THE COAST RANGE BATHOLITH BETWEEN HAINES,

ALASKA AND BENNETT LAKE, BRITISH COLUMBIA

Thesis by

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THE COAST RANGE BATHOLITH BETWEEN HAINES, ALASKA AND BENNETT LAKE, BRITISH COLUMBIA

INTRODUCTION

General Statement

The Coast Range batholith of western Canada and southeastern Alaska, which is a composite of many plutons from a few hundred yards to several miles in cross-sectional width, extends approximately 1,100 miles from the vicinity of Vancouver, British Columbia northwest to Kluane Lake, Yukon Territory. Its width varies from about 40 miles in the north to a maximum of about 120 miles in southern British Columbia. The northern end of the batholith has not been studied previously in detail. The author traversed this portion of the of the batholith from the northeastern contact at Bennett Lake, British Columbia along the tracks of the White Pass and Yukon Route railroad to Skagway, Alaska and from there by boat along Lynn Canal to Haines, Alaska and the southwestern contact of the batholith. The mapping was done on air photos, whose scale is approximately

1:38,000. The traverse was begun on August 4,
1951 and was finished on August 30, 1951.
About four weeks were spent studying thin
sections in March and April of 1952. The
purpose of this report is to present the results
of this study.

The author is indebted to Dr. Ian Campbell,
who kindly criticized the manuscript, for his
advice and suggestions. Mr. Wesley W. Patterson
of Skagway was extremely helpful to the author,
as was Mr. Kenneth Lamereaux, also of Skagway,
who loaned the author a 12 foot skiff for the
Lynn Canal part of the traverse.

Geography

All the area traversed, as shown on pl. 1,
lies in the Coast Mountains physiographic sub-
division of the Canadian-Alaskan Cordillera
(Bostock, 1948, map 922A). Bostock further
divides the Coast Mountains into the Boundary
Ranges, which lie along the Alaska-B.C. boundary
and are separated on the southwest from the main
Alaskan coast by the Alsek and Fairweather Ranges,
and into the Pacific Ranges, which lie along the
coast of southwestern British Columbia.

The Boundary Ranges are approximately 35 to

40 miles wide from the Portland Canal region to their northern terminus at Kusawa Lake, Yukon. They rise 4,000 to 6,000 feet above Lynn Canal and its tributary inlets. Lynn Canal is a typical fiord that extends from Icy Straits (20 miles west of Juneau) 75 miles north to its head near Haines. Three miles northeast of Haines it branches into Taiya Inlet, a mile-wide passage that extends 15 miles north to Skagway; Lutak Inlet, extending 6 miles to the west-northwest; and a small inlet between the two. The Taiya Inlet trough branches just west of Skagway into the Skagway Valley, which extends north-northeast to White Pass; and into the Taiya River Valley, which extends north to Chilkoot Pass.

The White Pass and Yukon Route, a narrow-gauge railroad, passes along the east side of the Skagway Valley from Skagway to White Pass. White Pass, elevation 2,900 feet, and Chilkoot Pass to the northwest, elevation 3,500 feet, are the only passes through the Coast Mountains between Taku Inlet, southeast of Juneau, and the Dezadeash Valley in the Yukon. The White Pass and Yukon Route extends northeast through White Pass, which is a broad, open pass about 10 miles long, to Log

Cabin, B.C. From Log Cabin it goes east and then north to Bennett and along the east shore of Bennett Lake, which for 16 miles lies in a relatively straight, steep-sided valley from 3,000 to 4,000 feet deep. Bennett Lake broadens north of this long, narrow section. The railroad extends north to Carcross, Yukon and to its terminus at Whitehorse, Yukon.

Many glaciers and several small ice fields lie in these mountains and reach their maximum development along the axis of the Ranges.

The climate of the area varies markedly from Haines to Bennett Lake. Haines and Skagway experience relatively mild, humid weather with annual precipitations of apprximately 35 and 25 inches per year, respectively, most of it falling as rain during the winter months. The precipitation generally decreases north from Skagway, except for the elevation effect, with Bennett receiving about 15 to 18 inches per year, much of which falls as snow in the winter. Summers are cool and relatively dry north of the axis of the Ranges and winters are severe. Unofficial winter temperatures of -60 F. have been reported from Bennett.

The timber and vegetation of the Alaskan side of the area consist of forests of hemlock,

spruce, cedar, and some pine, and of dense brush
of willow, alder, devil's club, and other luxuriant
growth. On the British Columbian side the forest
growth is largely spruce, with some poplar on well-
drained slopes. Alder and willow brush grow on
slides and burnt-over areas. Timber line lies at
about 3,000 feet from Haines to White Pass and
gradually ascends to over 4,000 feet at the north
end of Bennett Lake.

PREVIOUS WORK

The pre-Permian rocks of the Lower Stikine
River area form a complex of slate, schist, gneiss,
marble, and other metamorphosed and structurally
complex rocks (Kerr, 1948a, pp. 22-24), which Kerr
mapped as a single unit. Buddington and Chapin
(1929, pl. 1) mapped 20 separate units of pre-Perm-
ian sedimentary and volcanic rocks and their meta-
morphosed equivalents in southeastern Alaska. These
rocks are important to the present study only in
that they are present in the southwestern half of
the batholith as isolated septa and roof pendants.
They contain no recognizeable fossils and their
lithologic character is not distinctive, so that
they are not correlative with any fossiliferous
rocks further south.

The Permian rocks of southeastern Alaska

are largely cherty limestone beds with some clastic
sedimentary rocks and basaltic to felsitic volcanic
rocks (Buddington and Chapin, 1929, pp. 122 to 130).
Kerr found a section of Permian limestone in the
Taku River area that is about 500 feet thick (Kerr,
1948b, p. 23).

In the Taku River area east of the Coast
Range batholith Kerr reported approximately 9,000
feet of Triassic rocks, slightly more than half
of which are volcanic flows, tuff, and agglomerate,
and the remainder are intercalated clastic sedimen-
tary rocks (argillite, sandstone, and conglomerate)
with an upper limestone formation 200 to 600 feet
thick. These rocks are overlain by about 5,000
feet of Lower Jurassic clastic sedimentary rocks
and some intercalated volcanics (Kerr, 1948b, pp.
23-31). Unconformably overlying the Lower Jurassic
strata is a Jurassic(?) sequence of approximately
2,500 feet of limestone and 13,000 feet of argillite,
sandstone, and conglomerate with several thousand
feet of intercalated dacitic lava and tuff. This
sequence is unconformably (?) overlain by 18,000
feet of Lower Cretaceous clastic sedimentary rocks
and dacitic flows and tuffs- the lower half of the
section is dominantly volcanic and the upper half
is largely clastic sedimentary rock with some

limestone. The Mesozoic sediments of the Taku
River area appear to thin out very markedly to
the southwest (Kerr, 1948b, pp. 30-38).

Eocene conglomerate, sandstone, and volcanic
rocks lie in a basin extending from Admiralty
Island, 120 miles south of Haines, to the Ketchi-
kan district (Buddington and Chapin, 1929, pp. 260-
267). The volcanic rocks vary from basaltic to
rhyolitic tuff and some breccia, with the rhyolitic
types predominant.

Quaternary olivine basalt flows occur in the
Lower Stikine River area (Kerr, 1948a, pp. 39-45).
At Miles Canyon, in the Yukon River 4 miles south
of Whitehorse, an olivine basalt flow overlies
Tertiary river gravels. This flow is believed to
be of Quaternary age (Cockfield and Bell, 1929, pp.
33-35).

A. Knopf has described the hornblendite mass
that lies immediately north of Haines (Knopf, 1910).
This is the only published work on the geology of
the Haines-Bennett area. However, the studies of
Knopf in the Eagle River-Berners Bay area (Knopf,
1911, 1912), which lies 30 miles south of Haines
on the east side of Lynn Canal, and those of
Buddington further south in southeastern Alaska
(Buddington and Chapin, 1929) give much information
on the northern part of the Coast Range batholith

and the rocks that it intrudes. The most detailed

study of the northern part of the batholith has

been made by Kerr in the Lower Stikine River area,

B.C. (Kerr, 1948a) and in the Taku River area, B.

C. (Kerr, 1948b), the latter area being about

80 miles southeast of Haines. Phemister's work

on the southern end of the Coast Range batholith

just north of Vancouver, B.C. is of general interest

(Phemister, 1945).

In the Lower Stikine River area Kerr reported

(1948a, pp. 47-69) that the Coast Range batholith

is composed of the nine plutonic units listed

below:

Lower Cretaceous (?)   Quartz monzonite
Biotite-hornblende andesine-
                     granodiorite
Quartz diorite

Jurassic (?)   Hornblende-biotite oligoclase-
                     granodiorite
Hornblende-biotite andesine-
                     granodiorite
Hornblende oligoclase-
                     granodiorite
Hornblende andesine-
                     granodiorite

Triassic (?)   Pulaskite, nordmarkite,
                   nepheline syenite
Diorite

COAST RANGE INTRUSIVE ROCKS

The intrusive rocks of the Coast Range batho-
lith in the area traversed are comprised of two
major types- quartz diorite and quartz monzonite-
and two minor types- hornblendite and granodiorite.
Table 1 shows volumetric modes, determined with an
integrating stage, of 34 specimens collected at 1
to 3 mile intervals from each of the intrusive
masses that comprise the batholith. Sample localities
are denoted on pl. 1 by encircled specimen numbers.
The individual intrusive bodies of the batholith
recognized in this traverse will now be described
in a general order of oldest to youngest.

Hornblendite

The hornblendite mass north of Haines was

first described by Knopf (1910, p. 145)- "The
rock mass exposed along the shore north of Haines
is a remarkable occurrence geologically. Specimens
collected from the finest textured portions show
a rock composed of a coarsely crystalline aggregate
of feldspar, hornblende, and pyroxene, throughout
which are scattered some visible grains of magnetite.
The dark minerals (the hornblende and pyroxene)
make up half the bulk of the rock. When examined
microscopically the rock is found to consist of an
allotriomorphic granular assemblage of plagioclase
feldspar (bytownite), hornblende, and augite. Mag-
netite and apatite are present as accessory minerals
in unusually large amounts. From this normal type
of rock, which would be termed a gabbro, abrupt
variations in texture and mineral composition are

Table 1. Mineral composition of selected samples of intrusive rocks of the Coast Range batholith between Haines, Alaska and Bennett Lake, Yukon. Percentages by volume.

Sample no.	Quartz	Orthoclase	Microcline	Perthite	Plagioclase	Biotite	Hornblende	Augite	Accessory minerals*
2[1]	24	27			27 Ab$_{92}$	4			1
7	35	26			32 Ab$_{70}$	5	1		1
15	31	3		41	22 Ab$_{90}$	3			1
18	27				53 Ab$_{59}$	15	1		1
19	26	17			47 Ab$_{68}$	8	1		1
21	43	6			44 Ab$_{72}$	5	1		1
22	19			36	34 Ab$_{72}$	9			1
24	32	27			34 Ab$_{74}$	6	1		1
25	21	16		13	39 Ab$_{72}$	9			1
26	20	4			49 Ab$_{62}$	16	9		1
27	20	5			54 Ab$_{53}$	12	7		1
29	32		15	23	26 Ab$_{88}$	3			1
30	23	4			46 Ab$_{52}$	19	6		1
31	22	1			53 Ab$_{53}$	15	7		1
32	34			34	27 Ab$_{90}$	3			1
33	36			40	20 Ab$_{85}$	3			1
34	20			49	26 Ab$_{82}$	4			1
36	27			55	30 Ab$_{84}$	7			1
37	22	5			50 Ab$_{58}$	13	9		1
38	26	1			57 Ab$_{53}$	12	3		1
39	19			54	23 Ab$_{85}$	4			1
42	18	2			54 Ab$_{53}$	11	14		1
44	26		9		49 Ab$_{51}$	13	2		1
50[2]	19	2			42 Ab$_{52}$	14	5	5	1
51[3]	15				50 Ab$_{62}$	10	5		1
53	23				56 Ab$_{51}$	13	7		1
54	33	7			45 Ab$_{66}$	14	5	1	1
55	8				55 Ab$_{57}$	28	5		2
56	28	1			58 Ab$_{58}$	11	1		1
58	29	9			51 Ab$_{59}$	8	3		1
61	27	3			55 Ab$_{58}$	12	2		1
62	27	11			51 Ab$_{59}$	9	2		1
64	29	7			53 Ab$_{62}$	10	1		1
65[4]	15				65 Ab$_{48}$	13	7		1

* Percentages estimated.
[1] Spec. 2 contains 17.5% quartz-chlorite-carbonate veins.
[2] 12% of Spec. 50 is fine-grained protoclastic quartz, plagioclase, micropegmatite, orthoclase, and microcline.
[3] 20% of Spec. 50 is protoclastic material of the minerals as that in Spec. 50.
[4] Spec. 65 is an inclusion in rock of Spec. 64 type.

Colors are same as on pl. 1.

encountered. In places the cliffs for hundreds
of feet are composed solidly of formless horn-
blende individuals 6 inches long and 3 inches
broad. Commonly this hornblende rock contains
more or less grayish-green augite admixed with
it and is ramified by coarse white feldspathic
dikelets or blotched by masses of gabbro. In
places it even forms a breccia cemented by such
material. Locally the hornblendite contains
numerous lumps and particles of magnetite, which
can easily be recognized by the characteristic
blue tarnish that they assume upon weathered
surfaces. At no point along the shore, however,
has the segregation of magnetite proceeded far
enough to yield a solid body of iron ore, or
even a body of ore of commercial grade." This

mass has an outcrop belt about 1.2 miles wide.

Both its southern and northern contacts are

concealed by glacial drift and very thick

vegetation, so that its exact relation to the

basaltic rocks south of it and the quartz

diorite north of it are not known.

A thin section of hornblendite, specimen 47,

agreed with Knopf's general description given

above, except that only about 5% augite was

present. A dikelet (white to pink in hand

specimen) in this thin section consisted of about

90% wholly sericitized and kaolinized feldspar

(presumably plagioclase), the remainder being

mostly clear apatite and a little chlorite that

has replaced hornblende. The chloritization is

confined to the hornblende in the veins and is

assumed to be deuteric. About 95% of the feldspar

(all of which is altered) in this rock occurs in the dikelets. The northern part of this mass contains irregular fine-grained dikes of hornblende quartz diorite that contains fresh andesine. These dikes appear to have come from the Lutak Inlet mass described below. The hornblendite appears to have cooled at least to a temperature low enough for the original feldspar and that in the dikelets to be deuterically sericitized and kaolinized before the quartz diorite dikes were intruded.

The abrupt changes in grain size of the hornblendite, from 1/16 inch to about 6 inches in 2 to 3 inches distance, may be due to a differential loss of volatile constituents. The finer-grained portions may have lost their volatiles through sudden cooling and crystallized quickly, and the coarser-grained portions may have retained their volatiles and continued their crystallization through a much less viscous pegmatitic stage.

Hornblendite has been found at various localities along the western edge of the Coast Range batholith. Buddington mentions occurrences of hornblendite at Berners Bay, Etolin Island, Zimovia Straits, Kupreanof Island, Ford's Terror, Tracy Arm, Port Snettisham, Baranof Island, and at Knight Inlet (Buddington and

Chapin, 1929, pp. 194-198). Its remarkable
similarity at these localities suggests a common
origin, which may have been as an early differentiate
of the Coast Range batholith magma.

Quartz Diorite- Lutak Inlet to Taiya River Flats

The quartz diorite that extends from the south
side of Lutak Inlet north to the Taiya River Flats
is a composite of three separate plutons that are
divisible structurally and/or petrographically.

The first of these three plutons (discussing
them from south to north), the Lutak Inlet mass,
extends approximately 5.2 miles north from its
concealed contact with the hornblendite to a point
3.2 miles north of Taiya Point (which is at the
entrance of Taiya Inlet).

The well-defined foliation of the Lutak Inlet
quartz diorite is generally steeply dipping to the
north and has an average trend of about N65W. This
pluton contains a total thickness of about 0.4 miles
of schist present as septa or relatively tabular
roof pendants, which divide the quartz diorite into
8 large sill-like masses. Three of these masses
contain up to 10% schist bands that are parallel
to the foliation of the quartz diorite and are

irregularly spaced, and are from a few millimeters
to a few tens of feet wide. At several places these
separate bands of biotite and quartz-rich material
in the quartz diorite increase in amount toward the
septa giving a poorly-defined or gradational contact.
The author interprets these dark bands as layers of
schist that were partly assimilated after having
been invaded by closely-spaced sills of quartz
diorite. These were the only gradational contacts
found in the traverse across the batholith; all
other observed contacts were characteristically
sharp. At all but two of the contacts of this
quartz diorite with schist the foliation of the
quartz diorite pluton is parallel with the schistosity
of the schist septa. At the quartz diorite-schist
contacts on the north side of Lutak Inlet and also
3.2 miles north of Taiya Point the foliation of
the quartz diorite has swung from its regional
west-northwest trend to one almost perpendicular
to the schistosity of the septa.

The schist septa contain ptygmatically folded
quartz lenses that have both up-north and up-south
shear senses, implying that a rather thin series of
isoclinally folded argillite beds (or rocks of
similar chemical composition) has been invaded by

the magma along a previously developed cleavage
or schistosity. Quartz dioritic aplite and some
pegmatite cut the schist as tabular dikes and
irregular streaks up to several inches in width.
For $\frac{1}{2}$ mile south of the point where spec. 55 was
taken (see pl. 1) the quartz diorite contains many
narrow, tabular masses of breccia of randomly
oriented schist particles in matrices of quartz
dioritic aplite and pegmatite. The author inter-
prets these breccias as septa that were brecciated
during the last stages of crystallization of the
quartz diorite and then were injected by a late
stage pegmatitic melt, part of which lost its
volatile components and crystallized comparatively
quickly as aplite.

The Lutak Inlet pluton is composed of mottled
gray and black coarse-grained biotite quartz diorite.
In both outcrop and hand specimen it shows a well-
defined foliation in which the biotite and horn-
blende grains tend to wrap around the larger plagio-
clase and quartz grains. Five thin sections (spec.
50, 51, 53, 54, and 55) of this quartz diorite
showed from 10 to 38% of biotite, hornblende, and
fine-grained plagioclase, quartz, and some potash
feldspar that occurs interstitially between larger

partly granulated plagioclase and quartz grains.
This pluton was probably stressed just before or
after it was completely crystallized, giving
this protoclastic or cataclastic texture (referred
to hereafter in this report as an autoclastic
texture). The quartz diorite is allotriomorphic
granular, with about half the biotite as chunky
crystals and half of it as flakes that may have
been sheared to their present shape from original
chunky grains.

An average of volumetric modes of the 5 speci-
mens listed above show the quartz diorite to consist
of the following: 21% quartz, 4% orthoclase, 53%
andesine (Ab_{58}), 16% biotite, 4% hornblende, 1%
augite, and 1% accessories (magnetite, ilmenite,
apatite, sphene, and zircon).

The next separable quartz diorite pluton, the
Halatu Ridge mass, is partitioned from the one to
the south that has an autoclastic texture by a
septum of schist. This pluton is exposed from
3.2 to 6.5 miles north of Taiya Point. It is
bounded on the north by a 125 foot thick septum
of schist. The foliation of the Halatu Ridge mass
is parallel to the schistosity of the septum that
bounds it on the south but is markedly discordant

to the septum on the north.

.A 0.35 mile wide mass of schist, 4.8 miles
north of Taiya Point, occurs in this pluton. This
schist is cut by many quartz dioritic aplite dikes
that form up to one-half of the rock exposed. These
dikes generally strike east-west to northeast-
southwest and dip gently north, as shown in figure
2. Many of them are gently undulating but of
rather constant thickness. Similar dikes are
found in the quartz diorite just north of this
schist-aplite mass. These dikes may be aplitic
fillings of marginal fissures, slightly folded
after injection of aplite, associated with the
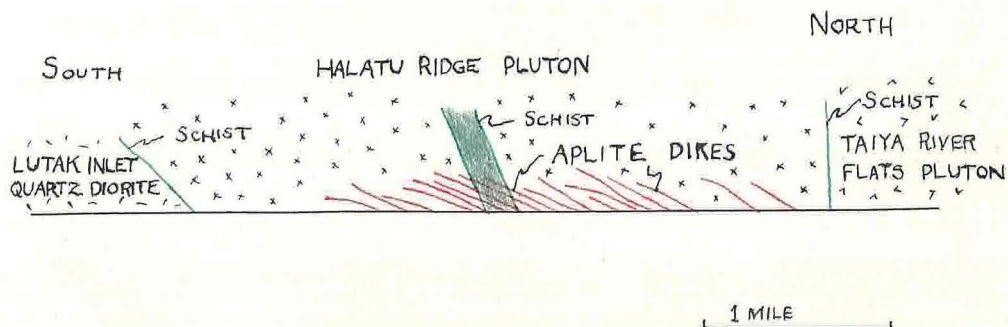Taiya River Flats pluton that is discussed below.

Figure 2. Showing aplite-filled marginal fissures
in the Halatu Ridge pluton and included schist.

The Halatu Ridge mass is represented in table 1 by spec. 56 and 58. This rock is different from the quartz diorite south of it in that its texture is hypidiomorphic subequi-granular without any mashing or recrystallization. Compositionally this quartz diorite is similar to the Lutak Inlet quartz diorite except that it has 6% less biotite, 6% more quartz, no augite, and allanite is an accessory. The differences may be within the sampling error, as both plutons contain schlieren and dark bands much richer in femic minerals.

The third pluton, the Taiya River Flats mass, found between Lutak Inlet and the Taiya River Flats extends from a schist septum 6.5 miles north of Taiya Point to beyond the Taiya River Flats, north of which it is not exposed.

This pluton is foliated for about 4 miles from its southern contact, grading north to a massive rock that is free of septa or other rock of country rock derivation. Inclusions are rather scarce in this pluton (as contrasted to the Halatu Ridge and Lutak Inlet plutons) and they are small (less than 6 inches long), well-rounded, and diversely oriented. A thin

section, spec. 65, of an inclusion in the un-
foliated northern part of this pluton shows
approximately 15% quartz, 65% zoned plagioclase
(averaging sodic labradorite), 13% biotite,
and 7% hornblende. All inclusions seen have a
well-foliated fine-grained fabric.

Three thin sections of the Taiya River Flats
pluton (spec. 61, 62, and 64) show normally zoned
plagioclase that varies from calcic labradorite to
sodic andesine. This is the only pluton in the
batholith in which markedly zoned plagioclase was
observed. The texture of this rock is hypidiomorphic
inequigranular in which subhedral to euhedral
plagioclase and chunky biotite subhedra contain
interstitial quartz and orthoclase. Three modes
give an average of 28% quartz, 7% orthoclase,
53% plagioclase (averaging about Ab_{56}), 10% biotite,
1% hornblende, and 1% accessory minerals (apatite,
magnetite, ilmenite, sphene, and zircon). The
rock type, therefore, is a granodiorite closely
allied to quartz diorite.

The evidence bearing on the relative ages of
the Lutak Inlet, Halatu Ridge, and Taiya River Flats
plutons may be summarized as follows: the Lutak
Inlet mass is autoclastic in texture, whereas the

other two are not; aplite-filled marginal
fissures appear to extend southward from the
Taiya River Flats pluton and cut the Halatu
Ridge mass. Hence the Lutak Inlet mass appears
to be the oldest because the stresses that caused
its autoclasis would probably have similarly
affected a pluton just north of it (the Halatu
Ridge mass), but the pluton that lies just north
of it is not autoclastic in texture; so the Halatu
Ridge mass was probably not present when the Lutak
Inlet mass was intruded. The schist septum between
those two plutons was probably too thin to have
cushioned the Halatu Ridge pluton from the stresses
that partly granulated the Lutak Inlet mass, if
one assumes that the Halatu Ridge mass is the older.
The Taiya River Flats pluton appears to be younger
than the Halatu Ridge pluton immediately south of
it because marginal fissures could only have
extended out of the Taiya River Flats pluton into
an older rock mass. If these three reasons are
valid the three plutons were successively intruded
from south to north, or the Lutak Inlet mass is the
oldest, the Halatu Ridge mass is intermediate in
age, and the Taiya River Flats mass is the youngest.

Quartz Diorite- Skagway to Mile 4

The Skagway pluton, of foliated quartz
diorite, extends (normal to the foliation) from
south of Skagway to 4 miles northeast of Skagway
(along the White Pass and Yukon Route tracks).
A smaller pluton of the same rock, the Mile 4
mass (which may once have been continuous with
the Skagway pluton), 0.7 miles wide across the
foliation, occurs one-half mile north of the
Skagway mass. These two masses are separated
by a mass of younger granite, which appears to
be a potassic variant of a much larger quartz
monzonite body to the north (that is discussed
below). A curved railroad cut intersects in three
places the contact of the Skagway quartz diorite
mass with the younger granite north of it. All
three exposures of this contact show that the granite
has irregularly transected the foliation of the
Skagway mass. Angular, diversely oriented blocks
of quartz diorite were found in the granite. At
these exposures the contact appeared to be about
vertical.

The northern and southern contacts of the
Mile 4 quartz diorite mass are essentially
planar with the foliations of the granite to

the south and the quartz monzonite to the north
parallel to the contacts and to the foliation of
the Mile 4 quartz diorite. Thus the northern
contact of the granite pluton that separates the
Mile 4 and Skagway masses is accordant and foliated
and its southern contact is discordant and no
foliation has developed. The granite may first
have been selectively and forcefully intruded
along a foliation surface in the quartz diorite,
and then later stoping, presumably guided by
joints, modified the southern contact of the
granite (with the Skagway mass).

Both the Skagway and Mile 4 masses contain
some schlieren and dark flow bands that have been
symmetrically folded so as to have horizontal
axial planes and steeply dipping trends parallel
with the foliation of the adjacent quartz diorite
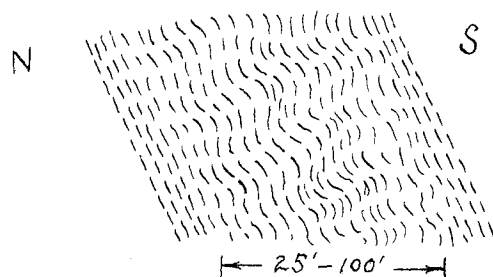that has not been so folded, as shown in figure 3.

Figure 3. Showing folding (schematically) of
foliation and schlieren in the Skagway and Mile
4 masses.

The author believes that the viscous, partly crystallized magma (with flow-banding and foliation already developed) was subjected to stress parallel to the foliation, that the magma chamber expanded in a direction normal to the foliation, and that the change of dimensions of the pluton took place by the folding of the foliation and the flow-banding (or schlieren). This folding appears to have taken place before the rock was completely crystalline because no clasis is evident in thin section.

The Skagway quartz diorite contains a total section of about 650 feet of schist, quartzite (often showing gently plunging boudins), and marble. The schistosity and bedding of the metamorphic rocks are generally parallel or subparallel to the foliation of the quartz diorite, but local truncations of the schistosity and bedding by the foliation of the igneous rock imply some stoping. The Mile 4 mass is devoid of schist and other metasedimentary rocks. The foliation of the quartz diorite in both masses is steeply dipping with a trend of about N80W.

Both the Skagway and the Mile 4 masses are

variable in composition with alternating bands
of medium gray quartz diorite several feet to
several tens of feet thick and darker bands much
richer in biotite and hornblende a few inches to
several feet thick. Three modes of the lighter,
more common type (spec. 37, 38, and 42) show an
average of 22% quartz, 3% orthoclase, 53% andesine
(Ab_{55}), 12% biotite, 9% hornblende, and 1% accessory
minerals (apatite, magnetite, ilmenite, sphene,
and zircon). This quartz diorite is generally
similar to those of the Lutak Inlet-Taiya River
section, except for its higher hornblende content.

Quartz Diorite- White Pass and Mile 26

The White Pass and Mile 26 quartz diorite
bodies, found on the south side of White Pass and
at Mile 26, respectively, on the railroad tracks
(Mile 0 is at Skagway; White Pass Summit is Mile
20), are similar to each other in structure and
petrography, and they may have been parts of the
same pluton before the intrusion of the quartz
monzonite that now separates them.

Three of the four contacts of the White Pass
and Mile 26 masses with the younger quartz monzonite
are exposed along the line of traverse. At these

three contacts the foliation of the quartz monzo-
nite is parallel to the foliation of the quartz
diorite . The quartz diorite is all well-foliated
or lineated. The foliation of the White Pass mass
trends E-W and dips from 0 to 37 degrees north. A
lineation plunging 75 degrees in a NE direction was
found. The foliation of the Mile 26 mass trends
about N60W and dips 65 to 77 degrees south. Inequi-
dimensional inclusions of biotite and hornblende-
rich rock (meta-andesite?), up to about 1 foot in
size, are generally parallel to the foliation; at
the locality where spec. 27 was collected the in-
clusions were tabular in shape and were flat-lying
in quartz diorite whose foliation dips 65 degrees.
These inclusions may have been sinking through the
magma after its foliation was developed and before
it became too viscous or crystalline to allow flowage
of an inclusion in it. No schist was found in these
two masses.

Four thin sections of the White Pass and Mile
26 bodies (spec. 26, 27, 30, and 31) show it to be
hypidiomorphic inequigranular with coarse subhedra
and euhedra of plagioclase and hornblende, chunky
subhedra of biotite, and anhedra of quartz set in
a fine-grained matrix of those minerals and ortho-
clase. An average of modes of these four sections

gives 21% quartz, 4% orthoclase, 50 % andesine
(with slight oscillatory zoning and averaging Ab_{55}),
16% biotite, 8% hornblende, and 1% accessory
minerals.

Quartz Diorite- Lake Lindeman

The quartz diorite mass at Lake Lindeman is
exposed for about one-half mile along the railroad
tracks. This rock, represented by spec. 18, is a
hypidiomorphic inequigranular quartz diorite very
similar to that in the Mile 26 and White Pass masses.
This quartz diorite, however, contains plagioclase
phenocrysts up to 12 mm. long, and the plagioclase
is slightly zoned but not oscillatorily.

At its most northerly contact the foliation of
the Lake Lindeman quartz diorite is parallel to
the foliation and inclusions of the younger quartz
monzonite. At the other exposed contact the quartz
monzonite cross-cuts the foliation of the quartz
diorite.

Quartz Diorite Correlations

Buddington states that quartz diorite forms
the western part of the main batholith, and his
descriptions correspond closely to those given

above (Buddington and Chapin, 1929, pp. 207-214).
Knopf's description of the quartz diorite of the
Eagle River area corresponds to that of the auto-
clastically-textured Lutak Inlet quartz diorite
pluton (Knopf, 1912, pp. 23-24). Kerr correlated
the quartz diorites of the Lower Stikine River
area, which generally correspond with those des-
cribed in this paper, with those described by
Buddington (Kerr, 1948a, pp. 59-61). If these
correlations are correct the quartz diorites in
the Haines-Lake Lindeman area were emplaced as the
seventh major unit of the Coast Range batholith.

Granodiorite- Dyea-Skagway Road

The mountain between Skagway and the mouth
of the Taiya River is underlain by the Dyea-
Skagway Road granodiorite pluton. This grano-
diorite is quantitatively similar to the Lutak
Inlet-Taiya River Flats quartz diorites (except
for its microcline content), but it is separable
from those quartz diorites in that it is lighter
colored, coarser-grained, rather homogeneous (ex-
cept for two zones of inclusions), and is foliated
or hornblende-lineated. One of the zones of in-
clusions, about 50 feet wide, at least one-half

mile long, and lying vertically at N70W, contains
from 25 to 50% fine to medium-grained, dark,
irregularly shaped and oriented fragments of
biotite-hornblende quartz diorite. The other
zone of inclusions is similar, but its extent
is not known. The shape and orientation of the
first zone suggests that it was formed either by
brecciation of a septum in situ or that blocks
were stoped off a now-eroded away tabular roof
pendant or septum and that these blocks were
stopped in their downward flow by an increase
in viscosity of the slowly crystallizing magma.
The subangular to rounded shapes of these inclusions
suggests rounding of originally angular fragments
by assimilation.

A volumetric mode of the Dyea-Skagway Road
granodiorite, spec. 44, shows 26% quartz, 9% micro-
cline, 49% slightly zoned calcic andesine (Ab$_{51}$),
13% biotite, 2% hornblende, and 1% accessory minerals.

The relative age of this granodiorite is not
known, as its contacts appear to lie beneath the
Taiya River Flats and the Skagway River. However,
in outcrop and thin section it generally corresponds
to Kerr's description of the biotite granodiorite
found in the Lower Stikine River area (Kerr, 1948a,
pp. 61-63), which is younger than the quartz diorite

found there and is younger than the quartz mon-
zonite associated with it. Thus a tentative corre-
lation may be made which would place this rock as
intermediate in age between the quartz diorites
described above and the quartz monzonite described
below.

Quartz Monzonite- Mile 4 to Bennett Lake

Quartz monzonite forms most of the eastern half
of the Coast Range batholith. As shown on pl. 1 it
extends from Mile 4 on the White Pass and Yukon
Route tracks (4 miles northeast of Skagway) to the
northeastern contact of the batholith at Bennett
Lake. As stated above, four masses of older quartz
diorite were found to divide the quartz monzonite
into 5 parts along the line of traverse. It is not
known whether these parts have underground or surface
connections, or whether they are separate plutons.
Two quartz monzonite masses were found on the east
shore of Bennett Lake north ofthe main batholith
contact. A small mass, one mile north of the main
batholith contact, was found exposed for one-half
mile along the lake shore. A second and larger pluton
extends for four miles along the lake shore at the
Yukon-B.C. boundary.

The main contact of the batholith, of quartz monzonite with the country rock to the northeast, at Bennett Lake is sharp, approximately vertical, and is almost parallel to the north-south axial planes of isoclinal folds of quartzite, conglomerate, phyllite, and chlorite schist. The actual contact is covered by slide debris. Spec. 15, of quartz monzonite, was collected about 100 feet southwest of the contact; it has no apparent foliation or lineation. A thin section of quartzite, spec. 14, taken about 100 feet northeast of the contact, shows about 20% quartz, 5% orthoclase, and 5% oligoclase from $\frac{1}{4}$ to 2 mm. in size set in a much finer-grained, partly sericitized quartzite matrix. The coarser-grained material and the sericite may have been introduced by emanations from the adjacent crystallizing magma, but this could not be proved.

If the feldspar of the quartz monzonite that intrudes this quartzite contains 10% kaolin and sericite, the feldspar contains about 1% water (assuming that the kaolin and sericite contain about 10% water) and the rock will contain about 2/3% water. About 1/2 % water could also be retained by the quartz monzonite in pore spaces, which are slightly enlarged during the differential shrinkage of the

rock upon cooling through the deuteric temperature
range. Hence the quartz monzonite may contain,
after solidification and cooling, up to 1 1/3%
original water. If then, this magma had a low
original (or magmatic) water content little or
none of it may have been forced into the wall
rocks during or just after solidification, and
the wall rocks would show very slight or no
hydrothermal alteration.

The stratified rocks north of the main
batholith are represented on pl. 1 by a single
color, as it was not possible in this survey to
map separate units.

Foliation and schlieren are poorly developed
or not present in the quartz monzonite. Most of
this rock is massive, but the few schlieren,
phenocryst lineations, and foliated parts found
have been plotted on pl. 1. The quartz monzonite
has developed a fair foliation at 5 of its observed
contacts, but the remainder of the schlieren and
folia appear to be randomly oriented with respect
to each other and to the boundaries of these plutons.

Spec. 28, from the quartz monzonite mass just
north of Summit Lake in White Pass, was collected
several feet from a contact with quartz diorite.
It is a massive quartz latite porphyry, composed of

about half medium-grained phenocrysts of euhedral
microperthite and beta-quartz and about half
groundmass. A magma composed of only 50% or fewer
crystals would probably not develope a foliation
during flowage because the crystals could move
during flowage or changes of shape of the magma
without interfering with each other (and thereby
retaining a massive structure). If the large
quartz monzonite bodies in the batholith were
only one-half crystalline at the time of their
emplacement they probably would not have developed
foliation.

Volumetric modes of 14 specimens of the quartz
monzonite (and closely related rock types), spec.
2, 7, 15, 19, 21, 22, 24, 25, 29, 32, 33, 34, 36,
and 39, show 10 quartz monzonites, 1 granodiorite,
1 granite, and 2 types on the quartz monzonite-
granite division line (potash feldspar/ plagioclase
ratio is 2). These variations are probably within
the sampling error as all the specimens are coarse-
grained, 4 to 6 mm., and all of the quartz monzonite
north of the Mile 26 quartz diorite mass is very
coarsely porphyritic with pink microperthite and
often plagioclase phenocrysts up to about 50 mm.
long. The average of the 14 modes gives 29% quartz,
10% orthoclase, 23% microperthite, 1% microcline,
31% oligoclase (Ab_{81}), 5% biotite, and 1% accessory

minerals (apatite, magnetite, ilmenite, sphene, and zircon). Four of these thin sections contain about 1% hornblende.

Quartz Monzonite Correlations

The quartz monzonite found from Bennett Lake to Mile 4 corresponds very closely to that found in the eastern part of the Coast Range batholith in the Taku River area (Kerr, 1948b, pp. 46-48). Kerr found the quartz monzonite in that area to be pink colored, uniform in composition, coarse-grained, commonly porphyritic, rather clean of inclusions, and affecting the wall rocks only slightly- all of which applies to the quartz monzonite described above. In the Lower Stikine River area Kerr mapped a mass of quartz monzonite 270 square miles in area that appeared to be a single pluton (Kerr, 1948a, p. 63). Kerr stated that quartz monzonite masses also extend (from the Stikine River) to the northwest at least as far as the Taku River, 125 miles away, and "throughout maintain the same composition and similar shapes" (1948a, p. 63).

DIKE ROCKS

Aplite Dikes

A number of aplite dikes, as shown on pl.
1, cut the Coast Range intrusives and the pre-
intrusive rocks. Three of these were examined
in thin section and found to correspond fairly
closely to the associated normal plutonic rocks.
A few small pegmatite dikes, up to about 2 feet
thick, were found associated with aplites. The
grain size of the quartz and feldspar in these
pegmatites was seldom larger than an inch. The
general scarcity of aplite and pegmatite, especially
in the quartz diorite, implies low hyperfusible
contents in the magmas that formed the various
plutons.

Rhyolite Dikes

Rhyolite dikes were found in the granodiorite
and quartz diorite north and northeast of Skagway.
They contain phenocrysts averaging about 1 mm. in
size of orthoclase and quartz, the latter of which
appears to be beta-quartz as it does not show prism
faces. The orthoclase occurs as twinned (law not

recognizable) graphic intergrowths with quartz.
The orthoclase-plagioclase ratio could not be
determined on account of the extreme fine grain
of the groundmass, but the plagioclase content
appears to be low so that these rocks are here
classed as rhyolite porphyries.

Basic Dikes

Twenty-four basalt and andesite dikes or
groups of dikes were found from the west side
of Taiya Inlet west of Skagway to Bennett Lake
in the Yukon. Two thin sections examined showed
one dike to be basalt porphyry with labradorite
and augite phenocrysts. The other dike is a
hornblende andesine whose feldspar is a sodic
andesine. The dikes west of Skagway on Taiya
Inlet are vesicular. If they were injected
before Pliocene time they would probably have had
heads of at least 5,000 feet, as there appears to
have been an upland surface of approximately that
age that now shows only as a generally accordant
summit level in this part of the Coast Mountains.
Hence the author is of the opinion that they were
emplaced in Quaternary time, when the present

valley system was moderately well developed and
the dikes would have had much lower heads of
basic magma above them during crystallization,
thus facilitating vesiculation.

CONCLUSIONS

The quartz diorite and granodiorite plutons
appear to have been injected into a closely folded
complex of pre-Jurassic rocks. The partial granu-
lation of the Lutak Inlet quartz diorite pluton,
was assumed above to have been caused by stresses
from below (and of the same origin as the stresses
that initially caused the emplacement of that
pluton); however, this clasis may have been
caused by horizontally-directed stresses in a
late stage of the folding of the country rock.
If the latter happened the Lutak Inlet pluton is
the only synkinematic pluton observed in this tra-
verse. The quartz diorite and granodiorite
plutons appear to have been intruded parallel to
the schistosity and bedding of the isoclinally
folded wall rock. Subsequent stoping (of unknown
butpresumably small magnitude) has somewhat
modified the wall rock-pluton surfaces. The
large quartz monzonite plutons were probably

intruded to a shallower level than the quartz
diorite and granodiorite plutons, or the quartz
monzonite plutons have not been eroded down as far
as the older plutons. However, both series of
plutons are now at the same level, and the older
series definitely indicates a level of intrusion
deeper than that of the younger series; hence the
the older quartz diorite and granodiorite plutons
must have been eroded at least several thousand
feet and possibly several miles before the emplace-
ment of the younger quartz monzonite.

The approximately 15,000 foot total sequence
of Mesozoic andesitic and dacitic volcanic rocks
in the Taku River area (Kerr, 1948b, pp. 30-38)
implies that some of the Coast Range batholith
plutons made their way entirely to the surface.

The author believes that all of the plutonic
bodies that form the Coast Range batholith from
Haines, Alaska to Bennett Lake, British Columbia
have been formed as a result of emplacement and
crystallization of magma. The reasons for this,
as exhibited in one or more of the plutons, may
be summarized as follows:

1. Sharp contacts (with few exceptions) of
plutons with wall rocks, septa, and roof

pendants.

2. Finer-grained porphyritic variations of phaneritic bodies at several contacts.

3. Foliation at contacts grading into massive rock.

4. Discordance at three localities between foliation in plutons and schistosity of septa.

5. Subangular to rounded, randomly oriented fragments or clots forming breccia zones in granodiorite.

6. Symmetrical folding of flow-layering and foliation, with trends parallel and axial planes perpendicular to the non-folded foliation of the remainder of the pluton.

7. Angular discordance between tabular inclusions and foliation.

8. Uniformity in structure and petrographic nature of individual plutons for distances up to 16 miles.

9. Associated dikes of aplite and some pegmatite.

10. Aplite dikes extending from a younger into an older pluton as marginal fissures.

11. A general sequence of intrusion from ultrabasic to acidic plutons.

12. Associated andesitic and dacitic vol-
canic rocks.

In this work the author has partly used ideas
and methods set forth by Balk in <u>Structural Behavior
of Igneous Rocks</u>. In a survey of this sort, of
course, only the grossest granotectonic features
were mapped. The word <u>inclusion</u> in the pages above
is equivalent to the word <u>clot</u> as used in Balk's
book.

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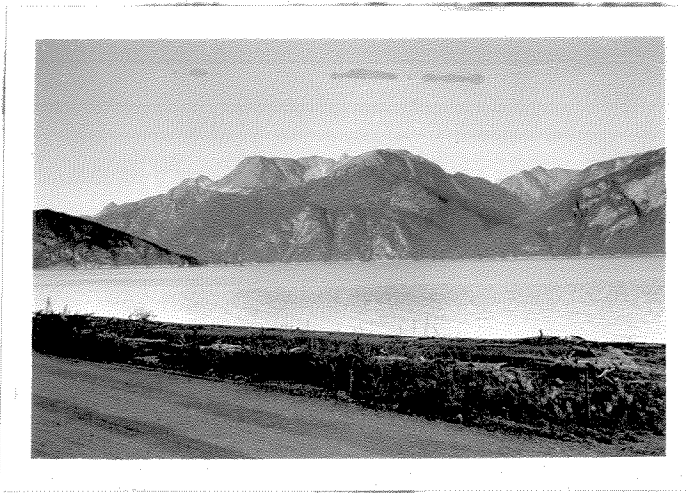
Figure 4. View northeast across Lynn Canal
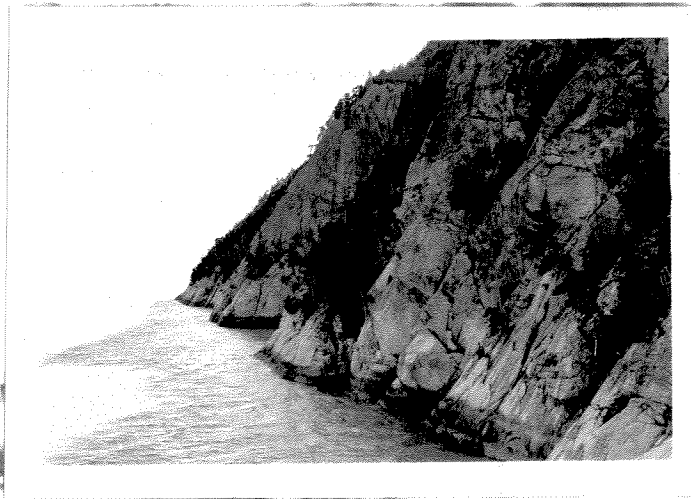from 2 miles northeast of Haines. Taiya Point
in left background.

Figure 5. Sea cliffs on west side of Taiya
Inlet 6½ miles north of Taiya Point.

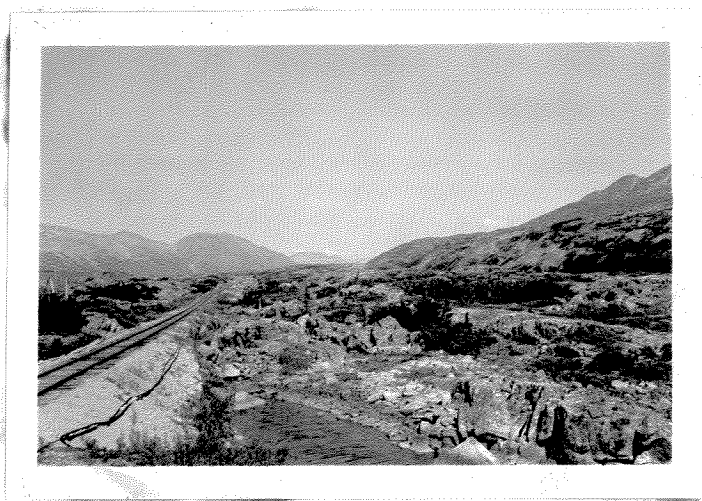Figure 6. View south of Taiya Inlet from
Taiya River Flats.

Figure 7. View north of White Pass from
just north of Summit Lake.

Figure 8. View north of Bennett Lake from just north of Bennett.

Figure 9. Hornblendite, 3/4 mile northeast of Haines, showing abrupt variations in texture.

Figure 10. Schist, in a septum in the Lutak
Inlet quartz diorite north of Taiya Point.

Figure 11. Inclusions in the Dyea-Skagway Road
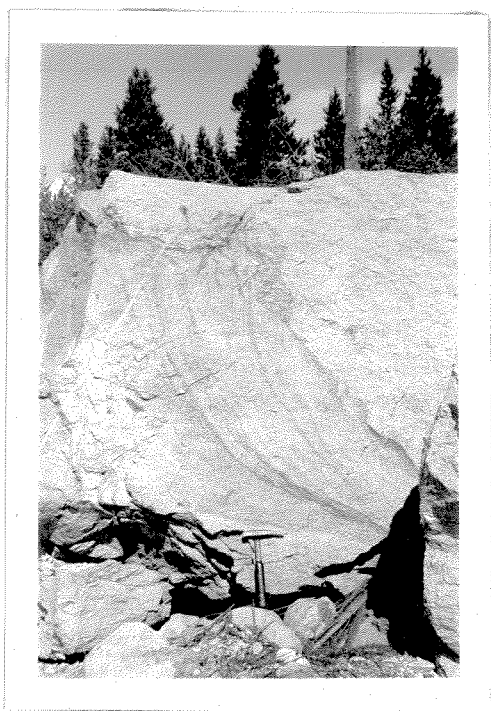granodiorite. Part of a large tabular zone of
inclusions.

Figure 12. Contact of the younger Bennett
quartz monzonite on the right that transects
the flow-layering of the Lindeman quartz diorite
on the left. Near railroad tracks east of Lake
Lindeman.