separate pluton is uncertain; it is treated in this report as part of the Annex Lakes pluton.

GEOCHRONOLOGY

A summary of radiometric ages for the plutonic sills and associated rocks east of Juneau is shown in table 1. All the K-Ar ages except that of the Turner Lake pluton are interpreted as minimum ages. The three most deformed and metamorphosed sills (Mount Juneau, Carlson Creek, and Lemon Creek Glacier plutons) are older than the foliated but less deformed Taku Cabin and Mendenhall Glacier plutons, and they were apparently emplaced into an environment of more active deformation and metamorphism. The K-Ar hornblende age of 66.5 Ma from the Mount Juneau pluton (table 1) closely agrees with the U-Pb age of 67±2 Ma on zircons from the Carlson Creek pluton reported by Gehrels and others (1984), but it is a minimum age. Preliminary results of current studies (D.A. Brew and A.B. Ford, unpub. data, 1989) suggest that the Mount Juneau pluton is older than the Carlson Creek pluton. The undeformed core (Flat Point pluton) of the variably deformed and synkinematically emplaced Annex Lakes pluton yielded a U-Pb age of 60.0 Ma that registers the end of intense deformation

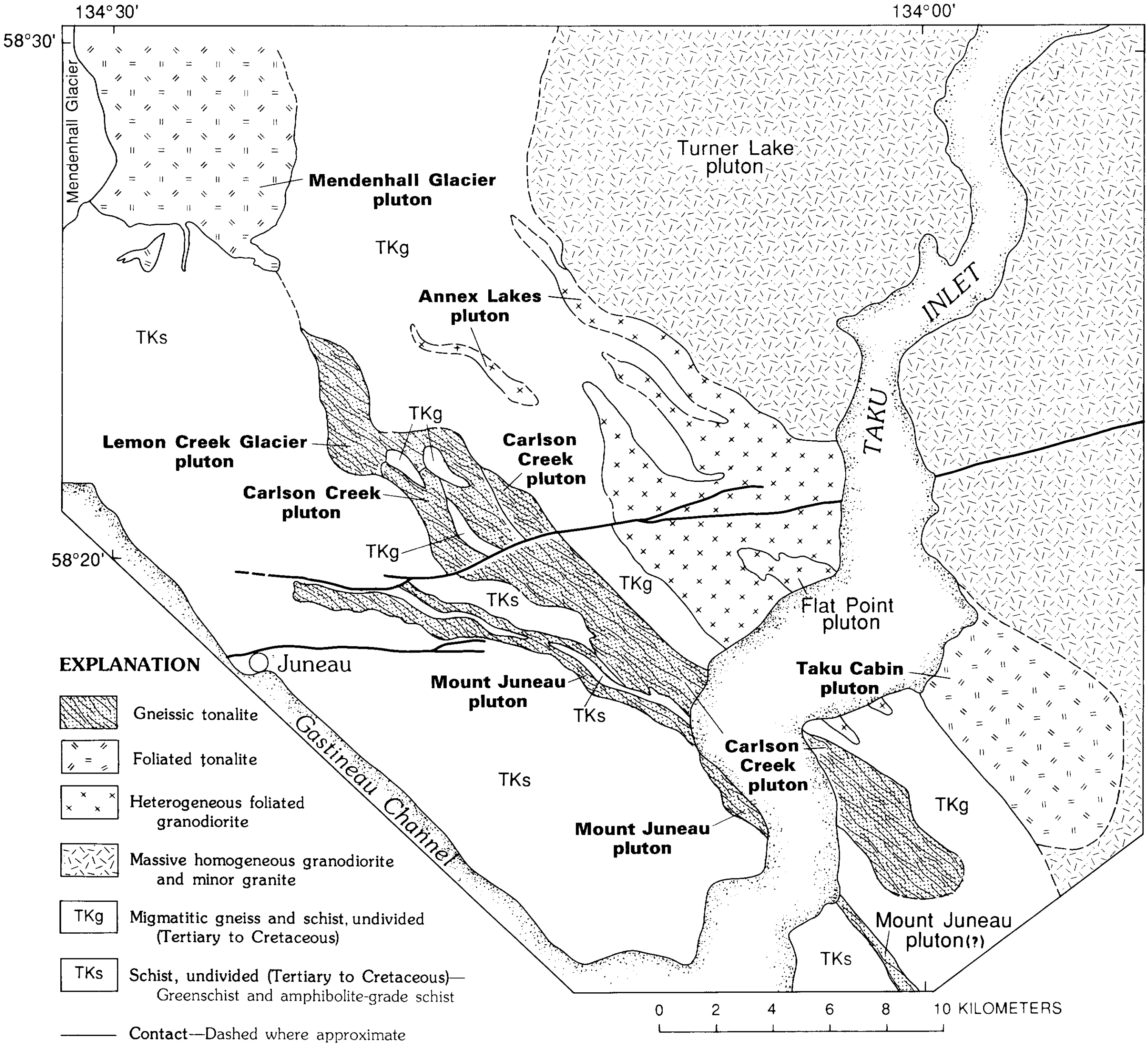

Figure 2. Geologic sketch map showing large sills in the (informal) Coast plutonic-metamorphic complex of Brew and Ford (1984b) east of Juneau. Plutons in bold type are those discussed in text.

and metamorphism (Gehrels and others, 1984). The Mendenhall Glacier and Taku Cabin plutons are late-synkinematically emplaced bodies (Brew and others, 1989a) with inferred ages between 55 and 60 Ma. K-Ar ages of 51 to 56 Ma on biotite-hornblende pairs from the migmatitic gneiss country rock reported by Forbes and Engels (1970) agree well with unpublished ages from J.G. Smith (1974) of 52 to 57 Ma on similar gneissic country rocks. The K-Ar ages of the sills and gneissic country rock probably reflect the latest major thermal event related to emplacement of the Turner Lake pluton (fig. 2).

METHODS

The information in this report is based largely on field notes, chemical analyses, and examination of stained rock slabs and thin sections. Rock names given in this report are based on modes (fig. 3) plotted on the rock classification diagram of Streckeisen (1973). Modes (percent quartz, K-feldspar, plagioclase, and mafic minerals) were determined by counting roughly 1,000 points on rock slabs stained for K-feldspar and plagioclase by the method of Norman (1974), and results are shown in tables and on triangular plots of K-feldspar, quartz, and plagioclase recalculated to 100 percent. Biotite and hornblende were counted together as total mafic minerals. The data for the Mount Juneau pluton include separate percentages for biotite, hornblende, epidote, chlorite, and total accessories, based on thin sections point counted in a previous study (Ford and Brew, 1981). In studies of the other plutons, relative amounts of biotite and hornblende were visually estimated by thin-section examination.

Major-element chemical analyses were done by whole-rock X-ray fluorescence determinations or by rapid rock methods (pre-1970 samples) at U.S. Geological Survey laboratories in Menlo Park, Calif., and Denver, Colo. The data were converted to normalized oxides and CIPW norms by the PETCAL 4 computer program (Bingler and others, 1976), and results were tabulated on a volatile-free basis for each pluton; an average chemical composition for each pluton was also tabulated. Normative An content of plagioclase and color index (CI) are also reported.

SUMMARY INFORMATION

Summary information is presented in both tables and figures that summarize the results of petrographic and chemical analyses for all plutons. In addition, variation and discriminant diagrams present data from each pluton for comparative studies. The Mendenhall Glacier body may have different petrographic and chemical characteristics outside of the study area.

Petrography

The general petrographic characteristics of the sills are listed in table 2, average modal compositions are plotted in figure 3, the occurrence of minerals is summarized in figure 4, and distribution of color index is shown in figure 5. Tonalite is the predominant composition, although much of the margins of the plutons is either quartz diorite or quartz monzodiorite. Plagioclase, quartz, hornblende, and biotite are the most common minerals in the sills; K-feldspar and iron oxides occur in trace to minor amounts in most of the rocks. Garnet is common in the Mount Juneau pluton, less common in the Carlson Creek and Lemon Creek Glacier plutons, and rare or absent in the other plutons. Coarse, well-formed, subhedral, zoned epidote is also common in the Mount Juneau pluton; epidote is rare in the other plutons and generally is found only in border-phase rocks. Traces of pyroxene were found only in the Carlson Creek and Mendenhall Glacier plutons; the pyroxene occurs as relict cores in hornblende or in cummingtonite-hornblende aggregates. Sphene is a common accessory mineral in all but the Carlson Creek and Lemon Creek Glacier plutons. In general, euhedral sphene occurs as large discrete well-formed grains, whereas anhedral sphene occurs as interstitial grains or granular intergrowths with mafic minerals. Subhedral sphene occurs either as discrete, rounded, or abraded grains or as well-developed intergrowths with mafic minerals. Clots of granular magnetite and anhedral apatite are common in the Taku Cabin and Mendenhall Glacier plutons. The nature of the clots is unclear; generally they are clustered with mafic minerals and may be a product of late crystallization or of hydrothermal derivation rather than a product of early crystallization or of xenolithic origin. The clots locally include subhedral zircon.

Chlorite, which is mostly found intergrown with biotite in rocks of the tonalite sills, typically exhibits characteristic anomalous interference colors under crossed nicols (table 2). Chlorite with anomalous blue colors is predominant in the Mount Juneau and Lemon Creek Glacier plutons, whereas chlorite with anomalous brown colors distinguishes the Mendenhall Glacier and Taku Cabin plutons. Chlorite with brown or blue interference colors is typical of the Carlson Creek and Annex Lakes plutons, but rarely are both chlorite types found in the same thin section. The anomalous interference colors are indicators of the composition and oxidation state of chlorite (Deer and others, 1975); brown colors indicate a more oxidized chlorite with higher percentage of trivalent iron (Fe_2O_3).

The An percent of plagioclase was estimated optically by the Michel-Lévy method on appropriate plagioclase grains using the diagram from Jones and Bloss (1980). Optically measured An compositions were used instead of normative An compositions in constructing figure 6 since more An data are available from optical measurements than from chemical analyses. The pattern of An distribution based on optically measured An content does not vary much from that based on normative values since a linear relationship exists between the results of the two methods (fig. 7) with significant scatter for both high and low values. The normative values consistently average 7 to 10 percent higher than values measured optically.

Chemistry

Major-element chemical data are summarized in tables 3 and 4, and data for individual plutons are presented in the "Description of Plutons" section. Binary and ternary variation diagrams (figs. 8–10) are presented to show chemical characteristics of the plutons; they do not necessarily imply common genetic relations or linkages of a differentiation sequence.

Major-element oxides plotted on variation diagrams (fig. 8) show fairly coherent but slightly scattered distribution patterns. The linear trends of decreasing MgO, FeO* (total iron), and TiO_2 with increasing SiO_2 are the most distinctive variations for the sills as a group. The sill rocks are largely metaluminous as indicated by their $Al_2O_3/(CaO+Na_2O+K_2)$ ratios (A/CNK ratios) of less than 1 (table 4), according to the classification of Shand (1949). The Annex Lakes pluton has higher A/CNK values, closer to 1 but less than 1.1 (table 4). The calc-alkaline character of the sill rocks is evident by their diopside and quartz normative compositions (tables 6*B*–11*B*), AFM plots (fig. 9), and except for the Annex Lakes pluton, average alkali-lime indexes of <1 (table 4). Sill rocks plot mostly as tonalite in Barker's (1979) ternary diagram of normative feldspar composition (fig. 10).

Comparison of norms with modes shows some discrepancies. Orthoclase, in particular, is generally much higher in the norm than in the mode (compare figs. 3, 10; see also tables 6–11). This discrepancy is probably due to the incorporation of K into early formed mafic minerals—biotite and hornblende—that are not calculated in the CIPW norms. Biotite is common in Juneau sill rocks, and the K it contributes to chemical analyses is attributed to orthoclase during calculation of CIPW norms, thus leading to erroneously high orthoclase values. Similarly, normative magnetite is high in samples from the Mount Juneau, Lemon Creek Glacier, and Carlson Creek plutons (tables 6, 8, 9), although visual examination of thin sections reveals very little opaque oxides (magnetite or ilmenite) in those samples. Biotite incorporates much trivalent iron (Fe^{+3}) (Deer and others, 1975), which is used to make magnetite in calculations of normative compositions.

The differentiation index (DI), which is calculated from the norms, can provide clues to the stage of fractionation of a rock. The average DI of the plutonic sills (table 4) ranges from a low of 42 (Lemon Creek Glacier pluton) to a high of 68 (Annex Lakes pluton); the other four tonalitic sills exhibit a much shorter range in average DI (53 to 56).

Comparisons

Comparisons of the data indicate close similarities between the plutonic sills in their average modal and chemical compositions (fig. 3; table 3), with the Annex Lakes pluton being least like the other sills. Differences between the plutonic sills are indicated by their petrographic and chemical characteristics (tables 2, 4), clustering patterns on the AFM diagram (fig. 9), and distribution of color index and An content (figs. 5, 6).

The Lemon Creek Glacier pluton is the most mafic of the sills as indicated by its higher content of mafic minerals, lower SiO_2 abundances, and lowest average values of differentiation index (DI), alkali-lime index, and A/CNK ratio.

The Annex Lakes pluton is the most varied and heterogeneous of the sills in its chemistry, lithology, and petrographic characteristics. It is the most siliceous and least mafic rich of the sills and contains more but variable amounts of K-feldspar. It also shows the highest average DI and alkali-lime index, and higher A/CNK values than the other sills. Five samples from the Annex Lakes pluton are slightly corundum normative (table 10*B*) and thus exemplify the diverse nature of this pluton.

Of the five tonalite sills, the Mount Juneau pluton exhibits the greatest range in modal mineral abundances, SiO_2, total iron, CaO, total alkali oxides, and scatter on the AFM diagram, as well as the most varied mineralogy. Abundant garnet and subhedral epidote are typical of the Mount Juneau pluton, and sphene and allanite occur there in much more abundance than in the other tonalite sills. Data for the Mount Juneau pluton show a gap in silica content from 56 to 60 percent (table 6*B*), whereas all but one of the samples from the Lemon Creek Glacier pluton fall within 56 to 60 percent SiO_2 (table 8*B*); this pattern may suggest a genetic link between the two plutons. The Taku Cabin and Mendenhall Glacier plutons are similar in their petrographic characteristics (table 2), chemistry (tables 3, 4), average modal composition (fig. 3), and megascopic description (tables 7, 11); they are the most homogeneous, and least deformed and metamorphosed of the tonalite sills.

DESCRIPTION OF PLUTONS

Data for each pluton are arranged as shown in table 5 and are presented in figures 12–22 and tables 6–11. These data include (1) a geologic sketch map with sample localities, (2) a QAP (quartz-alkali feldspar-plagioclase) diagram, and (3) a table consisting of descriptive information, petrographic data, and major-element chemical data. Additional petrographic features of the sills are presented in table 2. Symbols and abbreviations used in the tables are explained either in headnotes to tables or in table 5. Photographs of typical representative rock samples of each pluton are shown in figure 23. Sample localities, shown by numbered dots on geologic maps of plutons, represent samples that were point counted or chemically analyzed or both. The map numbers are listed in tables of petrographic data (tables 6*A*–11*A*) and (or) tables of chemistry (tables 6*B*–11*B*).

All modes plotted on the Streckeisen (QAP) diagram are based on point counts of stained slabs. For samples with no stained slabs and therefore no modal analysis, the modes and rock classification were estimated visually from thin sections and the rock names are reported in the far left column of tables of petrographic data (tables 7*A*–11*A*). For these samples, mafic mineral abundance (color index) was estimated by use of standard charts for estimating percentage composition of rocks; it is reported in the "Mafic minerals" column of the tables of petrographic data. The abundances of hornblende, biotite, opaque minerals, and sphene were visually estimated by thin section examination. For the Mount Juneau pluton, individual percentages of mafic minerals previously point counted from thin sections (Ford and Brew, 1981) were available for this study. Hornblende includes all primary and secondary brown and green amphiboles. The An percent was estimated by the Michel-Lévy method on appropriate plagioclase grains, and the diagram from Jones and Bloss (1980) was used to determine the plagioclase composition.

Data for the Lemon Creek Glacier pluton are divided into main- and border-phase rocks; averages of modal analyses are for main-phase rocks only. The border-phase rocks consist of more highly deformed and metamorphosed orthogneiss than the main-phase rocks. The data for the Flat Point pluton are distinguished from the data for the Annex Lakes pluton and are not used in the Annex Lakes averages.

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FIGURES 3–23; TABLES 1–11

Table 1. Summary of radiometric ages of plutonic sills, associated plutons, and metamorphic country rock east of Juneau

Body (Sample No.)	Mineral	Dating method	Age (Ma)	Reference
Mount Juneau pluton (64ABD43B)	Biotite Hornblende	K-Ar K-Ar	54.0±2 66.5±2	Brew and Smith (unpub. data,1974)
Mendenhall Glacier pluton (65ABD284)	Biotite Hornblende	K-Ar K-Ar	53.8±2 55.0±2	Brew and Smith (unpub. data,1974)
Mount Juneau pluton (76AF030A)	Hornblende	K-Ar	57.5±2	Wilson and Brew (unpub. data,1984)
Lemon Creek(?) pluton (TVC-1-1)	Biotite Hornblende	K-Ar K-Ar	53.8±1.6 56.1±1.2	Forbes and Engels (1970)
Carlson Creek pluton (81GS5)	Zircon	U-Pb	67.0±2	Gehrels and others (1984)
Flat Point pluton (82GS112)	Zircon	U-Pb	60.0±4	Gehrels and others (1984)
Migmatite of Observation Peak (65ABD312)	Biotite Hornblende	K-Ar K-Ar	53.8±2 57.4±2	Brew and Smith (unpub. data,1974)
Homogeneous gneiss (65ABD50A)	Biotite Hornblende	K-Ar K-Ar	52.0±2 55.4±2	Brew and Smith (unpub. data,1974)
Turner Lake pluton (82GS111)	Zircon	U-Pb	50.0±2	Gehrels and others (1984)

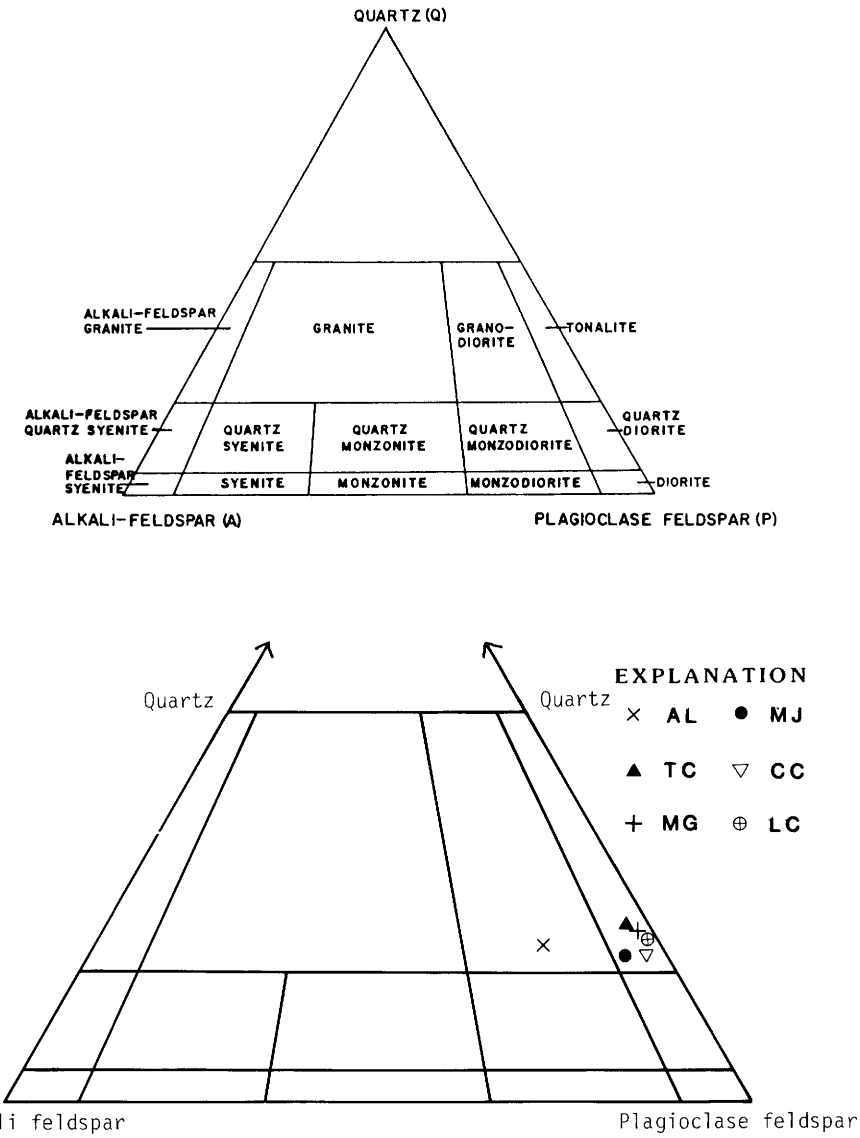


Figure 3. Average modal composition of large sills east of Juneau. Classification diagram is from Streckeisen (1973). AL, Annex Lakes pluton; TC, Taku Cabin pluton; MG, Mendenhall Glacier pluton; MJ, Mount Juneau pluton; CC, Carlson Creek pluton; LC, Lemon Creek Glacier pluton.

Table 2. Petrographic characteristics of plutonic sills east of Juneau

Pluton- - - - -	Mount Juneau	Carlson Creek	Lemon Creek Glacier	Mendenhall Glacier	Taku Cabin	Annex Lakes
Plagioclase (pct)	47-65	50-66	47-52	50-61	51-62	29-61
Average (pct)	55.2	56.6	49.8	53.5	56.8	50.4
Quartz (pct)	6-25	8-28	15-22	15-23	17-25	8-35
Average (pct)	17.8	18.9	17.2	19.5	21.7	21.6
K-feldspar (pct)	0-17	0-14	0-5	1-5	1-5	1-23
Average (pct)	4.9	2.7	1.2	2.0	2.7	14.4
Mafic minerals (pct)	10-37	10-36	21.38	21-32	15-23	5-27
Average (pct)	22.5	23.8	31.8	25.1	18.8	13.6
Major mafic mineral	Biotite	Hornblende	Hornblende	Hornblende	Hornblende	Biotite
Major rock type	Tonalite	Tonalite	Tonalite	Tonalite	Tonalite	Granodiorite
Minor rock type	Granodiorite, quartz diorite	Quartz diorite	Quartz monzo-diorite	Quartz diorite?	Granodiorite	Tonalite, granite, quartz monzodiorite
Major accessory	Garnet, epidote sphene	Apatite	Apatite	Sphene, apatite	Sphene	Sphene, allanite
An range (pct)	32-40	33-45	32-40	38-46	34-41	24-45
Average An (pct)	37	38	38	41	38	33
Main texture/fabric	Foliated, gneissic, porphyroblastic	Foliated, gneissic	Foliated, gneissic, lineated	Foliated, lineated, equigranular	Foliated, equigranular	Foliated, weakly gneissic to in-equigranular
Distinguishing features	Discrete subhedral zoned epidote with cores of allanite	Lacks magnetite and sphene	Mafic rich; lacks sphene	Magnetite-apatite clots; euhedral sphene	Magnetite-apatite clots; subhedral sphene	Very heterogeneous; K-feldspar phenocryst
Chlorite	Anomalous blue birefringence	Anomalous brown/ blue birefringence	Anomalous blue birefringence	Anomalous brown birefringence	Anomalous brown birefringence	Anomalous brown/ blue birefringence
Hornblende color/form	Light brown/ brownish green/ green; anhedral	Light brown/ greenish brown/ brownish green; anhedral	Light brown/ greenish brown/ brownish green; anhedral	Light brown/ greenish brown/ green; subhedral	Light brown/ greenish brown/ brownish green; subhedral	Light brown/ brownish green/ green; subhedral
Plagioclase	Anhedral to subhedral; weakly zoned, normal; partly altered to epidote and sericite± calcite	Anhedral to subhedral; weak to moderate zoning, continuous normal or oscillatory normal; partly altered to sericite±epidote and calcite	Anhedral; weak zoning, continuous normal; partly altered to sericite±epidote and calcite	Subhedral; moderate to weak multiple zoning, oscillatory normal; partly altered to sericite±epidote	Subhedral; strong multiple zoning, oscillatory normal; partly altered to sericite±clinozoicite	Subhedral; weakly zoned, continuous normal; partly altered to sericite±epidote and calcite
Primary sphene	Discrete euhedral/subhedral grains	Rare, mostly interstitial grains	Rare/absent	Discrete euhedral grains and anhedral interstitial and intergrowths with mafic minerals	Euhedral inclusions; anhedral interstitial and subhedral intergrowths with mafic minerals	Discrete euhedral/ subhedral grains and anhedral interstitial/ intergranular

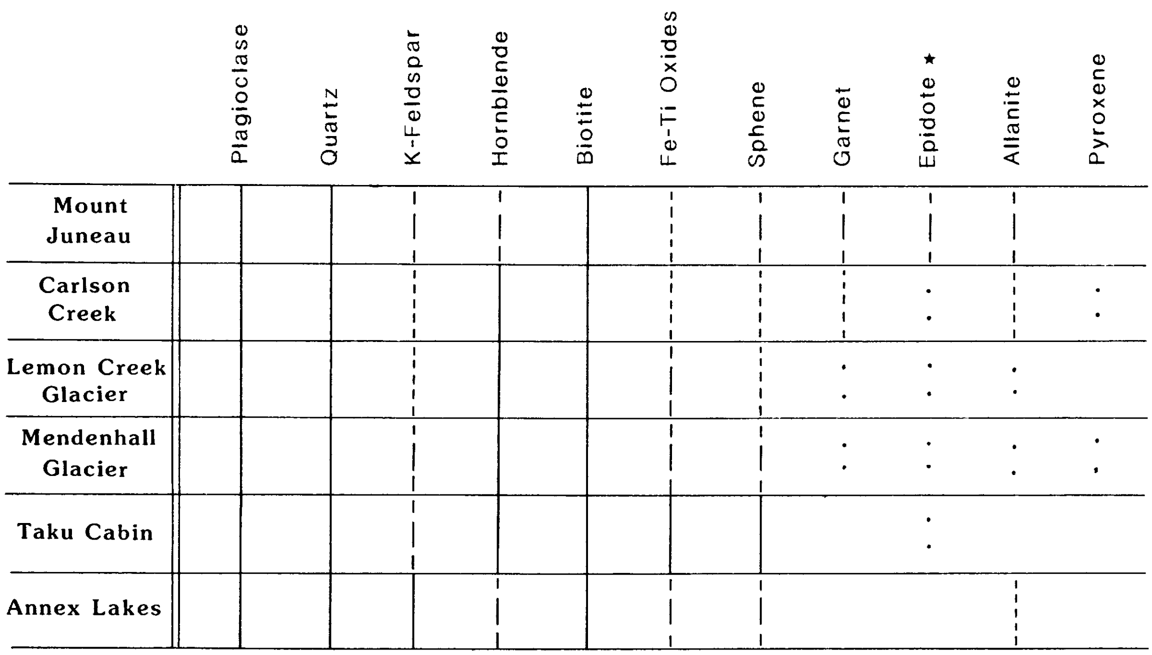


Figure 4. Mineral occurrences in large sills east of Juneau. Solid line, mineral occurs in all or nearly all thin sections; long dashed line, mineral occurs in most thin sections; short dashed line, mineral occurs sporadically in some or in many thin sections; dotted line, mineral occurs rarely and in only a few thin sections. Epidote* is coarse, well formed, subhedral, and primary-appearing. Hornblende includes all primary and secondary green and brown amphiboles. Accessory apatite and zircon occur in all or most rocks.

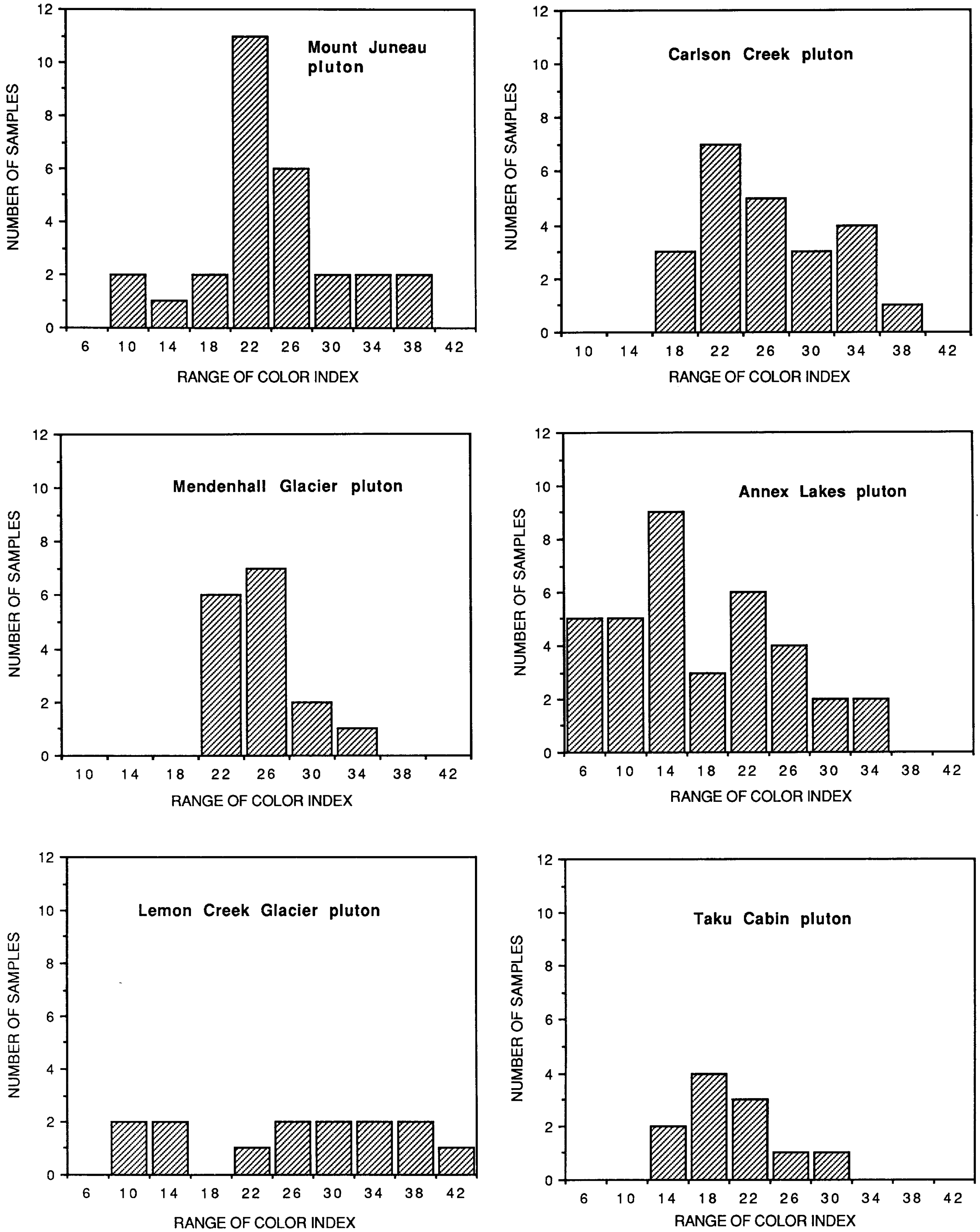


Figure 5. Distribution of color index (percentage of mafic minerals) in large sills east of Juneau. Numbers on horizontal axis (range of color index) correspond to midpoints of range.

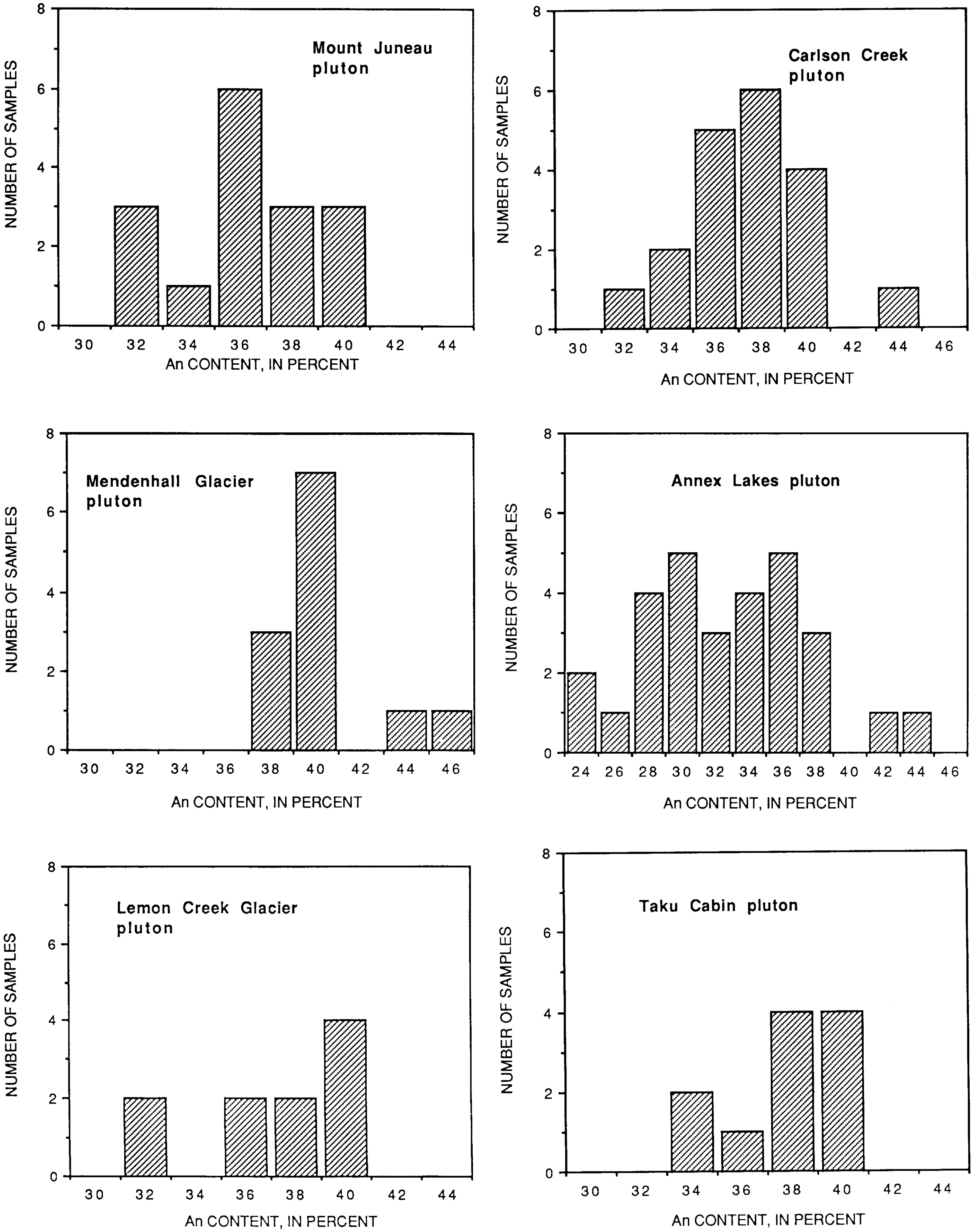


Figure 6. Distribution of anorthite (An) composition, in percent, in large sills east of Juneau. Numbers on horizontal axis (An content) correspond to midpoints of range. Anorthite content estimated optically by Michel-Lévy method.

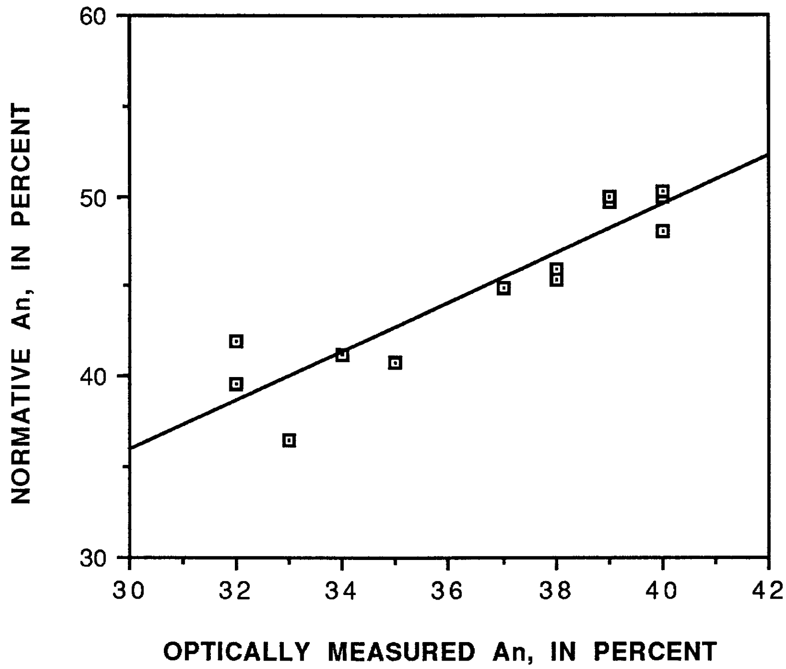


Figure 7. Normative An content plotted against optically measured An content for samples from large sills east of Juneau. Each box represents one sample for which normative chemistry was determined and An content was optically measured. Line is best fit line based on simple regression equation.

Table 3. Average major-element chemistry for plutonic sills east of Juneau

[Results in weight percent. Std. dev., standard deviation; Norm, normative; CI, color index; An, anorthite content of plagioclase; ---, not applicable]

Pluton - - - -	Mount Juneau		Carlson Creek		Lemon Creek Glacier		Mendenhall Glacier		Taku Cabin		Annex Lakes	
	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.
SiO_2	59.82	4.37	60.07	2.85	56.84	2.77	61.32	1.98	61.62	.08	65.59	4.03
Al_2O_3	18.40	.85	17.88	.78	18.02	1.68	17.57	.60	16.95	.04	17.30	.81
Fe_2O_3	2.06	.52	1.56	.97	2.10	.65	1.99	.50	2.57	.13	1.49	.61
FeO	4.09	1.70	4.47	1.13	5.40	1.28	3.71	.77	3.77	.18	2.15	1.03
MgO	2.49	1.10	2.94	.55	3.47	.86	2.70	.58	2.73	.07	1.38	.76
CaO	6.58	1.07	6.69	.92	7.73	.86	6.66	.47	6.26	.06	4.67	1.17
Na_2O	3.77	.43	3.62	.16	3.67	.31	3.59	.20	3.36	.03	4.38	.83
K_2O	1.64	.70	1.57	.38	1.45	.28	1.36	.40	1.72	.06	2.23	1.01
TiO_2	.73	.30	.81	.15	.83	.26	.72	.11	.68	---	.47	.25
P_2O_5	.29	.08	.28	.06	.36	.11	.28	.03	.23	---	.23	.15
MnO	.12	.04	.11	.02	.14	.03	.10	.02	.13	---	.09	.03
Norm CI	16.4	6.16	18.4	3.40	22.0	4.30	16.6	3.19	17.2	---	9.2	4.52
Norm An	47.1	4.85	47.6	2.80	46.8	6.10	47.8	.85	47.8	.42	35.6	8.56
Number of samples	12	12	10	10	7	7	9	9	2	2	10	10

Table 4. Chemical characteristics of plutonic sills east of Juneau

[Results in weight percent. FeO^*, total iron; A/CNK, molecular proportions of the ratio $Al_2O_3/CaO+Na_2O+K_2O$; avg., average; DI, differentiation index--sum of normative quartz, orthoclase, albite, nepheline, and leucite; Alk/lime, K_2O+Na_2O/CaO; ---, not applicable]

Pluton - - - - -	Mount Juneau	Carlson Creek	Lemon Creek Glacier	Mendenhall Glacier	Annex Lakes	Taku Cabin
SiO_2	53-64	57-66	51-60	57-64	60-69	62
Al_2O_3	18-19	16-19	15-20	17-19	16-18	17
FeO^*	3-9	4-7	7-9	4-7	2-6	6
CaO	5-8	5-8	7-9	6-7	4-6	6
K_2O+Na_2O	4-7	5-6	5-6	4-5	5-8	5
A/CNK	0.88-1.03	0.86-0.96	0.66-0.90	0.87-0.94	0.89-1.05	0.91
(avg.)	(0.94)	(0.90)	(0.83)	(0.90)	(0.95)	---
DI	42-66	46-65	36-49	47-60	56-74	56
(avg.)	(56)	(53)	(42)	(55)	(68)	---
Alk/lime	0.55-1.28	0.63-1.21	0.51-0.74	0.65-0.89	0.93-1.80	0.80-0.83
(avg.)	(0.88)	(0.82)	(66)	(0.75)	(1.33)	---

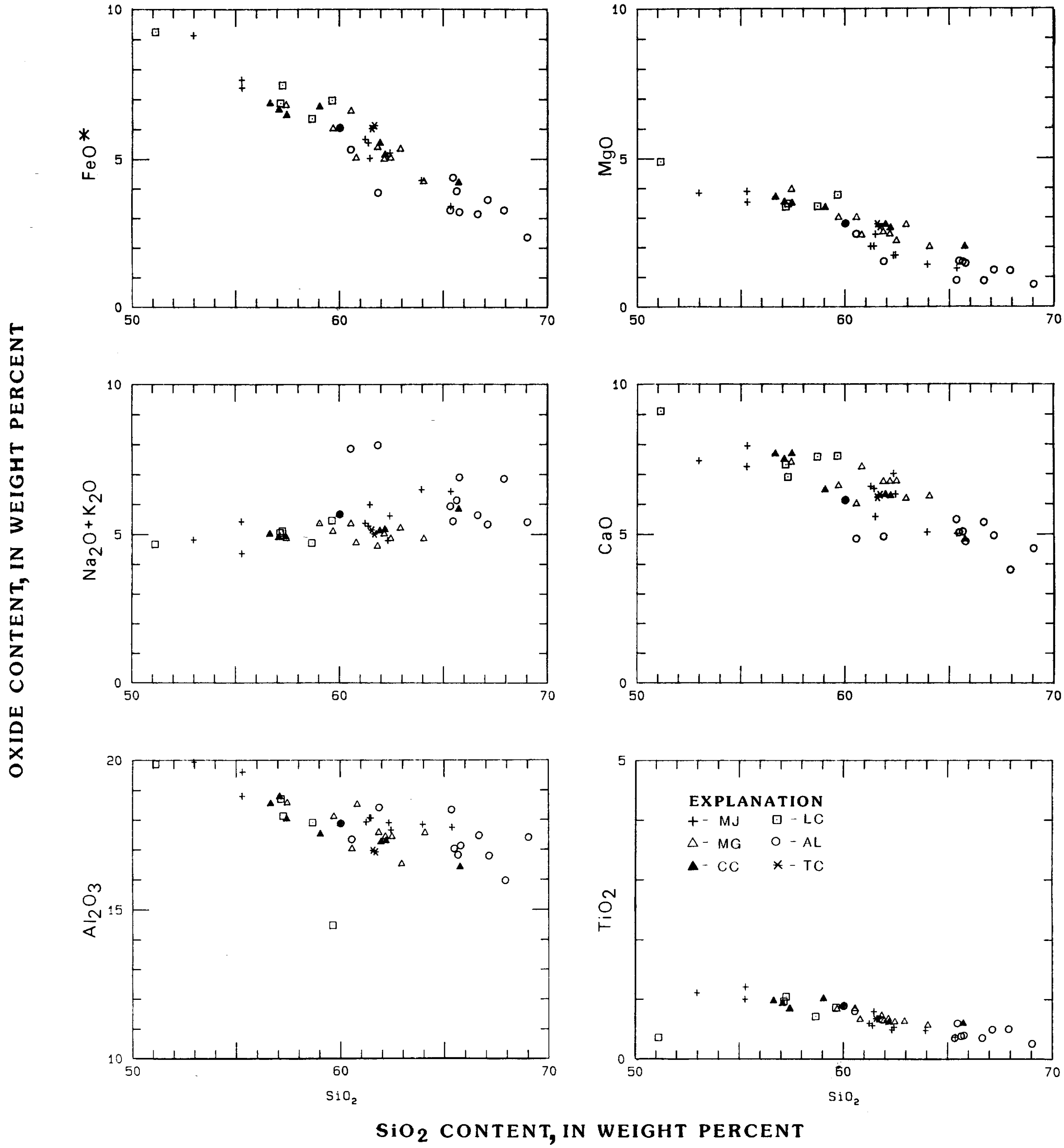


Figure 8. Variation between SiO_2 and major oxides in large sills east of Juneau. MJ, Mount Juneau pluton; MG, Mendenhall Glacier pluton; CC, Carlson Creek pluton; LC, Lemon Creek Glacier pluton; AL, Annex Lakes pluton; and TC, Taku Cabin pluton. FeO*, total iron.

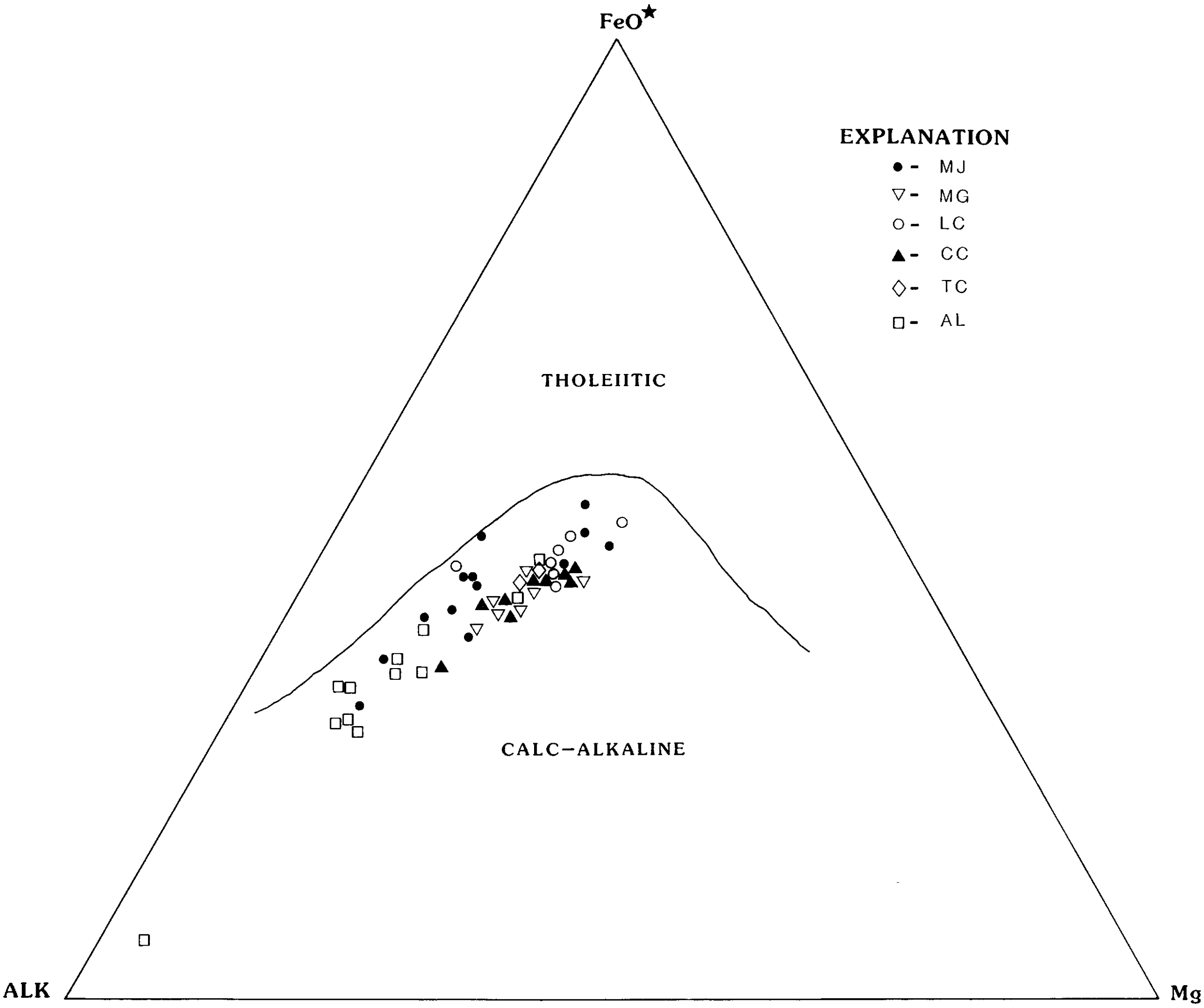


Figure 9. AFM diagram with plots of samples from large sills east of Juneau. Boundary line from Irvine and Baragar (1971). MJ, Mount Juneau pluton; MG, Mendenhall Glacier pluton; LC, Lemon Creek Glacier pluton; CC, Carlson Creek pluton; TC, Taku Cabin pluton; and AL, Annex Lakes pluton. FeO*, total iron; ALK, Na_2O+K_2O.

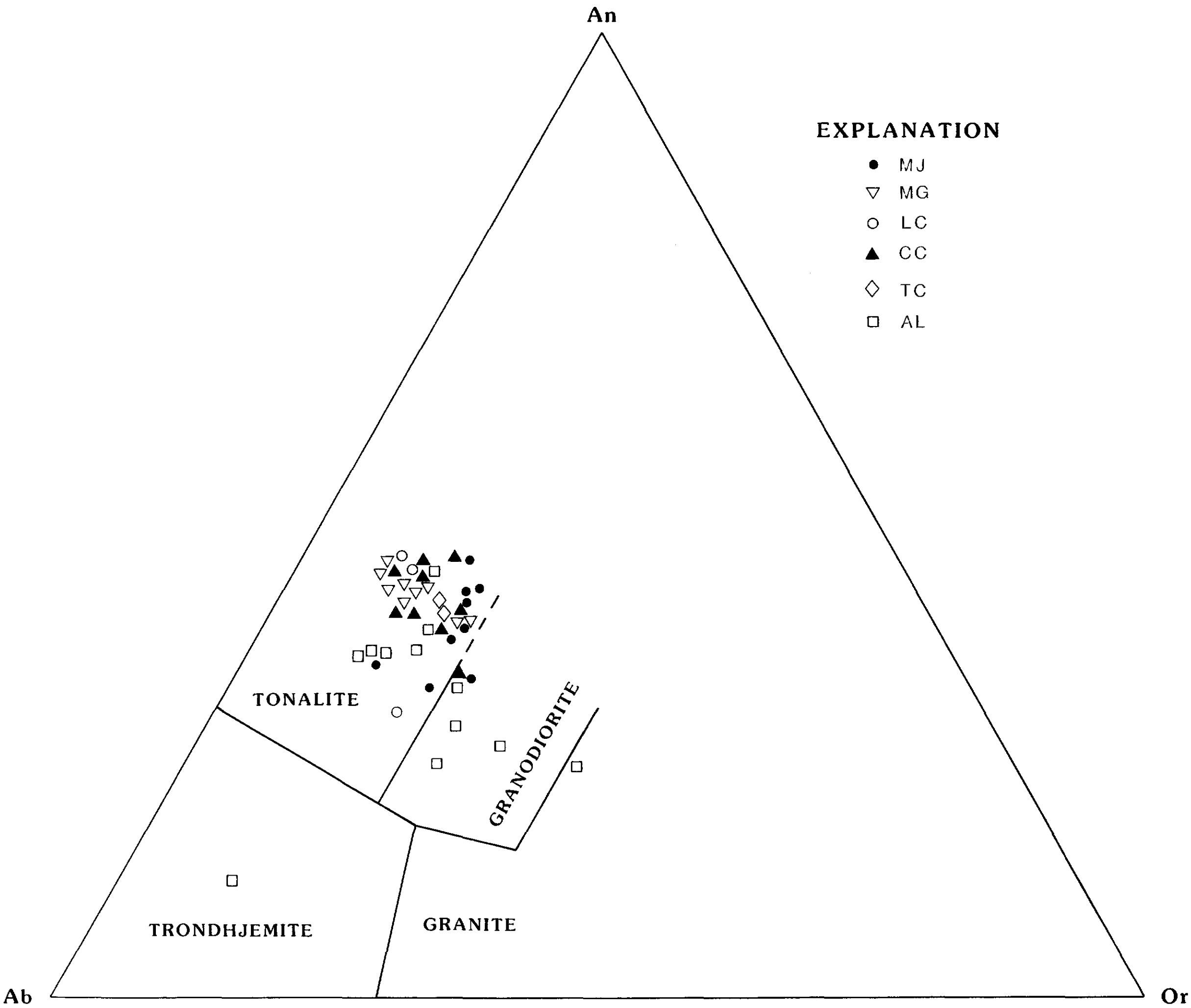


Figure 10. Plots of normative Ab-Or-An (albite-orthoclase-anorthite) content of rocks from large sills east of Juneau. Boundary fields from Barker (1979). MJ, Mount Juneau pluton; MG, Mendenhall Glacier pluton; LC, Lemon Creek Glacier pluton; CC, Carlson Creek pluton; TC, Taku Cabin pluton; and AL, Annex Lakes pluton.

Table 5. Organization of figures and tables with data on individual plutons

Name of pluton	Location map, figure No.	QAP diagram, figure No.	Descriptive summary, table No.	Petrographic data, table No.	Major-element chemistry, table No.
Mount Juneau	11	12	6	6A	6B
Mendenhall Glacier	13	14	7	7A	7B
Lemon Creek Glacier	15	16	8	8A	8B
Carlson Creek	17	18	9	9A	9B
Annex Lakes	19	20	10	10A	10B
Taku Cabin	21	22	11	11A	11B

Explanation of abbreviations in tables of petrographic data:

Accessory and secondary minerals (reported in tables in order of abundance):

al, allanite	cm, cummingtonite	pr, prehnite
ap, apatite	ep, epidote	px, pyroxene
ca, calcite	ga, garnet	se, sericite
chl, chlorite	mu, muscovite	sp, sphene
clz, clinozoisite	opq, opaques	zi, zircon

Abbreviations that begin with upper case letters in tables indicate an abundance of that mineral greater than a trace amount, that is, greater than 1 percent.

Main textures:

Al, allotriomorphic	Gn, gneissic	Ln, lineated
Au, augen	Gr, granular	Pb, porphyroblastic
Eg, equigranular	Hy, hypidiomorphic	Pc, protoclastic
Eq, equant	Iq, inequigranular	Pp, porphyritic
Fo, foliated	La, layered	Se, seriate

Mineral abundance determined by visual estimation: tr, trace (less than 1 percent); min, minor (1-5 percent); uncom, uncommon (5-10 percent); com, common (10-40 percent); abnt, abundant (greater than 40 percent).

Form of primary sphene: eu, euhedral; sbh, subhedral; an, anhedral.

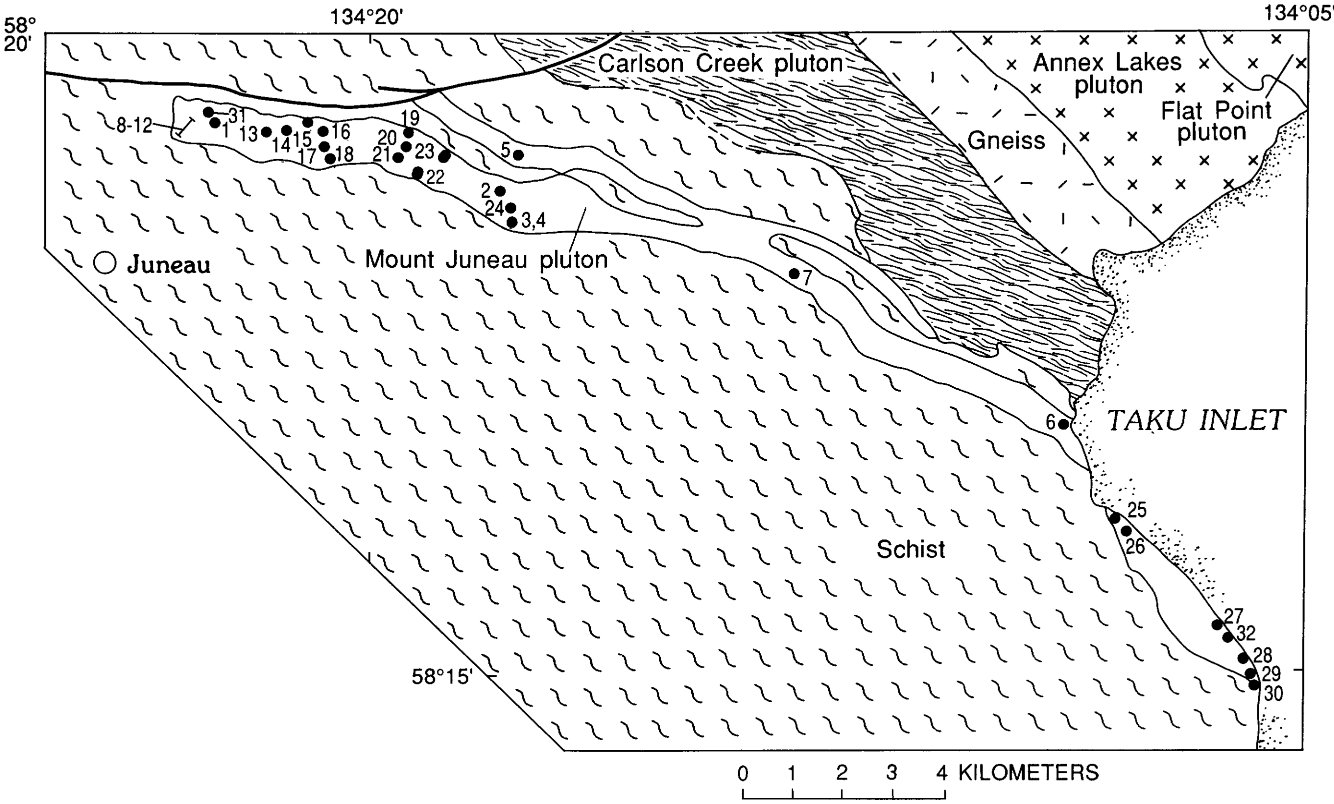


Figure 11. Geologic sketch map of the Mount Juneau pluton, showing sample locations. Samples 8 through 12 shown as a traverse line across pluton. Fault indicated by heavy line; contact dashed where approximately located.

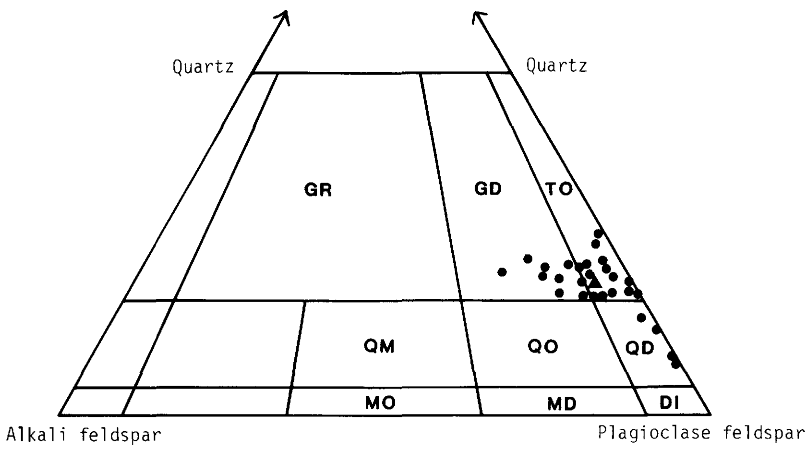


Figure 12. Compositional modes of selected samples from the Mount Juneau pluton plotted on plutonic rock classification diagram of Streckeisen (1973). Several pairs plot in same place. Average modal composition shown by dark triangle. GR, granite; GD, granodiorite; TO, tonalite; QM, quartz monzonite; QO, quartz monzodiorite; QD, quartz diorite; MO, monzonite; MD, monzodiorite; and DI, diorite.

Table 6. Petrographic and major-element chemical data for the Mount Juneau pluton

Major rock type:
Gneissic garnet- and sphene-bearing hornblende-biotite tonalite

Minor rock types:
Gneissic hornblende-biotite granodiorite and biotite-hornblende quartz diorite

Location:
East of Juneau and west of Taku Inlet

Age:
90(?) Ma (metamorphosed and deformed about 65? Ma)

Description:
Light to medium gray, and brownish gray to grayish brown, homogeneous to heterogeneous, medium to coarse grained and locally fine grained, foliated and locally lineated, gneissic and porphyroblastic to inequigranular. Biotite generally more common than hornblende. Typically contains medium- to coarse-grained, anhedral, augen-shaped plagioclase and hornblende; medium-grained anhedral granular quartz; medium-grained, lamellar biotite; intergranular quartz and K-feldspar; and minor but conspicuous rounded garnet, euhedral sphene, and subhedral primary-appearing epidote. Color index range 10–37, color index average 23

Comments:
Locally heterogeneous, most deformed and metamorphosed of Juneau sill bodies; exhibits most diverse and variable mineralogy of sill bodies. Pluton partly cuts across regional structure and isograds (Ford and Brew, 1973). Contains subhedral zoned epidote similar to the primary magmatic epidote described by Zen and Hammarstrom (1984)

(Table continued on next page.)

Table 6. Petrographic and major-element chemical data for the Mount Juneau pluton—Continued

A. Petrographic data

[Results in percent. Plg, plagioclase; Qtz, quartz; K-f, K-feldspar; Hbl, hornblende; Bio, biotite; An, anorthite content of plagioclase; n.d., not determined. See table 5 for other abbreviations]

Map No. (fig. 11)	Sample No.	Plg	Qtz	K-f	Mafic minerals	Hbl[1]	Bio[1]	Epidote[1,2]	Chlorite[1]	Accessory minerals	Percent accessories	Secondary minerals	Main texture	An
1	80DB022	60.8	16.8	1.3	21.1	n.d.	com	min	tr	Ga,ap	min	Ep	Pb-Pc-Gn	n.d.
2	80DB023	63.2	18.4	8.9	9.5	min	min	min	tr	Ga,Sp	min	ep	Pb-Gn	n.d.
3	82DB327c	61.1	25.0	7.6	[3]6.3	uncom	min	tr	tr	Ga,sp,ap,zi	min	ep,mu	Gn-La	32
4	82DB327d	62.5	20.5	11.8	[3]5.2	uncom	min	tr	tr	Ga,sp,ap,zi	min	ap,se	Gn-La	n.d.
5	82DB331	52.1	24.5	12.6	10.8	uncom	min	min	tr	Sp,ap,zi	min	ep,sp	Gn-La	32
6	85SD119	56.1	19.6	4.8	19.5	uncom	com	tr	tr	ap,al	tr	ep,mu	Au-Iq	37
7	85WN070	59.3	17.3	7.6	15.8	com	min	tr	min	Sp,ap,zi	min	ep,mu,ca	Gn	35
8	71AF117	54.7	14.9	.2	30.2	4.9	24.4	16.0	tr	Ga,ap,sp,opq	1.0	Se,opq	Fo-Gn-Pb	n.d.
9	71AF116	57.0	18.1	.1	24.4	n.d.	17.1	13.7	2.3	Ga,ap,al	5.0	mu,sp	Fo-Gn-Pb	n.d.
10	71AF115	55.6	21.6	2.4	20.4	tr	18.2	10.4	1.8	ga,ap,zi	.4	mu,sp	Fo-Gn-Pb	n.d.
11	71AF114	51.6	23.1	1.8	23.5	tr	20.0	12.9	2.2	Ga,Sp,ap,zi,opq	1.3	mu,sp	Fo-Gn-Pb	n.d.
12	71AF113	52.2	17.4	1.9	27.4	tr	22.1	13.6	2.6	Ga,sp,ap,opq	2.6	mu,sp	Fo-Gn-Pb	n.d.
13	71AF130	52.9	20.6	4.6	21.4	tr	18.6	7.6	2.3	Ga,opq,al,sp,ap	.5	mu,ca	Fo-Gn-Pb	n.d.
14	71AF132	55.8	20.3	2.3	21.2	1.5	17.5	10.6	1.9	ga,sp,al,ap	.2	mu,pr,ca	Fo-Gn-Au	n.d.
15	71AF134	54.8	16.0	3.2	25.0	2.8	19.7	11.9	1.0	Ga,sp,ap,opq	1.4	ca,se	Fo-Gn-Au	36
16	71AF135	55.1	15.3	5.9	23.2	6.2	15.2	6.1	1.2	Ga,sp,ap,al,opq	.5	mu,pr,ca	Fo-Gn-Au	40
17	71AF137	52.7	20.3	5.0	21.5	2.6	17.1	8.4	1.3	Ga,al,ap,sp	.5	mu,sp,ca	Fo-Gn-Au	37
18	71AF138	49.4	13.2	1.7	34.0	18.1	10.5	10.0	3.5	Ga,ap,sp,al,opq	1.7	Ca,sp	Fo-Gn	n.d.
19	71AF145	47.3	19.8	9.3	22.6	19.7	12.0	3.5	.4	Ga,ap,al,sp	.5	sp,opq	Fo-Gn-Pb	39
20	71AF144	48.9	19.5	10.8	20.8	8.5	11.1	4.1	.9	ga,sp,opq,ap	.4	se,opq	Fo-Gn-Au	36
21	71AF143	50.6	18.9	8.8	21.7	8.7	12.1	4.9	.3	Ga,sp,ap,al	.7	sp,opq	Fo-Gn-Pb	37
22[3]	71AF141	44.0	14.8	4.6	36.6	15.8	17.1	10.8	2.5	Ga,sp,al	1.3	sp,se	Fo-Gn	n.d.
23	64AF201	59.6	16.9	5.1	18.4	5.8	12.4	6.2	tr	opq,ap,sp	.2	se,sp	Fo-Gn	39
24	64AF229	48.0	22.0	17.0	13.0	6.0	6.7	3.0	tr	sp,opq	.3	mu,sp	Fo-Gn	n.d.
25	64AB044	56.5	5.9	0	29.0	15.7	7.7	.4	.7	Ga,opq,ap,zi	5.0	pr,sp,se	Fo-Gn	39
26	64AB043	61.4	6.7	0	25.2	18.9	1.7	.7	min	Ga,opq,ap	4.5	sp,ca,se	Fo-Ln-Gn	40
27	64AB040	53.8	11.4	1.2	33.6	21.7	10.7	.7	1.2	ap,zi,opq	tr	mu,sp,opq	Fo-Gn-Ln	37
28	64AB039	65.0	12.0	0	23.0	1.2	21.8	.2	n.d.	ap,zi	tr	mu,sp	Fo-Ln	32
29	64AF036	48.7	23.2	.7	27.4	1.3	25.4	.3	.4	sp,ap,zi	.4	se,sp	Fo-Gn	40
30[3]	64AF035	62.3	tr	0	37.7	33.8	1.6	n.d.	.7	opq,sp	1.6	mu,sp	Fo-Al-Gr	n.d.
	Average	55.2	17.8	4.9	22.5	7.0	15.4	7.1	1.3					
	Standard deviation	4.9	4.7	4.6	6.0	6.8	6.0	5.1	.9					
	Number of samples	28	28	28	26	23	23	23	23					

[1] Results reported in letter abbreviations (com, tr, etc.) are from this study (see table 5 for explanation of abbreviations). Results reported in volume percent were point counted from thin sections in an earlier study (Ford and Brew, 1981) and are not always consistent with the total mafic mineral percentages reported in this study.

[2] Includes clean and well-developed subhedral grains that appear primary.

[3] Not counted in averages.

Table 6. Petrographic and major-element chemical data for the Mount Juneau pluton—Continued

B. Major-element chemical data

[Samples were analyzed in laboratories of the U.S. Geological Survey by rapid-rock methods or by x-ray fluorescence. FeO was determined by wet chemical methods. Results normalized to 100-percent volatile free; percentages may not add up exactly to 100.00 because oxide and norm values were rounded off from three to two decimal places. LOI, loss on ignition (H_2O and CO_2); Norm, normative; CI, color index; An, anorthite content of plagioclase; DI, differentiation index--sum of normative quartz, orthoclase, albite, nepheline, and leucite; n.d., not determined]

Sample No.---	80DB 022	80DB 023	76BJ 008	64DB 039	64DB 040	64DB 043	64DB 044	64AF 201	64AF 229	87JS 007	76AF 030	71AF 137
Map No.------ (fig. 11)	1	2	21	28	27	26	25	23	24	31	32	17
Whole-rock analyses (weight percent)												
SiO_2	61.38	65.36	62.42	61.45	55.27	55.29	52.97	61.24	63.94	62.32	53.19	63.06
Al_2O_3	18.06	17.73	17.64	18.05	18.80	19.60	19.94	17.92	17.84	17.89	19.60	17.73
Fe_2O_3	2.11	1.31	1.94	3.45	2.15	1.51	2.32	2.02	1.82	2.01	2.14	1.94
FeO	3.65	2.23	3.47	1.93	5.72	6.03	7.05	3.85	2.64	3.28	6.13	3.06
MgO	2.03	1.29	1.73	2.43	3.88	3.52	3.83	2.02	1.42	1.72	4.39	1.63
CaO	6.50	5.02	6.32	5.58	7.25	7.94	7.45	6.58	5.07	7.01	8.37	5.91
Na_2O	3.20	4.19	3.47	4.46	4.19	4.02	4.03	3.34	3.85	3.06	3.78	3.67
K_2O	2.08	2.24	2.14	1.52	1.23	.33	.79	2.02	2.64	1.73	.85	2.14
TiO_2	.56	.37	.53	.80	1.00	1.21	1.11	.60	.48	.49	1.12	.52
P_2O_5	.27	.17	.21	.26	.39	.39	.36	.29	.23	.34	.33	.24
MnO	.15	.10	.12	.06	.13	.15	.17	.12	.08	.15	.11	.11
LOI	.59	.52	1.04	.78	1.59	.61	.96	.80	.98	.65	1.14	n.d.
CIPW norms (weight percent)												
Quartz	17.04	19.25	17.45	15.11	3.64	6.30	1.68	16.28	17.93	20.08	2.01	18.34
Orthoclase	12.29	13.23	12.66	8.99	7.24	1.96	4.64	11.98	15.57	n.d.	5.01	12.64
Albite	27.04	35.41	29.34	37.75	35.44	34.03	34.01	28.26	32.58	10.21	31.96	31.03
Anorthite	28.79	22.99	26.25	24.73	28.87	34.46	34.00	27.91	23.60	25.89	34.02	25.59
Diopside	1.39	.63	3.07	.95	3.76	1.96	.49	2.32	.01	2.17	4.40	1.75
Hypersthene	8.70	5.49	6.92	5.62	15.15	15.91	18.80	8.53	6.22	7.05	16.61	6.56
Magnetite	3.06	1.90	2.81	4.09	3.11	2.19	3.36	2.94	2.65	2.92	3.11	2.81
Ilmenite	1.08	.69	1.01	1.52	1.90	2.29	2.10	1.13	.91	.93	2.13	.99
Apatite	.63	.40	.50	.61	.90	.91	.84	.68	.54	.78	.77	.57
Norm CI	14.2	8.7	13.8	12.8	23.9	22.4	24.8	14.9	9.8	13.1	26.2	12.1
Norm An	51.6	39.4	47.2	39.6	44.9	50.3	49.9	49.7	42.0	53.7	51.6	45.2
DI	56.4	67.9	59.5	61.9	46.3	42.3	40.4	56.5	66.2	56.2	39.0	61.7

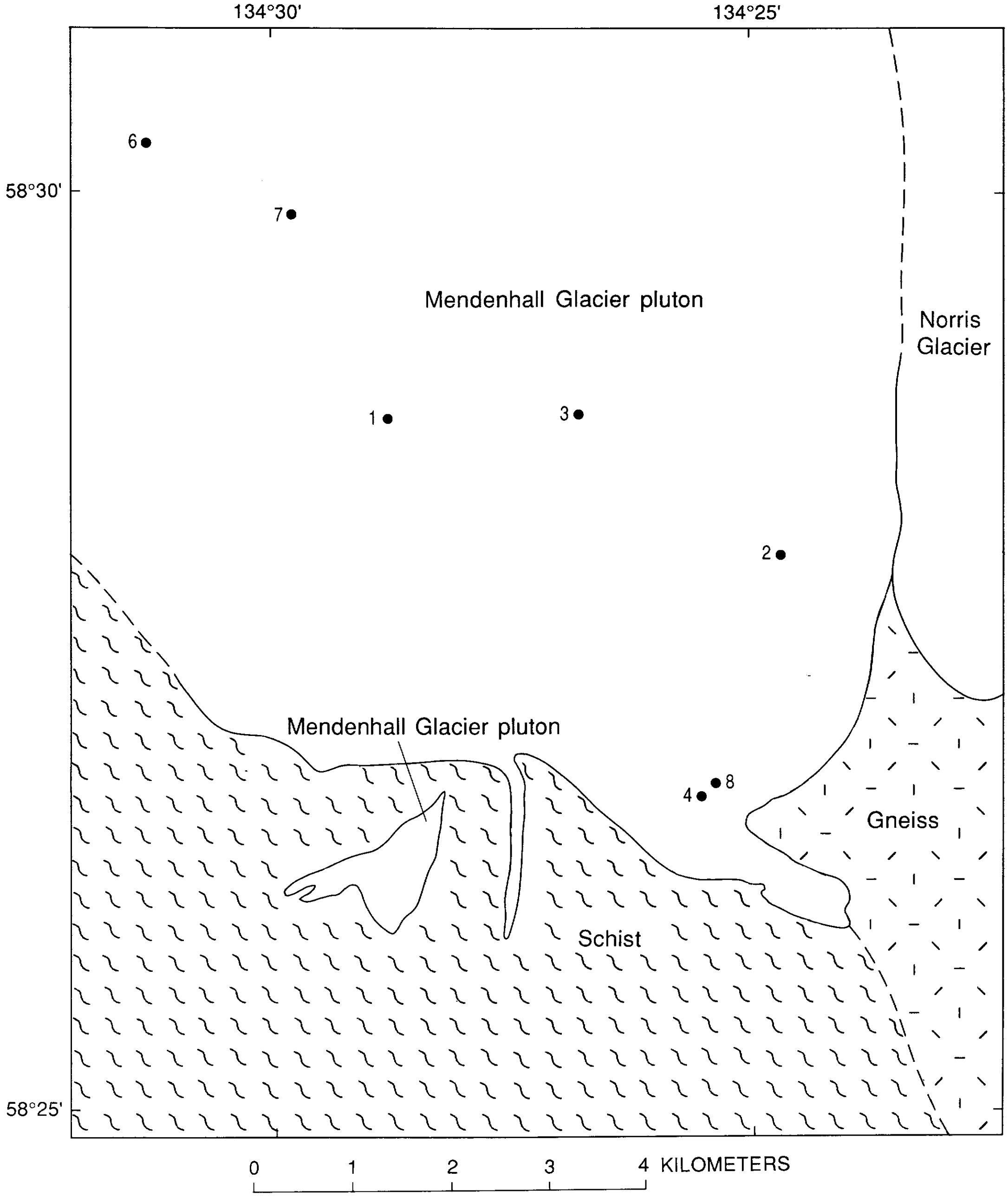


Figure 13. Geologic sketch map of the Mendenhall Glacier pluton, showing sample locations. Sample localities 5 and 9 not shown on map; they are located on western side of Mendenhall Glacier. Contacts dashed where approximately located.

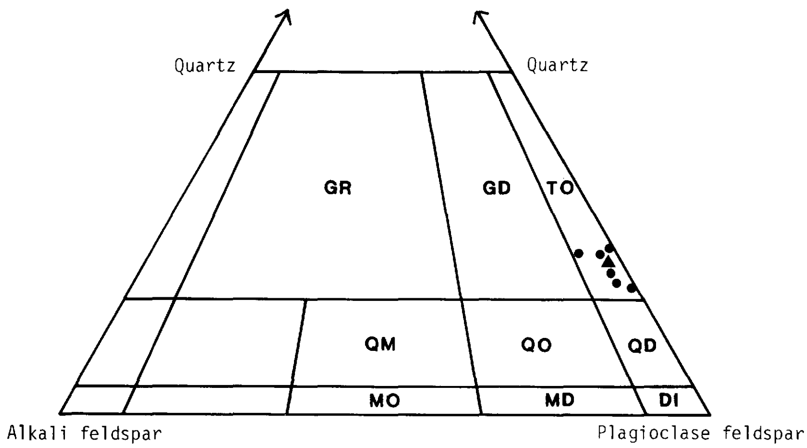


Figure 14. Compositional modes of selected samples from the Mendenhall Glacier pluton plotted on plutonic rock classification diagram of Streckeisen (1973). Average modal composition shown by dark triangle. GR, granite; GD, granodiorite; TO, tonalite; QM, quartz monzonite; QO, quartz monzodiorite; QD, quartz diorite; MO, monzonite; MD, monzodiorite; and DI, diorite.

Table 7. Petrographic and major-element chemical data for the Mendenhall Glacier pluton

Major rock type:
Sphene-bearing biotite-hornblende tonalite

Minor rock type:
Quartz diorite (lower border phase)

Location:
Northeast of Juneau and east of Mendenhall Glacier

Age:
55 to 60 Ma

Description:
Medium to light gray, homogeneous, medium to coarse grained, foliated and lineated, locally inequigranular to gneissic. Hornblende more common than biotite. Composed of medium- to coarse-grained, subhedral plagioclase and elongated hornblende; medium-grained tabular biotite; fine- to medium-grained, anhedral intergranular quartz; some coarser granular quartz; and fine- to medium-grained, interstitial K-feldspar. Conspicuous subhedral sphene and subhedral epidote locally common. Color index range 21–32, color index average 25

Comments:
Subhedral primary-appearing epidote present in more deformed and metamorphosed border-phase rocks. Very uniform and homogeneous pluton; many features are similar to Taku Cabin pluton. Garnet present in one sample

(Table continued on next page.)

Table 7. Petrographic and major-element chemical data for the Mendenhall Glacier pluton—Continued

A. Petrographic data

[Results in percent. An, anorthite content of plagioclase; QD, quartz diorite; TO, tonalite; n.d., not determined; ---, not present. See table 5 for other abbreviations]

Map No.[1] (fig. 13)	Sample No.	Plagio-clase	Quartz	K-feld-spar	Mafic minerals	Horn-blende	Biotite	Opaques	Sphene	Accessory minerals	Secondary minerals	Main texture	An
1	87SK096	53.6	21.5	2.1	22.7	com	uncom	min	tr-sbh	ap,al,zi	chl,ep,pr,sp	Fo-Hy-Iq	41
2	87SK097	49.8	21.2	5.0	24.1	com	uncom	min	min-eu	ap,zi	chl,ep,sp,pr	Fo-Ln-Iq	40
3	87RK172	54.6	22.8	.2	22.5	com	uncom	min	tr-sbh	ap,al,zi	chl,ep,sp,se	Fo-Hy-Iq	45
4	87RK173	52.4	18.0	2.2	27.5	com[2]	com	min	min-eu	ap,zi	chl,ep,sp,pr	Fo-Ln-Iq	39
5	87AF102	49.8	15.7	2.1	32.4	com[2]	com	tr	tr-sbh	ep,ap,zi	ep,sp	Fo-Gn-Ln	n.d.
6	80SK120	61.0	17.7	.3	21.1	com	uncom	min	tr	ep,ap,al	ep,sp,chl	Fo-Ln-Iq	39
QD	87RK177	abnt	uncom	tr	25	uncom[3]	com	min	---	ep,ap,px	sp,opq,ep	Fo-Ln-Eg	n.d.
TO	87SK101	abnt	com	min	25	com	uncom	min	tr-sbh	ap,zi	chl,ep,pr	Fo-Ln-Iq	41
TO	65Bd276	abnt	com	tr	25	com[2]	com	min	min-eu	ap,zi	chl,ep,sp,pr	Fo-Ln-Eg	40
TO	65Bd284	abnt	com	tr	25	com	com	min	---	ap,zi	chl,se	Fo-Ln-Eg	41
QD	65Bd293	abnt	uncom	tr	30	com	uncom	min	tr-sbh	ap,zi	chl,se,sp,pr	Fo-Iq	n.d.
TO	65AF243	abnt	com	min	20	com	uncom	min	min-an	ap,zi	chl,ep,sp	Fo-Ln-Eg	46
TO	65AF248	abnt	com	min	25	com	uncom	tr	min-eu	ap,zi,al	chl,ep,sp,se	Fo-Ln-Iq	40
TO	65AF263	abnt	com	tr	25	com[2]	com	tr	---	Ga,ap,zi	chl,ep,cm	Fo-Ln-Gn	n.d.
TO	65AF265	abnt	com	tr	16	com	uncom	min	tr-sbh	ap,zi	chl,pr,ep,sp	Fo-Iq	40
TO	65AF266	abnt	com	tr	20	com	uncom	min	tr-sbh	ap,zi,al	chl,ep,pr,sp	Fo-Ln	38
	Average	53.5	19.5	2.0	25.1								
	Standard deviation	4.2	2.8	1.7	4.2								
	Number of samples	6	6	6	6								

[1] Rock name rather than map number reported where no modal analysis was done.

[2] Most abundant mafic mineral.

[3] Altered to epidote and cummingtonite.

Table 7. Petrographic and major-element chemical data for the Mendenhall Glacier pluton—Continued

B. Major-element chemical data

[Samples were analyzed in laboratories of the U.S. Geological Survey by x-ray fluorescence. FeO was determined by wet chemical methods. Results normalized to 100-percent volatile free; percentages may not add up exactly to 100.00 because oxide and norm values were rounded off from three to two decimal places. LOI, loss on ignition (H_2O and CO_2); Norm, normative; CI, color index; An, anorthite content of plagioclase; DI, differentiation index--sum of normative quartz, orthoclase, albite, nepheline, and leucite]

Sample No.	87777 (JS37)	80SK 120	87AF 102	87SK 096	87SK 097	87SK 101	87RK 172	87RK 173	87RK 177
Map No. (fig. 13)	7	6	5	1	2	8	3	4	9
Whole-rock analyses (weight percent)									
SiO_2	60.54	59.68	62.93	61.83	62.46	60.80	64.05	62.15	57.40
Al_2O_3	17.02	18.11	16.51	17.56	17.43	18.51	17.55	17.43	18.03
Fe_2O_3	2.64	2.37	.99	2.29	2.12	2.29	1.65	1.63	1.90
FeO	4.24	3.89	4.45	3.33	3.13	2.98	2.75	3.54	5.10
MgO	3.00	3.00	2.76	2.51	2.21	2.41	2.01	2.44	3.95
CaO	6.00	6.61	6.18	6.74	6.76	7.24	6.25	6.75	7.40
Na_2O	3.38	3.68	3.19	3.70	3.47	3.77	3.74	3.69	3.72
K_2O	1.97	1.42	2.01	.90	1.39	.94	1.11	1.33	1.21
TiO_2	.85	.84	.63	.73	.63	.67	.57	.68	.85
P_2O_5	.24	.29	.23	.31	.31	.29	.24	.29	.32
MnO	.11	.11	.11	.10	.10	.09	.07	.09	.13
LOI	.60	.41	.54	1.01	.39	.39	.29	.32	.15
CIPW norms (weight percent)									
Quartz	15.29	13.68	17.93	18.70	19.43	16.46	21.37	17.41	8.54
Orthoclase	11.67	8.37	11.90	5.34	8.22	5.56	6.56	7.86	7.14
Albite	28.55	31.15	27.01	31.27	29.32	31.93	31.66	31.19	31.44
Anorthite	25.47	28.70	24.78	28.67	27.89	30.80	27.81	27.07	28.94
Diopside	2.22	1.75	3.61	2.26	2.93	2.60	1.33	3.68	4.64
Hypersthene	10.80	10.65	11.60	8.35	7.23	7.40	7.24	8.47	14.20
Magnetite	3.83	3.43	1.43	3.33	3.07	3.32	2.40	2.37	2.76
Ilmenite	1.61	1.60	1.21	1.39	1.19	1.27	1.07	1.28	1.61
Apatite	.56	.68	.54	.71	.72	.70	.56	.68	.75
Norm CI	18.5	17.4	17.8	15.3	14.4	14.6	12.0	15.8	23.2
Norm An	47.2	47.9	47.9	47.8	48.8	49.1	46.8	46.5	47.9
DI	55.5	53.2	56.8	55.3	56.9	53.9	59.6	56.5	47.2

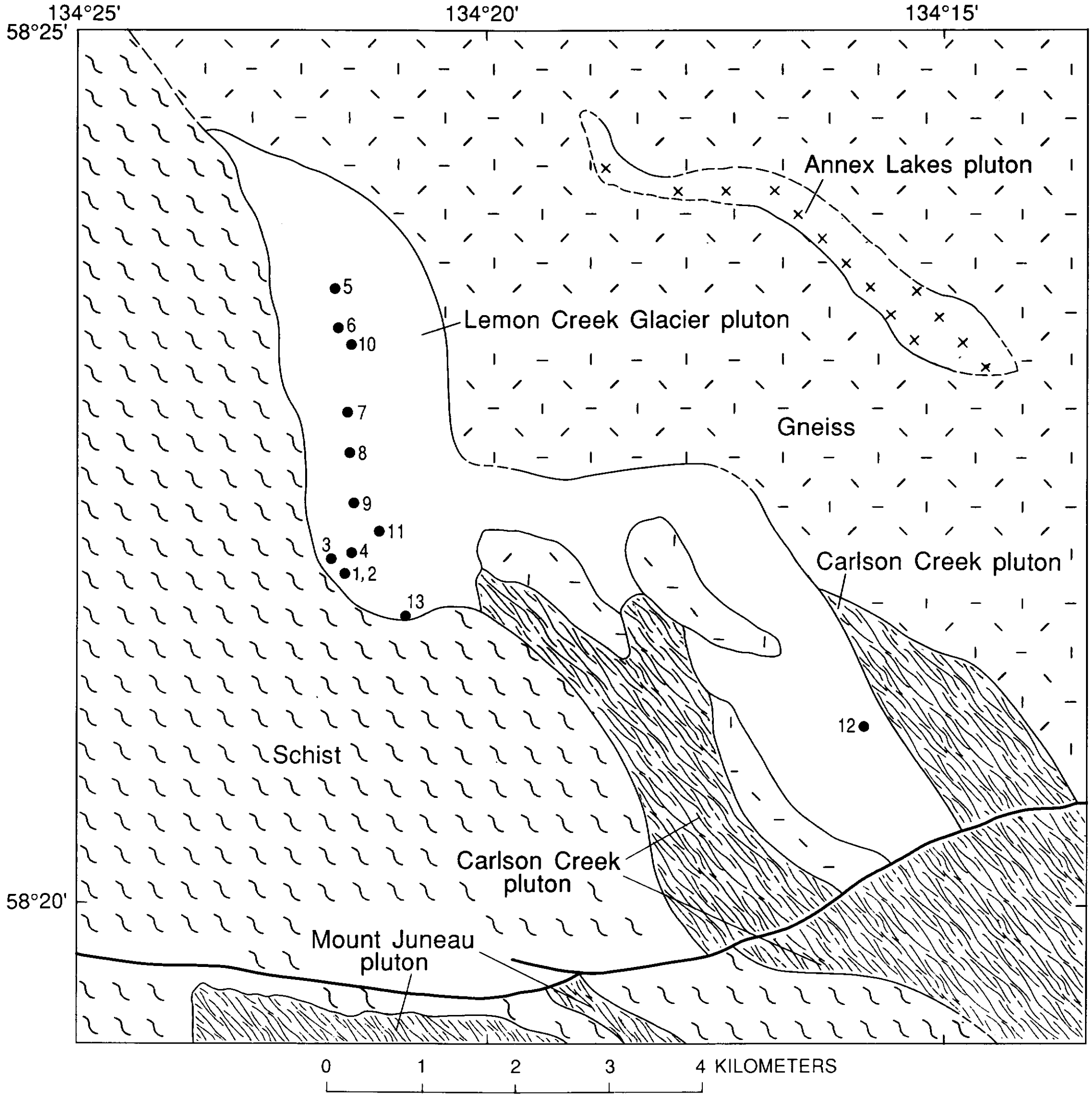


Figure 15. Geologic sketch map of the Lemon Creek Glacier pluton, showing sample locations. Heavy line indicates fault. Contact dashed where approximately located.

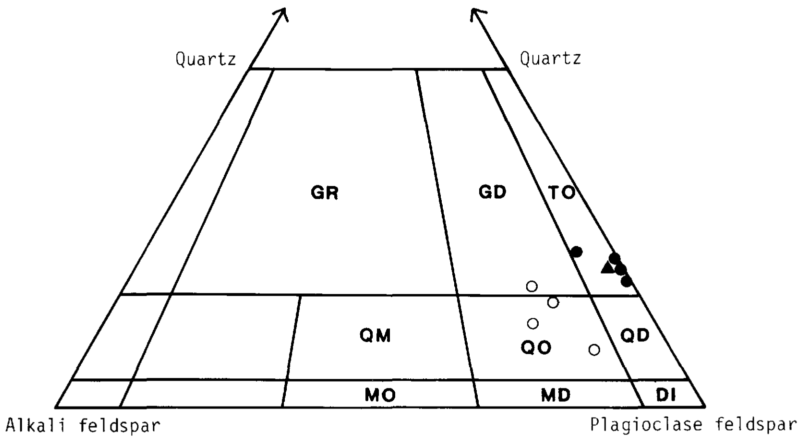


Figure 16. Compositional modes of selected samples from the Lemon Creek Glacier pluton plotted on plutonic rock classification diagram of Streckeisen (1973). Open circles are modes on border-phase rocks. Dots are modes on main-phase rocks (two samples plot in same place). Average modal composition of main phase shown by dark triangle. GR, granite; GD, granodiorite; TO, tonalite; QM, quartz monzonite; QO, quartz monzodiorite; QD, quartz diorite; MO, monzonite; MD, monzodiorite; and DI, diorite.

Table 8. Petrographic and major-element chemical data for the Lemon Creek Glacier pluton

Major rock type:
Biotite-hornblende tonalite

Minor rock type:
Sphene-biotite-hornblende quartz monzodiorite (border phase)

Location:
East of Juneau and northwest of Taku Inlet

Age:
65(?) to 70(?) Ma

Description:
Medium to dark or light gray, homogeneous to heterogeneous, medium to very coarse grained, foliated and lineated, gneissic, porphyroblastic to inequigranular, and weakly to strongly layered. Hornblende more common than biotite. Composed of medium to very coarse grained, porphyroblastic to augen-shaped, anhedral plagioclase; medium- to coarse-grained, tabular and elongated, anhedral hornblende; fine- to medium-grained, lamellar biotite; medium- to coarse-grained, anhedral stretched quartz and fine-grained, intergranular quartz, with intergranular K-feldspar. Color index range 21–38, color index average 32

Comments:
Lower and more deformed and metamorphosed border zone is more K-feldspar rich than main phase. Most mafic rich of the Juneau sill bodies. Locally contains garnet; main phase lacks sphene. One sample contains discrete subhedral primary-appearing epidote

(Table continued on next page.)

Table 8. Petrographic and major-element chemical data for the Lemon Creek Glacier pluton—Continued

A. Petrographic data

[Results in percent. An, anorthite content of plagioclase; TO, tonalite; n.d., not determined; ---, not present. See table 5 for other abbreviations]

Map No.[1] (fig. 15)	Sample No.	Plagio-clase	Quartz	K-feld-spar	Mafic minerals	Horn-blende	Biotite	Opaques	Sphene	Accessory minerals	Secondary minerals	Main texture	An
1	86DB047[2]	59.5	16.8	12.3	11.4	uncom	min	min	min-sbh	Ap,zi	chl,ep,clz,se	Fo-Gn-Pb	31
2	86DB047[2]	57.3	13.0	16.8	12.9	com	tr	min	min-sbh	ap	chl,ep,se	Fo-Gn-Pb	n.d.
3	86DB048[2]	60.3	21.0	15.3	3.4	uncom	min	min	tr-sbh	ap	chl,ep,se	Fo-Gn-Al-Gr	n.d.
4	86DB049[2]	69.4	9.1	10.5	11.0	com	tr	min	min-sbh	ap	ep,se,ca	Fo-Gn-Pc	n.d.
5	82DB298[3]	48.6	15.3	.1	36.0	com[4]	com	tr	---	ap,zi	chl,sp,pr,se	Fo-Ln-Au	40
6	82DB299[3]	46.5	15.7	.3	37.6	com[4]	com	tr	---	ap,zi	chl,sp,ep,se	Fo-Gn-Au-Ln	36
7	82DB302[3]	51.6	15.2	0	33.2	com[4]	com	tr	---	ap,zi	chl,sp,ep	Fo-Gn-Ln-Au	40
8	82DB305[3]	51.9	22.1	5.2	20.8	com[4]	com	min	---	ap,zi	chl,pr,sp	Fo-Gn-Ln	39
9	82DB307[3]	50.6	17.6	.5	31.4	com	uncom	min	---	ap	chl,sp,opq	Fo-Gn-Ln-Pb	38
TO	64AB236	abnt	com	tr	25	com	com	tr	---	Ga,Ep,ap,zi	chl,sp,mu,ep	Fo-Gn-Au-Pb	40
TO	64AB236	abnt	com	tr	30	com	com	tr	---	Ep,ap,zi,al	Ep,chl,sp	Fo-Gn-Au-Pb	n.d.
TO	65AF275	abnt	com	min	25	com	uncom	tr	---	ap,zi,ga	ca,chl,sp	Fo-Gn-Eg	37
TO	65AF274	abnt	com	tr	40	com	uncom	min	---	Ga,ap,zi	chl,sp	Fo-Gn-Pb	40
TO	65AF283	com	abnt	min	15	---	com	tr	---	Al,ap,zi	chl,sp	Fo-Gn-Pb	32
	Average	49.8	17.2	1.2	31.8								
	Standard deviation	2.3	2.9	2.2	6.6								
	Number of samples	5	5	5	5								

[1] Rock name rather than map number reported where no modal analysis was done.

[2] Border phase.

[3] Main phase.

[4] Most abundant mafic mineral.

Table 8. Petrographic and major-element chemical data for the Lemon Creek Glacier pluton—Continued

B. Major-element chemical data

[Samples were analyzed in laboratories of the U.S. Geological Survey by x-ray fluorescence. FeO was determined by wet chemical methods. Results normalized to 100-percent volatile free; percentages may not add up exactly to 100.00 because oxide and norm values were rounded off from three to two decimal places. LOI, loss on ignition (H_2O and CO_2); Norm, normative; Ci, color index; An, anorthite content of plagioclase; DI, differentiation index--sum of normative quartz, orthoclase, albite, nepheline, and leucite; ---, absent]

Sample No.---	80DB 021	82DB 303	82DB 305	87733	87JS 09	86DB 049	86DB 052
Map No.------- (fig. 15)	10	11	8	12	12	4	13
	Whole-rock analyses (weight percent)						
SiO_2	57.14	51.12	57.25	59.94	58.66	57.16	56.58
Al_2O_3	18.71	19.87	18.13	14.55	17.90	19.05	17.83
Fe_2O_3	1.68	1.80	1.70	2.70	1.95	3.30	1.55
FeO	5.37	7.63	5.94	4.58	4.60	3.69	5.99
MgO	3.37	4.90	3.47	3.78	3.38	1.95	3.45
CaO	7.32	9.11	6.90	7.65	7.59	7.50	8.01
Na_2O	3.73	3.51	3.45	3.77	3.48	4.30	3.45
K_2O	1.32	1.16	1.66	1.71	1.23	1.84	1.20
TiO_2	.97	.36	1.05	.87	.72	.72	1.12
P_2O_5	.30	.40	.34	.29	.34	.29	.59
MnO	.11	.15	.12	.14	.14	.21	.12
LOI	.41	.50	.61	.71	.56	1.49	.12
	CIPW norms (weight percent)						
Quartz	8.15	---	8.81	11.91	11.95	7.19	8.90
Orthoclase	7.81	6.85	9.80	10.13	7.29	10.90	7.07
Albite	31.47	29.68	29.20	31.93	29.44	36.40	29.17
Anorthite	30.39	35.05	29.07	17.71	29.59	27.23	29.96
Diopside	3.29	6.20	2.45	14.89	4.75	6.61	4.90
Hypersthene	13.85	8.71	15.44	7.20	12.01	4.86	14.27
Olivine	---	9.28	---	---	---	---	---
Magnetite	2.43	2.61	2.47	3.91	2.83	4.78	2.25
Ilmenite	1.84	.69	1.98	1.66	1.36	1.36	2.12
Apatite	.68	.94	.78	.67	.80	.66	1.36
Norm CI	21.4	27.5	22.3	27.7	20.9	17.6	16.6
Norm An	49.1	54.1	49.9	35.7	50.1	42.8	45.7
DI	47.5	36.5	47.8	31.2	48.7	54.5	55.2

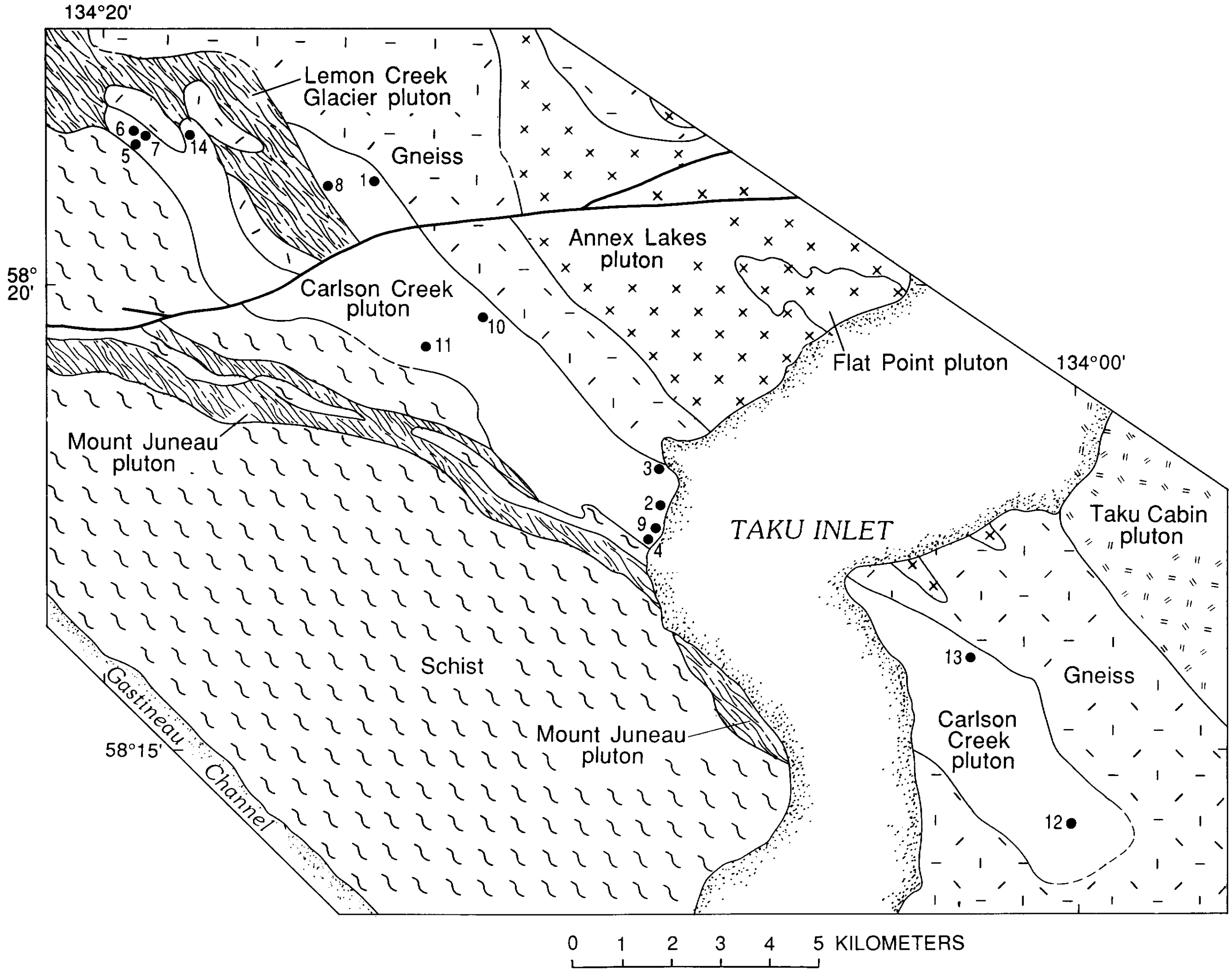


Figure 17. Geologic sketch map of the Carlson Creek pluton, showing sample locations. Heavy line indicates fault. Contacts dashed where approximately located.

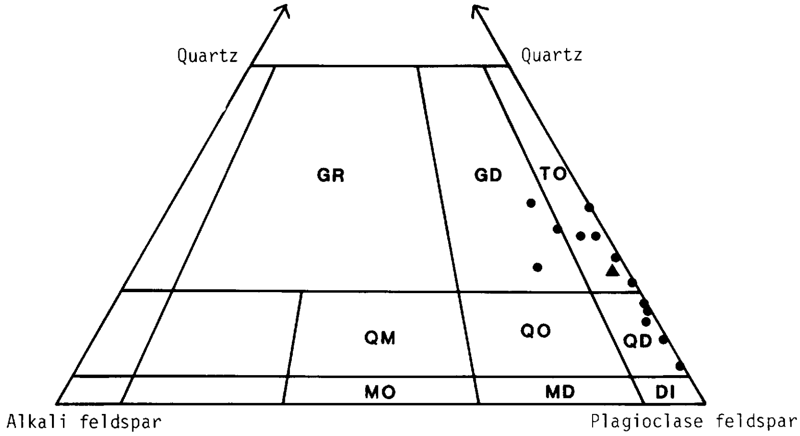


Figure 18. Compositional modes of selected samples from the Carlson Creek pluton plotted on plutonic rock classification diagram of Streckeisen (1973). Average modal composition shown by dark triangle. GR, granite; GD, granodiorite; TO, tonalite; QM, quartz monzonite; QO, quartz monzodiorite; QD, quartz diorite; MO, monzonite; MD, monzodiorite; and DI, diorite.

Table 9. Petrographic and major-element chemical data for the Carlson Creek pluton

Major rock types:
Biotite-hornblende tonalite and quartz diorite

Minor rock type:
Hornblende-biotite granodiorite

Location:
East of Juneau and northwest and southeast of Taku Inlet

Age:
67 Ma (Gehrels and others, 1984)

Description:
Medium gray to brownish gray, homogeneous to locally layered; medium to coarse grained and locally fine grained; foliated, locally lineated, gneissic, and porophyroblastic to inequigranular. Hornblende more common than biotite. Composed of coarse-grained, anhedral, porphyroblastic and augen-shaped plagioclase; medium- to coarse-grained, anhedral to subhedral, elongated, tabular hornblende; fine- to medium-grained platy biotite; medium- to coarse-grained, anhedral granular and stretched quartz; and intergranular quartz and K-feldspar. Color index range 17–33, color index average 26

Comments:
Rock composed of two phases: a felsic-rich phase of granodiorite or tonalite and a felsic-poor phase of quartz diorite. Quartz diorite more common in lower, more deformed and metamorphosed part of pluton

(Table continued on next page.)

Table 9. Petrographic and major-element chemical data for the Carlson Creek pluton—Continued

A. Petrographic data

[Results in percent. An, anorthite content of plagioclase; TO, tonalite; GD, granodiorite; n.d., not determined; ---, not present. See table 5 for other abbreviations]

Map No.[1] (fig. 17)	Sample No.	Plagio-clase	Quartz	K-feld-spar	Mafic minerals	Horn-blende	Biotite	Opaques	Sphene	Accessory minerals	Secondary minerals	Main texture	An
1	85DB086	54.7	35.4	8.8	[2]1.1	tr	min	tr	---	Ga,ap,zi	chl,mu,sp	Fo-Gn-La	n.d.
2	85EL113	50.2	25.3	5.7	18.8	uncom	com	tr	tr	ap,zi,al	chl,ep,sp,se	Fo-Gn-Pb	31
3	85SD116	54.0	21.4	1.3	23.3	com	uncom	tr	tr	Ap,zi	chl,ep,sp,se	Fo-Iq	38
4	85SD118	58.5	8.1	0	33.4	com	com	tr	---	Ap,zi,al	chl,sp,pr,ep	Fo-Ln-Au	39
5	86DB053	59.2	4.7	0	36.1	com	uncom	min	---	Ap,zi	chl,sp,pr	Fo-Gn-Pb	37
6	86DB054	67.8	14.8	0	17.4	uncom	uncom	tr	---	Ga,ap,zi	chl,sp,se	Fo-Gn-Pb	34
7	86DB055	64.3	13.5	.3	21.9	com	uncom	tr	---	Al,ap,zi	chl,sp,pr,ep	Fo-Gn-Pb	38
8	86SE005	50.3	27.5	.2	22.0	com	uncom	tr	tr	ap,zi	chl,sp,ca,ep	Fo-Al-Eg	36
9	87DB010	53.2	15.1	.1	31.6	com	com	min	tr	ap,al	chl,sp,ep,se	Fo-Gn-Au	40
10	87SK089	45.9	20.9	3.2	30.1	com	com	tr	---	ap,zi	chl,sp,ep,se	Fo-Au-Iq	34
11	87RK164	56.4	10.1	1.1	32.4	com	com	tr	---	ap,zi	chl,ep,sp,pr	Fo-Iq	40
12	87WN118	65.9	24.0	.2	10.0	uncom	uncom	tr	---	ap,zi	chl,sp,ep	Fo-Iq	n.d.
13	88DB029A	55.7	24.4	13.9	9.6	com	min	min	tr	ap,zi	chl,sp,ca	Fo-Gn	n.d.
TO	64AF118	abnt	com	tr	20	com	uncom	tr	---	ap,zi,al	chl,sp,ep,se	Fo-Gn-Pb	n.d.
TO	64AF121	abnt	com	min	16	com	uncom	tr	min	ap,zi	chl,sp,se	Fo-Gn-Au-Pb	40
TO	85SD117	abnt	com	tr	25	com	uncom	tr	---	ap,zi	chl,ep,se,sp	Fo-Gn-Iq	n.d.
TO	65Bd017	abnt	com	tr	25	com	uncom	tr	---	ap,zi	ep,se,chl,sp	Fo-Gn-Iq	40
GD	65Bd019	abnt	com	uncom	20	com	uncom	tr	---	ap,zi	chl,sp,se,opq	Fo-Gn-Pb	n.d.
TO	65Bd015	abnt	com	min	22	com	uncom	tr	---	ap,zi	chl,sp,se	Fo-Gn-Pb	39
TO	65Bd021	abnt	com	min	25	com	uncom	tr	tr	ap,zi	chl,ep,sp,opq	Fo-Al-Gr	36
TO	64Bd230	abnt	com	min	20	uncom	com	tr	tr	ap,zi,al	se,sp,opq	Fo-Gn-Au-La	37
GD	64Bd232	com	com	com	25	com	uncom	tr	---	Al,ap,zi	Ep,chl,sp,se	Fo-Gn-La-Au	39
TO	64Bd241	abnt	com	min	30	com	com	tr	---	Ap,Al,zi,px	sp,se,pr	Fo-Pb-Au	36
TO	65Bd399	abnt	com	tr	30	com	com	tr	tr	ap,zi	chl,ep,sp	Fo-Pb-Iq	39
TO	68Bd373	abnt	com	min	25	com	com	tr	---	ap,al	chl,opq,sp	Fo-Gn-Eg	33
TO	68Bd377	abnt	com	min	32	com	com	tr	---	ap,zi	chl,ep,ca,se	Fo-Iq	45
	Average	56.6	18.9	2.7	23.8								
	Standard deviation	6.4	8.7	4.3	8.9								
	Number of samples	13	13	13	12								

[1] Rock name rather than map number reported where no modal analysis was done.

[2] Low mafic count (not counted in average).

Table 9. Petrographic and major-element chemical data for the Carlson Creek pluton—Continued

B. Major-element chemical data

[Samples were analyzed in laboratories of the U.S. Geological Survey by x-ray fluorescence. FeO was determined by wet chemical methods. Results normalized to 100-percent volatile free; percentages may not add up exactly to 100.00 because oxide and norm values were rounded off from three to two decimal places. LOI, loss on ignition (H_2O and CO_2); Norm, normative; CI, color index; An, anorthite content of plagioclase; DI, differentiation index--sum of normative quartz, orthoclase, albite, nepheline, and leucite]

Sample No.--	85SD 116	80SK 126	85EL 113	8215	87DB 010	87SK 089	87RK 164	86DB 053	86DB 055	86DB 054
Map No.----- (fig. 17)	3	14	2		9	10	11	5	7	6
Whole-rock analyses (weight percent)										
SiO_2	62.18	59.03	65.74	57.06	57.43	61.94	56.64	58.90	61.73	59.17
Al_2O_3	17.29	17.52	16.41	18.78	18.57	17.25	18.54	18.72	17.87	18.17
Fe_2O_3	3.39	1.13	1.23	2.52	2.01	.98	1.64	.31	.31	.56
FeO	2.09	5.75	3.10	4.40	4.67	4.66	5.39	5.53	4.95	5.55
MgO	2.65	3.34	2.02	3.52	3.48	2.76	3.69	2.83	2.34	3.03
CaO	6.27	6.47	4.82	7.50	7.69	6.31	7.68	7.54	6.50	7.55
Na_2O	3.66	3.37	3.56	3.53	3.53	3.53	3.58	3.85	3.86	3.64
K_2O	1.50	1.99	2.28	1.36	1.33	1.58	1.43	1.00	1.34	1.10
TiO_2	.62	1.01	.60	.93	.84	.65	.98	.83	.71	.74
P_2O_5	.26	.28	.17	.27	.33	.23	.30	.39	.32	.36
MnO	.10	.11	.08	.11	.12	.11	.13	.11	.09	.12
LOI	.74	.34	.56	1.01	.71	.59	.54	.37	.64	.25
CIPW norms (weight percent)										
Quartz	19.09	10.82	21.89	9.51	9.55	15.93	7.24	10.30	14.66	11.22
Orthoclase	8.84	11.73	13.47	8.04	7.86	9.36	8.46	5.92	7.92	6.56
Albite	30.97	28.53	30.08	29.90	29.88	29.87	30.27	32.54	32.64	30.76
Anorthite	26.33	26.80	22.09	31.38	30.89	26.54	30.31	30.86	27.48	29.99
Diopside	2.39	2.85	.58	3.29	4.20	2.67	4.77	3.36	2.26	4.24
Hypersthene	5.70	15.05	8.58	11.83	12.36	12.45	14.02	14.11	12.53	14.18
Magnetite	4.91	1.64	1.78	3.65	2.91	1.42	2.38	.46	.44	.81
Ilmenite	1.17	1.92	1.14	1.77	1.60	1.23	1.86	1.58	1.35	1.40
Apatite	.61	.66	.40	.64	.75	.54	.70	.89	.73	.84
Norm CI	14.2	21.5	12.1	20.6	21.1	17.8	23.0	19.5	16.6	20.6
Norm An	45.9	48.4	42.3	51.2	50.8	47.1	50.0	48.7	45.7	49.4
DI	58.9	51.1	65.5	47.5	47.3	55.2	45.0	48.8	55.2	48.5

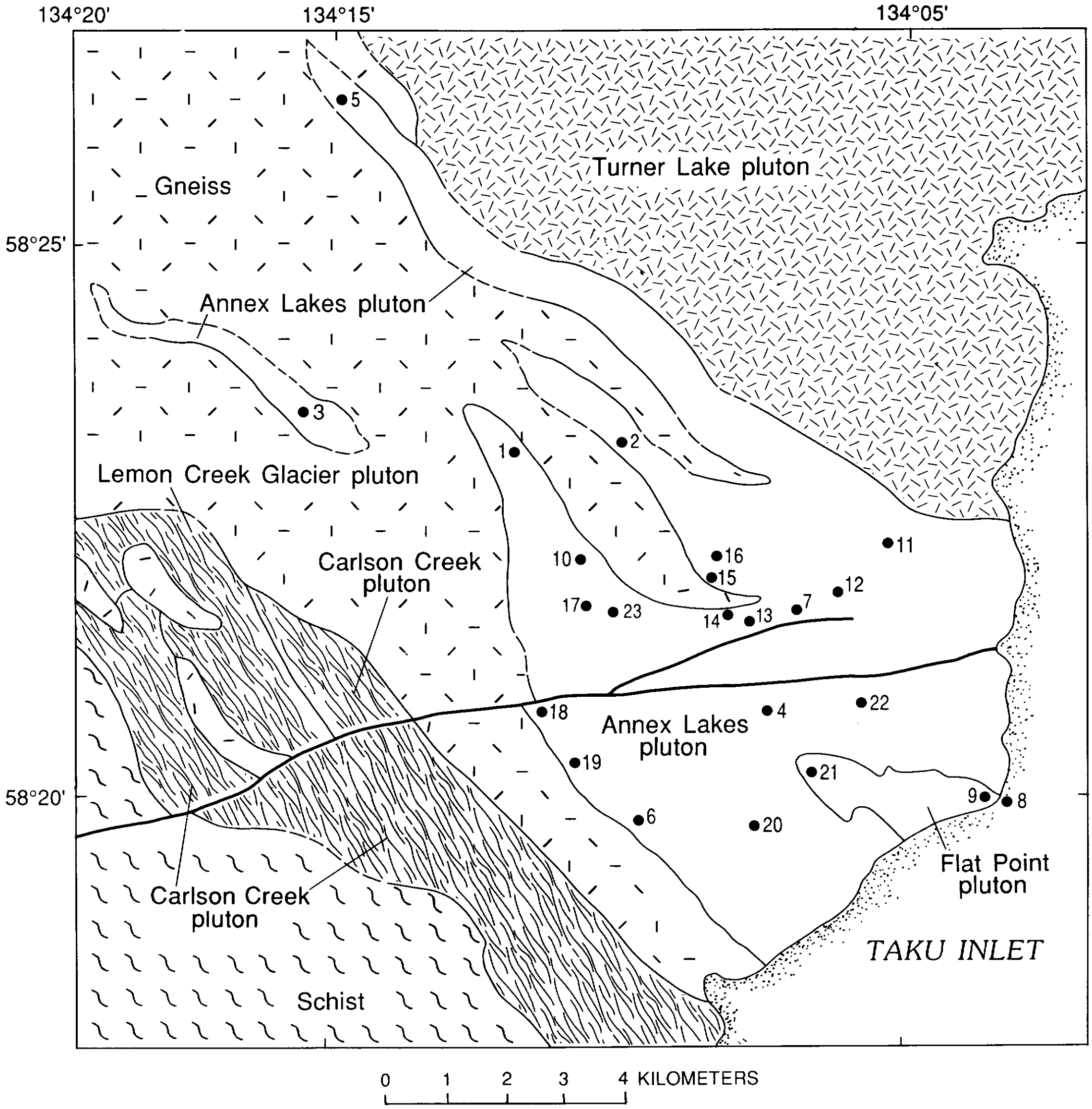


Figure 19. Geologic sketch map of the Annex Lakes pluton, showing sample locations. Heavy line indicates fault. Contacts dashed where approximately located.

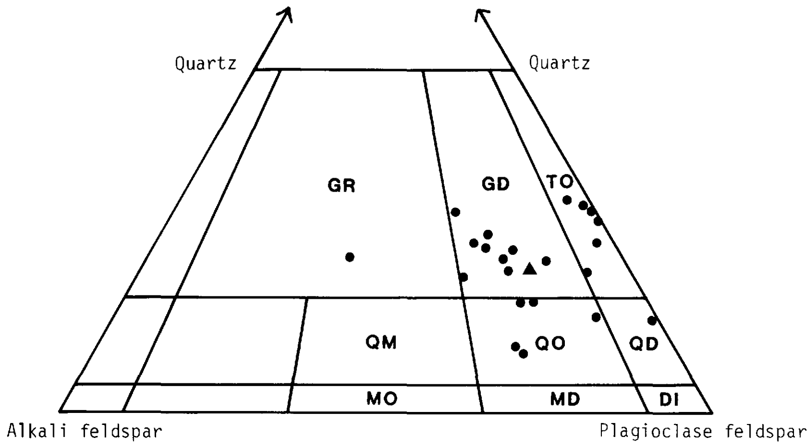


Figure 20. Compositional modes of selected samples from the Annex Lakes pluton plotted on plutonic rock classification diagram of Streckeisen (1973). Average modal composition shown by dark triangle. GR, granite; GD, granodiorite; TO, tonalite; QM, quartz monzonite; QO, quartz monzodiorite; QD, quartz diorite; MO, monzonite; MD, monzodiorite; and DI, diorite.

Table 10. Petrographic and major-element chemical data for the Annex Lakes pluton

Major rock types:
Sphene-bearing hornblende-biotite granodiorite and sphene-bearing biotite-hornblende granodiorite

Minor rock types:
Biotite granite and granodiorite, sphene- and hornblende-bearing biotite tonalite, and hornblende-biotite quartz monzodiorite

Location:
East of Juneau and west of Taku Inlet

Age:
60 Ma (Gehrels and others, 1984)

Description:
Light to medium gray, heterogeneous, fine to coarse grained, strongly to weakly foliated and locally lineated, gneissic to inequigranular and locally porphyroblastic or porphyritic. Contains mafic-rich segregations to weak layering. Biotite generally more abundant than hornblende. Rock typically contains coarse-grained to phenocrystic, anhedral K-feldspar; medium- to coarse-grained, subhedral plagioclase; fine- to medium-grained, platy biotite; medium-grained, subhedral, tabular or elongated hornblende; medium- to fine-grained, granular to intergranular quartz; and fine-grained interstitial K-feldspar. Sphene and allanite are conspicuous and locally common. Color index range 5–27, color index average 13

Comments:
Core zone (Flat Point pluton) is composed of weakly foliated, homogeneous coarse-grained biotite granodiorite and medium- to coarse-grained hornblende-biotite tonalite. Pluton is very heterogeneous in lithology and texture and might be a composite sill body of three to four individual sills

(Table continued on next page.)

Table 10. Petrographic and major-element chemical data for the Annex Lakes pluton—Continued

A. Petrographic data

[Results in percent. An, anorthite content of plagioclase; GR, granite; GD, granodiorite; QM, quartz monzonite; TO, tonalite; n.d., not determined; ---, not present. See table 5 for other abbreviations]

Map No.[1] (fig. 19)	Sample No.	Plagio-clase	Quartz	K-feld-spar	Mafic minerals	Horn-blende	Biotite	Opaques	Sphene	Accessory minerals	Secondary minerals	Main texture	An
1	86AF095	42.5	19.6	[2]22.6	15.3	min	uncom	tr	min-eu	Ap,zi,al	chl,sp,se	Fo-Hy-Eg	n.d.
2	86AF096	56.7	34.7	3.9	4.7	---	min	tr	---	ap,zi	chl,mu,sp	Hy-Eg	n.d.
3	86AF099	44.8	26.3	20.1	8.8	uncom	min	min	tr-an	ap,zi	chl,sp,se	Fo-Hy-Iq	37
4	80DB016	61.1	11.5	.6	26.8	com	com	tr	min-sbh	Ap,zi	chl,ep,pr,se	Fo-Eg-Eq	38
5	86SK374	60.7	20.9	[2]6.8	11.6	uncom	min	tr	min-an	Ap,zi,al	chl,sp,pr,se	Fo-Pb-Al	34
6	80SK122	53.7	16.1	15.2	15.0	uncom	uncom	tr	min-eu	ap,zi,al	chl,ep,sp,se	Fo-Ln-Iq	33
7	87AF096	41.1	33.0	21.3	4.6	---	min	tr	tr-an	ap,al,zi	chl,mu,ep,sp	Fo-La-Iq	34
8[3]	87DB011	60.0	25.5	2.8	11.8	min	uncom	min	min-sbh	ap,zi,al	chl,ep,sp,se	Iq-Eq	35
9[3]	82GS112	55.2	27.5	.7	16.6	uncom	uncom	tr	tr-sbh	ap,zi	chl,ep	Eg	n.d.
10	86SK363	54.4	8.1	[2]19.7	17.8	uncom	com	min	tr-sbh	Ap,zi	chl,se,ca	Fo-Ln-Pb	n.d.
11	88KS141	29.3	26.1	41.4	3.2	tr	min	min	---	Al,ap,zi	chl,mu,ep	Fo-Al-Eg	n.d.
12	88SK142	55.8	18.4	[2]18.1	7.8	uncom	tr	min	min-sbh	Ap,al,zi	chl,sp,se	Iq-Pp	32
13	88SK143	51.8	24.4	18.1	5.6	min	min	tr	tr-sbh	ap,zi,al	chl,sp,se	Fo-Iq-Al	n.d.
14	88SK144	53.4	22.5	[2]18.3	5.8	min	min	min	min-sbh	ap,zi,al	chl,sp	Fo-Gn-Pb	n.d.
15	88SK145	53.9	30.3	1.7	14.0	min	com	tr	tr-sbh	ap,zi	ep,chl,sp	Fo-Al-Gn	n.d.
16	88SK146	47.2	7.9	[2]18.0	26.8	com	min	tr	min-sbh	ap,al,zi	chl,sp	Fo-Pp-Al	n.d.
17	88DB630	59.4	13.1	7.6	19.8	min	com	min	tr-an	ap,zi	chl,sp	Fo-Al-Iq	31
18	88DB031	45.9	23.3	13.9	17.0	uncom	com	min	min-sbh	ap,zi,al	chl,sp,se	Fo-Iq-Gn	33
19	88DB032	37.3	22.5	14.1	26.2	com	uncom	tr	tr-sbh	ap,zi,al	chl,sp,ep,pr	Fo-Gn-Al	n.d.
20	88DB033	[2]53.4	22.2	[2]10.6	14.0	tr	com	tr	min-eu	ap,zi,al	chl,mu,pr	Fo-Pp-Iq	27
21[3]	88DB034	47.9	26.7	19.1	6.3	tr	uncom	tr	tr-an	Al,ap,zi	chl,sp,se	Fo-Pp-Iq	n.d.
22	88DB035	55.5	30.3	1.1	13.2	min	com	min	min-sbh	ap,al	chl,sp,ep	Fo-Iq-Pp	n.d.
GR	83DB080	abnt	com	com	15	min	uncom	min	tr-sbh	Al,Ap,zi	Chl,mu,sp	Fo-Gn-Pb	24
GD	85E1111	abnt	com	uncom	20	com	uncom	min	min-eu	Ap,zi,al	chl,ep,sp	Fo-Gn-Iq	36
QM	83DB081	com	uncom	com	8	---	uncom	min	tr-sbh	Al,ap,zi	chl,sp,mu	Fo-Iq-Al	28
TO	64Fd068	abnt	com	min	17	min	com	tr	min-sbh	Ap	chl,sp,se	Fo-Gn-Iq	43
TO	65Fd070	abnt	com	min	35	com	uncom	min	min-an	Ap,zi	chl,sp,pr	Fo-Gn-Iq	45
GD	65Fd073	abnt	com	min	21	com	uncom	min	tr-an	ap,zi	chl,sp	Fo-Gn-Pb	30
GD	65Bd106	abnt	com	uncom	26	com	com	tr	min-an	ap,zi	chl,sp,se,pr	Fo-Gn-Ln	38
GR	65Bd100	com	com	com	15	uncom	min	min	min-eu	ap,zi	chl,sp,ep,se	Pb-Gr	24
GR	65Fd077	com	com	com	5	min	min	min	tr-an	Al,ap,zi	chl,sp,se	Pp-Al-Gr	29
GD	65Fd091	abnt	com	uncom	22	com	com	min	min-an	ap,al,zi	chl,sp	Fo-Gn-Iq	33
GR	65Bd411	com	com	com	15	---	com	min	tr-an	ap,al,zi	chl,mu	Fo-Al-Iq	30
GR	65Fd080	com	com	com	26	min	com	min	min-an	Al,ap,zi	chl,sp,opq,se	Fo-Gn-Al	26
GD	64Bd050	abnt	com	uncom	31	com	com	tr	min-sbh	ap,zi	chl,sp,se,ep	Fo-Gn-Ln	38
GR	64Bd051	com	com	com	8	tr	uncom	min	tr-an	Al,ap,zi	chl,mu,sp	Fo-Gn-Iq	28
GR	64Bd052	com	com	com	11	---	com	min	tr-sbh	ap,zi	chl,mu,sp,ep	Iq-Al	29
	Average	50.4	21.6	14.4	13.6								
	Standard deviation	8.4	7.8	9.8	7.6								
	Number of samples	19	19	19	19								

[1] Rock name rather than map number reported where no modal analysis was done.
[2] Phenocrystic (greater than 1 cm).
[3] Flat point pluton (core of Annex Lakes pluton); not counted in average.

Table 10. Petrographic and major-element chemical data for the Annex Lakes pluton—Continued

B. Major-element chemical data

[Samples were analyzed in laboratories of the U.S. Geological Survey by x-ray fluorescence. FeO was determined by wet chemical methods. Results normalized to 100-percent volatile free; percentages may not add up exactly to 100.00 because oxide and norm values were rounded off from three to two decimal places. LOI, loss on ignition (H_2O and CO_2); Norm, normative; CI, color index; An, anorthite content of plagioclase; DI, differentiation index--sum of normative quartz, orthoclase, albite, nepheline, and leucite; ---, absent]

Sample No.--	80SK 122	80DB 016	82GS 112	86AF 095	86AF[1] 096	86AF 099	86SK 363	86SK 374	(JS10) 87734	JS41	87DB 011	87JS 10	87AF 096
Map No.----- (fig. 19)	6	4	9	1	2	3	10	5	23	8	8	23	7
						Whole-rock analyses (weight percent)							
SiO_2	65.78	60.01	64.46	61.85	73.14	67.91	60.54	65.65	65.34	58.95	67.13	66.65	69.03
Al_2O_3	17.13	17.87	17.03	18.41	16.24	15.97	17.34	16.82	18.34	18.47	16.78	17.47	17.41
Fe_2O_3	1.30	2.08	1.81	1.79	.05	1.41	2.33	1.55	1.40	2.53	1.62	1.76	1.27
FeO	2.05	4.18	2.75	2.26	.47	2.01	3.23	2.53	2.02	4.29	2.17	1.57	1.22
MgO	1.46	2.80	1.54	1.53	.35	1.21	2.45	1.51	.88	3.03	1.23	.87	.75
CaO	4.75	6.12	5.06	4.92	1.83	3.81	4.85	5.06	5.49	6.60	4.95	5.39	4.52
Na_2O	4.12	3.75	3.75	4.88	6.46	3.64	3.94	3.73	4.56	3.50	3.95	4.33	4.42
K_2O	2.79	1.92	1.68	3.09	1.26	3.21	3.93	2.41	1.37	1.47	1.38	1.30	.99
TiO_2	.40	.89	.60	.66	.09	.51	.81	.38	.35	.81	.50	.35	.26
P_2O_5	.18	.24	.25	.51	.06	.24	.48	.26	.12	.24	.23	.17	.08
MnO	.06	.12	.07	.09	.04	.08	.11	.09	.13	.10	.05	.13	.07
LOI	.45	.54	.37	.25	.25	.38	4.13	.13	.39	.91	.53	.35	.54
						CIPW norms (weight percent)							
Quartz	18.86	12.66	23.53	9.85	26.15	24.33	9.24	21.36	20.02	13.03	26.20	23.88	28.60
Corundum	---	---	.43	---	1.08	.16	---	---	---	---	.34	---	1.05
Orthoclase	16.47	11.34	9.94	18.27	7.45	18.99	23.20	14.22	8.11	8.71	8.13	7.70	5.83
Albite	34.82	31.70	31.75	41.32	54.63	30.78	33.31	31.52	38.58	29.64	33.45	36.66	37.38
Anorthite	20.03	26.28	23.49	19.20	8.66	17.32	18.06	22.05	25.52	30.33	23.06	24.38	21.89
Diopside	1.92	2.05	---	1.55	---	---	2.34	1.20	.78	.68	---	1.02	---
Hypersthene	4.85	10.69	6.54	4.80	1.63	4.87	7.84	6.07	4.02	11.86	5.00	2.75	2.74
Magnetite	1.88	3.02	2.62	2.60	.07	2.04	3.38	2.25	2.03	3.67	2.35	2.55	1.84
Ilmenite	.75	1.70	1.14	1.26	.17	.96	1.54	.73	.67	1.53	.94	.67	.50
Apatite	.42	.56	.57	1.18	.14	.56	1.11	.61	.28	.56	.54	.40	.19
Norm CI	9.4	17.5	10.3	10.2	1.9	7.9	15.1	10.2	7.5	17.7	8.3	7.0	5.1
Norm An	36.5	45.3	42.5	31.7	13.7	36.0	35.2	41.2	39.8	50.6	40.8	39.9	36.9
DI	70.15	55.71	65.22	69.44	88.24	74.10	65.75	67.10	66.71	51.37	67.77	68.24	71.80

[1]Altered rock, not counted in average.

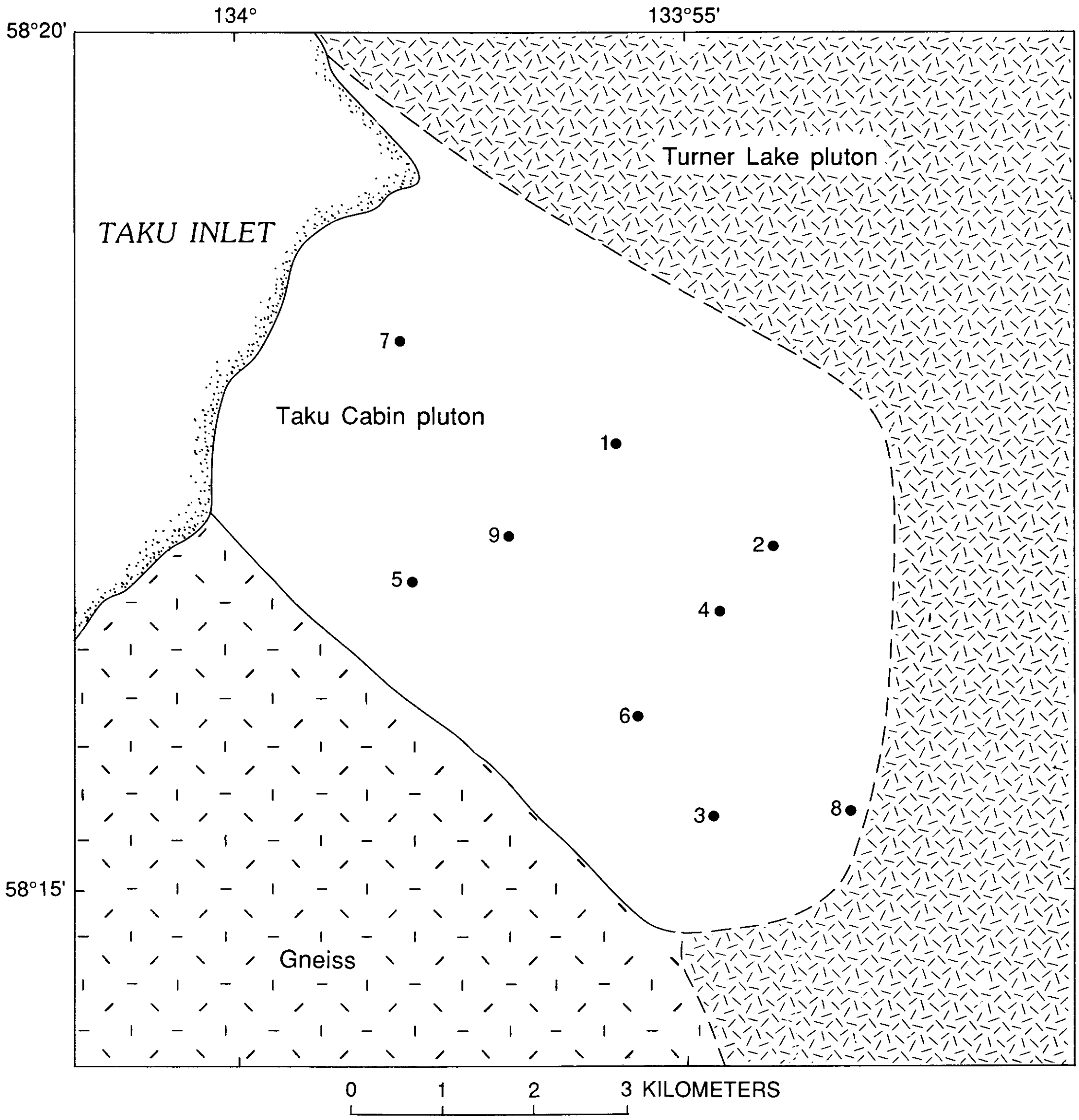


Figure 21. Geologic sketch map of the Taku Cabin pluton, showing sample locations. Contacts dashed where approximately located.

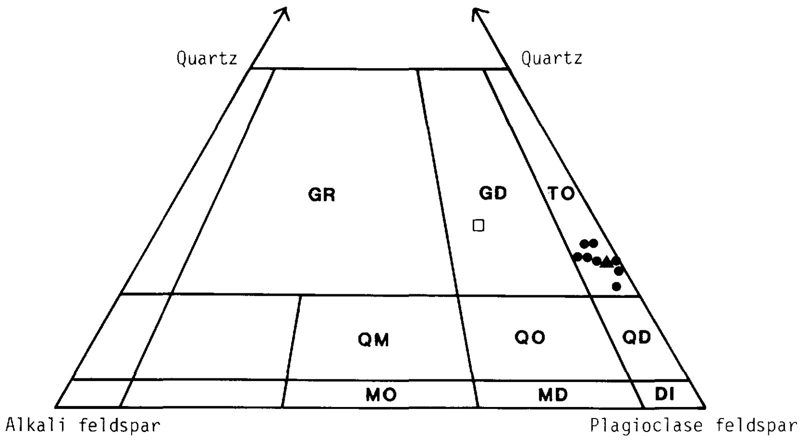


Figure 22. Compositional modes of samples from the Taku Cabin pluton plotted on plutonic rock classification diagram of Streckeisen (1973). Open square is mode on sample from felsic sill layer in pluton. Average modal composition shown by dark triangle. GR, granite; GD, granodiorite; TO, tonalite; QM, quartz monzonite; QO, quartz monzodiorite; QD, quartz diorite; MO, monzonite; MD, monzodiorite; and DI, diorite.

Table 11. Petrographic and major-element chemical data for the Taku Cabin pluton

Major rock type:
Sphene-biotite-hornblende tonalite

Minor rock type:
Sphene- and allanite-bearing hornblende-biotite granodiorite

Location:
Taku Inlet, south of Turner Lake and north of Lake Dorothy

Age:
55 to 60 Ma

Description:
Light to medium gray, homogeneous, medium to coarse grained, and foliated. Typically hypidiomorphic equigranular but ranges from seriate to inequigranular. Contains medium- to coarse-grained subhedral plagioclase; anhedral quartz; interstitial K-feldspar and quartz; and coarse- to medium-grained, tabular, euhedral hornblende and platy biotite. Hornblende more common than biotite in tonalite, and biotite more common in granodiorite. Well jointed. Sphene and magnetite conspicuous. Locally, hornblende phenocrystic (>1 cm). Color index range 15–23, color index average 19

Comments:
Granodiorite forms sill layer in tonalite. Some quartz diorite in lower border-phase rocks. Not as deformed or metamorphosed as Mount Juneau, Carlson Creek, or Lemon Creek Glacier plutons. Body is very similar to Mendenhall Glacier pluton

(Table continued on next page.)

Table 11. Petrographic and major-element chemical data for the Taku Cabin pluton—Continued

A. Petrographic data

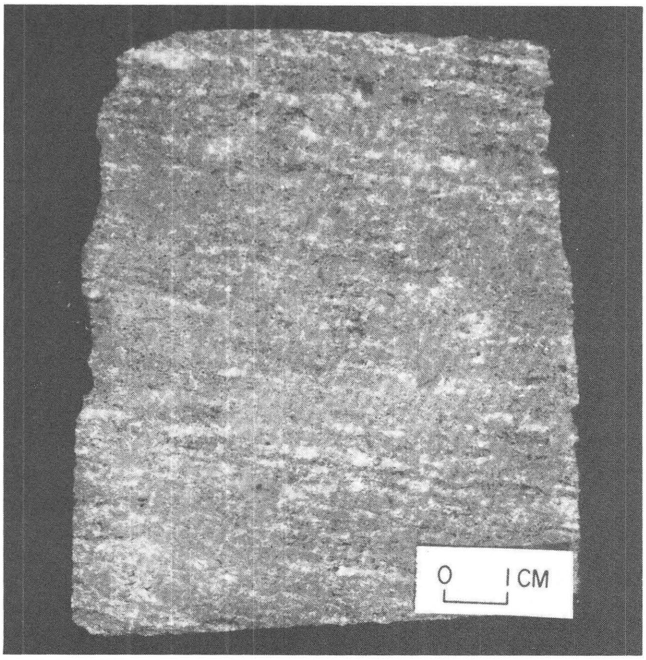
[Results in percent. An, anorthite content of plagioclase; GD, granodiorite; QD, quartz diorite. See table 5 for other abbreviations]

Map No.[1] (fig. 21)	Sample No.	Plagio-clase	Quartz	K-feld-spar	Mafic minerals	Horn-blende	Biotite	Opaques	Sphene	Accessory minerals	Secondary minerals	Main texture	An
1	85DB110	56.5	22.5	4.4	16.6	com	uncom	min	min-sbh	Ap,zi	chl,sp,pr,chl	Fo-Ln,Eg	38
2	85DB111	57.8	22.1	3.6	16.5	com	uncom	min	uncom-sbh	ap,zi	chl,sp,ep,pr	Fo-Hy-Eg	39
3	85DB112	54.5	23.8	2.3	19.4	com	uncom	min	uncom-sbh	ap,zi	chl,sp,ep,pr	Fo-Se-Eg	40
4	85SD068	56.1	24.8	3.7	15.4	uncom[2]	uncom	min	min-sbh	ap,zi	chl,sp,opq	Fo-Hy	39
5[3]	85SD067	40.6	29.0	19.4	11.0	tr	uncom	min	min-sbh	al,ap,zi	chl,ep,mu,sp	Fo-Hy-Eg	32
6	85E1065	61.5	20.9	.8	16.8	uncom[2]	uncom	min	min-sbh	ap,zi	chl,sp,ep,pr	Fo-Hy-Eg	34
7	85SD108	58.4	17.4	2.1	22.1	com	uncom	min	min-eu	ap,zi	chl,sp,ep,pr	Fo-Hy-Eg	39
8	86RK085	58.1	21.1	.3	20.5	com	uncom	min	min-eu	ap,zi	chl,sp,ep,pr	Fo-Hy-Eg	40
9	85E1069	51.2	20.9	4.7	23.2	com	uncom	min	min-sbh	ap,zi	chl,sp,ep	Fo-Hy-Eg	41
GD	85E1071	com	com	com	10	min	uncom	min	tr-an	al,ap,zi	chl,sp,clz,ep	Fo-Al	31
QD	85WN087	abnt	uncom	min	25	com	min	min	min-sbh	ap,zi	chl,ap,sp,pr	Fo-Gn-Hy	36
GD	65Fd053	abnt	com	com	15	min	uncom	min	tr-an	Al,ap,zi	Ep,chl,sp,se	Al-Iq-Pp	31
GD	65Fd054	abnt	uncom	min	15	uncom	uncom	min	tr-an	Al,ap,zi	Ep,chl,sp,se	Al	34
QD	85WN086	abnt	com	uncom	30	com	uncom	min	min-sbh	ap,zi	chl,sp,se	Fo-Hy-Eg	40
	Average	56.8	21.7	2.7	18.8								
	Standard deviation	3.0	2.2	1.6	2.9								
	Number of samples	8	8	8	8								

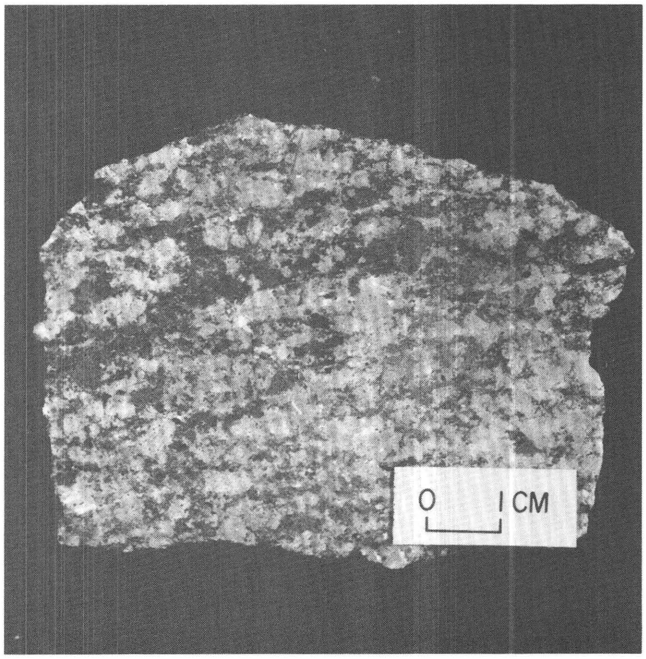
[1] Rock name rather than map number reported where no modal analysis was done.

[2] Most abundant mafic mineral.

[3] Felsic sill layer in tonalite--not included with main-phase average.



A



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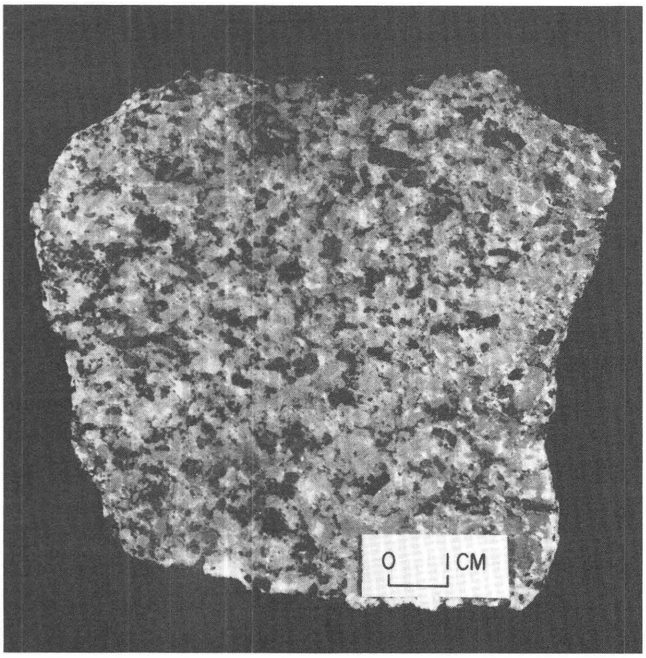

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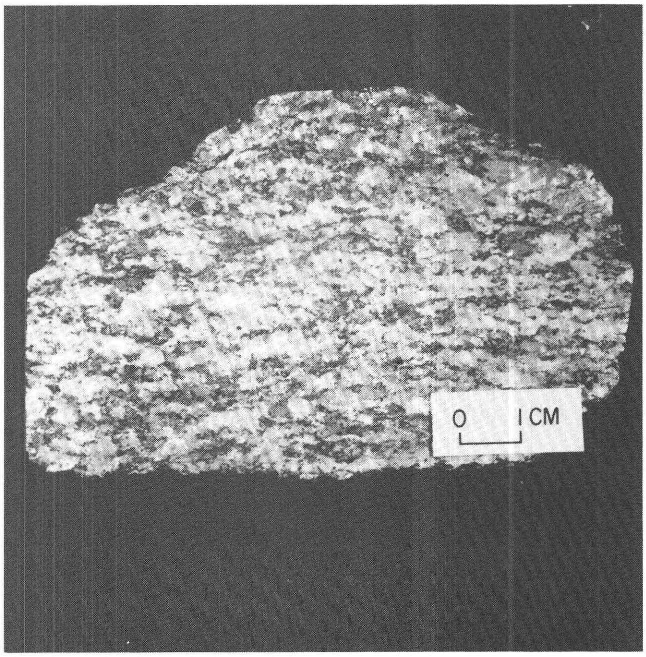


D

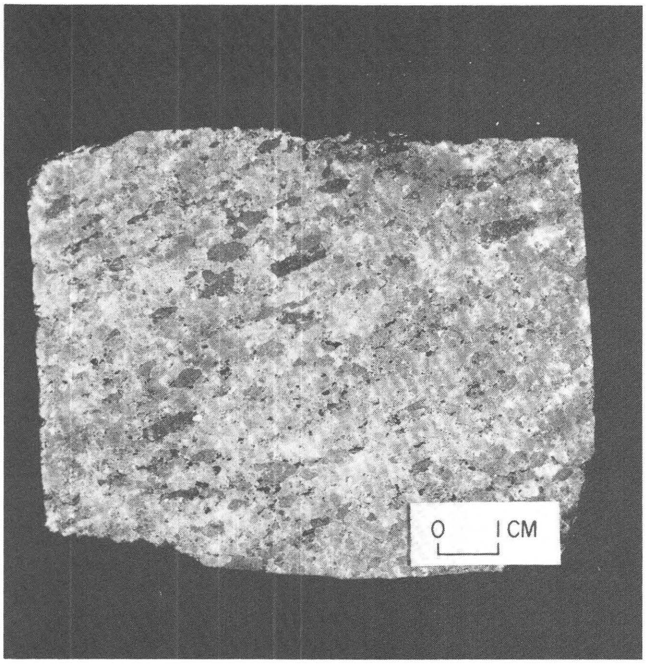
Figure 23. Stained slabs from the Juneau sills, showing typical textures of each pluton. Plagioclase is medium dark gray, K-feldspar is grayish white, and quartz is light gray. *A*, Gneissic hornblende-biotite tonalite from the Mount Juneau pluton; *B*, weakly foliated biotite-hornblende tonalite from the Mendenhall Glacier pluton; *C*, foliated and weakly banded biotite-hornblende tonalite from the Lemon Creek Glacier pluton; *D*, strongly foliated biotite-hornblende tonalite from the Carlson Creek pluton; *E*, foliated equigranular biotite-hornblende tonalite from the Taku Cabin pluton; *F*, weakly foliated porphyritic biotite granodiorite from the Annex Lakes pluton (phenocrysts are K-feldspar); and *G*, gneissic hornblende-biotite granodiorite from the Annex Lakes pluton.

Table 11. Petrographic and major-element chemical data for the Taku Cabin pluton—Continued

B. Major-element chemical data

[Samples were analyzed in laboratories of the U.S. Geological Survey by x-ray fluorescence. FeO was determined by wet chemical methods. Results normalized to 100-percent volatile free; percentages may not add up exactly to 100.00 because oxide and norm values were rounded off from three to two decimal places. LOI, loss in ignition (H_2O and CO_2); Norm, normative; CI, color index; An, anorthote content of plagioclase; DI, differentiation index--sum of normative quartz, orthoclase, albite, nepheline, and leucite]

Sample No.-------	85DB 110	85DB 112
Map No.------------ (fig. 21)	1	3
Whole-rock analyses (weight percent)		
SiO_2	61.56	61.68
Al_2O_3	16.97	16.92
Fe_2O_3	2.66	2.48
FeO	3.64	3.89
MgO	2.78	2.68
CaO	6.22	6.30
Na_2O	3.38	3.34
K_2O	1.76	1.67
TiO_2	.68	.68
P_2O_5	.22	.23
MnO	.13	.12
LOI	.52	.51
CIPW norms (weight percent)		
Quartz	17.43	17.85
Diopside	2.81	2.87
Orthoclase	10.39	9.88
Albite	28.62	28.28
Anorthite	25.92	26.21
Hypersthene	9.17	9.48
Magnetite	3.86	3.60
Ilmenite	1.29	1.29
Apatite	.52	.54
Norm CI	17.1	17.2
Norm An	47.5	48.1
DI	56.4	56.0



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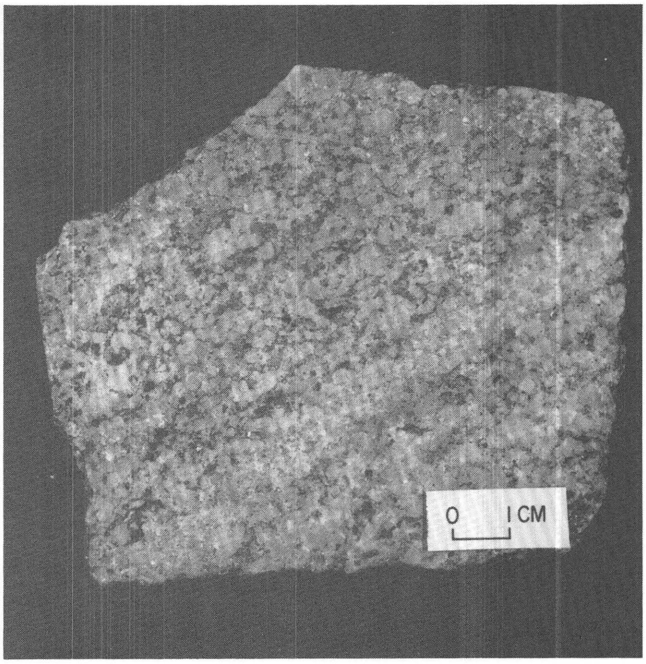

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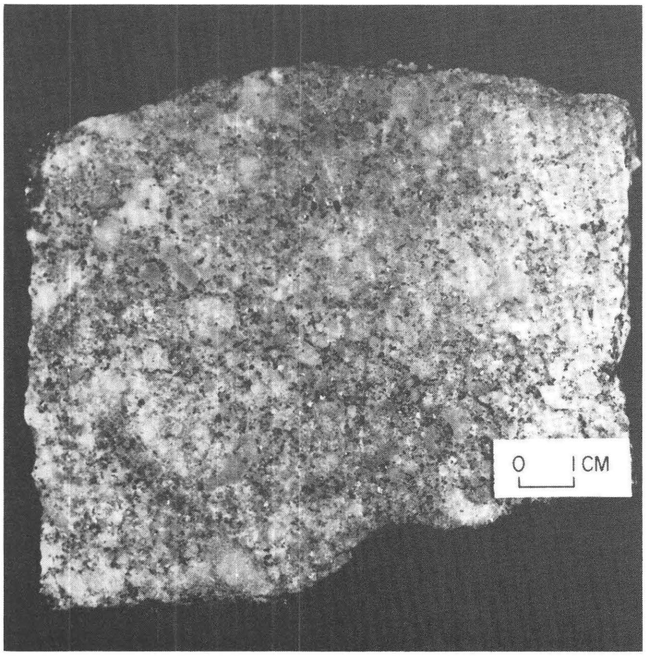

F

Figure 23.—Continued

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