GEOLOGY OF THE STRACHAN CREEK AREA,

BRITISH COLUMBIA

by

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ABSTRACT

The Strachan Creek area is on the east shore of Howe Sound about three miles north of the town of Horseshoe Bay, B.C. The rocks of the area consist of migmatite of the Bowen Island group, volcanic rocks of the Gambier group, plutonic rocks of the Coast Intrusions, and late basic and acidic dykes. These rocks are described and their relationships discussed.

A striking feature of the Strachan Creek area is the banding in the diorite, one of the units of the Coast Intrusions. Each complete band is a couplet composed of one light- and one dark-coloured layer, one layer grading into the other. The light-coloured layer is composed mostly of plagioclase, whereas the dark-coloured layer is composed mostly of hornblende and magnetite. Generally, the ratio of hornblende (plus magnetite) to plagioclase decreases downward from a sharp contact, the couplets thus resembling inverted "graded-bedding". The author tentatively concludes that the banding in the diorite originated by a process of differentiation and crystal rising within a cooling diorite magma.

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CHAPTER I

INTRODUCTION

The area mapped is on the east shore of Howe Sound about four miles north of Horseshoe Bay, B.C. The area extends from Sunset Creek to Newman Creek and from the sea shore inland about a mile. It forms a considerable part of the western slope of Mt. Strachan.

The area is readily accessible by car, boat or train. The Pacific Great Eastern Railway runs parallel to the coastline at an elevation of about 100 feet above sea level. The Upper Levels Highway, a new road, is being built parallel to the railroad and about 75 feet above it.

Field work was done by the author during the 1957-58 university winter session. It was limited mostly to the weekends. Much of the area was difficult to explore as the slopes are either covered with dense growth or are steep rock cliffs.

Physiography

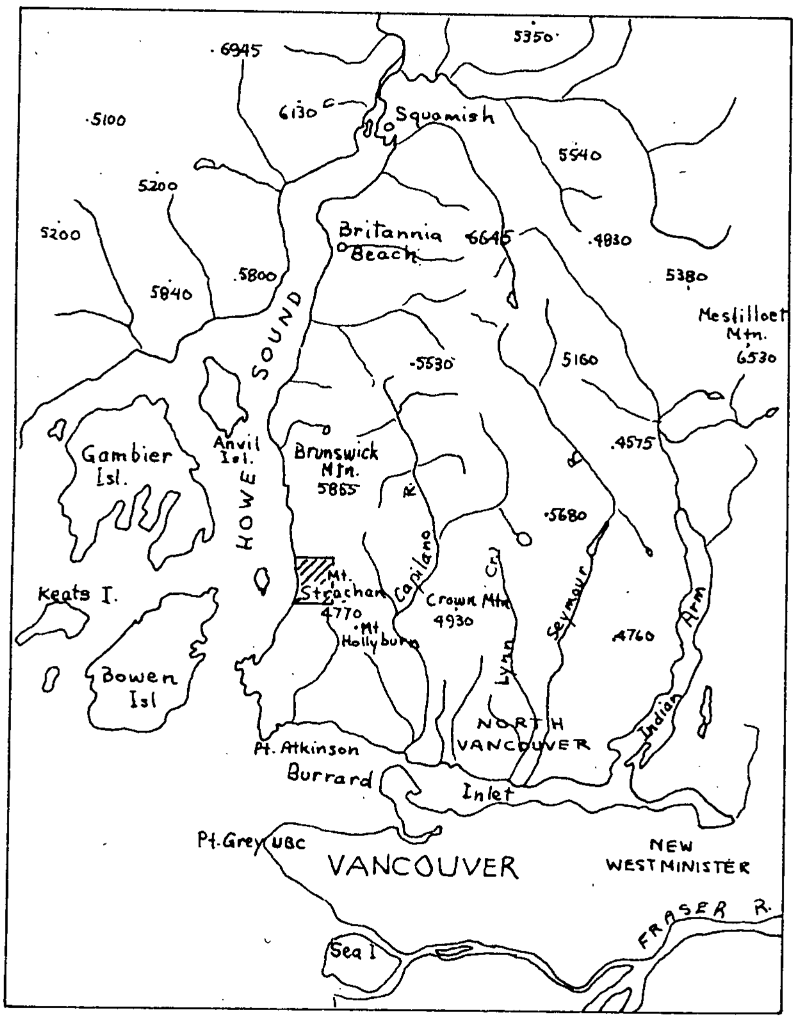
The map-area is in a typically rugged section of the Coast Mountains of B.C. The mountains rise abruptly from Howe Sound to elevations of more than 5000 feet.

Five creeks cut through the area. All of them are in the youthful stage of development as they show V-shaped valleys and many rapids and waterfalls in places many tens of feet high. The larger creeks are floored with huge boulders of granodiorite several feet in diameter most of which are smooth and fairly well rounded. The large size of the boulders attest to the great competency of the spring floods in moving material down stream.

In the interstream areas, talus is abundant and in many places a little digging revealed talus below a thin soil and vegetative cover. The talus piles are mostly covered by vegetation and only at the base of actively eroding rock cliffs is there any exposed talus. The inter-stream areas are covered with dense forest growth whose continuity, in many places, are broken by steep, high rock cliffs. Cliffs were encountered mostly at elevations of around 700, 1400, and 3400 feet. The cliffs around 1400 feet coincide with the approximate position of a contact between granodiorite and diorite.

LOCATION MAP

Scale: One Inch to 8 Miles



CHAPTER II

GENERAL GEOLOGY

The general geology of the Vancouver North area is summarized in the following table which is based on Armstrong's work (1954).

PLEISTOCENE and RECENT

CENOZOIC	Tertiary	
	Miocene or later	Basaltic flows, dykes, sills, tuff.
	Upper Eocene	Kitsilano formation -- conglomerate, sandstone, shale.
	Eocene	Burrard formation -- sandstone, shale, conglomerate, minor tuff and basalt.
MESOZOIC	Main Plutonic rocks ?	
	Triassic ? and/or later	
	Gambier Group	Tuff, breccia, agglomerate, slate, andesite, argillite, arkose, greywacke, quartzite, conglomerate.
	---- angular unconformity ----	
	Plutonic rocks ?	
	Triassic ? and/or earlier	
	Bower Island Group	Volcanic and metamorphic rocks, minor sedimentary rocks.

The rocks in the area north of Vancouver consist of granitic rocks of the Coast Range batholith, metamorphic and volcanic rocks of the Bowen Island group, sedimentary and volcanic rocks of the Gambier group, and Tertiary sediments and minor intrusives.

In areal extent the granitic rocks of the Coast Range batholith predominate. Nevertheless, large areas of Mesozoic rocks (Bowen Island and

Gambier groups) are found throughout the Vancouver North area, ie. the head of Lynn Creek, Mt. Strachan and Mt. Hollyburn, along the east shore of Howe Sound, Bowen Island, Gambier Island, and some of the smaller islands in Howe Sound, (see Location Map, p.3).

The Bowen Island group has two main divisions, one consisting of mainly basaltic and andesitic lavas and the other of interbedded tuffs and sedimentary rocks. All the rocks of this group have been recrystallized to some extent, but primary structures are generally preserved. In some areas, however, these rocks have been extensively metamorphosed and metasomatized such that the original textures have been obliterated, ie. the summits of Mounts Strachan and Hollyburn.

In most places the Gambier group consists of pyroclastic rocks and lavas with minor interbedded sedimentary rocks. On Mount Brunswick, however, the section is at least 6000 feet thick of which 2000 feet is composed of slate, argillite, quartzite, and arkose.

The age relation between the Bowen Island group and the Gambier group has been well established by an angular unconformity which separates the two groups. Armstrong (1954, p. 2) states that,

> During the interval represented by this unconformity the Bowen Island group rocks were folded, metamorphosed, and partly granitized; some of the plutonic rocks were formed; and the land was uplifted and eroded.

Furthermore, at the base of the Gambier group there is a basal conglomerate which has rounded and subrounded boulders lithologically similar to the rock types of the Bowen Island group and to the older plutonic rocks.

The batholithic rocks of the Vancouver North area consist of granite, grandiorite, quartz diorite, diorite, and minor gabbro. Grandiorite and quartz diorite are, by far, the most abundant of the plutonic rocks mentioned above.

There is apparently more than one period of intrusion of the plutonic rocks. Granitic pebbles in the volcanic rocks of the Bowen Island group indicate that some plutonic rocks were formed prior to the deposition of this group, but no bodies of plutonic rocks were recognized as belonging to this relative age. Armstrong (1954, p. 5) notes that some plutonic rocks formed before the deposition of the Gambier group whereas others formed after. For example, the granodiorite mass in the southern part of Gambier Island is unconformably overlain by the Gambier group rocks, whereas the hornblende diorite and quartz diorite of Mt. Hanover and Mt. Harvey, about 3 miles north of the Strachan Creek area, appear to intrude the Gambier group. Since the contact between the plutonic rocks and the Gambier group over most of the Vancouver North area generally is not exposed, the age relationship of these rocks can not be definitely established. However, by using the potassium-argon method, Folinsbee (1957) has determined an absolute age of 105 million years for the Coast Range batholith at Vancouver. No mention is made of the type of rock used for the age determination, but probably a sample of granodiorite or quartz diorite was used since these are the most abundant plutonic rocks. This would place the main period of plutonic intrusion in the Middle Cretaceous.

Tertiary rocks of the area consist of the Burrard formation, the Kitsilano formation, and minor intrusions and volcanic rocks of Miocene age or later.

The Burrard formation is composed of about 2000 feet of sandstone, shale, conglomerate, and minor tuff and basalt. It dips gently to the south. It is mostly of continental origin and fossil plants within it are of Eocene age, (Berry, 1926).

The Kitsilano formation consists of about 2000 feet of conglomerate, sandstone, and shale mostly of continental origin resting on the eroded surface of the Burrard formation. It also dips gently to the south and fossil plants within it are of Upper Eocene age, (Berry, 1926).

The minor intrusions and volcanic rocks of Miocene age or later consist of basaltic dykes and sills, and minor tuffs. Basaltic dykes are seen to cut the Kitsilano and Burrard formations and the plutonic rocks. At Sentinal Hill and Little Mountain, laccolith-like bodies of basalt crop out. Tuff is found on the south side of False Creek.

CHAPTER III

GEOLOGY OF THE STRACHAN CREEK AREA

The geology of the Strachan Creek area is shown in the following table.

PLEISTOCENE and RECENT		
TERTIARY	Late dykes	
MESOZOIC	Plutonic rocks	Granite, Granodiorite; Diorite
	Gambier Group	
	Bowen Island Group	

The oldest rock exposed in the Strachan Creek area is migmatite which underlies a small area and is bordered by granite, granodiorite, and diorite. This mass of migmatite is well exposed along the road cut near Strachan Creek No. 1 and is correlated with the Bowen Island group because of its similarity in lithology to the Bowen Island group rocks of the summits of Mounts Strachan and Hollyburn. This correlation is at best only the most reasonable assumption as there is the possibility that the migmatite belongs to the Gambier group.

The Gambier group within the Strachan Creek area is composed mostly of volcanic rocks, i.e. tuff, agglomerate, and porphyritic basalt. A bed of volcanic conglomerate within the sequence of volcanics strikes N40°W and dips 40° to the NE. Its attitude probably represents the general attitude of the volcanics. The contact between the Gambier group and the Bowen Island group is not exposed in the Strachan Creek area. Elsewhere, however, Armstrong recognized an angular unconformity separating the two groups, Bowen Island below and Gambier above.

The plutonic rocks of the area consist of granite, diorite, and granodiorite. The age relationships of these rocks are not definitely established because outcrops of their contacts are scarce. However, exposures of the granite-diorite contact indicate that granite probably formed later than diorite. Granite dykes in the vicinity of Strachan Creek No. 1 contain inclusions of diorite suggesting that the granite magma stoped off parts of the diorite during intrusion (see Figure 24, p. 44). Diorite, just south of Strachan Creek No. 2, is cut by what appears to be an apophyse of granodiorite which suggests that the granodiorite is younger than the diorite. The age relationship between granodiorite and granite, however, is not determinable because exposures of the contact of these rocks do not reveal conclusive evidence.

All the plutonic rocks exposed in the Strachan Creek area appear to have formed after the deposition of the Gambier group. If the Gambier group rocks were younger than the plutonic rocks, then the contacts of these rocks would be conformable. However, it is seen that both the diorite and the granodiorite truncates the general strike of the Gambier group rocks which is represented by the attitude of the conglomerate bed.

Many late dykes, acidic and basic, are found in the area. The basic dykes are of dioritic and basaltic composition. Some are porphyritic and others are non-porphyritic. The acidic dykes are of granite and aplite.

Bowen Island Group

Within the Strachan Creek area, migmatite of the Bowen Island group crops out only along and near the road cut in the vicinity of Strachan Creek

No. 1. This body of migmatite extends up the slope of the mountain to an elevation of approximately 600 feet and extends to the north of Strachan Creek No. 1 for about 600 feet. Its southern contact follows the creek and is against granite, and its northern contact is against granodiorite.

A few miles to the south, outside of the Strachan Creek area, there is a large mass of migmatite which extends from the shore-line to approximately a half mile inland. It appears to be similar to the migmatite of the area under investigation in both lithology and structure.

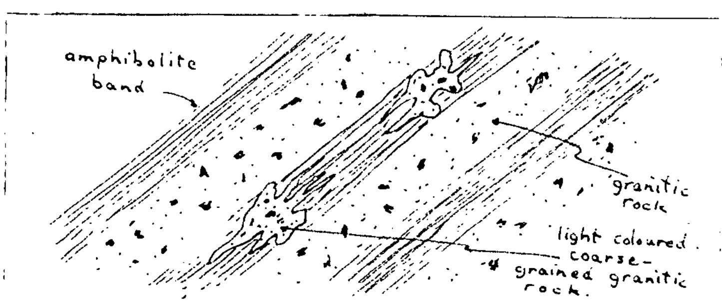
Armstrong (1954) shows a small mass of migmatite on Strachan Creek No. 2 at an elevation of 1000 feet, but the author did not encounter it during a traverse up this creek. It is probably a much smaller mass than is indicated on the map.

Migmatites are rocks composed of both granitic and metamorphic parts and here, the migmatite consists of a metamorphic host rock which is streaked and veined with granitic material.

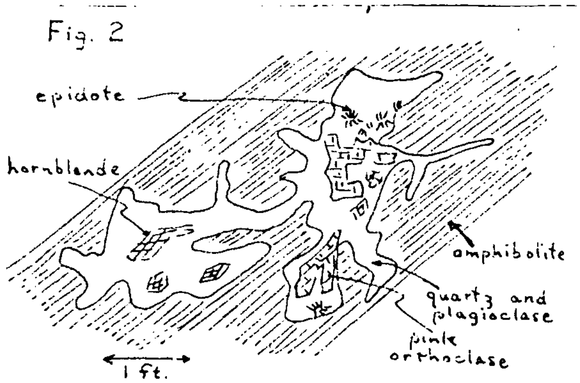
The migmatite, in general, consists of gneissic amphibolite and granitic rock alternating in bands ranging from a few inches to a foot or more in width. Generally, the bands and foliation of the amphibolite strike N 40° E and dip northwest 25° to 85°. At different intervals, the dark amphibolite bands are interrupted by light-coloured, quite coarse-grained, granitic rock, (see Figure 1).

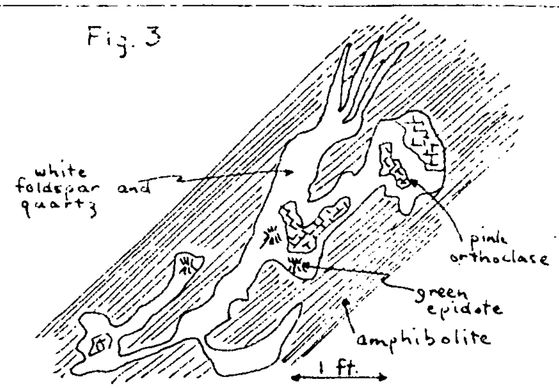
Figure 1.

Banded migmatite. Dark amphibolite band interrupted by granitic material.



In some places, the granitic part consists of irregular patches and streaks of whitish rock rather than regular bands, (see Figures 2 and 3). In general, however, the streaks seem to be stretched out parallel to the foliation within the amphibolite. These granitic streaks, in many places, contain areas of coarse, pink orthoclase and small patches of green, radiating crystals of epidote.





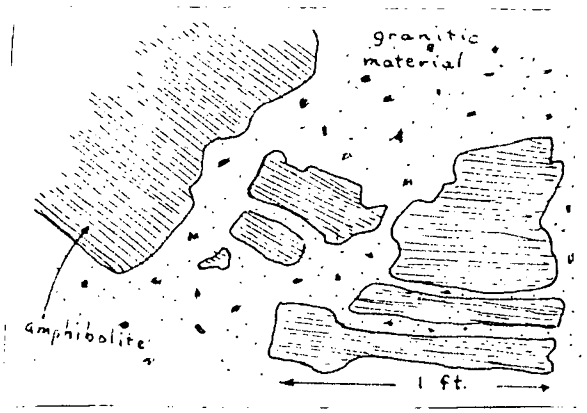
Figures 2 and 3. Gneissic amphibolite bands containing granitic streaks which are stretched out parallel to the foliation.

The granitic part is composed mostly of coarse, anhedral grains of pink orthoclase, white plagioclase, and clear transparent quartz in approximately equal amounts. The pink orthoclase commonly occupies the central part of the granitic streaks.

In other places in the same outcrop, the light material is the matrix which surrounds and cements large and small angular blocks of amphibolite, (see Figure 4). In some specimens, the banding within the amphibolite blocks line up with each other, but in others, the blocks do not have a common orientation. In a few places, local areas of oriented and unoriented blocks of amphibolite occur within ten feet of each other.

Figure 4.

Amphibolite blocks surrounded by granitic material.

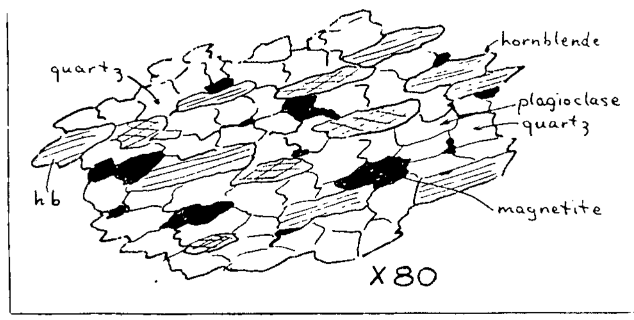


The amphibolites are dark, medium- to fine-grained rocks composed mostly of hornblende and plagioclase separated into distinct laminae that similate bedding. Generally, the dark bands are thicker than the light bands. Pyrite is fairly abundant in the migmatites, but there is no apparent control for its occurence. It is found as lenses or small pods both in and cutting across the dark and light bands.

In thin sections of the dark bands, plagioclase (An_{42} to An_{48}) 50%, and hornblende 40% are seen to be the dominant minerals and chlorite, orthoclase, epidote, quartz, magnetite, pyrite, biotite, and apatite occur in smaller amounts. The texture of the dark band is allotriomorphic, equigranular, and medium-grained. The preferred orientation of the hornblende and the separation of the hornblende and plagioclase into different laminae are easily discernible in thin-section, (see Figure 5). Chlorite is stretched out in the direction of foliation. The plagioclase grains of the dark bands are mostly untwinned and occur as somewhat spherical grains predominantly of one size. Quartz is interstitial, filling the space between hornblende and plagioclase. Hornblende is generally free of inclusions, but in some places encloses small, round grains of apatite, pyrite, magnetite, and plagioclase. Relatively little alteration of the minerals has occurred, although biotite is partly altered to chlorite, especially along the cleavage traces.

Figure 5.

Thin-section of gneissic amphibolite in ordinary light. X80.



In the light-coloured bands, the mineralogy is essentially the same as that of the dark bands except that the relative proportions of the minerals are different. Plagioclase and quartz occurs in approximately equal amounts and make up approximately 90 per cent of the rock. Hornblende makes up about 8 per cent of the light bands. Quartz occupies large interstitial areas between plagioclase and hornblende and generally shows wavy extinction. A small quantity of biotite is present, but it is mostly altered to chlorite and zoisite. Hornblende occurs as scattered grains, regular in outline, and showing slight poikilitic texture having inclusions of plagioclase and iron ore. Cataclastic texture is apparent in thin-section as most quartz grains show wavy extinction and finely crushed grains are found between large grains.

The general strike of the banding and foliation of the migmatite is N 70° E to N 40° E and the dip 30° to 50° to the northwest, (see Figure 6). The dip may vary from 30 to 50 degrees in a very short distance. Epidote veins are rather abundant and cut the rock in many directions.

These migmatites could have originated in several ways, (1) by injection of magma along surfaces of weakness of pre-existing rocks, (2) by partial replacement of host rock by ionic exchange of material between host rock and fluid, or (3) by differential fusion of host rock of varied composition.

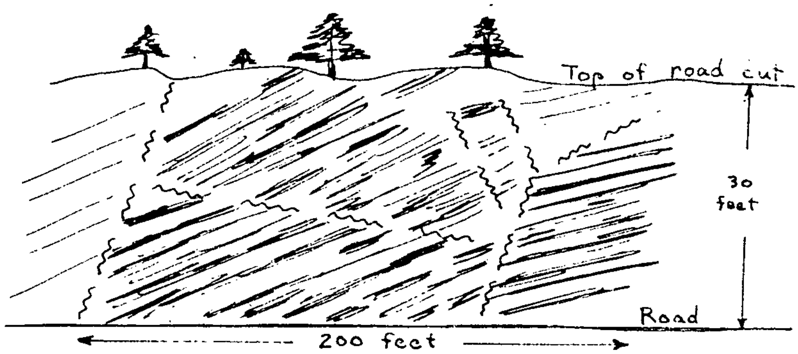


Figure 6. Attitude of the migmatite in the road cut near Strachan Creek No. 1.

In some places the granitic component appears to have originated by injection of granitic magma into amphibolite such that the light-coloured granitic material encloses and surrounds angular blocks of amphibolite and, in general, acts as the cementing matrix, (see Figure 4). Here, the granitic material forms sharp contacts with the amphibolite.

In other places the granitic material appears to have formed by partial replacement of the dark material probably by magmatic emanations, or some active fluid of unknown origin. Ionic exchange of material between the host rock and the fluids which penetrate the host rock along paths of minimum resistance would result in the formation of migmatite. In places where there are numerous regular alternating bands of light and dark material which show uniform width and sharp contacts for several tens of feet, (see Figure 1), it seems likely that the banding is due to partial replacement as it is difficult to visualize such regular injection.

There arises also the possibility that the migmatite originated by differential fusion of host rock of uniform composition, yielding a low-melting granitic or pegmatitic liquid (magma) distributed through the rock as discontinuous streaks and veins. To test this possibility, a sample of the granitic part of the migmatite was taken of an isolated lens of the light material within the dark material. If the light material were formed by differential fusion, then its components possibly could have been derived from the melting (fusion) of parts of the amphibolite. A comparison of the mineral composition of the isolated lens of granitic material and of the amphibolite is illustrated in Table I.

TABLE I

COMPARISON OF MINERAL COMPOSITION OF THE MAIN PLUTONIC ROCKS AND OF THE COMPONENTS OF THE MIGMATITE

Minerals	Amphibolite	Isolated lens of granitic material	Granodiorite	Diorite	Granite
Plagioclase	An_{44}	An_{40}	An_{40}	An_{44}	An_{20}
	50 %	45 %	60 %	40-60 %	1 %
Quartz	3	45	10-15	2-15	30
K-feldspar	4	1	5-10		60
Hornblende	40	8	5	30-40	
Biotite	1	1	15		5-8

It is seen that the plagioclase has approximately the same average composition in both the amphibolite and the isolated lens of granitic material. However, if the granitic material is the result of partial fusion of the amphibolite, then the plagioclase of the granitic material would be more sodic in composition than the plagioclase of the amphibolite. The phase diagram of the albite-anorthite system as determined from artificial melts by N.L. Bowen shows that if a crystal of plagioclase of a given composition (eg. An_{44}) is heated to its melting point, the first liquid to form is of much more sodic composition, ie. an albitic liquid would be formed by partial fusion of more calcic crystals. Thus, the isolated lens probably is not the reult of partial fusion of amphibolite.

A comparison of the estimated mineral composition of granite, granodiorite, and diorite with the isolated lens of granitic material is illustrated in Table I. It is seen that the mineral composition of neither the granite, granodiorite, nor the diorite is similar to the composition of the isolated lens. The granite contains much more K-feldspar and much less plagioclase than the isolated lens. The diorite has much more hornblende and much less quartz than the isolated lens. The granodiorite has more K-feldspar and biotite, and much less quartz and hornblende than the isolated lens. Thus, the evidence is inconclusive as to whether the magmatic emanations or active fluids came from the granite, diorite, or granodiorite magma.

In conclusion it seems to the author that the migmatite of the Strachan Creek area formed possibly partly by replacement and partly by injection of magma. The source of the magma or of the active fluids is not known, but could possibly have been derived from the granite, granodiorite, or diorite magma.

The Gambier Group

The Gambier group of rocks is found in the northern portion of the Strachan Creek area. These rocks occupy an area extending from the shore of Howe Sound to an elevation of about 2000 feet. The eastern contact of the

Gambier group is against granodiorite, whereas its southern contact is against diorite. The Gambier group consists of tuffs, basalt, volcanic agglomerate, porphyritic basalt, and volcanic conglomerate. The stratigraphic sequence of these rocks, however, has not been worked out in detail. The best exposures of these rocks are found in the road and railroad cuts just north of Newman Creek. The sequence of rocks at this locality is illustrated in the sketch in Figure 7.

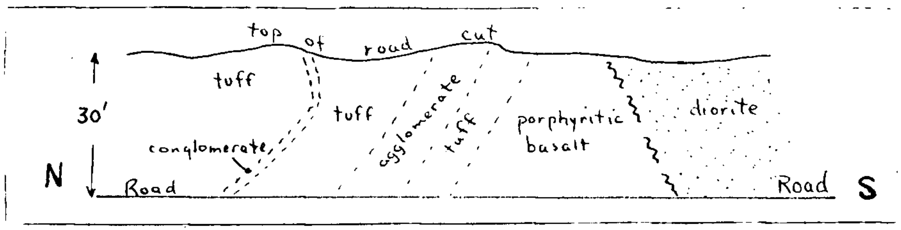


Figure 7. Section exposed in the road cut just north of Newman Creek.

Porphyritic basalt is found adjacent to a fault contact with diorite. The basalt is a greenish rock containing small white phenocrysts of plagioclase scattered throughout a dark, aphanitic groundmass. Phenocrysts make up approximately 15 per cent of the rock.

In thin-sections of porphyritic basalt, the essential minerals are seen to be chlorite 35%, plagioclase 30%, sericite 10%, and epidote 20%. Accessory minerals are pyrite, calcite, and augite. The plagioclase in the groundmass is of labradorite composition. Sericite is more abundant near the contact with diorite. On the other hand, epidote is evenly distributed and always quite abundant. The rock has marked trachytic texture.

Tuff is by far the predominant rock type of the Gambier group within the Strachan Creek area. It is found adjacent to and north of the porphyritic basalt. In general appearance in hand-specimen, the tuff resembles an altered greywacke, but the presence, in thin-section, of chlorite pseudomorphs after shards suggests that it is a tuff. The tuff is green and fine-grained. As seen in thin-section, the main constituents of the tuff are lithic fragments 60%, epidote 30%, and chlorite 10%. The groundmass consists of chlorite and epidote and a very minor amount of feldspar. Broken fragments of plagioclase are present as medium-sized grains embedded in the fine-grained groundmass. Most of the lithic fragments show textures of volcanic rocks. A small proportion of quartz is present as irregular, small grains or as aggregates of small grains set in the groundmass.

Volcanic agglomerate occurs as a bed within the tuff. In outcrop the agglomerate is a purplish rock with prominent clastic texture. Most of the angular fragments of volcanic rock are less than an inch across. However, many large, angular blocks over a foot in diameter are also present. On a weathered surface, the angular blocks are conspicuous because they are whitish, whereas the groundmass is purplish. Epidote occurs as small clumps scattered throughout the rock. It also occurs as tiny veinlets (1/8" to 1/4" thick) cutting the agglomerate.

In thin-sections of the volcanic agglomerate it is seen that lithic fragments of varying sizes and shapes make up about 95 per cent of the rock. Most of the lithic fragments are angular and so closely packed that the groundmass is distinguished only with difficulty. All the fragments are of volcanic rocks and many of them have trachytic texture. The groundmass consists of minute grains of feldspar which, in some places, appear as distinct, separate grains, but in other places, appear to be welded so that individual grains are not distinguishable. The last feature suggests that the rock has been somewhat recrystallized.

A bed of volcanic conglomerate is found within the tuffs in the Strachan Creek area. This conglomerate bed is exposed in the road cut approximately 2000 feet north of Newman Creek. Here, it is about one foot thick, (see Figure 8). The same bed is exposed in the railroad cut nearby and here the strike of the conglomerate bed is N 40° W and the dip about 40° to the northeast. The attitude of the conglomerate bed probably represents the general attitude of the volcanics of this area.

The conglomerate consists of large boulders, cobbles, and pebbles embedded in a matrix of fine-grained rock detritus. The boulders are variable in size, but average 4 inches in diameter. The largest ones are about two feet in diameter. The boulders and pebbles are well rounded. The majority of the pebbles and boulders are of volcanic rocks, ie. basalt, andesite, tuff, porphyritic basalt and andesite. One pebble of quartz and one of quartz diorite occurs in the conglomerate.

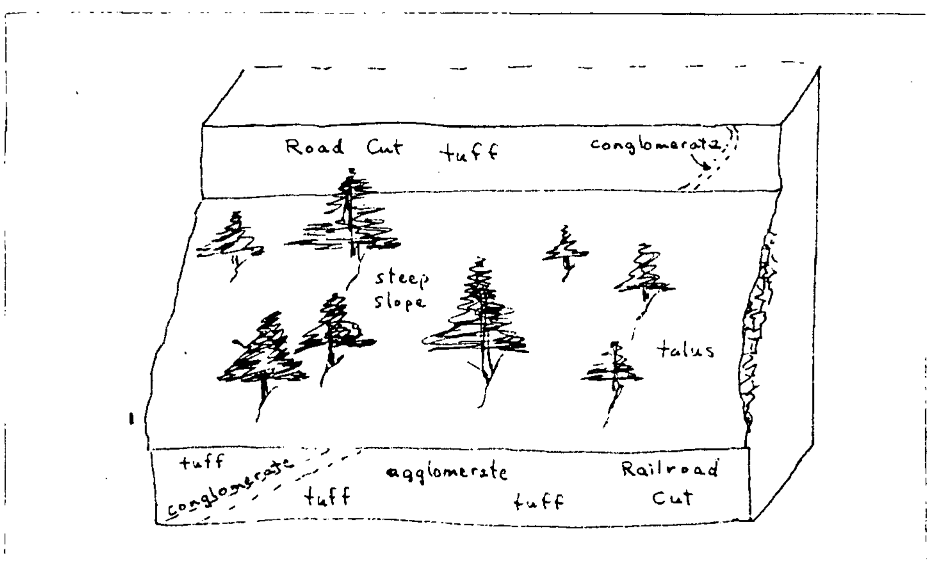


Figure 8. Sections exposed in the road and railroad cuts north of Newman Creek.

The conglomerate probably was laid down as either a terrestrial (stream) or marine (shore-line) deposit. The provenance of the conglomerate, judging by the abundance of volcanic boulders and pebbles, was a volcanic terrain containing small areas of plutonic rocks.

Diorite

Diorite forms an elongate body having a general N-S trend extending from Newman Creek to Strachan Creek No. 1, a distance of approximately one and a quarter miles. It extends up the slope of the mountain generally to an elevation of 1400 feet, where it comes into contact with granodiorite. There are three types of diorite, ie. banded, non-banded, and potash-rich types. The banded diorite grades into the non-banded type and the two have essentially the same mineral composition. The potash-rich diorite, on the other hand, contains a high proportion of pink K-feldspar and is due to alteration of non-banded diorite.

In hand specimen, the unbanded diorite is typically greenish and medium-grained, allotrimorphic, and equigranular in texture. The mafic minerals on the average form approximately 30-40 per cent of the rock. The diorite is essentially a hornblende-plagioclase rock with appreciable magnetite.

Pyrite is rather abundant in certain scattered localities in all types of diorite. It occurs as stringers, lenses, or pods of almost solid pyrite. Stringers are generally a fraction of an inch thick, but some pods may be fairly large, ie. 15 inches long by 3 inches wide. Epidote is generally closely associated with pyrite, (see Figure 9).

In thin-sections of the unbanded diorite, plagioclase (average composition An_{44}) and hornblende are seen to be the essential minerals. Quartz is present in very small amounts (2%), but in a few samples is as much as 15 percent of the diorite. The accessory minerals are apatite, zircon, iron ores (pyrite and magnetite), biotite, and augite. Alteration products are epidote, chlorite, sericite, and minor serpentine and talc. Some calcite veins occur in fissures in the rock.

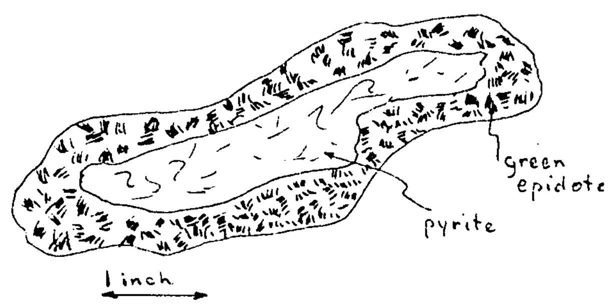


Figure 9. Pyrite surrounded by epidote as seen in an outcrop of diorite.

The plagioclase shows zoning which is generally the normal type (labradorite cores, about An_{65}, to andesine rims, about An_{35}), but in some thin-sections oscillatory zoning is found. The boundary of the zones of many grains is corroded indicating reaction between the plagioclase and the melt during crystallization. In some places, plagioclase laths are altered to sericite and chlorite and are consequently quite cloudy. Generally, plagioclase forms from 40-60 per cent of the rock.

Hornblende is dark green in thin-section and is strongly pleochroic (yellow to light green to dark green on rotation). It is poikilitic, containing small roundish inclusions of plagioclase, iron ore, and apatite. In many sections it is partly altered to epidote and chlorite. The borders of hornblende are almost invariably ragged and irregular suggesting corrosion by the magma during crystallization. Rarely, it is found as fairly euhedral crystals.

Quartz is interstitial, clear, and shows undulatory extinction. Apatite is ubiquitous.

Orthoclase-rich diorite is found just south of Strachan Creek No. 2 along both the road and railroad cuts. The southern contact of orthoclase-rich diorite is against granodiorite which, near the contact, contains many veins of pink orthoclase, (see Figure 10). It is a fault contact. Pink orthoclase occurs in both the diorite and granodiorite (1) with epidote as thin veinlets less than a quarter inch wide, (2) as disseminated grains, and (3) as pegmatitic lenses (or pods) composed essentially of orthoclase, quartz, and epidote, (see Figures 11 and 12). Within the granodiorite, the amount of pink orthoclase decreases away from the fault contact for a distance of approximately 100 feet, whereas in the

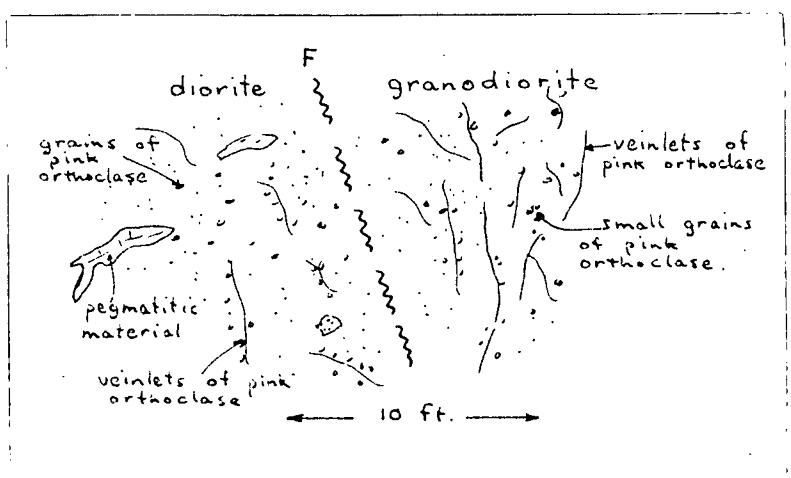


Figure 10. Fault contact between granodiorite and diorite in a road cut near Strachan Creek No. 2. Locality has high amount of pink orthoclase.

diorite, pink orthoclase is abundant for over 500 feet from the contact.

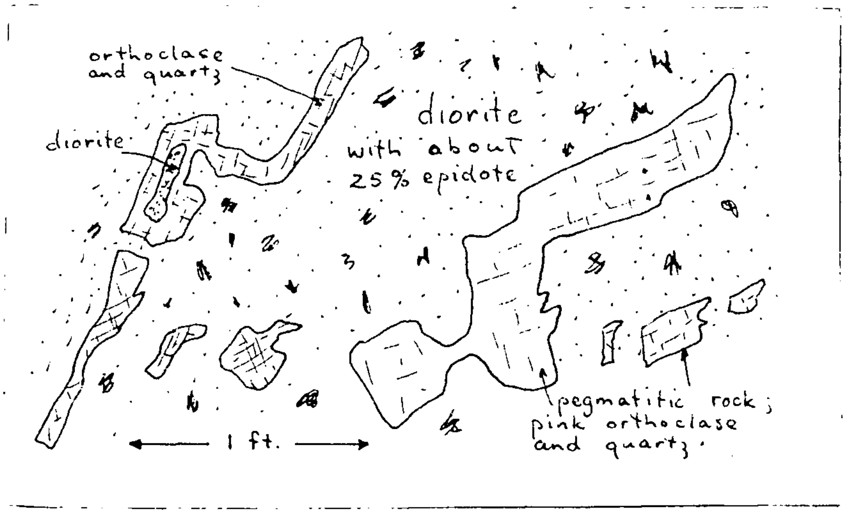


Figure 11. Pegmatitic lenses in diorite in the road cut near Strachan Creek No. 2.

Pegmatitic lenses (usually with 60% or more pink orthoclase) are abundant in diorite, and as a result gives the rock an overall spotted appearance when viewed at a distance, (see Figure 11). These pegmatitic lenses and also the abundant orthoclase are probably the result of late hydro-thermal solutions emanating from the granite when it was crystallizing. A thin-

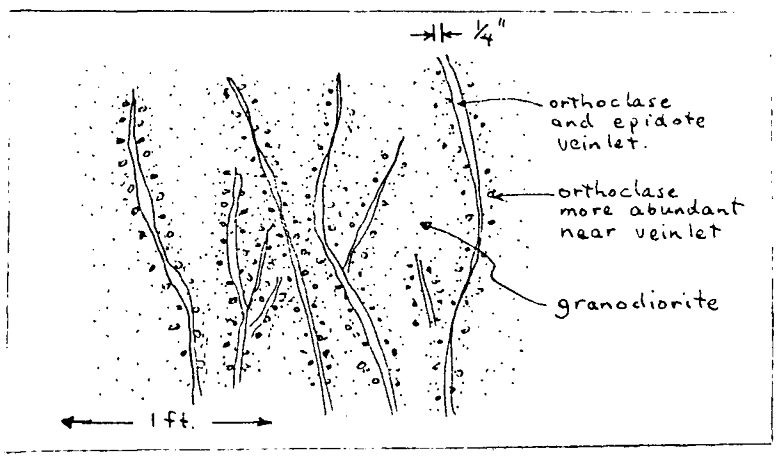


Figure 12. Orthoclase-epidote veinlets in granodiorite in road cut near Strachan Creek No. 2.

section of orthoclase-rich diorite showed that it is highly altered and contains much clinozoisite 35%, sericite 10%, and chlorite 5%. Cataclastic texture is apparently due to faulting. The hydrothermal solutions probably invaded the rock along the fault and permeated the country rock along the crushed zones.

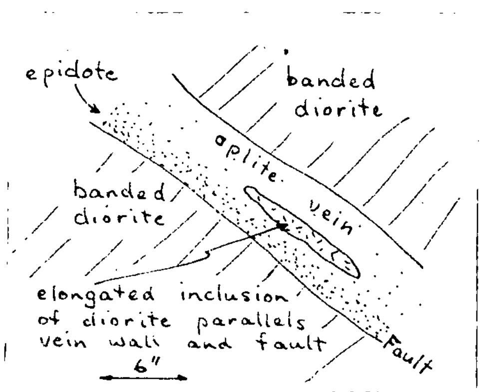


Figure 13. Aplite vein in banded diorite as seen in road cut.

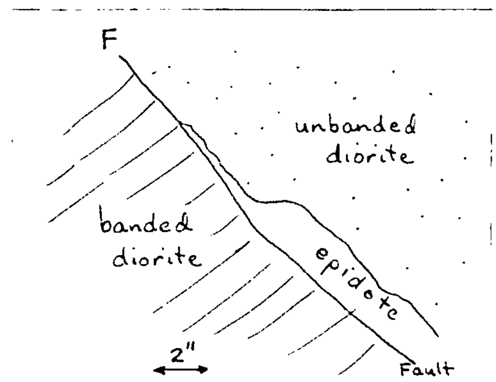


Figure 14. Epidote vein following fault plane in diorite.

Epidote is abundant in all phases of the diorite. It is frequently associated with pyrite and forms the borders of aplite veins, (see Figure 13). It may also occupy parts of fault planes, (see Figure 14), joints, fractures, and may parallel the banding. Epidote occurs as disseminated grains only in rather minor amounts.

Armstrong (1954) thinks that the hornblendic and biotitic diorites are border facies of granodiorite and may not be of igneous or magmatic origin. He states,

> Normally, the ratio of hornblende to biotite in the plutonic rocks increases near the exposed areas of older volcanic and sedimentary strata, indicating the profound influence of these older formations on the composition of the plutonic rocks.

The northern contact of the diorite of the map-area is against volcanic rocks of the Gambier group, whereas its southern contact is with granite. To the east and up the mountain slope diorite gives way to granodiorite. The contact between these two rock types is not exposed, so it is not possible to say whether the contact is sharp or gradational. Just north of Strachan Creek No. 1 diorite appears to be cut by an apophyse of granodiorite suggesting that granodiorite is younger than diorite.

Masses of granodiorite bordered by diorite have been described from other parts of the world. Compton (1955), in his study of the Bald Rock batholith, found a gradation from leucotrondhjemite to trondhjemite to granodiorite to tonalite from the core of the pluton out to the rim. The width of the tonalite border was of the order of 1000 feet. Akaad (1956) described the Ardara granitic diapir of Ireland in which he also found a tonalite border surrounding a granodiorite core.

The diorite of the Strachan Creek area possibly represent the border facies of the large granodiorite mass. However, exposures of the contact between diorite and granodiorite are very poor and much of the diorite and granodiorite is covered such that their relationships are obscured.

It seems more likely that the diorite and granodiorite represent two separate (but perhaps related) intrusions, whereby the granodiorite was formed later and in places cut through the diorite as can be seen in the road cut near Strachan Creek No. 1.

Banding in the Diorite

Banding is prominent in the diorite in the area just north of the contact between granite and diorite, that is, between Sunset Creek and Strachan Creek No. 1, and occurs in both the road cut and the railroad cut. Each complete band is a couplet composed of one light and one dark-coloured layer; one layer grading into the other. The characteristics of the banding are listed below.

(a) Across the strike, the banding may be interrupted by wide zones of massive, unbanded diorite which range in width from 20 to 50 feet. In places the banding is very faint and difficult to distinguish.

(b) The banding is found only near the contacts of the granite and the migmatite.

(c) The banding strikes N 40-70° E and dips about 60-70° NW.

(d) The difference in colour between the light and dark band is due to the large difference in the ratio of mafic minerals to feldspar in each. The white bands have very little hornblende and magnetite, whereas the dark bands have over 40 per cent mafic minerals. Iron ore (magnetite and pyrite) is generally closely associated with hornblende.

(e) The light bands are generally one half an inch thick, but are an inch or more in a few places. The dark bands are generally over one inch thick and in some places are over 6 inches thick. The dark bands finally grade into unbanded diorite. The dark bands are generally much thicker than the light ones. The ratio is approximately 3:1 but may be quite variable.

(f) Over a distance of one foot at one locality there are ten couplets.

(g) The bands are, in many places, wavy and undulating and their attitude varies considerably over a short distance (a foot or so), but the overall trend remains constant, (see Figure 15).

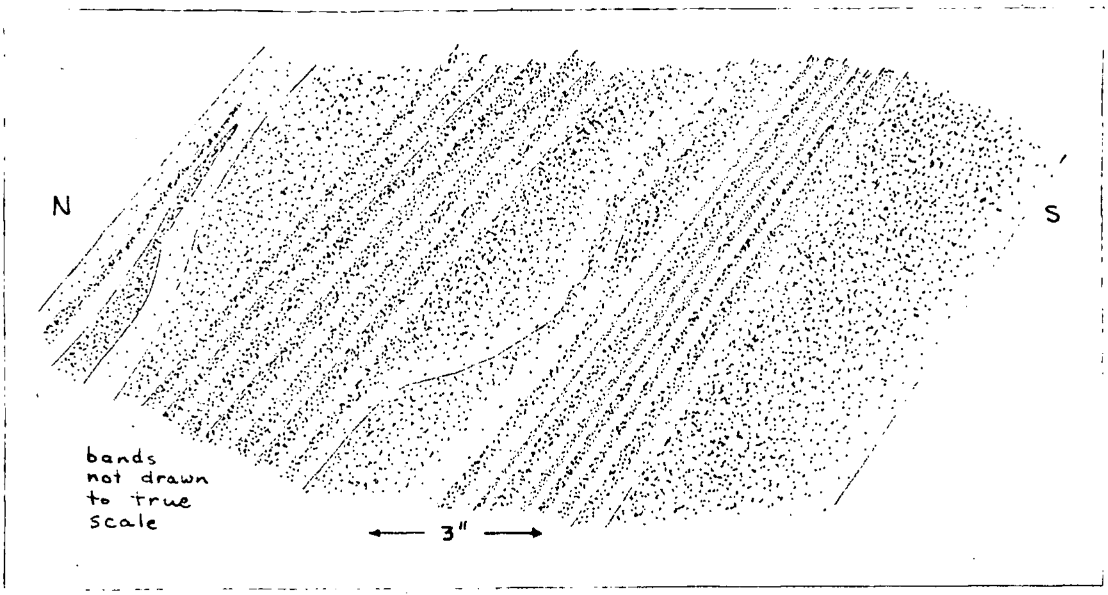


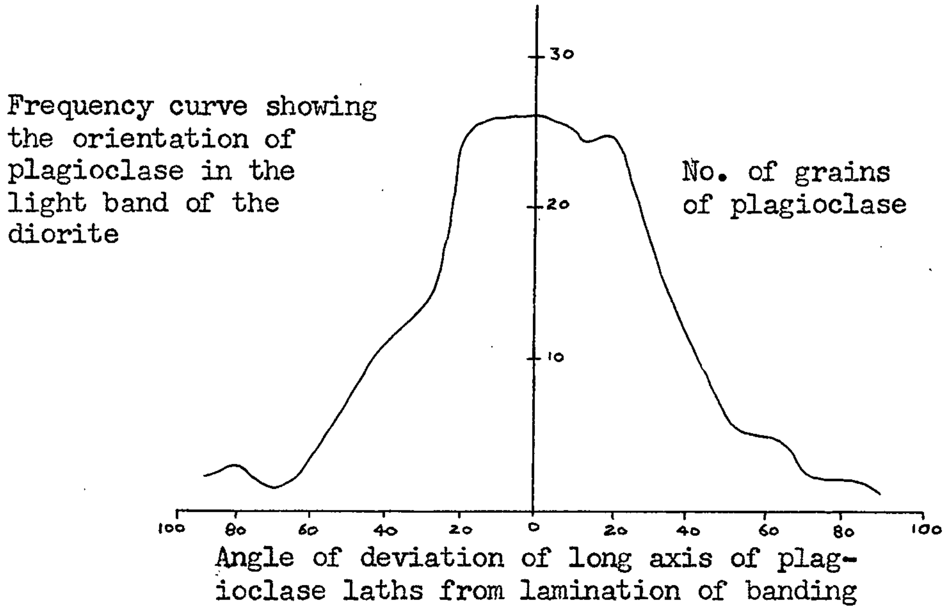
Figure 15. Banding in the diorite in the road cut.

(h) In some places the bands merge and look somewhat like inverted "cross-bedding", (see Figure 15). Outside the map-area, near the Lookout Point on the Upper Levels Highway approximately a mile from the town of Horseshoe Bay, this feature is well exposed.

(i) Magnetite is more abundant in the dark bands and appears to be most abundant near the sharp contact from where it gradually decreases in abundance until, in the light bands, it becomes a very minor constituent.

(j) The contact between the light and dark band is not everywhere sharp. Both contacts may be gradational, (see Figure 17).

(k) The plagioclase in both bands is zoned (Core An_{72} to rim An_{42}) and generally has a rough lamination parallel to the banding, (see Figure 16). The orientation of plagioclase laths was measured on the flat



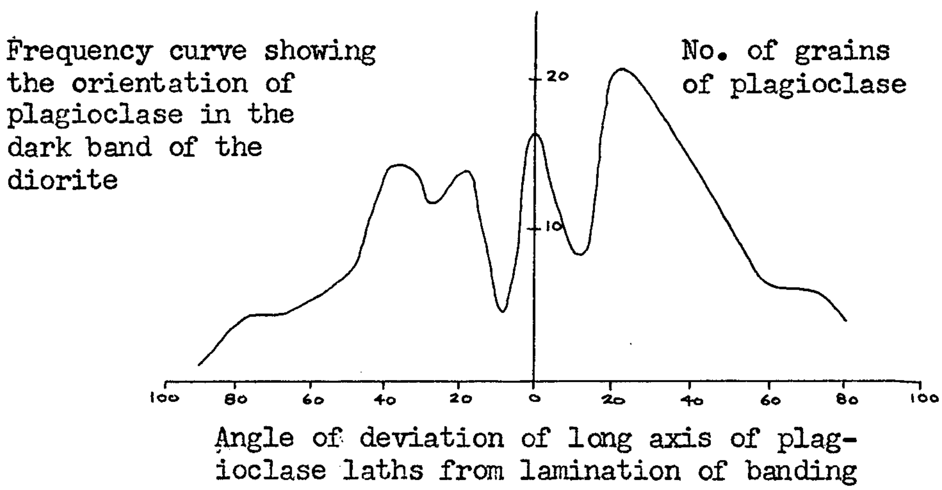


Figure 16. Orientation of plagioclase in the light and dark bands in the diorite. The measurements were made on the flat stage using oriented thin-sections of both the light and dark bands of the diorite.

stage and it was found that the plagioclase in the light band is better oriented than those of the dark band. Hornblende appears to be interstitial and is not apparently oriented, (see Figure 19, p. 36).

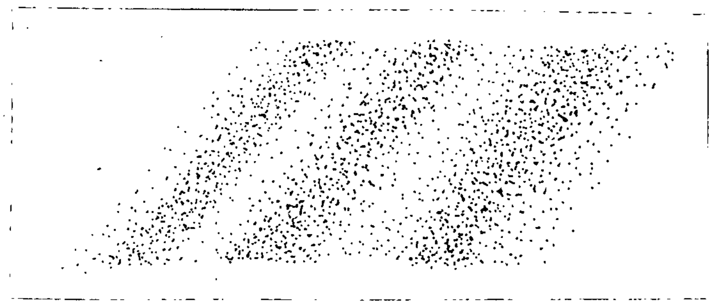


Figure 17. Gradational contacts of banding in diorite.

(1) The grains size of the minerals appears to be slightly larger in the dark band near the sharp contact. There seems to be a gradation in grain size from dark to light band. In other words, it is very similar to inverted "graded bedding".

Origin of the Banding in the Diorite

The type of banding found in the diorite has been described extensively. Cloos (1936) describes very similar banding which he found in the granodiorite of the Sierra Nevada pluton in California. He calls the banding "blatterschlieren" (blatter = pages). It should be noted, however, that in the bands of the Sierra Nevada pluton the ratio of mafic minerals to plagioclase decreases upwards from a sharp contact whereas in the bands of the Strachan Creek area the ratio increases. G.K. Gilbert (1906) describes banding in granite in the Sierra Nevada pluton which is quite similar to blatterschlieren and to the banding in the diorite of the Strachan Creek area. However, the banding which Gilbert describes has one feature that is not seen in the Strachan Creek area. One series of bands is truncated by another series of bands giving the appearance of an "unconformity", (see Figure 18).

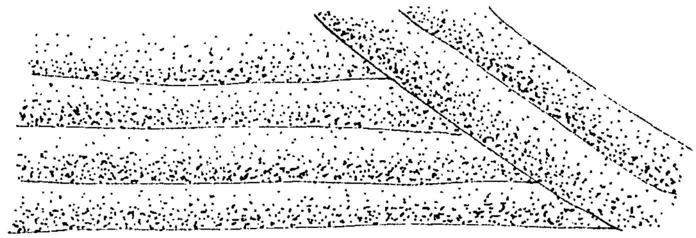


Figure 18. Banding in granite which Gilbert describes from the Sierra Nevada pluton of California.

The blatterschlieren, Gilbert's banding, and the banding in the Strachan Creek area show a sharp contact at the base of the dark band, gradation in colour, minerals, and grains size from dark to light bands, and some alignment of feldspars parallel to the bands. Both the blatterschlieren and the banding in the Strachan Creek area are found near the contacts of older rocks, and are cut by a younger granite. The similarities in the characteristics of the banding in the three areas described above suggest that their mode of origin is similar.

There are at least five ways in which the banding in the Strachan Creek area might possibly have formed. These are grouped into non-magmatic and magmatic origins and are listed below.

1. Non-magmatic Origins.

   (a) Banding represents original stratification of sedimentary rocks which have since been replaced.

The banding may have formed as a result of replacement of former steeply dipping, overturned, graded beds of sedimentary rocks. If the original rocks were a series of alternating layers of sedimentary rocks of different composition (eg. arkose and tuff), then this would explain the compositional difference of the bands. This hypothesis seems to fit most of the features of the bands. It accounts for the inverted "graded-bedding", the difference in grain size, the sharp contacts, the "cross-bedding", and the great number of bands. A strong argument for the granitization or replacement origin is that the attitude of the banding in the diorite and the attitude of the lamination in the migmatite roughly coincide. Armstrong (1954) has noted that the lamination in the Bowen Island group has the same general trend throughout the North Vancouver area and that it represents primary structures. Phemister (1945) also observed that the laminated type of pre-batholithic rocks (Bowen Island group) in the vicinity of Vancouver are metasediments. The lamination in these rocks represent bedding planes and in the field show consistent strike and dip over considerable areas. Thus, it is likely that the lamination in the migmatite of the Strachan Creek area is a primary structure and represents original bedding. Since its attitude is congruent with the attitude of the banding in the diorite, then it is possible that the banding in the diorite also represents bedding planes. Thus, it is visualized that, before dioritization, the area now represented by diorite consisted of a series of steeply dipping sedimentary rocks. Granitization then altered these rocks to diorite and the banding of the diorite is the original bedding of the sedimentary rocks which has been preserved. The migmatite would represent a knot resistant to the wave of granitization that formed the diorite.

There are, however, many difficulties with this hypothesis.

If, originally, the bands were graded beds, then it seems likely that graded bedding would be present in rocks surrounding the Strachan Creek area. However, graded bedding does not occur in any of the sedimentary or metamorphic rocks of the North Vancouver area. Also, the migmatite of the Strachan Creek area does not show graded bedding. No metamorphic textures (ie. foliation, schistosity, and cataclastic texture) and no new typically metamorphic minerals are present in the diorite. The uniformity of mineral composition of the diorite and the universal occurrence of apatite, zircon, iron ore, and biotite as accessory minerals is not easily explained by an origin through granitization. It seems most probably that the original sediments would have variable composition and, when granitized, would not all be altered to diorite of uniform mineral composition.

(b) Banding as a result of metamorphism of dioritic rocks.

The possibility arises that the banding in the diorite is the result of post-crystallization metamorphism of pre-existing dioritic rocks where metamorphic differentiation separated the minerals into light and dark bands to produce a gneissic rock. There are various processes of metamorphic differentitation by which contrasted mineral assemblages may develop from an originally uniform parent rock. The separation of minerals may be produced by solution, by solid diffusion, and by the force of crystallization. Solid diffusion is the migration of ions through continuous crystal lattices, but only through strictly limited distances (generally minute). The force of crystallization is vaguely defined (Turner 1948, p. 137) as "the driving force causing diffusion of appropriate chemical substances through a crystalline mass towards actively growing porphyroblasts or other crystals". Most writers visualize metamorphic differentiation as a phenomenon essentially connected with solution and redeposition of chemical components of rocks during metamorphism.

There are, however, many facts which can not be readily explained by this hypothesis. If the banding of the diorite was formed by metamorphic differentiation, then it is very likely that the bands would be symmetrical, ie. the light and dark bands would be of equal width and all contacts would be gradational. A strong argument against a metamorphic origin of the banding in the diorite is that the texture of the diorite, as seen in thin-section and in hand-specimen, certainly appear to be magmatic, ie. the crystals intermesh, there are no relict minerals, and there are no new, typically metamorphic minerals.

2. Magmatic Origins

(a) Banding due to cooling effects near a cold contact.

The banding may be the result of differential cooling in the vicinity of the margins of the diorite. During the cooling stage of the diorite, a thermal gradient would be set up at its margin. There would be a gradual increase in the temperature of the magma from a cool margin inwards to a hot central core. At the margin of the diorite intrusion, the magma would be against cool rocks. Thus, crystallization would begin from the margin inward. Since plagioclase appears to be early, crystallization would begin at the margin with plagioclase and would gradually move inward with increasing formation of hornblende and magnetite until one complete couplet is formed. In order to get repeated bands, there must have been either periodic halts in the cooling of the magma or periodic changes in the thermal gradient. The latter may be brought about by convection currents which would bring in new heat supplies and fresh magma from below or from the hotter central part of the magma.

Localization of crystallization along the cooling walls has frequently been invoked to explain gradual variation in mineral constituents near the margin of intrusive bodies. There are many examples of crystallization from the margin inwards. In the Skaergaard intrusion (Wager and Deer, 1933-39) the marginal border group has in some places elongated feldspars perpendicular to the contact, and everywhere shows a gradation of mineral composition from the margin inwards indicating that the magma crystallized from the margin in towards the centre. Another example is that many pegmatite veins have crystals perpendicular to the walls of the vein which obviously began to form at the walls and grew inwards. Also many dykes and sills have chilled margins and show a gradation in mineral composition and in the size of the minerals from the contact in towards the centre suggesting that they crystallized from the walls inward. Thus, it is seen that crystallization from the margin inwards is not uncommon.

It seems probable that the banding resulted from cooling effects near a cool contact and crystallization from the margin inward, but this effect is most probably subsidiary to the greater changes that differentiation and crystal rising would produce. It seems very unlikely that the multiple bands could have formed solely by differential cooling. Some other process such as differentiation, crystal settling, or diffusion is necessary to produce a separation of minerals.

(b) Banding through differential movements, (Cloos, 1936).

Cloos argues that the blatterschlieren of the Sierra Nevada pluton are due to differential movements in the magma. Evidence that movement occurred in the diorite magma of Strachan Creek are possibly the waviness of some of the bands, the rough alinement of plagioclase parallel to the banding, (see Figure 16, p. 28), and the presence of "cross-bedding". Cloos argues that the blatterschlieren were formed where movements in the magma were strong, and that areas of unbanded rock were areas of quiesence. Since the blatterschlieren and the banding in the diorite are similar, there is a possibility that they have similar origins. However, evidence that movements occurred in the diorite magma are not common and signs of strong movement are absent. Thus, it seems unlikely, though not impossible, that the banding resulted from differential movements in the diorite magma.

(c) Banding through differentiation and crystal rising.

It is possible that the banding in the diorite resulted from the process of differentiation and crystal rising. In this process the relative densities of plagioclase and hornblende (plus magnetite) and the viscosity of the magma would play an important role. It is important to note that there is a significant and sufficient difference in the densities of plagioclase and hornblende to bring about their separation through settling or rising in an appropriate liquid medium. Plagioclase has a density of 2.60-2.75 whereas common hornblende has a density of 3.05-3.47 (Dana, Textbook of Mineralogy). From the study of the paragenesis of the minerals in the dark bands it appears that hornblende formed simultaneously with and slightly after plagioclase, (see Figure 19). Hornblende occurs as interstitial material filling the spaces between laths of plagioclase, and in places is intergrown with plagioclase. There are many inclusions of plagioclase in hornblende, but the reverse is not true. The crystals of plagioclase are subhedral, and in many places are intergrown with one another. In

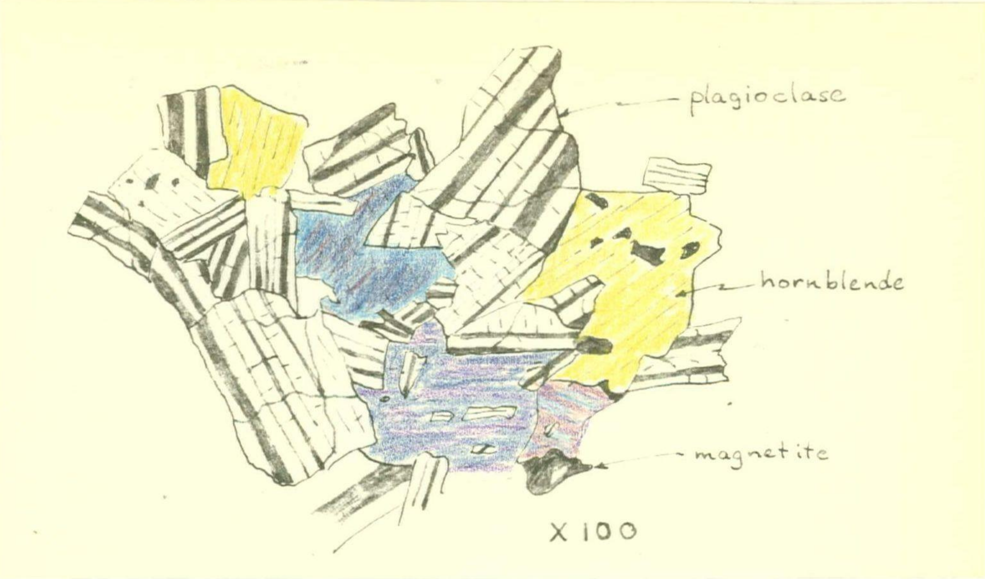


Figure 19. Dark band of diorite as seen in thin-section under crossed nicols. Hornblende is interstitial and contain inclusions of plagioclase and magnetite. X 100.

some places they show corroded edges where they are in contact with hornblende. Since the hornblende formed after the plagioclase, then it could not have settled out to form the dark bands. It is possible, however, that the plagioclase floated and consequently caused the separation of the light and dark minerals. The banding may have developed either on the floor or near the roof of the diorite intrusion. It seems improbable, however, that the banding developed on the floor of the intrusion because the plagioclase, on crystallization, would start to rise through the denser magma. The plagioclase would not accumulate into a layer because there would be nothing to arrest their rise and consequently the plagioclase crystals would continue to move upwards until either the magma becomes too viscuous or the plagioclase is stopped by a barrier.

The author visualizes the banding as a result of differentiation near the roof of the diorite intrusive whereby the plagioclase separated out from the magma and rose to the roof where it accumulated as a layer. Consider the crystallization of the first couplet at the roof of the intrusion. The composition of the magma forming this couplet would be uniform before crystallization started. Crystallization would begin with plagioclase crystals which, being lighter than the magma, would rise and accumulate against the roof. The separation of plagioclase from the melt forming the couplet would enrich the lower part of the couplet with heavy constituents. When an appreciable amount of plagioclase crystals had accumulated at the roof, crystallization of hornblende began and filled the spaces between the plagioclase laths. Plagioclase and hornblende (and the other minor constituents of the diorite) would then continue to crystallize until the couplet is solidified. In this way a separation of plagioclase and hornblende is produced. After the first couplet had solidified, convection currents would bring in a new supply of magma of uniform composition similar to that of the first couplet. Crystallization of plagioclase would begin and these crystals would rise and accumulate against the base of the dark band of the first couplet. The process of separation by differentiation and crystal rising would be repeated until the second couplet is produced. Many repetitions of this process would result in multiple bands.

The width of the light band (plagioclase band) would depend significantly on the rate of crystallization of the plagioclase and the length of time that the plagioclase had to accumulate at the roof before crystallization of hornblende and consequently the whole couplet. The variations in the width of the couplets may be the result of changes in the temperature gradient as a result of convection currents. The rough lamination of the plagioclases in the light bands reflect the tendency of the plagioclase plates to float to the roof with their flat faces parallel to the roof, or the effect of currents within the magma flowing parallel to the roof. The variations in the width of a single dark band may be the result of convection currents which carried away parts of the heavy constituents or of the sinking of parts of the heavy constituents of the dark band to lower parts of the magma as a result of gravity.

After solidification of the diorite magma, the whole mass of diorite was overturned and the banding assumed its present attitude. This is a necessary inference and a major objection to the hypothesis as there is no evidence to suggest that the diorite was overturned after consolidation.

In conclusion it is seen that none of the hypotheses fit perfectly the features of the banding, but possibly the origin of the banding through differentiation and crystal rising is the most reasonable and the easiest to visualize.

Granodiorite

A large part of the Strachan Creek area is underlain by granodiorite. In general, the granodiorite covers most of the eastern half of the Strachan Creek area. Along the road and railroad cut between Strachan Creek No. 1 and Strachan Creek No. 2, there is a 500 foot section of granodiorite. Throughout most of the area, granodiorite is bordered by diorite. To the northwest, however, granodiorite is adjacent to the volcanic rocks of the Gambier group, and to the southwest it is in contact with granite. The

The granodiorite-granite contact is exposed outside of the Strachan Creek area in a road cut approximately a half mile to the south of Sunset Creek. Here, it is very sharp, and neither the granite nor the granodiorite shows signs of chilling. Instead, both rocks are coarse-grained right at the contact and here the crystals interlock. No conclusive evidence of the age relationship of granite and granodiorite is present in this exposure.

Granodiorite appears to have formed later than the Gambier group. The strike of the conglomerate bed of the Gambier group is truncated by granodiorite. The granodiorite of the Strachan Creek area is connected to the granodiorite of Mounts Harvey and Hanover three miles to the north, so as to form one large continuous mass related in age. Armstrong (1954) notes that the granodiorite of Mounts Harvey and Hanover originated after the deposition of the Gambier group. Thus, the granodiorite of the Strachan Creek area formed at the same time.

In hand-specimen, a typical sample of granodiorite is greyish white and coarse-grained, inequigranular, and allotriomorphic in texture. The mafic minerals constitute from 5 to 20 per cent of the rock. The granodiorite is uniform not only in mineralogical composition and texture, but also in the constant presence of round dark inclusions. These inclusions form approximately one to two per cent of the rock and are evenly distributed. The weathering of feldspar produces a white surface on the weathered surface of granodiorite.

In thin-sections of granodiorite, it is seen that the essential minerals making up the granodiorite are plagioclase (average, An_{40}) 60%, biotite 15%, hornblende 5%, quartz, and orthoclase. Quartz forms from 10 to 15 per cent and orthoclase up to 10 per cent of the rock. The accessory minerals are apatite, sphene, and iron ore. Alteration products are epidote, clinozoisite, and sericite. Plagioclase shows marked zoning which is generally of the oscillatory type, but normal zoning is also present. Phemister (1945, p. 65) has studied the zoning of plagioclase of a normal granodiorite of the batholith near Vancouver and describes plagioclase crystals with up to ten zones of the oscillatory type. These zones range in composition from An_{28} to An_{72} with an average composition of An_{41}. Phemister also mentions that he observed reverse zoning in granodiorite, but this is not found in any specimens from the Strachan Creek area. Hornblende is strongly pleochroic in tones of green and has smooth grains boundaries, and in places is subhedral. Many crystals are twinned. Generally, hornblende contains inclusions of apatite, feldspar, and iron ore. Biotite is present as ragged grains partly altered to chlorite, especially along cleavage traces. Generally, it contains round inclusions of plagioclase and iron ore (pyrite and magnetite). Quartz is mainly interstitial, but in places forms large, irregularly bounded grains which show wavy extinction, incipient fracturing, and minute bubbles and inclusions. Orthoclase occurs as clear, untwinned interstitial areas which in some places surrounds plagioclase laths. Alteration is not prominent. In general, the granodiorite has no directive textures, but in a few places the inclusions are roughly oriented.

The presence of (1) an apophyse of granodiorite cutting diorite, (2) the uniform pattern in the overall texture of the granodiorite, and (3) the constant mineral composition of the granodiorite suggests a magmatic origin of the granodiorite.

Small Inclusions in Granodiorite

Small basic xenoliths are invariably found in the granodiorite. Generally, they form 1 to 2 per cent of the rock, but in some places they make up to 5 per cent of the rock. They appear to be evenly distributed throughout the granodiorite regardless of contact relations. In general, the inclusions are round to subround in outline, but in a few places sharp angles are noted. There are some elongated inclusions (see Figure 20) which have a ratio of length to width ranging from 2:1 to 5:1. The largest inclusion seen in outcrop is approximately 7 inches in its longest direction, but many boulders of granodiorite in the creek beds contain inclusions over a foot or more in diameter. The size of the inclusions grade from 7 inches to less than a quarter of an inch across. The majority of the inclusions, however, are about 1 to 2 inches in diameter. The contact between xenolith and granodiorite is sharp, but generally, the crystals intermesh across the contact, (see Figures 20, 21, and 22). In most places the xenoliths show random orientation.

Figure 20.

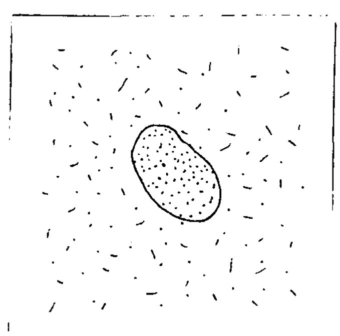


Figure 21.

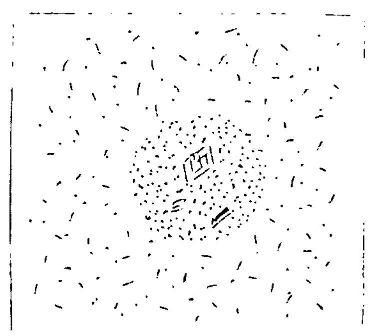


Figure 22.

Small inclusions in the granodiorite. Figure 20 is of an elongate inclusion with sharp contacts. A large feldspar crystal lies across the boundary. Figure 21 is of an oval inclusion which has sharp contacts without interlocking crystals across the contact. Figure 22 is of a round inclusion with phenocrysts or porphyroblasts.

Variations in the type of xenoliths are observed. Most of them are of dark, fine-grained, essentially dioritic rocks, but a few are of very fine-grained, dark, basaltic rocks. The author found one xenolith of a metamorphic rock with definite foliation and with a composition of quartz, feldspar, chlorite, and epidote. Some xenoliths of dioritic composition have faint banding due to a preferred orientation and segregation of mafic minerals. One type of xenolith is characteristic and dominant in granodiorite. It is a finely granular rock of dioritic composition composed mainly of hornblende and plagioclase. In places it is porphyritic or porphyroblastic, having large white phenocrysts or porphyroblasts of plagioclase ranging from 1/8 to 1/4 inches in diameter in a fine-grained, dark groundmass.

In thin-sections of the most common (dioritic) type of xenolith, the minerals are seen to be plagioclase (zoned, rim An_{20} to core An_{48}) 55%, hornblende 30%, biotite 5%, quartz, chlorite, orthoclase, zoisite, sericite, sphene, and clinozoisite. Quartz is interstitial, encloses well formed laths of plagioclase and subhedral crystals of hornblende, and has undulatory extinction. There appears to be two stages in the formation of hornblende. The early hornblende crystals are subhedral to euhedral and relatively free of inclusions. The later hornblende appear as anhedral grains with ragged crystal outlines and poikilitic texture, containing small inclusions of plagioclase, apatite, and iron ore.

Phemister (1945) proposes that the xenoliths represent fragments of pre-batholithic dykes and other country rocks which were caught up into the intruding magma and made over into basic patches which were in equilibrium with the surrounding magma. A strong argument for this hypothesis is is that a chemical analysis (made by Phemister) of the composition of a common type of xenolith in the granodiorite of the Caulfields area near Vancouver is very similar to that of the pre-batholithic dykes. Also, at Caulfields the inclusions show all stages of conversion to granodiorite.

Granite

The main mass of pink granite occurs in the southern part of the Strachan Creek area and extends from the southern boundary of the area northward to approximately 1000 feet north of Sunset Creek and up the slope of the mountain to an elevation of more than 3000 feet. Armstrong (1954) shows this mass to continue as an alongate body about 4 miles long and 1/4 to 1/3 mile wide, having a general northwesterly trend. Good exposures are found along the seashore, and along the road and railroad cuts. To the south, just outside of the Strachan Creek area, granite is in contact with granodiorite. Just to the north of Sunset Creek the main mass of granite gives way to diorite. The contact here is not exposed, but within a few feet of it both the granite and granodiorite is exposed. About 300 feet above the road cut, the contact is occupied by a dark, porphyritic, dioritic dyke.

To the north of the main mass of granite many smaller dykes of granite are found. They cut the diorite and range in width from 20 to 300 feet, (see Figure 23). The contact of the granite dykes with the diorite is generally quite sharp. In a few places the granite dykes contain small, angular inclusions of diorite near the contact, (see Figure 24). This suggests that the granite magma stoped off parts of the walls of the diorite during its intrusion.

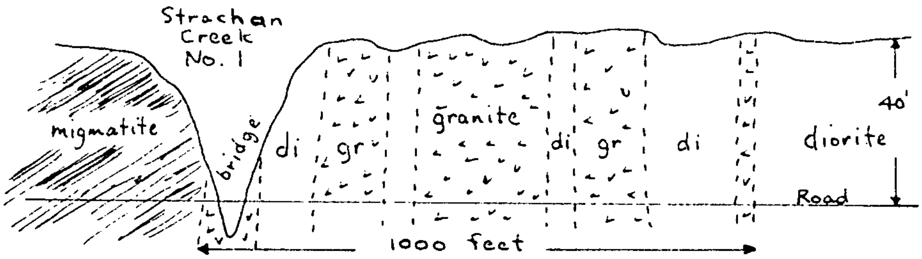


Figure 23. Section exposed in road cut near Strachan Creek No. 1. Diorite cut by numerous dykes of granite.

In hand-specimen, the granite is typically pale pink and coarse-grained, allotriomorphic to hypidiomorphic, and inequigranular in texture. Mafic minerals make up less than 5 per cent of the rock and in general are well distributed throughout. The melanocratic minerals are generally much smaller than the leucocratic minerals. The pink colour of the granite is due to the abundance of K-feldspar. The rock is well jointed and has many fractures and joints. The granite in the vicinity of Sunset Creek is cut

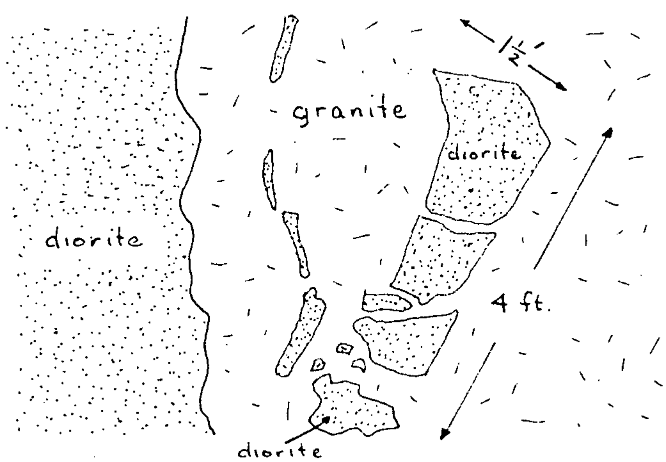


Figure 24. Granite-diorite contact as seen in road cut near Strachan Creek No. 1. Note the large inclusions of diorite in granite.

by numerous thin, black veinlets approximately 1/10th of an inch thick. These veinlets form a sort of network or boxwork (see Figure 25) and appear to be related to the jointing as the two are closely associated. The veinlets are composed mainly of biotite with minor amounts of chlorite and sericite. These minerals are well oriented parallel to the walls of the veinlets.

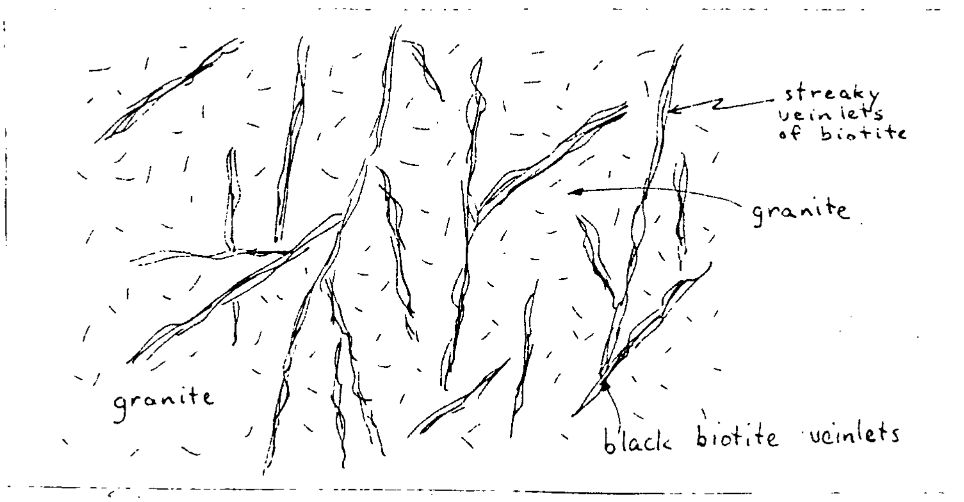


Figure 25. Veinlets of black biotite forming a network in granite.

In thin-section the mineral composition of the granite is seen to be microperthite 60%, quartz 30%, biotite 5-8%, plagioclase An_{20}, apatite, magnetite, pyrite, sericite, chlorite, zoisite, clinozoisite, and andalusite. Microperthite and quartz are predominant and all the other minerals are present only in rather minor amounts. Mafic minerals form from 4-8 per cent of the rock. Andalusite is present only in one thin-section. Here, it occurs as subhedral, squarish crystals surrounded by a very thin rim of sericite. Some andalusite crystals are enclosed in quartz, while others are embedded in a fine-grained, crushed matrix of quartz grains. The paragenesis of the minerals show that andalusite formed after the crystallization of microperthite, plagioclase, and biotite, but before the formation of quartz. This suggests that the andalusite is of primary origin. That is, the magma had an excess of alumina after having satisfied the requirements of feldspar and mica, and this excess was used up in the formation of andalusite. In all thin-sections the granite shows cataclastic texture. The boundaries of large microperthite and quartz grains appear to be granulated. Large areas of the thin-sections show fine-grained, broken up crystals of quartz and K-feldspar. Many thin veinlets of fine-grained granulated material cut through the rock. The veinlets are seen to weave between the large grains and in places even cut through the large grains. Large microperthite grains are encircled by very fine-grained granular quartz. The cataclastic action seems to have occurred after the consolidation of the rock because all the quartz has wavy extinction and there is no interstitial quartz between the granulated grains.

The granite appears to be a typical high level granite emplaced as magma. A strong argument for this hypothesis is that the granite has a uniform pattern in its overall texture and its mineral composition is everywhere constant. The presence of granite dykes containing blocks of diorite indicate that the magma stoped off parts of the diorite during intrusion. The general occurrence of cataclastic texture in the granite suggests that the granite suffered post-crystallization stresses. Perhaps it wedged its way further after solidification.

Dyke Rocks

Several varieties of dykes are found cutting the plutonic rocks of the Strachan Creek area. The dykes can be divided on the basis of composition into two groups, basic dykes and acidic dykes.

The basic dykes of the Strachan Creek area consist of gabbro, porphyritic and non-porphyritic diorite, and basaltic (or trap) dykes. All the basic dykes, except for one gabbroic dyke, are found in the main mass of granite. The best exposures of the basic dykes are found in the road and the railroad cuts near Sunset Creek. Only one dyke of gabbro occurs in the map-area and it is found just north of Strachan Creek No. 1 at an elevation of about 1200 feet. It has very sharp contacts with the adjacent diorite and is finer grain near its margin than towards its centre. In thin-section the essential minerals are seen to be plagioclase (An_{56}) 50%, augite 20%, chlorite 15%, and quartz 5%. Accessory minerals are pyrite, magnetite, apatite, and calcite. The porphyritic diorite dykes are exposed along the road cut just north of Sunset Creek, (see Figure 26). They are medium- to fine-grained, greyish green rocks which are spotted with large white phenocrysts of plagioclase. The essential minerals are plagioclase (average An_{44}) 60%, hornblende 30%, and magnetite 5%, and the accessory minerals are quartz, chlorite, epidote, biotite, and apatite. Phenocrysts of plagioclase show oscillatory zoning. No directive textures are apparent in either hand-specimens or thin-sections of the rock. The non-porphyritic diorite dykes

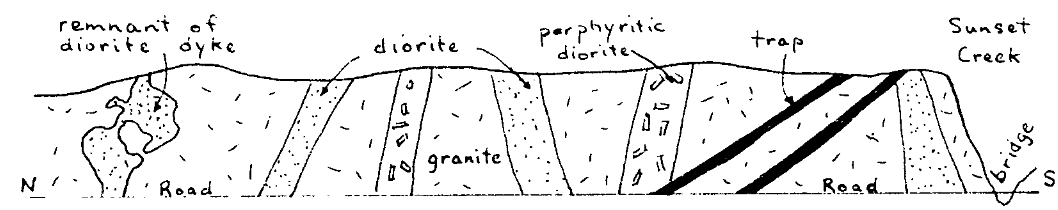


Figure 26. Section exposed in road cut just north of Sunset Creek. Granite is cut by numerous dykes.

are also exposed along the road cut just north of Sunset Creek, (see Figure 26). One of these dykes is found in the granite at elevations of 12-1400 feet. The dioritic dykes are grey and medium-grained, allotriomorphic, and inequigranular in texture. The mafic minerals occur as evenly distributed clots or bunches composed mainly of biotite. In hand-specimen, it is seen that plagioclase 60%, biotite 25%, hornblende 8%, and iron ore 3% are the essential minerals. In a few places the mafic minerals show a preferred orientation. The trap dykes are very fine-grained, black rocks of basaltic composition.

The basic dykes were intruded after the formation of the plutonic rocks. Strong evidence for this is that many of the basic dykes show chilled borders and are of finer grain near their margins than in the central part of the dyke. Generally, the contacts of the dykes with the adjacent rocks are very sharp. The age relations between the various basic dykes is not certain. However, it is clear that the trap dykes are later than the porphyritic and non-porphyritic diorite dykes as the trap dykes cut both of these dykes, (see Figure 26).

The acidic dykes are found in the diorite at various intervals from Sunset Creek to Newman Creek. All of them are too small and too irregular to be mapped. In the Strachan Creek area they are represented by aplite and pegmatite dykes. In places they follow fault planes, (see Figure 27). Where aplite occupies a fault plane, it is bounded on one wall by the fault and on the other by country rock, (see Figures 13 and 27). Both contacts are sharp. In some places epidote occurs in the aplite only along the fault wall, but in other places epidote is present along both

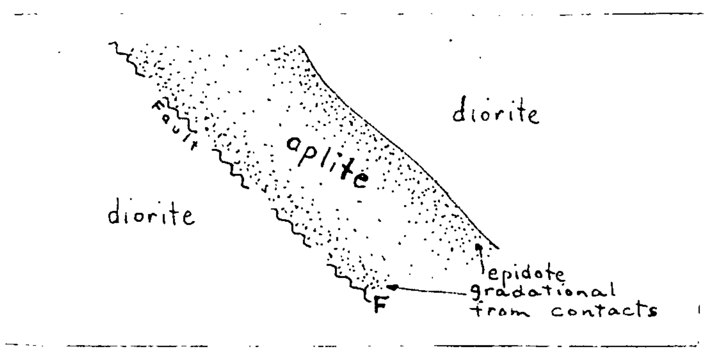


Figure 27. Epidote grading in abundance from both walls of the aplite vein toward the centre.

contacts, (see Figure 27). In both of these instances, epidote is more abundant near the contact and gradually decreases in abundance towards the centre of the dyke. In hand-specimen, the aplite consists essentially of orthoclase 50%, plagioclase 25%, and quartz 15%. The accessory minerals are epidote, biotite, chlorite, magnetite, and hematite. The aplite dykes probably represent the late emanations of a consolidating granitic magma.

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ABSENCE REPORT

Please report holidays in terms of days and sick leave in hours. Please do not report periods of less than a half hour.

DIVISION ------------------------------WEEK ENDING SATURDAY--------------

NAME	SICK LEAVE	LEAVE WITHOUT PAY	VACATION

APPROVED ____________________

Division Head.

LEGEND

CENOZOIC

TERTIARY

- TRAP DYKE
- BASIC DYKES – GABBRO, DIORITE

MESOZOIC

- G — GRANITE
- G D — GRANODIORITE
- D — DIORITE

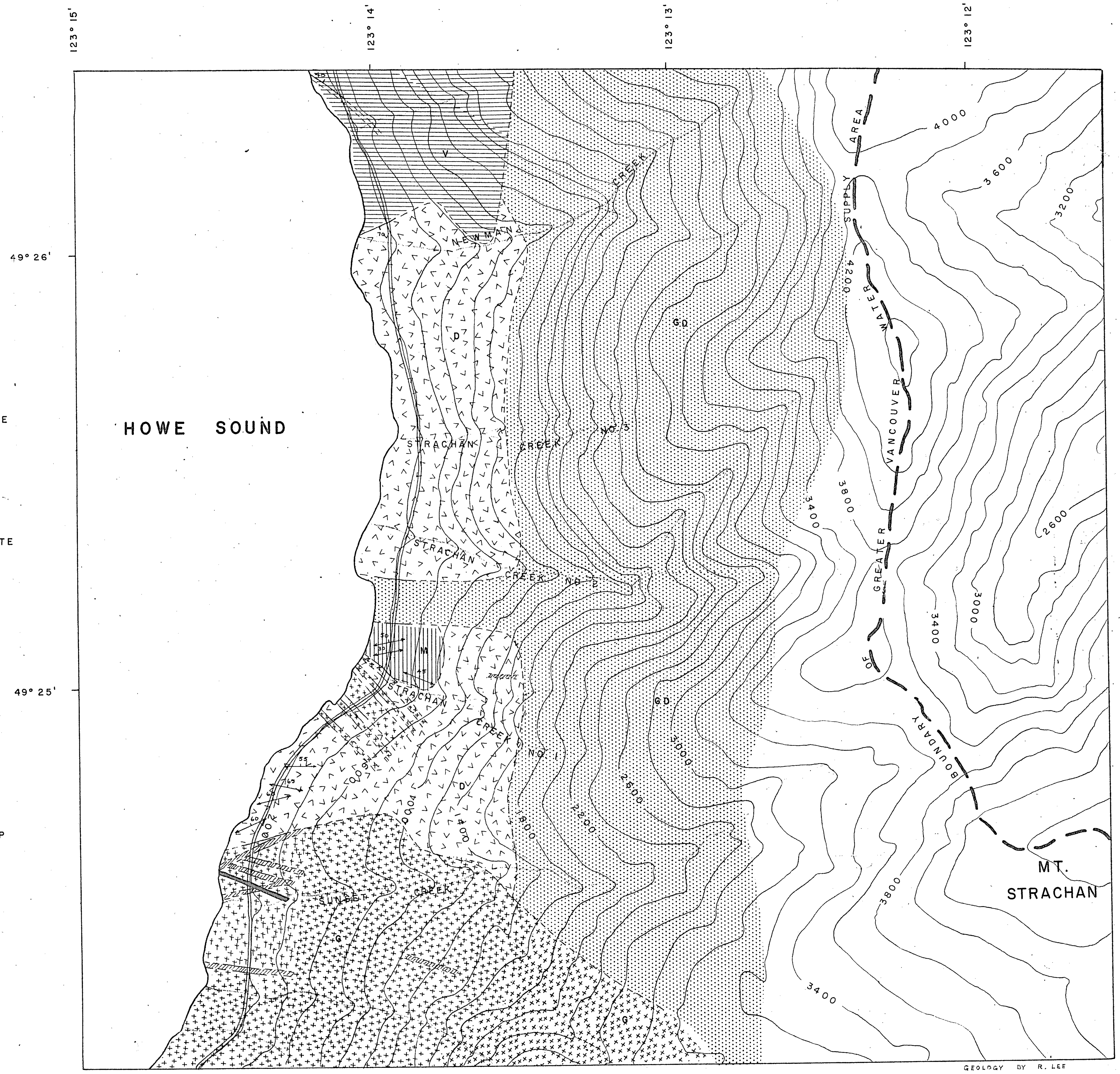
TRIASSIC AND/OR LATER

- V — GAMBIER GROUP — VOLCANICS CONGLOMERATE

TRIASSIC AND/OR EARLIER

- M — BOWEN ISLAND GROUP — MIGMATITE

- CONTOURS
- GEOLOGICAL BOUNDARY – ASSUMED
- GEOLOGICAL CONTACT SHOWING DIP
- STRIKE AND DIP OF BANDING
- ROAD
- SHORE – LINE



SCALE 1:10,000

1/5 0 1/5 2/5 3/5 4/5 1 MILE

CONTOUR INTERVAL 200'

GEOLOGICAL MAP
STRACHAN CREEK AREA
VANCOUVER DISTRICT
BRITISH COLUMBIA