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DOUGLAS CHANNEL-HECATE STRAIT MAP-AREA, BRITISH COLUMBIA

(Report, 10 figures and Map 23-1970)

J. A. Roddick

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ABSTRACT

About 85 per cent of the map-area is underlain by granitoid rocks, and most of the remainder by metasedimentary and metavolcanic rocks. At least one third of the granitoid rocks are gneissic, migmatitic complexes. Comparatively homogeneous plutonic rock ranges from gabbro to quartz monzonite. A broad belt of granitoid gneiss forms the oldest known unit (probably pre-Permian). It is overlain by a central belt of metasedimentary strata which may include Permian rocks. The dominant northwest-trending structures are deflected in a left hand sense by the Hawkesbury Warp, one of the major flexures in the Coast Mountains. The western part of the area is cut by several northwest-trending faults of probable right-hand displacement.

Frontispiece. View southeasterly up Gardner Canal from over Hawkesbury Island. Contact between agmatite (unit 1b) in left foreground and metasediments (unit 2a) in right foreground. (B.C. Government Air Photograph 501:108)

DOUGLAS CHANNEL-HECATE STRAIT MAP-AREA, BRITISH COLUMBIA

INTRODUCTION

Douglas Channel and Hecate Strait map-areas include about 6,700 square miles of plutonic and metamorphic terrane not covered by water. Except for parts of the outer islands the area is mountainous. Although the highest point in the map-area, Atna Peak, exceeds 7,500 feet elevation, most of the ridge crests lie between 4,000 and 6,000 feet above sea level. Small communities exist at Butedale, Hartley Bay, Trutch Island and, just east of the map-area, at Kemano. The largest nearby community is Kitimat about 4 miles north of Douglas Channel map-area.

The area contains no producing mines, but Surf Inlet Mine, near the south edge of the map-area on Princess Royal Island, produced considerable gold mainly from 1917 to 1926, and Drum Lummon Mine at Drumlummon Bay on the northwest side of Douglas Channel produced some copper in 1919 and 1920. The area also contains scattered prospects of which those near Ecstall River and on Banks Island have attracted the most exploration activity in recent years.

The principal previous geological work in the area was the examination of shore exposures by Dolmage (1922, 1923) in 1920 and 1921. A minor amount of detailed mapping has been done by mining companies around Surf Inlet Mine and the Ecstall River prospects, and by the Aluminum Company of Canada around Kemano. The Whitesail Lake map-area to the east was mapped on a reconnaissance scale by S. Duffell (1959), and the Terrace, east half map-area to the north by Duffell and Souther (1964). R.A. Stuart (1960) mapped the Tahtsa Lake-Kemano power tunnel and vicinity on a scale of 1 inch to 1 mile.

The present work is part of the Geological Survey's 'Coast Mountains Project' begun in 1962. This report is based on the examination of the shoreline by Souther, Hutchison and Baer during part of the 1963 field season, and a rapid reconnaissance of the interior terrain by Roddick, Hutchison and Baer during part of the 1965 season.

The map-area is well-dissected by fiords and channels which provide good, almost continuous exposures. Northwest-trending channels such as Grenville Channel, however, yielded less geological information than might have been expected, not only because they parallel the regional trends of the rock units, but also because they have been developed mainly in narrow belts of metasedimentary rocks.

Except possibly for a few of the highest peaks the entire area has been glaciated, producing many smooth, striated outcrops along the shore, steep valley walls, and rounded bold ridge tops. Rugged topography and rapid erosion aided by heavy precipitation has left most of the area curiously barren of glacial deposits other than erratic boulders.

The western fringe of the map-area has been classified by Holland (1964) as part of Hecate Lowland and Milbanke Strandflat. The Hecate Lowland

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is bounded on the east by a generalized line along the 2,000-foot contour, but contains some higher peaks on Banks and Campania Islands. The Milbanke Strandflat is a low, flat plain, mostly below 100 feet elevation, that includes the southwest corner of Banks Island, the Estevan Group, and the west side of Campania Island. Holland points out that the concordance of summits in the Hecate Lowland indicates an old erosion surface whereas Milbanke Strandflat is a wave-cut surface. Although the summits are not markedly concordant in this part of Hecate Lowland, here and there deeply weathered rocks were observed. The summits probably represent a modified ancient erosion surface, possibly a western continuation of the Interior Plateau now isolated by the uplift of the Coast Mountains.

GENERAL GEOLOGY

General Statement

As its southeastern corner is situated on the axis of the Coast Crystalline Belt, Douglas Channel-Hecate Strait map-area includes the full width of the belt west of the axis but only part of that to the east. Yet on the basis of superficial reconnaissance of the excluded terrain to the east only small changes in the relative abundance of the different rock types in the map-area (changes favouring the more acidic granitic rocks) would be required to make them representative of the full width of the Coast Crystalline Belt. In the map-area granitoid rocks underlie about 88 per cent of the land area, and of these about one third are migmatitic. Metasedimentary and metavolcanic rocks form the remaining 12 per cent. The granitoid rocks underlie the following areas: basic complexes, gabbro and diorite (units 5, 6 and 7), 13 per cent; quartz diorite, 27 per cent; granodiorite, 24 per cent; quartz monzonite, 6 per cent; acidic gneisses, 18 per cent.

Owing to the lack of fossils and the difficulty of interpreting isotopic age determinations in a complex metamorphic terrane, the ages of most of the rock-units are not known. Although relative ages have been established between some of the units at a few places, extrapolation to other parts of the map-area necessitates lithological correlation in which little confidence is felt, especially those involving plutonic rocks.

The oldest stratified rocks are the granitoid gneisses, together with associated gneissic plutonic rock and metasediments (unit 1) which underlie extensive areas northeast of the axis of the Coast Crystalline Belt. The unit forms a northwest-trending antiformal structure (Foch Antiform) best preserved northwest of Douglas Channel from where it extends into Prince Rupert-Skeena map-area. To the southeast in the vicinity of Brim River the antiform loses its character probably because of little understood plastic deformation. The crest of the antiform is breached, exposing quartz diorite (8e) and granodiorite (9c). In places the plutonic rock grades into the gneiss and seems to underlie it (the whole having moved up together) but elsewhere the plutonic rock intruded the gneiss unit.

Along part of the southwest limb of the antiform the gneisses grade into a thick overlying metasedimentary assemblage (unit 2) that is less granitoid than unit 1 and characterized by amphibolite and schist. Farther west, on the islands, unit 2 is represented by micaceous quartzites (2b) but it is not known whether unit 2b is a siliceous facies of unit 2a, or a different horizon. Unit 2c is a thick crystalline limestone member within unit 2a and provides the main basis for correlating unit 2 with the Permian to the east. The latter contains a limestone that appears to overlie gneissic terrane similar to parts of unit 1. Unit 1 is, in part at least, a granitized form of the lower strata of unit 2 but gradation between the two also occurs along strike, for example, the transition across Devastation Channel. Also, in the vicinity of Marmor Peak, the limestone member (unit 2c) is preserved whereas the strata above and below have been converted to granitoid gneiss. A major stratigraphic hiatus may exist between or within units 1 and 2 but it was not recognized. Both units comprise rocks belonging to the amphibolite facies and show no clear difference in metamorphic grade.

On Porcher Island a greenstone assemblage (unit 3) overlies and seems to grade into unit 2a. As the greenstone is restricted to the vicinity of Porcher Island where outcrops are limited, little is known about it. Unit 3 is tentatively correlated with the Upper Triassic greenstone in northwest Mount Waddington map-area and altered parts of the Karmutsen Formation on Vancouver and the Queen Charlotte Islands. It lacks the varied sedimentary intercalations of the Hazelton Group (unit 4) as represented in the northeast part of the map-area.

Greenstone, siliceous tuff and intercalated sediments (unit 4) form a northeast-trending, northwest-dipping belt in the northeast corner of the map-area. The assemblage lies apparently unconformably on units 1 and 2a. The greenstone can be traced eastward into strata mapped as Hazelton Group in Whitesail Lake map-area. The youngest, consolidated, stratified rocks are basalt flows on Bonilla Island and in Kitkatla Channel. They are little deformed and essentially unaltered. The flows are correlated with similar rocks of Upper Miocene age in Bella Coola-Laredo Sound map-area.

In contrast to the scattered blocks of stratified rocks, the plutonic rocks form the matrix of the map-area. Although no quartz diorite line can be drawn through the Douglas Channel-Hecate Strait map-area, in Prince Rupert-Skeena map-area to the north, Hutchison (1967) showed a quartz diorite line as far south as Skeena River. Were it to be extended, it would pass southeasterly into Terrace, east half map-area and not intersect Douglas Channel map-area. A diorite line, however, can be drawn from Snag Point on Skeena River about 10 miles east of Ecstall River, along the west side of the central belt of unit 2a to Douglas Channel and thence across the southern tip of Hawkesbury Island to the southern border of Douglas Channel map-area which is intersected about 4 miles east of Yule Lake. This diorite line marks the eastern limit of nearly all of the basic plutonic rocks (units 5, 6, 7).

The basic complexes (unit 5) are characterized by dioritic migmatites and gneisses and are a major component of the islands west of Grenville and Princess Royal Channels. Metasedimentary screens, agmatitic zones, and pervasive broad scale granitization, features common in the unit, give it an internal geometry similar to that in parts of unit 1, but quartz and K-feldspar, which are common in unit 1, are rare in unit 5. Where the dioritic complexes contain gabbroic phases (5a), as on McCauley Island, this phase is older than the dioritic phase, and where the dioritic complexes are in contact with more acid plutonic rocks, the latter are younger.

Quartz diorite (unit 8) and granodiorite (unit 9) are about equal in abundance and underlie about half of the map-area. Both gradational and cross-cutting relationships are common between the two units and pre-Middle Jurassic rocks.

In addition to constituting numerous irregularly shaped masses throughout the map-area, quartz diorite and/or granodiorite form three plutons (named Captain Cove, Ecstall and Butedale) which have northwest-trending, tadpole shapes. The 'heads' of the first two named are well-defined and clearly exhibit intrusive (but not necessarily magmatic) relationships whereas the 'tails' commonly have gradational or intricate contacts. The 'head' of Butedale Pluton, which could be considered a bulge in the elongated tail of Ecstall Pluton rather than a separate 'tadpole' pluton, does not clearly show the 'head-tail' relationships of this breed of pluton. The dip of metamorphic strata southeasterly beneath the head of Ecstall Pluton north of Skeena River suggests both upward and northward movement of the pluton.

The quartz diorite and granodiorite are rarely uniform over broad areas. Zones of migmatite and metasedimentary screens appear here and there and small lensoid amphibolitic inclusions are ubiquitous but variable in abundance. Unit 8e in the core of Foch Antiform contains exceptionally abundant screens of gneiss.

Quartz monzonite forms small stocks in the northeastern corner of the map-area, and underlies the central part of Campania and Banks Islands. In most places the quartz monzonite is a clean massive rock with sharply defined intrusive contacts, but the fine-grained garnetiferous quartz monzonite that forms elongate zones mainly on Pitt Island, is intricately interdigitated with gneissic and migmatitic diorite (unit 5b).

Contact relations everywhere indicate the more acid plutonic rock to be younger than any more basic plutonic rock in contact with it, but isotopic ages bear a close relationship to the position of the plutons in the Coast Crystalline Belt than to rock type. The isotopic ages range from Early Cretaceous in the west to Late Cretaceous near the axis of the crystalline belt to Tertiary on the east side. Hence a young-looking quartz monzonite on Campania Island in the western zone yields an older age (115 m.y.) than granodiorite in Butedale Pluton (67 m.y.).

The main structures in the area are: the Hawkesbury Warp which is a major flexure in the northwest trend of the Coast Crystalline Belt; Foch Antiform, a large structure that is partly overturned to the southwest; and three inferred major faults, Grenville Channel, Kitkatla, and Principe-Laredo Fault all of which lie in waterways. The Hawkesbury Warp was superimposed on strata previously deformed into northwest-trending folds. Nothing is known about the age or movement on the main faults, although right-lateral movement is suspected from evidence on small parallel faults.

Douglas Channel-Hecate Strait map-area connects the geology of Prince Rupert-Skeena map-area to the north with that of Bella Coola-Laredo Sound to the south, yet the patterns are somewhat different in each of the three areas. Prince Rupert-Skeena has proportionately more of the metasedimentary and gneiss terrane that once doubtlessly mantled the entire region. The more extensive cover and the presence of low-grade metamorphic rocks in the western part of Prince Rupert map-area indicate a generally higher stratigraphic level there. Also no equivalent of the shallow easterly dips of western Tsimpsean Peninsula exists in the southern two areas where steep easterly dips predominate in spite of numerous exceptions. The gentle northeasterly dips of the northeast limb of Foch Antiform extend into Prince Rupert-Skeena map-area but have no equivalent in Bella Coola map-area. The granitoid gneiss belt of the two northern map-areas becomes fragmented and disappears in Bella Coola map-area but reappears farther south in Mount Waddington map-area. Thus Bella Coola-Laredo Sound map-area seems to represent the deepest stratigraphic level, yet it has the greatest encroachment into the Coast Crystalline Belt of Mesozoic volcanic cover, which suggests much uplift and erosion of the belt prior to deposition of the volcanic rocks. Bella Coola map-area also has a much higher proportion of quartz monzonite than the northern areas, and an extensive region underlain by dioritized greenstone east of the axis of the Coast Crystalline Belt which has no equivalent to the north.

Map-unit 1

This unit forms a broad belt, 16 to 32 miles wide, traversing the northeastern part of the map-area. The belt is commonly breached by plutonic rock, especially along the axis. In the northwestern part of the belt at least, most of the plutonic rock exposures may be accounted for by the erosion of unit 1 from along the crest of a broad antiformal structure (*see* cross-section A-B).

Unit 1 is a heterogeneous assemblage consisting mainly of granitoid gneiss, gneissic quartz diorite, rusty fine-grained gneiss and schist, and a variety of complex migmatites. As the unit repeatedly grades into plutonic rock and in many places into the overlying metasedimentary rocks of unit 2, it is very difficult to map. From about 6 miles northeast of Crab Lake to beyond the northern border of the map-area, unit 1 apparently forms a broad northwesterly trending anticlinal structure, hereafter referred to as the Foch Antiform, overturned to the southwest. The northeast limb dips at moderate angles (30 to 45 degrees) to the northeast whereas the southwest limb dips steeply northeast. The structure of the southwestern part of the belt is more complex and not understood.

The unit in most places represents the amphibolite-facies metamorphic grade. Garnetiferous rocks are common, whereas sillimanite-bearing rocks are rare and scattered but seem to be restricted mainly to a narrow zone along the contact of the apparent base of the unit with plutonic rock on the southwest limb of the antiformal structure. Sillimanite, however, was also observed on the northeasterly limb in Emsley Cove (Kitimat Arm).

The age of unit 1 is not known but it grades into overlying unit 2, and is, in part at least, the altered equivalent of the lower part of unit 2. If the tentative correlation of unit 2 with a sequence in the Whitesail Lake map-area from which probable Permian fossils were collected is correct, unit 1 may comprise chiefly pre-Permian strata.

Unit 1 is a variable complex and as generalizations fail to convey an adequate picture at any one place the main areas of its occurrence are described separately.

Northwest of Douglas Channel

The dominant rock in this area is a gneissic quartz diorite, but the unit is characterized by numerous screens of fine-grained rusty gneiss and schist which show perfect gradation into the plutonic rock (*see* Fig. 1). The less granitoid phase is dominated by hornblende-biotite gneiss and schist that are commonly banded and garnetiferous. Less common are marble and skarn beds. On the ridge about 3 miles west of Foch Lake is a 300-foot-thick bed of thinly layered white marble, that is similar to that on Marmor Peak in the southeast corner of Douglas Channel map-area. The skarn beds are characterized by garnet, epidote and diopside, and range from fine- to coarse-grained.

Near the unnamed falls on the northwest side of Douglas Channel opposite Grant Point an assemblage of mica schist, quartzite, and amphibolite-biotite-garnet schist of unit 2 is in vertical conformable contact with gneissic quartz diorite containing numerous layers of biotite schist (unit 1). Inland, northwest of Douglas Channel, the contact is difficult to locate as it is a zone of *lit-par-lit* migmatite of the metasediments of unit 2 and the more granitoid unit 1.

Sillimanite-garnet-quartz-hornblende schist (and gneiss) was observed at several places on the ridge south of peak 5760', about six miles north of Johnston Lake.

The rocks trend slightly north of west along the northwest side of Douglas Channel but trend anomalously northeast along the east side of the northern part of Foch Lake and on the ridge to the east. From Foch Lake northwesterly, trends are more or less consistently northwest. Moderate to steep dips to the northeast prevail and give the impression that unit 2 underlies the plutonic rock to the east. As the metamorphic grade increases generally to the northeast, overturning of the strata to the southwest is implied. This requires, however, a narrow zone of sharp flexure as no westerly dips were recorded. Other explanations are possible, as tight to isoclinal folding (*see* Fig. 2) is known to be present locally and may be widespread. A number of small drag folds display axial plunges of 45 to 75 degrees to the northwest and suggest upward and northerly movement of the terrain lying to the northeast. This left-hand sense of movement is reflected also by the Hawkesbury Warp.

Figure 1.

Irregularly layered gneiss on ridge west of Gilttoyees Inlet. Much of the dark phase has a granitoid character. (GSC 119832)

Figure 2.

Tight antiform in banded gneiss (unit 1) on ridge about 2 miles south-east of Johnston Lake. (GSC 119784)

Between Devastation Channel and Europa Reach

The main rock types include banded hornblende (± biotite) schist and gneiss, leucocratic fine- to medium-grained quartz-feldspar schist and gneiss, graphitic schist, irregularly layered gneiss, garnet-biotite schist, and garnet-staurolite-kyanite schist and gneiss. Along the northeast side of Alan Reach an average assortment would be contorted, nebulitic, gneissic quartz diorite (40 per cent), contorted migmatitic gneiss (20 per cent), banded and irregularly layered gneiss (20 per cent), hornblendic schist and gneiss (10 per cent) and aplitic and pegmatitic veining. The ridges southwest of the lower part of Owyacumish Creek are underlain by irregularly layered and veined gneiss which consists mainly of hornblende and biotite schist with intercalated feldspathic layers ranging in width from less than one millimetre to several inches. In most parts of this area the dark component predominates. In places the rocks have a regular trend (*see* Fig. 3) but elsewhere they exhibit a striking fluidal deformation (*see* Figs. 4 and 5). The gneiss in this area resembles part of the Kemano Gneiss described by Stuart (1960) about 20 miles to the east and is almost certainly correlative with it. Stringers and pods of epidote (*see* Fig. 6) which appear here and there in the hornblende schist component of the gneiss are of interest in that they appear to be older than the feldspathization of the rock. The pods especially are more resistant to granitization than the schist, and survive as knots in the plutonic rock commonly with small shreds of schist adhering to them.

Garnet-sillimanite-biotite schist is present in the narrow band of unit 1 about 4 miles east of Crab Lake. Minor banded limestone and diopsidic skarn appear in the complex of schist and gneiss on Rix Island.

Opposite Allen Point at the west end of Europa Reach a band of rusty metasediments (finely banded hornblende schist, biotite schist, quartz-feldspar schist and minor 1- to 2-inch-wide bands of limestone) belonging to map-unit 2a separate unit 1 from quartz diorite to the east. These metasediments grade into the migmatitic complex of unit 1, but have a sharp contact with the quartz diorite.

The dominant trend swings from slighly north of west along the east side of Devastation Channel to northwesterly, southeast of Crab Lake. An "S"-shaped kink (part of the Hawkesbury Warp) in the structural trend noticeable along the eastern part of Crab Lake where north to northeast strikes prevail may be related to the enlarged southeastern end of the granodiorite body (unit 9c) east of Crab Lake. Most of the strata dip southwesterly, the main exception being the eastern part of Crab Lake where most dips are to the west or northwest. Along the north side of Alan Reach, and especially around Shearwater Point, unusually shallow dips (15 to 35 degrees) to the south suggest an open southwesterly-trending synform to the south and an open antiform to the north. Southerly plunging drag folds (30 to 50 degrees) were observed east of Crab Lake and southeast of Shearwater Point, but those north of Crab Lake plunge steeply (70 degrees) northwest, and those on the east side of Devastation Channel plunge moderately (45 to 70 degrees) to the west.

South of Alan Reach

Unit 1 extends south of Alan Reach and underlies much of the drainage basin of Kiltuish River, but its limits there are uncertain because of its dominantly granitoid character. Although mainly granitoid the unit is characterized by numerous rusty screens and border zones of schist, gneisses, and complex agmatites. The plutonic component is mainly a medium- to coarse-grained hornblende>biotite quartz diorite locally bearing sphene and epidote, and is almost everywhere foliated. Along the west shore of Kiltuish Inlet and on the ridge to the west is an unmapped, poorly defined, northerly trending zone of fine- to medium-grained quartz monzonite, related probably to the larger bodies south of the head of Kiltuish River.

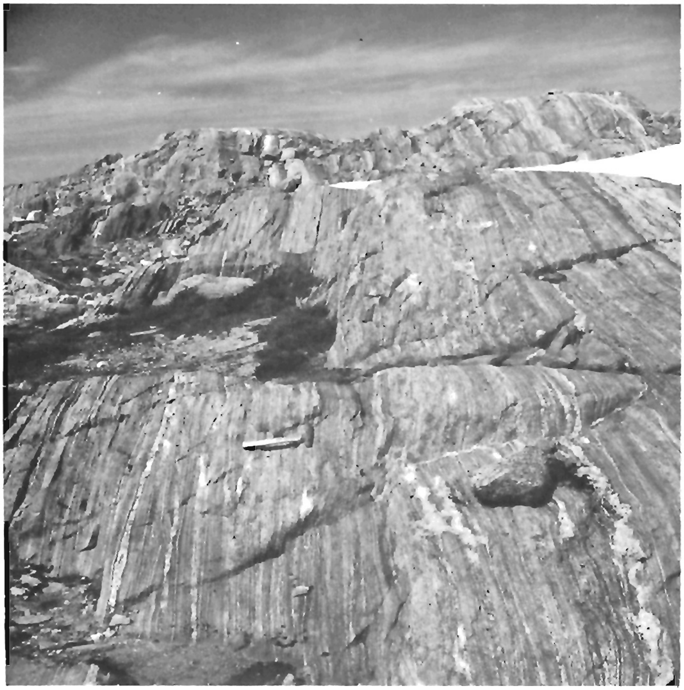

Figure 3.

Banded gneiss (unit 1) on ridge west of lower Owyacumish Creek. (GSC 119827)

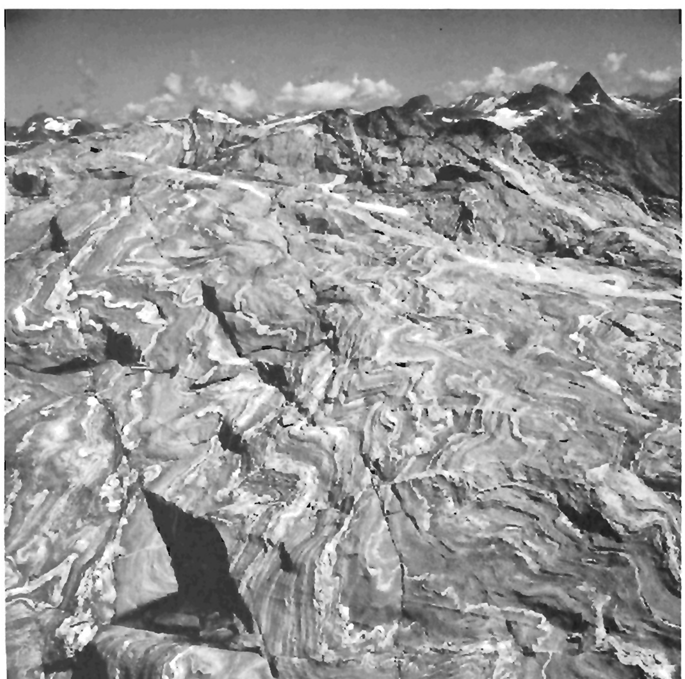

Figure 4.

Contorted veined gneiss (unit 1) on ridge west of lower Owyacumish Creek. (GSC 119788)

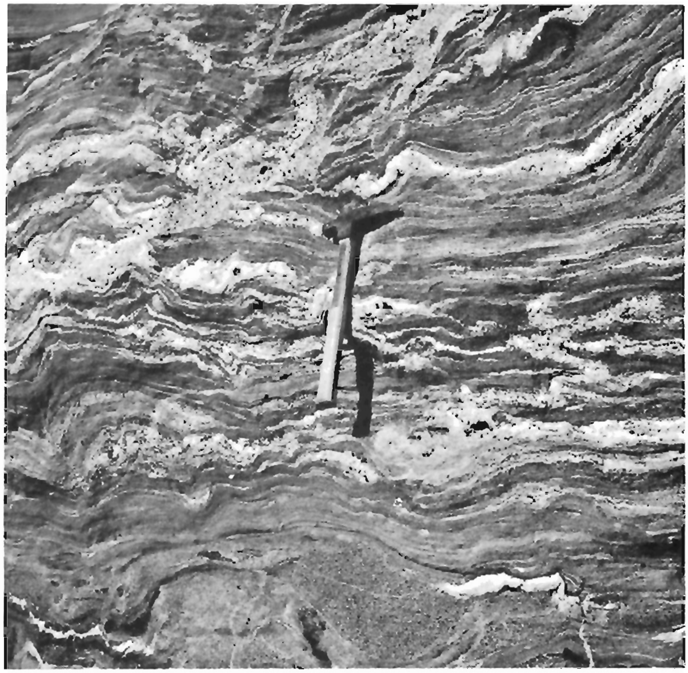

Figure 5.

Veined gneiss (unit 1) on ridge west of lower Owyacumish Creek. (GSC 119785)

Figure 6.

Large epidote knot in an unreplaced remnant of schist in a matrix of gneissic quartz diorite (unit 1), west of mouth of Owyacumish Creek. (GSC 119826)

Figure 7. Angular agmatite at contact between hornblende> biotite quartz diorite (unit 8b) and amphibolite (unit 1), west of head of Kiltuish River. (GSC 119768)

West of Kiltuish Inlet and Kiltuish River the nongranitic component of the unit includes in order of decreasing abundance, (1) hornblende-biotite schist, (2) biotite schist, (3) banded gneiss, (4) amphibolitic and quartzitic bands, (5) thin layers of marble and diopsidic skarn, and (6) anastomosing quartzofeldspathic veins. In most places these rocks form abundant rusty zones and screens in the quartz diorite but locally they form spectacular angular agmatite, as on the ridge south of the head of Kiltuish River (*see* Fig. 7).

East of Kiltuish Inlet and Kiltuish River the rocks are similar but areas of agmatitic fluidal gneiss are more common. The eastern margin of the unit is characterized by schists that contain abundant garnet, and commonly sillimanite. It should be emphasized that screens of schist in the quartz diorite on the east bear garnet and sillimanite, whereas screens apparently similar in composition in the quartz diorite on the west do not. The garnet and sillimanite do not appear to be the products of contact metamorphism but represent a high grade of metamorphism reached prior to the formation of the plutonic rock. In both east and west parts of the unit innumerable examples of regular gradations into the quartz diorite both along and across strike may be observed. On the west side of the northern part of 'Europa Lake' small elongated vuggy inclusions containing abundant garnet were noted in the quartz diorite, which is itself garnetiferous.

Map-unit 1 is interrupted northeast of Head Lake by a quartz monzonite body (10a) but is well developed to the southeast where it outcrops over a width of almost 6 miles in the vicinity of Marmor Peak. Within this belt is a thick coarse marble unit (2c) that is thought to be the same carbonate member that appears within unit 2a on Kumealon Inlet near the north end of Grenville Channel. If the correlation is correct, unit 1 in the vicinity of Marmor Peak is partly granitized unit 2a. The rock at the western contact of the marble consists of several hundred feet of hornblende- and epidote-rich gneissic skarn, flanked by garnet-bearing schists, gneisses and hornblende-plagioclase amphibolites. Quartz-mica schist, biotite-garnet schist, and quartz-hornblende-biotite schist are most abundant. Some garnet-sillimanite schist was observed in float but not in outcrop. The rock of the eastern contact consists of hornblende-biotite-quartz-garnet schist that becomes more gneissic farther east, and contains up to 20 per cent boudinaged and contorted quartz veins near the contact with a hornblende-chlorite diorite, which is a minor unmapped phase of the quartz diorite.

North of Marmor Peak the schist and gneisses of unit 1 appear to fray into narrow tapering rusty bands that disappear into hornblende>biotite quartz diorite. The contacts are gradational in some places and sharp in others. The schists are commonly garnetiferous, and in many places the plutonic rock is also garnetiferous. That the garnet in the quartz diorite has been derived from the schists is evident in many outcrops where the schist grades into the plutonic rock. Fragments, swirls, and wisps of gneiss and schist form a migmatitic complex that has necessarily been much simplified on the map.

Two occurrences of sillimanite were noted northeast of Marmor Peak, further confirming the presence of a sillimanite zone along the eastern margin of this band of unit 1 throughout Douglas Channel map-area.

The western margin of unit 1 in the vicinity of Marmor Peak consists of a gross agmatite, made up of very large blocks, commonly exceeding 100 feet across, of biotite-hornblende schist and amphibolite in a quartz diorite matrix. This agmatite is best seen in cirque walls where it forms spectacular exposures.

Around Marmor Peak and to the south the beds strike slightly west of north and dip 55 to 80 degrees east. North of Marmor Peak the trends are variable and the structure evidently complex.

Gilttoyees Creek to east of Mussel River

The northeast belt of unit 1 extends from the head of Gilttoyees Creek to east of the head of Mussel River in the southeast corner of the map-area. From the northern border of the map-area to the vicinity of Falls River this belt forms the northeast limb of Foch Antiform with dips ranging from almost zero to about 30 degrees to the northeast, which, in this rugged terrain, account for the irregular western contact and outliers on the peaks west of it. The rocks consist of gross migmatite that includes quartz diorite, banded quartz-feldspar-biotite-hornblende gneiss, quartz-muscovite-biotite-feldspar gneiss, biotite-hornblende-quartz schist, buff-weathering crystalline limestone and skarn zones. The migmatitic form is commonly elongate agmatite, veined gneiss, *lit-par-lit* gneiss, or screen gneiss on all of which additional complexity is superposed by numerous stockworks of pegmatite and aplite. The granitoid component ranges from 30 to 70 per cent of this rock. Sillimanite was observed in rusty weathering feldspar-biotite gneiss in Emsley Cove near the northeastern contact, and, more centrally, in garnet-biotite-quartz schist on the mountain west of the north end of Jesse Lake. Although irregular the southwestern contact is distinct enough to be observed from the air, but not so the eastern contact which is arbitrarily placed where gneissic screens in the adjoining granodiorite (9b) become less abundant. From a distance the rocks in this vicinity have a stratiform appearance, the apparent 'up-section' sequence being hornblende>biotite quartz diorite (unit 8b), quartz diorite with abundant gneiss (8e), migmatites (1), and biotite>hornblende granodiorite (9b).

From Douglas Channel southeast to the vicinity of Kemano Bay, the mixture of gneiss and granitic rock, except for the larger plutons, could not be adequately differentiated by this rapid reconnaissance. In places the position of the contact is based on extrapolation from meagre data. The more complex areas are agmatitic, consisting of blocks of banded gneiss in a quartz dioritic or granodioritic matrix. Many of the gneiss blocks are highly granitized, but the less altered parts comprise layers of hornblende or biotite schist alternating with more feldspathic or quartzose layers. Even in the clearer areas, the granitic rock is commonly gneissic and contains screens of schist and fine-grained gneiss. In Kildala Arm where veined and banded gneiss dominate, substantial beds of buff-weathering, faintly bedded crystalline limestone and minor skarn were observed especially along the south shore opposite the mouth of Dala River.

In the large region between Kildala Arm and Kemano River, the most abundant rock types are irregularly layered, veined and banded gneisses. Within the gneiss are layers of hornblende and/or biotite schist, amphibolite, and quartz-feldspar rock. In minor quantities are graphitic schist (near Powerline Pass) meta-arkose, quartzite, and quartz-sericite schist. On the ridges both north and south of 'Powerline Pass' garnet-bearing schist and fine-grained gneiss are common. Epidote is abundant in some of the amphibolite zones. Locally the gneisses are chloritized and commonly they are cut by aplitic stockworks. In places the aplitic material contains small garnets. On the ridge about 4 miles north of 'Powerline Pass' staurolite is present in biotite-garnet gneiss. In numerous areas the gneiss is nebulitic and passes into gneissic granodiorite.

The general northwest trend of unit 1 is interrupted by the easterly trends of the Hawkesbury Warp south of Kaldala River. Anomalous northerly trends were observed on the ridges east of Falls River and northeasterly trends southeast of the upper part of Kildala River. In most places the strata dips moderately (30 to 50 degrees) to the northeast, or north. Very gentle dips west of Falls River contrast with vertical foliation in the granodiorite at the head of Falls River.

Map-unit 1a

The southwestern part of Maitland Island and the adjacent part of Hawkesbury Island are underlain mainly by complex agmatite which at the southwestern tip of Maitland Island consists of six main phases that were examined and described as follows by J.G. Souther (unpublished data).

(1) Garnet-bearing, biotite augen-gneiss. This rock is not layered but has a well defined foliation formed by parallel elongated clusters of biotite and wavy lenses of feldspar augen. The gneiss forms angular, commonly rotated blocks that locally contain bands and blocks of epidote-pyroxene rock (probably derived from limestone) and are enveloped in other places.

(2) Fine-grained, medium grey aplite cuts phase 1.

(3) Basic dykes cut both the above, but now occur as disjointed rectangular inclusions arranged in streams oriented in several directions. These inclusions are locally rotated with respect to one another in phase 4.

(4) All the above phases are enclosed and cut by garnetiferous biotite> hornblende granodiorite which forms about 30 per cent of the rock. Contacts with the older phases are sharp.

(5) Fine-grained, white, garnetiferous aplite form discrete veins that commonly well out into large bodies (more than 100 feet across) containing blocks of all the above phases and combinations of those phases.

(6) Aplite and leucocratic pegmatite form straight cross-cutting veins with parallel margins.'

Also present but not really a part of the agmatite are young basalt dykes with fine-grained chilled margins.

The proportion of the phases varies considerably from place to place. Other outcrops, for example, consist mainly of augen-gneiss (1) cut by garnetiferous aplite (5) and aplite and pegmatite (6), or mainly garnetiferous aplite (5) enclosing blocks of garnet-epidote granodiorite (4).

The variable trends indicate complex structure. The dominant attitude is slightly north of west with moderate southerly dips, but vertical and even northerly dips are not uncommon.

Map-unit 2

The assemblage of mainly metasedimentary rocks that forms map-unit 2 includes hornblende-plagioclase amphibolite schist, with lesser amounts of quartzite, crystalline limestone, migmatite and granitoid rocks. It forms the main central belt of metasedimentary rocks in the Coast Mountains. In the map-area the chief belt of these rocks extends from the north border of the map-area east of Ecstall River, where it is about 7 miles wide, to Hawkesbury Island where it is about 17 miles wide. The second major occurrence flanks the northeast side of the northwestern part of Grenville Channel and underlies the eastern part of Porcher Island. A facies (2b) characterized by micaceous quartzite outcrops in Princess Royal Channel and forms small bodies southwest of Grenville and Princess Royal Channels. Nowhere in the map-area is the structure simple enough to establish a section of these rocks. Consequently it is not known whether the more arenaceous character of the metasediments in the west in contrast to the pelitic character of those in the central belt is the result of a facies change or different stratigraphic levels.

Although the rocks are locally contorted, the prevailing attitude is a northwest trend with steep easterly dips. The main central belt forms part of the western limb of Foch Antiform referred to in the description of unit 1.

Unit 2a grades downward into unit 1 on the west limb of Foch Antiform and also grades into unit 1 along strike across Devastation Channel. Contacts with plutonic rock are commonly sharp, but locally gradational, and in places faulted.

Most of unit 2 falls in the almandine-amphibolite subfacies but on Hawkesbury Island some of the rocks belong to the sillimanite-almandine subfacies. In general the metamorphic grade of unit 2 is the same as unit 1 but the latter is much more granitoid.

The lack of fossils and critical structural relations in the map-area make it difficult to establish the age of unit 2. In Whitesail Lake map-area to the east P.B. Read (1963) collected fossils from a dark grey, massive argillaceous limestone which were examined by E.W. Bamber of the Geological Survey whose report follows:

Field No. S-1962-2-TD G.S.C. loc. 46826

Stenopora sp.

Age: *Stenopora* ranges from Mississippian to Permian. This specimen is similar to Permian species described from southwestern British Columbia.

Caninia sp.

Age: This appears to be the same species as that described as *Caninia* sp. by S. Smith from the Similkameen District of B.C. Smith gives the age of his coral as "Upper Carboniferous or (more probably) Permian", basing his age determination on other corals in the collection.

These collections (46826) are Carboniferous or Permian in age and are more likely to be Permian than Carboniferous.

Field No. S-1961-1-TD G.S.C. loc. 46825

Fenestellid Bryozoa
Age: Probably Carboniferous or Permian.

The fossiliferous limestone and associated tuffaceous shale, slate, greywacke, and sandstone of the Whitesail Lake map-area are possibly unmetamorphosed equivalents of part of unit 2 (the limestone being correlated with 2c or 2d). Although the correlation is by no means certain, unit 2 is tentatively assigned to the Permian (?). Weak support for this conclusion lies in the similarity in appearance of some of the banded quartzites on the western islands with the typical ribbon cherts of the Cache Creek Group. It is possible to construct an opposing case by correlating the magnetite-bearing crystalline limestone that outcrops on the northeast side of the northern part of Grenville Channel and on the west side of Porcher Island with the similarly magnetite-bearing Quatsino Limestone and its equivalents of Upper Triassic age, but this correlation disregards the great thickness of pelitic rocks that are associated with the limestone of unit 2 but not with known Upper Triassic rocks of the coastal region.

Map-unit 2a

Hawkesbury Island: The most abundant rocks in the unit are amphibolite and schist, both of which consist mainly of plagioclase, hornblende and biotite in varying proportions. In outcrop, these rocks are dark grey or rusty reddish brown, with common but not very distinct banding. Foliation is weak especially where the rocks contain little biotite. Less common rocks include biotite schist (garnet-bearing in places), kyanite-staurolite-almandine mica schist, sericite-epidote schist, fine-grained sillimanite-quartz-plagioclase gneiss, graphitic plagioclase schists, quartzite and crystalline limestone. Most of the original rocks were pelitic sediments, probably partly tuffaceous. The unit is riddled with irregular granitoid areas that consist of medium-grained quartz-feldspar gneiss, *lit-par-lit* gneiss, agmatite and rarely homogeneous quartz diorite or granodiorite.

On the west side of Hawkesbury Island unit 2a grades into the quartz diorite (8b) underlying the southern part of the island through a complex zone of agmatite and *lit-par-lit* migmatite which extends about a mile along the shore but is probably only several hundred feet wide. On the east side, biotite-hornblende schists display a sharp contact with granodiorite (9c) which in turn grades into the quartz diorite (8b). Near the northern end of the island banded schist and fine-grained gneiss grade into foliated agmatite (1a).

The general trend of unit 2a is about N15°W but across Hawkesbury Island, it is about N60°W. This flexure, the Hawkesbury Warp, resembles a large dragfold. A number of small northwest-trending faults displaying left-hand offsets that were observed by P.L. Money (1959) are compatible with this concept. The structure, however, is not compatible with dragging caused by a counter-clockwise rotation of the Pacific Ocean Basin (White, 1959, p. 60). If not a drag structure the Hawkesbury Warp may be related in some way to the circular area of basic plutonic rock centred on Gil Island. A gravity map by R.A. Stacey and L.E. Stephens (1969) of the Observatories Branch clearly shows the Hawkesbury Warp but not the Gil Island basic area.

The grade of metamorphism reached by map-unit 2a on Hawkesbury Island appears to be the staurolite-quartz and kyanite-muscovite-quartz grades of the almandine-amphibolite subfacies. Sillimanite, observed near the mouth of the creek draining the northernmost lake on Hawkesbury Island, indicates local higher metamorphic grades. Very little effect there can be attributed to contact metamorphism.

Ecstall Mine area: Between the mine (about 2 miles west of Johnston Lake) and the north edge of the map-area unit 1 varies from 7 to 9 miles in width. The west boundary, against quartz diorite and granodiorite is sharp, but the east boundary is gradational and arbitrarily located. The latter contact is a complex migmatitic zone up to 3 miles wide, characterized by numerous screens of garnetiferous gneiss and schist in a gneissic quartz diorite (unit 1).

Most of the rock consists of well foliated, fine- to medium-grained combinations of plagioclase, hornblende and biotite yielding various types of amphibolite and schist. In minor quantities are layers of chlorite schist, chlorite-quartz schist, argillite, graphitic schists, quartzite, "salt and pepper greywacke", conglomerate, schistose skarns containing diopside, scapolite, zoisite and calcite. Of some value as indicators of metamorphic grade are rare occurrences of biotite-garnet-kyanite schist. These rocks, belonging to the almandine amphibolite subfacies (medium to rather high metamorphic grade), are found mainly north of Big Falls Creek. To the south low- to medium-grade rocks of the greenschist facies are more common.

The main trend of the rocks is about N15^{o}W in the Ecstall Mine area, but about N45^{o}W near Johnston Lake. The dips are steep to the northeast as far north as Big Falls Creek, north of which closed folds (a syncline flanked by two anticlines) with vertical axial planes appear to be present. Common in the area are small folds with crests 1 foot to 20 feet apart and vertical to 60-degree south-plunging axes. Small northwest-trending shear zones are numerous and most show left-hand displacement (Read, 1958).

Near the western contact unit 2a varies considerably from north to south. On the ridge northwest of Johnston Lake leucocratic granitoid gneiss and fine-grained thinly laminated grey gneiss, intercalated with dark schist bands and rare skarn layers, dominate unit 2a up to the contact. Rare sill-like granodiorite layers were observed near the contact. Farther south, on the ridge northeast of Gavel Lake, granodiorite of the Ecstall Pluton is in sharp vertical contact with light grey weathering thinly bedded quartzite with 1/2 inch alternating bands of biotite schist. The quartzitic rocks form a band about 2,000 feet wide grading into schists to the east. As the limits along strike of the quartzite are not known the rock is included with unit 2a but it more properly belongs in unit 2b. As it cuts different members of unit 2a from place to place, the contact is regionally discordant but apparently concordant in detail.

Moderate to steep easterly dips dominate the eastern part of the belt. The increase in regional metamorphic grade (based mainly on the increasing abundance of biotite-garnet-schist and sillimanite schist) towards the east suggests that the sequence is overturned. Numerous small dragfolds have axes plunging 50 to 70 degrees NNW and NW and are shaped so as to indicate a relative upward and northerly movement of the terrain to the east, that is, left-hand movement.

Fossil remains of indeterminate character were found in the central part of the metasedimentary belt.

Gribbell Island: A remarkable long narrow screen of fine- to medium-grained banded gneiss roughly bisects the northern end of Gribbell Island (*see* Fig. 8). The screen is only about 700 feet wide but more than 7 miles long. The dark layers consist of hornblende>biotite schist, and the light layers consist mainly of plagioclase with variable amounts of quartz and minor amounts of hornblende and biotite. The layers range in width from a fraction of an inch to about 2 feet. Except along the southern part of its western side the screen is in contact with clean massive granodiorite (unit 9c). The contacts with granodiorite are sharp and nearly vertical where examined. The contact with the quartz diorite (8b) on the southwest side was not observed. The trend of the layers is surprisingly consistent. In view of the extreme length to width ratio of the screen it is necessarily a comparatively delicate structure yet much less deformed by the emplacement of the adjacent plutonic rocks than would be expected.

Figure 8. Screen of banded gneiss (unit 1) in granodiorite (unit 9c) on north end of Gribbell Island. (GSC 119831)

Grenville Channel: The metasedimentary rocks on the east side of the northern part of Grenville Channel resemble those in the Ecstall belt. As there, the grain size and apparent metamorphic grade increases to the east, but only slightly, and fails to reach the grade attained on the east side of the Ecstall Pluton. The rock consists mainly of rusty weathering, thinly laminated schist and amphibolite with minor limestone, conglomerate, quartzite and slate. The sequence from west to east in the vicinity of Kumealon Inlet includes the following:

1) black biotite-quartz-feldspar-chlorite schist, massive except for feldspathized zones and stringers. This rock contains some epidote pods and pyritization.

2) amphibolitic schist, dioritic in places, and locally garnetiferous.

3) stretched pebble-conglomerate containing granitic clasts up to 10 inches across with 1:2:3 dimension ratio in a quartz-biotite-feldspar schist matrix.

4) very fine grained schist (biotite) that preserves some original bedding features.

5) one thick generally massive bed of coarse grey crystalline limestone (unit 2c) that has in places a strong petroliferous odour. It is about 1,700 feet thick. At one place where the limestone is banded, it is brecciated and cemented with calcite. The banded limestone blocks are clearly rotated.

6) dark greenstone schist that is dioritized in places.

7) finely laminated hornblende-biotite-feldspar schist.

8) phyllitic schist with fine garnets and a slaty fracture at the contact with a leucocratic phase of the granodiorite of the Ecstall Pluton.

The outcrop width is more than 20,000 feet. Although some of the beds are locally tightly folded the major units are not repeated. On this basis the total thickness of the unit probably exceeds 10,000 feet. The crystalline limestone is similar to that on Marmor Peak in the southeast corner of the map-area. There, however, it is coarse and thicker, and associated with more highly metamorphosed rocks that have been mapped as unit 1. If the two carbonates are the same member much of unit 1 between Devastation Channel and Mussel River is the metamorphic equivalent of unit 2a.

Between Baker Inlet and Kumealon Inlet, the conglomerate mentioned above is strongly deformed. The bed ranges from 20 to 100 feet thick and the pebbles are extremely flattened and drawn out - in places to pencil-like shapes, striking northwesterly and plunging about 10 degrees. About 25 per cent of the pebbles appear to consist of granodiorite.

The rock trends more or less parallel with the shoreline. Northwest of Kumealon Inlet steep westerly to vertical dips prevail. In the western part of Baker Inlet the rocks dip moderately to the west and in the eastern part they dip moderately to the east or are vertical, but no simple anticline is present.

Porcher Island: A comparatively wide belt of stratified rocks underlies the eastern part of Porcher Island. Along Ogden Channel the belt is bordered on the southwest by a biotite gneiss containing garnet and epidote that forms a complex border zone of unit 10d. The biotite is strongly smeared out. The actual contact is in a creek and not exposed, but the adjoining part of unit 2a is grey and white, thinly laminated schist mixed with fine-grained granodioritic material. Except for a few minor dragfolds the strata are not deformed. Between the contact and a small body of quartz diorite (8b) which underlies Peninsula Point the rock consists chiefly of dark green and blackish sediments, well-bedded quartzite, biotite schist and minor limestone, but it also includes some plutonic material. At one place the chloritic sediments grade within about 100 yards through a *lit-par-lit* zone into coarse-grained diorite. At another place the quartzite grades into plastically deformed layers of diorite and biotite gneiss which reflect differences in original lithology. Although graded bedding indicating southwest facing tops was observed at one point, little significance may be attached to it, as isoclinal folding is probable. Near the quartz diorite dark sediments are interbedded with coarse-grained hornblendite and biotite schist, and contain zones and patches of epidote and a few marble lenses. The contact with the quartz diorite is intrusive. East of the quartz diorite the rock is mainly dark green to black metasediments, probably of volcanic derivation, with some quartzite, biotite schist and minor limestone. The eastern contact appears to be intrusive against coarse-grained gneissic diorite (3).

Map-unit 2b

A number of narrow bands of metasedimentary rocks lying mainly west of Grenville and Princess Royal Channels but including also some strata on the east side of the latter are characterized by abundant quartzite. These rocks are mapped as a separate unit although it is by no means certain that they form a valid unit.

Princess Royal Channel: The metasedimentary sequence here consists mainly of thin-bedded impure quartzite with interlayers of quartz-feldspar-biotite schist. Locally beds of marble and dark green waxy hornblende skarn were observed. The eastern and apparently upper part of the sequence is characterized by evenly bedded, flaggy, graded siltstone in which the primary bedding features are well preserved. On the south side of Khutze Inlet these features indicate that the beds are right side up and become younger eastward.

The metasedimentary sequence as a whole is rusty weathering, and here and there contains stringers of granitic material. Locally agmatitic zones were noted. Areas veined by granitic material in places exhibit biotite-hornblende-garnet schist layers but these are not extensively developed.

About 2 miles south of Griffin Point impure dark quartzites are cut by a network of aplitic material that contains about 5 per cent hornblende crystals which are everywhere aligned strictly parallel with the bedding of the quartzite even in veins which cut sharply across the bedding. Blocks of quartzite isolated by the vein material are not rotated but remain aligned.

The eastern contact is difficult to locate. Near it lenses of feldspathic material 1/2 inch to 2 inches thick in the metasediments become more abundant. The rock gradually becomes more dioritic forming an elongate agmatite with concordant inclusions and numerous screens, and finally passes into a well-foliated, very heterogeneous diorite. The western contact lies beneath sea level in Princess Royal Channel.

North of Butedale, on Work Island, the metasedimentary sequence consists mainly of thinly layered, biotite-quartz schist with considerable intercalated marble near the western end. Garnet was also observed there in some of the schist beds.

The rock forming the peninsula between Princess Royal Channel and Klekane Inlet is similar to that on Work Island, but also contains dark impure quartzite and black hornfelsic siltstone.

A narrow band of metasediments is exposed on the southwest shore of Princess Royal Channel between Butedale and Redcliff Point. It consists of rusty weathering quartzite, thinly laminated (varve-like) silty limestone, interbedded conglomerate, sandstone, and argillite. Some of these rocks seem to be only moderately indurated and not greatly folded. The conglomerate contains granitic boulders up to about 8 inches across. In places the clasts have been deformed producing elongate shapes with 1:1:4 dimensions. Although the lineation is regular and strong, the conglomeratic nature of the rock is preserved. Interbedded with the conglomerate is a thinly laminated, well-banded sandstone exhibiting on some of the sea cliffs isoclinal folds of 6 to 8 feet amplitude. The weathered surface of the sandstone is pitted in a manner suggesting the presence of limestone clasts.

The quartzite beds are thinly laminated in most places, rusty weathering, locally conglomeratic and interbedded with 1- to 2-foot bands of limestone. Impure layers contain phlogopite but no garnet. At the contact with *schlieren*-laden granodiorite to the west the quartzite and limestone beds are intensely deformed, and strongly lineated with tabular streaks of granitic material along minor fold axes. The western contact is sharper and less complex, and the metasedimentary rocks are less metamorphosed than at the eastern contact exposed on Khutze Inlet.

Gil Island: Rocks of map-unit 2b outcrop on the south and east shore of Gil Island. The two occurrences are probably separate, but as only sparse data are available from the interior of the island, the possibility that they are connected is not eliminated.

The main metasedimentary occurrences on the south side of Gil Island is that on Fawcett Point. It consists mainly of rusty weathering, flaggy, well-bedded dark grey quartzite with intercalated beds of crystalline limestone, skarn and garnet-biotite schist. Thick competent beds of quartzite alternate with thin-bedded quartzite containing calcareous partings. The thin-bedded quartzite and limy bands commonly exhibit minor folds that do not appear in the thicker beds. The axes of the minor folds plunge steeply, almost down dip. The skarn bands are characterized by epidote and garnet. Calcareous layers vary from thin partings to beds several feet thick. One 100-foot-wide white crystalline limestone bed and a wider zone of ribbon limestone were recorded. In places the metasediments are dioritized, mostly along zones parallel with the bedding.

On the east side of Gil Island, both north and south of Shrub Point, the metasedimentary series is made up mainly of garnet-biotite schist with lesser amounts of quartzite, crystalline limestone, chert, and breccia (containing greywacke and epidote-garnet skarn). The series is well bedded in most places. Dioritization of the sediments is evident here and there. Areas of agmatite and substantial bodies of coarse-grained diorite within the dominantly sedimentary area were observed.

Although locally contorted the beds on the south side of Gil Island have a general northerly strike and a moderate to steep easterly dip. The attitudes in the metasedimentary rocks on the east side of Gil Island are consistent for short distances only and no prevailing trend is evident.

Islands of the Estevan Group: On this cluster of islands, which lies southeast of Banks Island, strata of map-unit 2b are mainly along the shore. The most abundant rocks are a well-bedded series of intercalated quartzite and marble. Most of the beds are 1 inch to 2 inches thick. In places the marble has flowed plastically and broken up the included quartzite beds. Quartzite and marble are present on the northern end of Dewdney Island but there they appear less metamorphosed than elsewhere on the Estevan Group.

On the northwest side of Trutch Island, paragneiss is locally more abundant than either quartzite or marble. This sequence also contains interlayers of diorite which have been clearly derived from the metasedimentary sequence. Paragneiss and amphibolite also appears intercalated with the quartzite and marble on the northeast shore of Lotbinière Island.

Both sharp and gradational contacts were observed. The contact between the sequence of paragneiss, quartzite and marble on the northwest end of Trutch Island and diorite (5b) is gradational through a broad migmatitic zone (more than 1,000 feet wide). Granitic material gradually becomes more common in the metasediments, then dominant, and finally comparatively free of inclusions. A similar migmatitic contact appears on the east side of Prior Island and extends along the northeast side of Lotbinière Island. In contrast the contact on the northern part of Dewdney Island between quartzite and quartz diorite (8b) is sharp although schlieren and inclusions (mainly amphibolite but some quartzite) in the plutonic rock are more abundant near the contact. The predominance of amphibolite inclusions suggests that the inclusions come mainly from a deeper level rather than from the exposed metasedimentary strata of the wall-rock.

Banks Island: On the south end of Banks Island map-unit 2b is exposed in Calamity Bay, where it consists of interbedded quartzite, crystalline sandy limestone and slate. The quartzite is commonly cherty and has regular 1/4 to 1 inch layers alternating with finely laminated material. In places the layering has been beautifully etched by wave action. Although the strata may appear relatively undeformed, isoclinal folds of 6- to 10-foot amplitude are common. Near the contact contortion of the metasediments is pronounced. The contact itself is sharp in places and agmatitic in others. The dioritic rock exhibits a jumble of textures ranging from very fine grained to pegmatitic. The same metasedimentary strata outcrop again on the shore about a mile east of Calamity Bay.

On the west coast of Banks Island, south of Grief Point, unit 2b comprises a locally more highly metamorphosed sequence that includes garnet-bearing, biotite-quartz schist. Some of the garnet crystals range up to 1 inch in length but they are strongly flattened and drawn out parallel with the bedding. Most of the rock is regularly bedded argillaceous quartzite that looks relatively unmetamorphosed yet contains well-developed, fine-grained, biotite-rich layers in which garnet is abundant. Near the contact the sediments are dioritized, and agmatitic zones are common.

On the east side of Banks Island, in the vicinity of Keecha Point, the metasedimentary sequence consists mainly of interbedded argillaceous quartzite and limestone, all very thinly bedded. Isoclinal folding with plastic flowage of the carbonate is evident. The same rocks outcrop south of Gale Point, where sinuous quartzite fragments are found 'floating' in the limestone. In places, the limestone bedding, instead of flowing around the quartzite fragments is curiously truncated against them. In this area also, are skarn zones containing some molybdenite.

The substantial muskeg area that covers the central part of the north end of Banks Island separates rocks of unit 2c from those of unit 2b outcropping on the north side of Kingkown Inlet. Although more or less on strike with those to the north the Kingkown Inlet series is less calcareous. It consists mainly (about 80 per cent) of partly laminated impure quartzite beds 1 foot to 2 feet thick, and biotite schist. Abundant aplitic material was observed in the metasediments. The beds in the central part of the outcrop area are flat, but both flanks have shallow to moderate dips to the northeast. The metasediments do not cross the wider part of Kingkown Inlet but swing eastward into a migmatitic zone bordering the narrow eastward extension of the inlet.

At the west end of Kingkown Lake are outcrops of interbedded quartzite, marble, and amphibolite. In the marble, knots of garnet and quartz form discontinuous layers. At one point a 15-foot-wide quartz vein containing chalcopyrite was recorded.

North of Kelp Point on the west side of Banks Island is a narrow strip of metasediments, chiefly biotite schist. Although lacking the characteristic quartzite of unit 2b, these metasediments are mapped as such because other remnants of unit 2b outcrop on Banks Island both to the northwest and to the southeast. The quartzite presumably lies just offshore. The contact with granodiorite (9c) exhibits some *lit-par-lit* structure. Where exposed at the northern end of the schists the contact is highly sheared parallel with the foliation in the plutonic rock. The granodiorite itself is also considerably sheared and shattered, possibly because of a major fault west of the island. A number of small displacements on minor northwest-trending shears indicate general left-hand movement.

Pitt Island: Between Lundy Cove and Oar Point on the west side of Pitt Island is a narrow strip of metasedimentary rock comprised mainly of banded quartzite and micaceous quartz-feldspar rock that locally has the character of a fine-grained quartz diorite, and rare beds of biotite schist. In places the thin, white (1 inch to 2 inches) quartzite layers in wider dark micaceous layers give the rock the appearance of striped candy. This sequence contains no limestone. In most places the beds are wavy and not greatly deformed, but locally they are extremely contorted, commonly about vertical axes. The metasediments are cut by a few dykes of fine-grained quartz diorite, possibly related but different in appearance to the larger body of quartz diorite to the east. The contact of the metasediments with the main quartz diorite mass is sharply and locally crosscutting. In places the metasediments at the contact are slightly brecciated.

Another thin strip of metasediments, dominantly well-bedded quartzite, commonly cherty, in places interbedded with crystalline limestone outcrops along the southeast shore of Anger Island and on the small islands adjacent. Complex areas that are mainly a mixture of quartzite and pegmatitic diorite appear here and there in the metasedimentary strip, particularly on the offshore islands.

McCauley Island to Goschen Island: A long thin strip of metasediments extends about 25 miles from the sharp re-entrant of the shore south of Morrison Point on McCauley Island to the north end of Goschen Island. It consists mainly of fine-grained, thin-bedded, laminated, greenish grey quartzite interbedded with varying amounts of black slate (commonly graphitic), chloritic argillite probably volcanic-derived, ribbon chert, crystalline limestone and minor schistose material. The quartzite is argillaceous in many places. Skarn is present locally. A considerable amount of granitic material forms numerous lenses and layers in the metasedimentary rock. On Spicer Island feldspathization of the metasediments is common. On McCauley Island in the bay opposite Elbow Point (Pitt Island), schistose material forms broken and ruptured beds in a limestone-chert sequence. Severe crumpling, and dragfolding was observed in the limestone particularly on McCauley and Dolphin Islands, and intense shear-folding on Goschen Island.

The complex structure and possibly the preservation of the metasedimentary belt itself can be attributed to Kitkatla and parallel faults along or more commonly, near the belt. On Goschen Island, at the east end of Freeman Passage, the faulting has resulted in intensely sheared and broken granitic rock in which the mafic minerals especially have been strongly smeared out. There the metasedimentary rocks also are intensely sheared. Small boudins of both quartzite and plutonic rocks are found in a sheared gouge matrix. The fault zone extends southeast along the comparatively straight northeast shore of Goschen Island and crosses Dolphin and Spicer Islands. It does not pass directly across to McCauley Island, but is offset about a mile to the east. Another similar fault zone or an offset extension of Kitkatla Fault underlies the conspicuous lineament that extends from Connis Cove across McCauley Island to the bay south of Morrison Point.

Gurd Island: The rocks on Gurd Island are very dark and commonly massive. In some places their sedimentary character is not evident. The rock consists mainly of blackish weathering, dark grey quartzite here and there interbedded with buff weathering, brown limestone and light green-grey, well-laminated quartzite. Most of the limestone beds are 6 inches to 2 feet thick, although one bed about 100 feet wide was observed on the small island off the western corner of Gurd Island. On the north side of the island the metasediments are dioritized in places. The southern contact of these rocks with crystalline rock (5b) is sharp, planar and concordant. Although both rocks are foliated, no increase in shearing is evident at the contact, nor is there any reaction or transition zone. At the north end of the island the contact is not exposed but the crystalline rock is intensely sheared.

Porcher Island: The Gurd Island rocks extend to the inner side of Porcher Peninsula but those outcropping on the outer side between Oval Hill and Fan Point are somewhat different. There they consist mainly of banded, steel-grey quartzite, quartz-feldspar greywacke (?), chlorite schist, quartz-feldspar schist and hornblende schist. Also present are beds of epidote-chlorite rock (with quartz eyes) which in places is granular and may be sheared, altered diorite. Some zones resemble highly altered volcanic rock. The sequence on Porcher Peninsula is more distinctly bedded than that on Gurd Island.

Map-unit 2c

As mentioned in the description of unit 2a on Grenville Channel, a generally massive, coarsely crystalline limestone member (2c), about 1,700 feet thick, outcrops on Kumealon Inlet. The carbonate unit lies conformably within unit 2a, and on the inlet trends northwesterly with a dip of about 60 degrees southwest. The limestone could not be found intersecting either the shoreline to the northwest or Baker Inlet to the southeast, probably because of faulting in the intervening areas of poor outcrop. What appears to be the same limestone member transects Gibson Island at the north end of Grenville Channel.

Unit 2c on Marmor Peak in the southeastern corner of Douglas Channel map-area is coarser and thicker (about 3,000 feet) than on Kumealon Inlet but seems to be the same member more highly metamorphosed. The marble is grey and greyish buff weathering and thick bedded (5 to 10 feet). Intercalated with it and apparently increasing its outcrop width are numerous zones of quartz, commonly with chlorite, epidote and muscovite, and by some layers of diorite and dioritic gneiss. Narrow schistose, commonly boudinaged amphibolitic and skarn zones are also present. In addition an extensive stockwork of pegmatite cuts the marble. The marble exhibits many small folds with axial planes striking N20°E and dipping 30 to 60 degrees east and with directionally variable but steeply plunging axes. Although the carbonate on Marmor Peak is thought to be the same as that on Kumealon Inlet it is flanked by more granitoid metamorphic rocks (mapped as unit 1) that probably represent partly granitized unit 2 strata.

Map-unit 2d

This subdivision of unit 2 comprises several bodies having crystalline limestone as the dominant lithology that outcrop on Banks Island and one small occurrence on Dolphin Island.

The narrow band of metasedimentary rock that outcrops on the south shore of Dolphin Island is of a higher metamorphic grade than the main metasedimentary band (2b) to the east. It consists of thinly banded garnetiferous skarny limestone through which are scattered pea-sized garnet crystals.

At the north end of Banks Island, map-unit 2d outcrops in Deadman Inlet and along the shore for about two miles to the west. The metasediments consist mainly of thinly bedded limy and quartzose rocks. Limestone, quartzite, calcareous schist, hornblende schist and chloritic schist are the most common rock types. The eastern contact is a fault marked by intensely sheared quartz diorite (8b). Immediately west of the fault, the rock is a highly sheared agmatite consisting of fragments of hornblende schist and gneiss (two-thirds of the rock) in a granodiorite matrix (one-third). Although the entire agmatite is sheared, there are narrow zones of very intense shearing. The western contact is also agmatitic, but not sheared. It is made up of metasedimentary blocks in granodiorite (9c), and *lit-par-lit* zones. The contact complex is 250 to 300 feet wide.

On the northeast side of Banks Island, about 4 miles northwest of Colby Bay, crystalline limestone, banded and ribbon chert, and minor siltstone form a metasedimentary wedge in diorite (5b). Limestone, the most abundant lithology, appears to be of two types, one rose coloured and the other white. It is not known whether the colour variation can be accounted for by differences in extent of recrystallization alone, or whether primary compositional differences are responsible. Here and there diorite appears in the limestone as wavy lenses. Pyrite is common in the carbonate. The northeast contact is fairly sharp, but the diorite near it is foliated, heterogeneous and chloritized, and the limestone has recrystallized to a marble. The southwestern contact is nearly parallel with the shore for some distance and gives the impression of being complex as exposures of heterogeneous diorite and limestone alternate along the shore. The contact zone does not appear, however, to be more than a few tens of feet wide.

On the west coast in Waller Bay metasediments separate granodiorite (9c) and quartz diorite (8b). As at the north end of Banks Island crystalline limestone and calcareous sediments make up most of the section. Intercalated with these are beds of reddish weathering, biotite-bearing quartzite, white quartzite, micaceous and sericitic schist and minor greywacke. In most places both the crystalline limestone and quartzite are very impure. Some beds contain graded bedding that indicates west-facing tops, and as the beds dip moderately to steeply eastward, some overturning is also indicated. Locally the beds are highly contorted, in particular, the limestone. The more northerly of the two contacts exposed on the coast is sharp and crosscutting. The plutonic rock is aplitic, however, and not typical of the main granodiorite body. In the aplite are numerous inclusions of banded, commonly skarny limestone and quartzite. The southern contact is a reddish weathering agmatitic zone with a dioritic matrix.

Map-unit 3

This unit is restricted to Porcher Island and the north end of Pitt Island. It consists mainly of greenstone that commonly grades into a very fine grained diorite, and feldspar porphyry. The unit also contains minor amounts of chloritic schist, quartzite and amphibolite. Feldspathized zones, epidote stringers and nodules are common. In places the rock has been invaded by aplite, hornblende pegmatite, and quartz dioritic material that form agmatitic zones up to 500 feet wide. The aplite is locally garnetiferous. Young, unmetamorphosed basalt dykes cut the unit at many places.

On the east side of Porcher Inlet unit 3 grades into the underlying unit 2b. In the vicinity of the entrance to Salt Lagoon (most of which lies north of the map-area on Porcher Island) a zone of highly sheared granodiorite, quartz diorite and biotite-garnet gneiss (9d) separates unit 3 from unit 2a.

Map-unit 4 (Hazelton Group)

Recognizable Hazelton Group forms a northwesterly-trending belt about 3 miles wide extending from Dahlaks Creek to the northeast corner of the map-area. On the ridge west of Atna Peak the group consists of about 11,000 feet of metasediments and greenstone. The rocks are chloritized and epidotized, and show other features of the greenschist facies. Steep easterly dips prevail east of Atna Peak but to the west moderate northwesterly dips dominate.

The lower 4,000 feet include a conspicuous light grey weathering, siliceous tuff bed that is about 1,000 feet thick on the south side of Atna Peak. Most of it is very fine grained (0.03 mm) quartz and plagioclase, chlorite, actinolite, muscovite and minor apatite. Intercalated with the altered tuff are beds up to 10 feet thick of thinly laminated, calcareous, micaceous quartzite (average grain size 0.01 to 0.02 mm). Some layers contain about 40 per cent calcite and others about 40 per cent biotite and chlorite, and minor epidote. Except for epidote, lime-silicates have not formed. Near the top of the siliceous tuff are beds of pebble-conglomerate containing fragments of feldspar porphyry in a limy matrix. Beneath the siliceous tuff at the base of the unit is an assemblage of dark, thinly bedded, highly carbonaceous breccia derived from siliceous volcanic rocks. The fragments are elongate subangular dacite (?), mainly 1 to 3 mm long, containing saussuritized plagioclase. Quartz veinlets are abundant in the breccia.

The light grey tuffaceous unit is overlain by greenish weathering, volcanic-derived rocks. Low temperature alteration has reduced much of the volcanic material to a nondescript fine-grained assemblage of quartz, plagioclase, sericite, chlorite, epidote, and pale brown biotite. Locally the greenstone is phyllitic or schistose, and in places amygdaloidal and porphyritic (altered plagioclase). One bed exhibits conspicuous euhedral porphyroblasts of chloritoid 3 to 4 mm long. Quartz veins and epidote alteration are ubiquitous. This greenstone sequence includes beds of very fine grained greywacke with quartz-chlorite matrix and 0.5 mm patches of chlorite, biotite and hornblende; a chloritized andesite consisting of a trachytic textured matrix of 0.25 mm plagioclase laths about 15 per cent, 1 mm long, fresh plagioclase, and scattered chlorite and magnetite (no original mafic minerals survive); rusty, fine-grained (0.4 mm) quartzite with pale brown biotite and epidote; black, highly carbonaceous, siliceous argillite; pebble-conglomerate containing stretched pebbles evidently derived from the light weathering siliceous tuff unit; and at the top of Atna Peak, a bed of black siliceous, thinly laminated slate containing quartzose layers alternating with layers rich in actinolite and chlorite, irregular areas of epidote, and much carbonaceous material.

East of Atna Peak the Hazelton Group lies on a sequence of graphitic biotite schists and slates in which andalusite and garnet have developed. These rocks are distinctly higher in metamorphic grade than the overlying rocks, and may be separated from them by a regional unconformity. Where examined, however, no angular unconformity was recognized.

Map-units 5-10

General Statement

About 13 per cent of the land area is underlain by basic complexes, gabbro and diorite (units 5, 6 and 7), about 27 per cent by quartz diorite (unit 8), about 24 per cent by granodiorite (unit 9), and about 6 per cent by quartz monzonite (unit 10). Plutonic rocks excluding the granitoid gneisses thus form about 70 per cent of the land area. Most of the basic plutonic rocks (units 5, 6 and 7) lie near or west of Grenville and Princess Royal Channels, but the distribution of the remaining plutonic rocks form no distinctive pattern. Most of the plutonic bodies have a northwesterly elongation parallel with the regional trend of the pre-Jurassic stratified rocks. The basic plutonic rocks are on the whole more complex than the acid varieties. The former are more apt to be migmatitic, to contain abundant inclusions and screens of older rocks, and to show abundant megascopic evidence of granitization. Only rarely do the more acid rocks exhibit equally complex phases.

Map-unit 5

Basic complexes (unit 5) lie southwest of a line that parallels but lies about eight miles east of Grenville and Princess Royal Channels. They consist chiefly of dioritic migmatite, heterogeneous diorite, and gabbro. For descriptive purposes the complexes are subdivided into those containing gabbro (5a) and those lacking gabbro (5b). More detailed work could probably subdivide the complexes into simpler components, but this would not be possible for some which maintain their complexity down to hand specimen and probably microscopic scales.

Map-unit 5a

Most of the gabbro in the map-area is found in the gabbro-diorite complexes on McCauley Island and near Tuwartz Inlet at the southern end of Pitt Island. Most of McCauley Island west of the screen of metasedimentary rocks (2b) is underlain by a black weathering, coarse-grained hornblende gabbro which in many places grades into a somewhat finer but still coarse-grained diorite. Hornblende, which forms 60 to 90 per cent of the gabbro, is in narrow crystals that commonly exceed 1 inch in length, and in places exceed 3 inches. These weather out in relief and give the gabbro its characteristically rough surface. Although mainly coarse-grained, the gabbro has a variable texture - medium- and even fine-grained phases are fairly common. In places the gabbro is streaky and nebulously banded, and in a few places, with hornblende diorite, it forms the matrix of an agmatite containing about 50 per cent rounded amphibolite inclusions. In the agmatitic areas all intermediate phases between amphibolite, diorite and gabbro are represented. Pyrite and magnetite are commonly found in the gabbro. Although a faint foliation was observed locally, most of the gabbro-diorite complex is massive and the jointing is widely spaced. Possibly related to this is the hummocky topography that characterizes the interior part of McCauley Island. The gabbro is cut by a large number of narrow (1- to 18-inch-wide) basaltic dykes, which weather recessively into the gabbro. Quartz and epidote veins also cut the gabbro in places.

The rock is much the same near Tuwartz Inlet at the south end of Pitt Island. The variable textured gabbro and diorite are cut by dykes of dark, fine-grained microdiorite that in places form a stockwork. One limestone screen was observed in the gabbro-diorite complex. At the contact with the biotite>hornblende quartz diorite (8a) south of the complex, the dioritic phase is whitish and biotite is the dominant mafic mineral. Although no apophyses of diorite or gabbro appear in the quartz diorite, stringers of the latter cut the former.

Similar but more migmatitic is the dark heterogeneous gabbro-diorite complex in the vicinity of Barnard Harbour, southeast of Gil Island. In places the rock there is an irregular mixture of limestone and skarn blocks in a dioritic matrix, with much epidotization.

Map-unit 5b

The main occurrences of this unit are on Pitt, Banks, and Princess Royal Islands. The complexes consist chiefly of heterogeneous diorite, commonly gneissic, and characterized by epidote and chlorite, and by numerous metasedimentary screens. Hornblende is the dominant mineral but here and there biotite is conspicuous. The diorite phase has clearly formed by granitization of metasedimentary and metavolcanic rock. The remnant screens are mainly amphibolite, schist and skarn but rarely quartzite, which suggests the parent rocks were more likely unit 2a and 3 rather than the highly quartzitic unit 2b which is resistant to dioritization although some feldspathization is common. In places, such as the south end of Banks Island, wispy lighter coloured and more siliceous zones in the diorite suggest the early stages of conversion to quartz diorite. Steep northwest-trending foliation is common and invariably parallel with the contained metasedimentary screens.

Pitt Island: Near Hevenor Inlet on Pitt Island the diorite is strongly foliated and commonly gneissic. Steep dipping, northwest attitudes dominate except near the head of the inlet where they swing to the northeast. Zones of agmatite and gneiss, and gradation into quartz diorite are common. The inclusions, which consist mainly of amphibolite and range from elongate to ribbon varieties, are locally abundant. Biotite schist and quartzite screens are also common and range from a few feet to more than 100 feet in width. Phases of the diorite are almost massive, with only ghostly, nebulitic relicts of the former banding.

At the southeastern end of Pitt Island and the southern part of adjacent Farrant Island, the diorite is dark, fine-grained and commonly chloritized. Here and there are screens of metasediments which include amphibolite, limestone with epidote skarn, biotite-garnet schist and quartzite. Zones and streaks within the screens are commonly dioritized. The diorite there is more massive than farther north on Pitt Island but alternating bands of fine- and coarse-grained material form local planar structures. The coarse-grained phase contains in places hornblende crystals up to 2 inches long. Locally the diorite is intensely sheared along northwest trends.

Gneissic diorite and dioritic migmatite is exposed on the east side of Pitt Island along Grenville Channel where most of the rock is a sheared gneissic hornblende>biotite diorite that commonly grades into quartz diorite. The shearing is thought to be related to an inferred major fault in Grenville Channel. In places the diorite contains plagioclase augen and elongate, lensoid, amphibolitic inclusions, but it is characterized by thin screens of rusty-weathering metasedimentary rocks. These include a 50-foot-thick bed of marble, thin beds of buff-weathering crystalline limestone in places containing garnet, epidotic and diopsidic skarn, hornblende schist, and greenish to purplish quartzite derived possibly from unit 2b. In places, hornblende schist alternates with 2- to 6-inch-thick beds of crystalline limestone. The metasedimentary screens conform to the foliation of the diorite which is normally vertical and parallel with Grenville Channel.

A large area between Hevenor Lagoon and Ogden Channel is underlain mainly by unit 5b. Owing to the poor exposures only sparse data are available. The complex is made up of numerous screens of quartz-biotite and biotite-hornblende schist, fine-grained gneiss, quartzite, amphibolite, and argillite, with intervening areas of gneissic diorite, massive diorite, quartz diorite, and minor granodiorite and quartz monzonite (10d). The area around Hevenor Lagoon and the eastern part of Hevenor Inlet is underlain mainly by hornblende>biotite diorite that is more homogeneous than that elsewhere in the unit. More detailed work could probably separate this phase as unit 7b. Quartzite and argillite were observed only at the contact with Captain Cove Pluton in the cove and on Ogden Channel. Sills of the garnet-bearing, commonly aplitic quartz monzonite (10d) were recorded in the eastern part of the unit. The quartz monzonite and unit 5b are intimately interfingered northwest of Wyndham Lake. Screens and foliated plutonic rock of unit 5b strike mainly northwesterly and dip vertically to moderately east.

Campania Island: On the northeast side of Campania Island a diorite complex is exposed. It is likely related to the diorite on Gil Island to the east, but owing probably to alteration by the quartz monzonite pluton (10a) biotite is commonly the dominant mafic mineral. Most of the diorite is coarse grained. Between it and the granodiorite is a 'migmatitic complex' of quartz diorite, granodiorite, bands of gneiss, amphibolite, skarn, and aplitic stockworks.

A similar complex underlies the southeastern end of Campania Island, but it contains more metasedimentary bands, including thinly bedded quartzite, biotite schist, crystalline limestone, and garnetiferous skarn. The garnet in places forms aphanitic masses about 1 inch across rather than large discrete crystals. In the complex are zones up to 100 feet wide of inclusion-free granodiorite. The granodiorite also forms discontinuous lenses in the metasediments. Other granitoid zones consist of garnet-bearing, gneissic quartz diorite. Diorite was not observed but probably lies a short distance offshore.

Princess Royal Channel: The area underlain by unit 5b in the vicinity of Yule Lake is about 7 miles wide and thins northward to its termination in a probable synclinal nose on the west side of Klekane Inlet. A complex of lithologies are present and roughly estimated at 50 per cent migmatite, 35 per cent comparatively clean plutonic rock, and 15 per cent metasedimentary rock. The metasedimentary rock consists chiefly of well-bedded hornblende-biotite-quartz schist grading into fine-grained gneiss, and dark impure quartzite. These rocks commonly form screens ranging in width from a few feet to several hundred feet. The migmatitic areas consist chiefly of elongate agmatite, irregularly layered gneiss, and ribbon gneiss. The latter is made up of gneissic plutonic rock containing numerous ribbons and *schlieren* of schistose rocks. Sphene and especially epidote are common in these areas. The plutonic phase is mainly well-foliated or gneissic diorite and quartz diorite. Inclusions and *schlieren* are abundant in most places, but locally absent. The heterogeneity of the plutonic rock and the irregular manner in which it grades into migmatitic and metasedimentary rocks make it difficult to map on any scale.

Map-unit 6

Discrete gabbro plutons (unit 6) are rare in the map-area, but several small ones were discovered. Two lie east of the Grenville Channel-Princess Royal Channel line. The only one that is entirely exposed lies in quartz diorite terrane on a ridge south of Barrie Reach (Gardner Canal) and consists of irregular textured, coarse-grained hornblende gabbro, containing areas of lighter coloured hornblende diorite. The country rock is a much lighter coloured quartz diorite that commonly grades into hornblende diorite. Dykes of diorite cut the gabbro, but the main mass of the quartz diorite passes beneath the gabbro which seems to be a rootless pod several hundred feet thick and evidently older than the country rock. The gabbro body on a ridge south of the middle part of Kildala River seems to be a similar rootless pod but is not as well exposed.

Other gabbroic masses, on Banks, Gil and Farrant Islands have been mapped as discrete plutons but could also be considered as phases of the diorites that are associated with them.

About midway along the northeast shore of Banks Island hornblende (and pyroxene ?) gabbro forms a small mass less than one mile across. The gabbro has a heterogeneous texture owing to the variability in grain size and in the proportion of hornblende to plagioclase, and light and dark bands are common. Much of the rock is epidotized and chloritized. The gabbro is cut by very coarse, 'dogtooth' hornblende pegmatite veins and a few basaltic dykes. The contacts are poorly exposed - at one place the gabbro grades into the adjacent diorite, and at another the contact is sharp.

The small body of gabbro exposed near the north end of Gil Island is characterized by exceedingly coarse hornblende crystals, many 2 to 3 inches long. Dioritic zones, which are common in the gabbro, have a northerly trend apparently athwart the elongation of the body. The contacts appear to be gradational but are poorly exposed.

Little is known about the gabbro mass exposed on a small hill on Farrant Island, except that it is a massive, dark, heterogeneous body and is cut by a dyke of diorite or quartz diorite about 100 feet thick.

Map-unit 7

Although most of the diorite in the project area forms part of the complexes mapped as unit 5, some bodies of more homogeneous diorite have been mapped separately as unit 7. Most of the diorite (7b) is a comparatively simple hornblende-plagioclase rock, locally containing minor biotite. The well-foliated diorite (7a) on the east side of Campania Island differs in that it is rich in biotite, and extensively chloritized and epidotized. The biotite as well as the later alteration may be attributed to the emplacement of the quartz monzonite pluton (10a) which constitutes most of the island. The two rocks are separated by a narrow, sheared zone of gneissic diorite (5b) or quartz diorite. Numerous pegmatites which cut the diorite probably originated in the quartz monzonite pluton. The Campania Island diorite forms the western limit of a roughly circular ring of diorite and dioritic complex (units 5a, 5b, 7b) that is centred on Gil Island. On the island itself, is the largest of the comparatively homogeneous diorite bodies (7b). There most of the diorite is dark, medium- to coarse-grained and contains much more hornblende than biotite. Although less abundant, biotite forms large ragged plates in contrast to the smaller stubby hornblende crystals. The rock contains a few amphibolitic bands but is generally free from small lensoid inclusions. The principal complication is a fine-grained, light coloured, clear diorite that intrudes the coarser diorite and is bordered by agmatite. The fine-grained diorite forms a few large zones, but mainly dykes and anastomosing stringers of metasomatic origin. In the northern part of the island the main diorite is only faintly foliated but in the southern part it is strongly foliated and commonly chlorite and epidote-bearing. On the west side of the island about two miles south of Blackrock Point, the diorite is pyritized and rusty, and stained with malachite.

Diorite similar to that on Gil Island is also found on the east side and south of Ashdown Island, on Fin Island, and on the southern tip of Hawkesbury Island.

The circular pattern formed by the dioritic rocks around Gil Island is not understood. The foliation attitudes do not indicate a simple domal structure. Although the trends near the outer margins of the area are generally tangential, exceptions are common. On Gil Island, northeast trends with steep to vertical dips prevail over the southwest quarter of the island, but northwest trends dominate the southeast quarter and the northern tip, and northerly trends, the intervening area. The basic rocks are not reflected in the gravity map of the area (Stacey and Stephens, 1969).

The easternmost mappable diorite is exposed on the northeast shore of Gardner Canal east of Rix Island. It is similar to that on Gil Island except that it contains a few narrow bands of gneiss. The southern contact with granitoid gneiss (unit 1) is sharp.

Map-unit 8

Quartz diorite (unit 8) is the most abundant rock type in the map-area, underlying about 27 per cent of the land area. The quartz diorite has been subdivided on the basis of its mafic minerals into biotite>hornblende (8a), hornblende>biotite (8b), hornblende-chlorite (8c), and hornblende only (8d). One additional variety, 8e, is characterized by abundant gneiss and common migmatitic zones, but on the basis of the mafic ratio may be considered part of 8b. More than 80 per cent of the quartz diorite is of the hornblende>biotite variety (8b).

Map-unit 8a

Except for two small bodies at the south end of Pitt Island unit 8a is restricted to the north sides of Gardner Canal and Kildala River. On Pitt Island the rock is a medium-grained biotite>hornblende quartz diorite containing 10 to 20 per cent mafic minerals, a few *schlieren* and a few elongate inclusions. Steeply dipping foliation parallels the contacts. The quartz diorite is associated with dioritic complexes (units 5a, 5c). As the southern contact of the body on Tuwartz Inlet is approached, the diorite rock becomes whitish yet retains a hornblende>biotite mafic ratio although biotite increases. Eight to ten feet from the contact the diorite is conformably veined by the quartz diorite. Beyond this zone the quartz diorite contains no inclusions of the diorite but a few long dark *schlieren* parallel the contact. In contrasts the northern contact is an agmatitic zone of dioritic blocks in a quartz dioritic matrix. The contact area is complicated by a zone of dioritic pegmatite. The contacts of the quartz diorite body that form McCreight Point are gradational over several hundred feet.

The biotite>hornblende quartz diorite on the north side of Europa Reach (Gardner Canal) is commonly nebulitic but otherwise moderately homogeneous. In most places it contains about 15 per cent biotite and about 5 per cent hornblende. Less than 1 per cent of the quartz diorite consists of dark lensoid inclusions which parallel a moderate to strong foliation. The western contact is against rusty schist (unit 2a) and is sharp and concordant, dipping about 70 degrees southwest. Near the contact in the quartz diorite are a few 30-foot-wide screens of rusty weathering gneiss and rare lensoid inclusions. A vertically dipping garnetiferous band in the quartz diorite crosses the base of Salient Point. The garnet forms extremely irregular poikiloblastic crystals which make up 1 to 5 per cent of the quartz diorite. The contact with unit 1 is placed at the first occurrence of migmatite which consists of contorted, discontinuous layers of biotite gneiss and quartz-feldspar gneiss intercalated with quartz diorite and pegmatite. Owing to its pyrite content the migmatite is rusty. Where mapped the contact is rather abrupt, yet arbitrary, owing to the presence of substantial areas of quartz diorite in unit 1.

The small body of unit 8a underlying the mouth of Owyacumish Creek is similar and probably connected with above body beneath unit 1. The eastern part of the Owyacumish Creek pluton, however, contains more hornblende than biotite and is perfectly gradational into hornblende>biotite granodiorite (unit 9c).

Medium- to coarse-grained, biotite>hornblende quartz diorite with an uneven texture forms a pluton between Kildala River and Dahlaks Creek. Biotite ranges from 10 to 20 per cent, hornblende forms less than 5 per cent, and quartz makes up about 10 per cent of the rock. In places epidote is conspicuous and the mafic minerals are partly chloritized. In the southeastern part of the pluton the rock grades into granodiorite and may contain as much as 35 per cent quartz. The northern contact is concordant and dips moderately to the north. There the metavolcanic rocks (4) are dioritized, and the quartz diorite contains about 4 per cent elongate inclusions. Inclusions decrease toward the core where they are absent. In most places the rock is not foliated.

Map-unit 8b

Banks Island: Most of the rock underlying the southwestern part of Banks Island is a massive, clean, medium- to coarse-grained, hornblende>biotite quartz diorite. Local variations show moderate foliation (especially at the northern end of the pluton where it is constricted between metasedimentary screens), biotite>hornblende, gradation into diorite, and gradation into granodiorite at the southwest corner of the island owing to the presence of K-feldspar megacrysts. The quartz diorite is also cut by a few apophyses of biotite>hornblende granodiorite near Spearer Point. The mean specific gravity of 17 specimens of the quartz diorite is 2.80.

The quartz diorite on the northeast side of the island is similar to that above but it is more strongly foliated, contains more inclusions (elongate) and considerable epidote. The east side of the pluton is intensely sheared at the north end, the shearing is thought to be related to the probable major fault in Principe Channel. Hornblende is much more abundant than biotite. The inclusions are amphibolitic and commonly form long narrow streaks that parallel the northwest-trending foliation. The mean specific gravity of 26 specimens is 2.76.

Islands of the Estevan Group: The quartz diorite on these islands is medium-grained, very dark and commonly greenish. Hornblende exceeds biotite and total mafic mineral content is about 20 per cent. It is characterized by about 10 per cent elongated amphibolitic inclusions, and conspicuous chlorite, epidote and sphene. K-feldspar megacrysts are widely distributed, in places changing the rock to granodiorite. The quartz diorite is well foliated and locally intensely sheared. The vertical fissures are commonly filled with epidote. Hornblende normally parallels the foliation but much of the biotite lies athwart. On the southwest part of Trutch Island the foliation trends westerly to slightly north of west, and the shearing trends northwesterly to northerly. Inclusions are irregularly distributed and range from 5 to 40 per cent of the rock. This pluton is the densest quartz diorite pluton in the project area (mean specific gravity of 28 specimens is 2.82). With respect to its inclusions and epidote content it resembles the quartz diorite on the northeast side of Banks Island but its specific gravity is closer to that on southwestern Banks Island.

Southern part of Pitt Island: The central southern part of Pitt Island is underlain by a medium-grained, hornblende>biotite quartz diorite with very few inclusions except in contact areas. It contains minor epidote and sphene. Along the shore of Principe Channel the quartz diorite is well foliated, but in the interior of the island it is faintly foliated or massive. In Monckton Inlet it is dioritic-looking but staining revealed 5 to 10 per cent quartz. At the eastern end of the inlet where the quartz diorite grades into diorite (5a), amphibolitic inclusions form 10 to 30 per cent of rock. Most are lensoid and clustered into 'schools', in contrast to the bun-shapes and scattered distribution characteristic of the interior part of the pluton. North of mouth of Buchan Inlet the quartz diorite contains some angular blocks of well-banded metasedimentary rocks that include amphibolite, biotite schist and quartzite which are probably related to the metasedimentary rocks that outcrop north of Oar Point. In Lundy Cove at the north end of the metasedimentary band, the quartz diorite is well-foliated to gneissic and contain ribbons, *schlieren*, and very elongate inclusions. Those become more abundant where the rock grades into diorite. Light coloured, commonly aplitic, biotite-rich granodiorite (9b) which forms most of the coast south of Monckton Inlet cuts or replaces the coarser, darker quartz diorite.

The mean specific gravity of 58 specimens from this pluton is 2.76, which agrees with that of the pluton across Principe Channel on the northeast side of Banks Island.

Captain Cove Pluton: This body underlies the northwest part of Pitt Island and adjacent parts of Porcher and McCauley Islands. It is a tadpole-shaped body with its head to the northwest and its tail grading into the pluton described above. The head of the pluton is cored by quartz monzonite (10b) which underlies the northern end of McCauley Island. Most of Captain Cove Pluton consists of medium- to coarse-grained hornblende>biotite quartz diorite characterized by abundant epidote and sphene. This composition is consistent except along the northeast shore of Petrel Channel where rock representing the central part of the quartz diorite phase of the pluton contains biotite as the dominant mafic mineral. Biotite, although subordinate in most places, forms conspicuous 'buttons'. The central parts of the pluton are massive or only faintly foliated but near the contacts the foliation is well developed. As the pluton is well dissected by waterways, it is possible to examine contacts in several places. In Captain Cove, where the eastern contact is exposed, moderately foliated quartz diorite gives way to strongly foliated rock near the contact. Both epidote and sphene increase in abundance. Amphibolitic inclusions also become more abundant and are clustered in zones and clumps. Closer to the actual contact large blocks of layered amphibolite and quartzite up to 30 feet across and some screens are exposed. The quartz diorite contains apparently smeared-out mafic mineral and the feldspar has an augen-like appearance. About 3 per cent of the rock consists of long, very narrow amphibolite ribbons. Farther south this contact is exposed again in Newcombe Harbour. There the foliated dioritic-looking quartz diorite is separated by an interval without outcrop from a *lit-par-lit* migmatite that contains coarse-grained hornblende gneiss and biotite gneiss. On the east side of Ogden Channel the actual contact is not exposed but near it in the quartz diorite is a large screen of quartzite which has sharp conformable contacts with the plutonic rock. On the west side of Ogden Channel the contact is complicated by agmatite having an aplitic matrix and exhibiting considerable shearing and augen structure. In Hevenor Inlet, which crosses both east and west contacts, the eastern contact, which is with well-foliated diorite, appears to be gradational. The western contact on the other hand is very sharp against an agmatite consisting of dark mafic-rich diorite blocks in a matrix of lighter quartz diorite. The western contact is exposed also on Mathers Point, where the quartz diorite is strongly foliated and contains feldspar augen and chloritized mafic mineral. It is apparently faulted against banded quartzite and biotite schists. On McCauley Island the west contact is an intense shear zone, related to the Kitkatla Fault.

The Captain Cove quartz diorite differs from that farther to the south around Tuwartz Lake mainly in the abundance of epidote and sphene in the former. It also has a distinctly lower specific gravity (2.73 versus 2.76).

The two areas of quartz diorite seem to be connected by a narrow neck, and if they are parts of one pluton, the southern end is probably closer to the root zone.

Princess Royal Island: Most of the northern end of the island consists of a rather dark dioritic-looking hornblende>biotite quartz diorite containing fairly common bands of dark dioritic gneiss. The mafic minerals are rather abundant generally forming 25 to 35 per cent of the rock; in most places hornblende is much more abundant than biotite. In places, particularly near Cougar, Bear and Deer Lakes sphene and epidote are common and biotite forms large crystals although hornblende is more abundant. Inclusions form elongate 'schools', thin ribbons and screens. This rock may be related to the Captain Cove Pluton judging from the epidote and sphene content, but it is generally darker and has a higher specific gravity (2.78).

Ecstall Pluton: This large pluton extends about 72 miles from north of Skeena River in Prince Rupert map-area south to Hartley Bay near the entrance to Douglas Channel. It ranges in width in Douglas Channel map-area from about 8 to 14 miles. The pluton consists mainly of granodiorite and quartz diorite. The largest area of quartz diorite is curiously located in the central part of the pluton. It consists of a medium- to coarse-grained hornblende>biotite quartz diorite. Mafic mineral content averages about 12 per cent and both epidote and sphene are common. In most places the rock is free from inclusions and massive or only faintly foliated. In the field the rock has more the appearance of granodiorite than quartz diorite and in places K-feldspar megacrysts are conspicuous but staining of the rock showed that K-feldspar content is less than 5 per cent. The contacts with the surrounding granodiorite are gradational. The rock contains rare zones of agmatite, and isolated areas where inclusions amount to about 10 per cent of the rock. Excepting this, however, inclusions amount to less than 3 per cent of rock and are mainly elongate and amphibolitic. Twenty-six specimens of this rock have a mean specific gravity of 2.73.

In mineralogy and specific gravity this quartz diorite is very similar to that of Captain Cove Pluton, however, it does, contain fewer inclusions and screens.

The quartz diorite between Grenville Channel and Hartley Bay forms the southern tip of the Ecstall Pluton. Except for local variation the rock is a medium grained, hornblende>biotite quartz diorite containing epidote and sphene, and about 20 per cent mafic mineral. In most places the rock is moderately foliated. The inclusions are localized in schools with practically none in the intervening areas. Many of these inclusions are very elongate and schistose. On the west side of Douglas Channel south of Kiskosh Inlet the quartz diorite seems to grade into the granodiorite that lies to the north of it. The contact area, however, is complicated by an extensive stockwork of aplite. Along Grenville Channel the rock is a bit more basic and more dioritic looking. Nineteen specimens of the quartz diorite have a mean specific gravity of 2.75. Along Grenville Channel the rock is distinctly denser and has a mean specific gravity of 2.80. In general this quartz diorite is denser and contains more inclusions than the quartz diorite farther north in Ecstall Pluton.

Gribbell Island and south end of Hawkesbury Island: The rock is consistently hornblende>biotite quartz diorite with a total mafic content of about 25 per cent. Most of the rock is medium to coarse grained. K-feldspar is locally present but amounts to less than 5 per cent of the rock. Epidote is ubiquitous and sphene is common especially on the southwestern part of Gribbell Island. In most places the rock is massive and free from inclusions. Much of the quartz diorite is cut by pegmatitic stockwork. The stockwork is especially conspicuous in the central part of Gribbell Island. On the west side of Gribbell Island, where the contact with granodiorite (9c) is exposed the quartz diorite is gneissic containing bands 1 foot to 2 feet wide of quartz diorite and a lighter aplitic phase. Also present in the contact zone are blocks of quartzite with partings of biotite schist and about 10 per cent aplitic stockwork. The mean specific gravity of 20 specimens of this quartz diorite is 2.70.

Aaltanhash River: This body of quartz diorite extends from the north end of Verney Passage southeastward to the southern edge of the map-area. It consists mainly of medium- to coarse-grained hornblende>biotite quartz diorite, containing from 2 to 5 per cent K-feldspar and locally grades into granodiorite. The average mafic mineral content is about 15 per cent. Locally biotite is the dominant mafic mineral. Epidote and sphene were recorded at a number of stations but these are less abundant than farther to the northwest in the Ecstall and Captain Cove Plutons. Amphibolitic inclusions commonly form less than 3 per cent of the rock although locally they may make up as much as 20 per cent. The quartz diorite ranges from massive to well foliated but in most places it is faintly foliated. The contact with the Butedale granodiorite (9c) to the west is gradational; the contact with the migmatite to the east is complex. Southwest of Alan Reach quartz diorite appears to overlie the gneiss complex but farther southeast the contact is vertical. The mean specific gravity of 34 specimens of the quartz diorite is 2.74.

South of Europa Reach: The quartz diorite body extends from Europa Reach to near the southeast corner of the map-area. Most of the rock is a medium- to coarse-grained hornblende biotite>quartz diorite. In areas not delineated near the head of Kowesas River and in the central part of the pluton southeast of Europa Reach biotite is commonly the dominant mafic mineral. Sphene was recorded at five places along the east side. Garnet appears in the plutonic rock near the contact with schists and gneiss on Europa Lake and also about 4 miles north of Marmor Peak. The mafic mineral content varies from about 10 to more than 50 per cent but averages about 20 per cent. In many places the rock is nearly free from inclusions but elongate inclusions, screens of metasediments, and ribbons, do appear here and there. East of Kiltuish Inlet and Kiltuish River the contact is generally not well defined but dips moderately to the northeast and east. Farther south it is vertical. Most of the quartz diorite has faint to moderate foliation. The mean specific gravity of 59 specimens of the quartz diorite is 2.78. The southern end of the pluton is less dense (2.69) and in composition closely approaches granodiorite.

Foch Lagoon: The rock here consists mainly of hornblende>biotite quartz diorite with about 25 per cent mafic mineral. The rock is generally coarse grained but biotite forms tiny crystals in contrast to the larger blocky prisms of hornblende. Sphene and epidote are found here and there. The rock contains a variety of inclusions but none are very abundant. Most are mafic-rich and are in bun, lense and irregular shapes. They are commonly nebulous and pass in to wispy *schlieren*. The northern part of the west side of Foch Lagoon exhibits nebulous gneissic zones in which the mafic minerals are segregated into discontinuous layers. In most places the quartz diorite is well foliated and as the lagoon is beneath the crest of Foch Antiform much of the foliation is flat-lying. The actual contact with the surrounding gneissic rocks is not exposed. In the southern part of the lagoon aplitic veins are fairly extensive. The mean specific gravity of 12 specimens is 2.76. The same quartz diorite apparently outcrops in the upper part of Ecstall River to the northwest but it was examined at only one place. There it is marked by abundant veins and irregular patches of pegmatite (*see* Fig. 9).

West side of Hawkesbury Island: Outcrops along the shore of Douglas Channel opposite Kitkiata Inlet consist mainly of medium- to coarse-grained,

Figure 9. Pegmatite veins and patches in quartz diorite (unit 8b) about 8 miles east of Johnston Lake. (GSC 119781)

hornblende>biotite quartz diorite with epidote and sphene. The mafic minerals are chloritized and the feldspar is chalky indicating a widespread hydrothermal alteration. The quartz diorite is practically free from inclusions except for several screens of amphibolitic paragneiss. The contact with quartz monzonite to the south is a fault with a 6- to 10-inch-wide brecciated zone. The northern contact is located where clean, homogeneous, moderately foliated quartz diorite (possibly granodiorite) passes within a few feet into a complex that is half plutonic rock and half highly contorted, finely banded, crystalline limestone, feldspathic gneiss and biotite schist (unit 2a).

Map-unit 8c

The pluton north of Dala River in the northeast corner of the map-area is distinctive. Most of it consists of dark grey weathering coarse-grained hornblende-chlorite quartz diorite. The mafic mineral which forms about 10 per cent of the rock consists of hornblende only and in most places it is wholly converted to chlorite. The rock is characterized by conspicuous large smoky quartz crystals as well as by extensive chlorite and epidote alteration. At the western end of the pluton biotite becomes conspicuous and the rock is richer in potassium feldspar locally becoming granodiorite. Where they can be seen at all, rounded amphibolitic inclusions make up about 5 per cent of the rock. Locally the rock consists of a well-developed agmatite that is made up of subangular blocks of fine-grained greenstone in a matrix of coarse-grained hornblende quartz diorite. The large smoky quartz crystals of the quartz diorite have developed also in the greenstone blocks. In most places the rock has no foliation. Twelve specimens of the quartz diorite have a mean specific gravity of 2.74. The pluton appears to be an intrusive body but it is in marked contrast to the clean unaltered granodiorite to the south. No data are available on the actual contact with the Hazelton Group (4). Near the contact on a ridge 5 miles west of Atna Peak, greenstone of the Hazelton Group is extensively veined to quartz and epidote, suggesting but not proving an intrusive contact. If the greenstone blocks in the quartz diorite were derived from the Hazelton Group, the pluton is post-Middle Jurassic. In the Kitimat dock area, a short distance north of the map-area, however, greenstone dykes, presumably feeders to the Hazelton Group volcanic assemblage contain fragments of the quartz diorite. Age relations therefore, remain in doubt.

Map-unit 8d

One small pluton of dioritic-looking, medium-grained hornblende quartz diorite outcrops in the northeastern part of the map-area between Dala River and Dahlaks Creek. It commonly contains about 50 per cent hornblende, and about 10 per cent bluish grey quartz. Here and there in the western part of the pluton the rock grades into diorite. No foliation or inclusions were observed. The contacts are not exposed and the position of the western and southern contacts especially are not accurately known. The specific gravity of six specimens from this pluton ranges widely (from 2.73 to 2.95). The rock is darker, fine-grained and much more heterogeneous than the quartz diorite to the south between Dahlaks Creek and Kildala River.

Map-unit 8e

The quartz diorite that underlies unit 1 northwest of Gilttoyees Inlet forms the core of the Foch Antiform. Only the phase that outcrops mainly along the west side of Foch Inlet is a comparatively clean uniform hornblende>biotite quartz diorite (8b). The remainder (unit 8e) commonly contains areas of gneiss and migmatite, and although these areas are not so ubiquitous as to make the whole a migmatite they are more abundant than in other areas mapped as unit 8b. Where free from gneiss and migmatite unit 8e is indistinguishable from unit 8b, and more detailed mapping could probably delineate such areas.

The outcrops along Gilttoyees Inlet exhibit the elongate agmatite that characterizes the unit. It consists of drawn-out lenses of medium-grained diorite in a matrix of coarse-grained quartz diorite. The lenses grade into narrow discontinuous bands which in turn grade into gneissic quartz diorite. Pegmatite and aplite veins commonly form 10 to 20 per cent of the rock. West of Gilttoyees Inlet, agmatite is rarer, but the quartz diorite is commonly gneissic and biotite is more abundant, in fact the dominant mafic mineral, in most outcrops on Foch Lake and in the narrow tongue of unit 8e northeast of Kitkiata Lake. The latter area contains conspicuous feldspar megacrysts up to 2 inches long, which in places make the rock an augen-gneiss wherein the augen are separated mainly by smeared biotite.

The contact between unit 8e and unit 1 is exposed on Douglas Channel, south of Foch Lagoon. There schist and quartzite (unit 1) grades through a *lit-par-lit* complex into gneissic quartz diorite containing mafic-rich bands but no schist or quartzite. The gneissic quartz diorite is in sharp contact with hornblende>biotite quartz diorite (8e) that is only moderately foliated but contains numerous *schlieren*. The 70-degree northeasterly dip of the contact zone brings unit 8e over unit 1. Where the *schlieren*-bearing quartz diorite becomes more massive and free of *schlieren* it grades into unit 8b.

Unite 8e appears to be a transitional element between unit 1 and unit 8b. It was not recognized southeast of Douglas Channel, an area which has been more extensively metasomatized by K-feldspar. Forty-seven specimens of quartz diorite from unit 8e have a mean specific gravity of 2.74, which is slightly less than the 2.77 of the underlying quartz diorite (8b).

Map-unit 9

Granodiorite underlies about 24 per cent of the land-area and is not restricted to any particular part of it. The largest masses form the Butedale Granodiorite and part of the Ecstall Pluton. Most of the granodioritic bodies have a northwesterly elongation parallel with the regional trend.

The granodiorite has been subdivided into five varieties, of which hornblende>biotite granodiorite (9c), underlying about 13 per cent of the land area, and biotite>hornblende granodiorite (9b) underlying about 10 per cent, are by far the most abundant. Small bodies of biotite granodiorite (9a) and an uncommon fine-grained, even textured granodiorite (9e) are restricted to the area northeast of the gneiss belt (unit 1). Sheared granodiorite and gneiss complex (9d) was observed only on Porcher Island.

Map-units 9a and 9b

Lower Dala River valley: The pluton underlying lower Dala River valley is poorly exposed and its limits are not known precisely. It consists of a very coarse grained, white and black, biotite granodiorite (9a). Biotite forms 10 to 20 per cent of the rock and is commonly sufficiently well-oriented to give the rock a distinct foliation. Hornblende is rarely present. The mafic minerals are partly chloritized. Quartz is very conspicuous on the weathered surface, and resembles that in the quartz diorite to the northeast. Inclusions are rare. The rock is apparently the same as the granodiorite west of the northern part of Kitimat Arm.

Five specimens have a mean specific gravity of 2.65, which is low for a granodiorite and may indicate the presence of small miarolitic cavities.

Campania Island: Granodiorite (9b) forms the western fringe and northern end of Campania Island. It consists of an irregular textured, fine- to medium-grained biotite>hornblende granodiorite with finely disseminated K-feldspar, and a few narrow amphibolitic layers and scattered gneiss bands. Epidote is common in the granodiorite at the northern end of the island, and sphene on Jewsbury Peninsula. The K-feldspar content in places is less than 5 per cent dropping the rock class to quartz diorite. A few inclusions were observed here and there, but they are nowhere abundant. At one place on the southwest shore of the island blocks similar to this granodiorite are found in the quartz monzonite. Where not faulted, the contact is probably intrusive but it was not observed.

Between Kildala River and Kemano Bay: This broad region is underlain mainly by gneiss and gneissic plutonic rock of unit 1. In it, however, are poorly defined areas underlain by plutonic rock, which although in places gneissic and contaminated by zones of gneiss are sufficiently homogeneous to justify separating them from the gneiss complex. One such area extends northwest from Powell Peak on the east margin of the map-area. It is underlain by a faintly foliated medium- to coarse-grained, biotite granodiorite (9a). The rock contains about 10 per cent biotite and no inclusions. It is in fairly sharp contact with highly contorted gneisses to west.

The larger area of granodiorite (9b) to the north is similar but contains visible hornblende, although biotite dominates, and zones of complex *schlieren* and gneissic diorite. Locally the granodiorite contains up to 10 per cent elongate amphibolitic inclusions. The contacts are complexly gradational.

A third area of granodiorite (9b) lies northeast of Brim River and is connected with the above at its northern end. Hornblende is more abundant and locally dominant. K-feldspar is highly variable and in places the rock passes into quartz diorite. The southern part has a moderate, easterly-trending foliation that dips steeply to moderately north. Up to 5 per cent inclusions may be present. The four specimens collected have a mean specific gravity 2.73, which is appreciably higher than 2.67 of the previously described granodiorite.

Map-unit 9c

Banks Island: About half of Banks Island is underlain by medium- to coarse-grained granodiorite. In most places hornblende is the dominant mafic mineral but in the southern part of the body along the west coast biotite exceeds hornblende. Both the mafic minerals and K-feldspar are irregularly distributed. In the western part of the body K-feldspar forms 5 to 10 per cent of the rock and in the eastern part 10 to 20 per cent. The quartz content averages about 20 per cent in the west and decreases to about 10 per cent on the east side. Epidote, which occurs mainly in veins and sphene crystals, is common throughout the granodiorite. Inclusions are rare in the interior of the pluton but are locally abundant especially on the east shore of the island in the vicinity of Kooryet Island. Most of the inclusions consist of elongate lenses of amphibolite. Foliation, distributed similarly to the inclusions, is faint or lacking in the central part of the pluton and well developed in the outer areas. No major contacts of the granodiorite are exposed in the areas examined. In Foul Bay an unmapped zone of aplitic granodiorite separates the main pluton from the metasedimentary rocks. The aplitic granodiorite sharply cross-cuts the metasediments and contains abundant inclusions of banded limestone and quartzite with some skarn. On the island off Foul Bay the contact with this aplitic granodiorite is sharp and locally agmatitic. The mean specific gravity of 75 specimens of the main granodiorite is 2.70. This, however, is a biased figure because the pluton was more extensively sampled along the west coast of the island and there the specific gravity is distinctly less than to the east. The mean specific gravity of specimens gathered along the west coast is about 2.68 and those from the eastern part of the pluton about 2.74. The true mean specific gravity of the pluton is probably closer to 2.72 than 2.70.

Ecstall Pluton granodiorite: In Douglas Channel map-area the Ecstall Pluton is confined between the two belts of sedimentary rock, one lying mainly east of Grenville Channel and the other underlying much of Ecstall River Valley. The southern end and the central part of the pluton consists of quartz diorite, the remainder of granodiorite.

The granodiorite part is divisible into northern and southern core areas (separated by the central quartz diorite) that consist of a leucocratic, biotite>hornblende phase, and an outer area made up of a more basic, hornblende>biotite phase. The rock in the two core areas is mainly massive coarse-grained biotite>hornblende granodiorite characterized in many places by 5 to 10 per cent K-feldspar megacrysts (*'dent de cheval'*). Mafic minerals form 3 to 10 per cent of the rock, and quartz, 15 to 20 per cent. As in other phases of Ecstall Pluton epidote and sphene are common. Inclusions are small, rounded, and nebulous but rarely seen. Petrographic work by W.W. Hutchison showed that the plagioclase has an anorthite content ranging from 22 to 30, and averaging about 26. Sixteen specimens from the northern core have a mean specific gravity of 2.66, and 21 from the southern core 2.67. Pegmatite and aplite veins are particularly abundant in the southern core. South of Weare Lake they form about 20 per cent of the rock, and are commonly subhorizontal, possibly formed by hydrous fluids penetrating fractures in the granodiorite developed as overlying rock was unloaded by erosion.

Strong shearing trending north to northeasterly and dipping vertically to 50 degrees east cuts the granodiorite at many places along the northerly-trending part of Lowe Lake.

The two core areas are gradational into adjacent granodiorite, but numerous dykes of the core granodiorite penetrate the quartz diorite north of the west end of Belowe Lake. The core granodiorite appears to be in contact with the central quartz diorite west of the northern part of Lowe Lake but the contact was not observed.

The outer parts of Ecstall Pluton consists mainly of hornblende>biotite granodiorite. Quartz, K-feldspar and combined mafic minerals, each form from 10 to 15 per cent of the rock. Epidote and sphene are common. In general the rock is slightly darker, denser, and better foliated than the core granodiorite.

In the Kumealon Lake area the granodiorite is locally given an augen appearance owing to K-feldspar metacrysts. The contact with biotite schist of the metasedimentary belt to the west is sharp, concordant and vertical. Although the granodiorite becomes darker near the contact, it remains almost free of inclusions except for a few thin *schlieren*. The hornblende-biotite ratio increases, foliation is better developed and the K-feldspar content decreases, probably dropping the rock to quartz diorite in places. In contrast to hornblende, biotite characteristically has grown across the foliation. The plagioclase in the hornblende>biotite phase of the granodiorite in this area averages An_{27}. Eight specimens have a mean specific gravity of 2.68 which is slightly more than the core but distinctly less than border phases of the Ecstall Pluton to the east and south.

Farther south in the vicinity of Batchellor Lake, the hornblende>biotite granodiorite is similar although somewhat richer in mafic minerals. The contact with the metasedimentary rock, however, differs in that it is gradational from granodiorite through well-foliated, *schlieren*-bearing quartz diorite into banded gneiss and finally into quartzofeldspathic gneiss and hornblende schist. The gneissic rocks dip moderately to the east, and thus beneath the main mass of granodiorite. Aplite and pegmatite dykes which are common at the north end of Batchellor Lake are in part displaced along planes parallel with the foliation. The plagioclase in the granodiorite averages An_{29}. Fourteen specimens have a mean specific gravity of 2.73, the same as the central quartz diorite mass.

The hornblende>biotite granodiorite that forms most of the east side of Ecstall Pluton is similar to that around Batchellor Lake. The eastern contact against the metasedimentary belt is sharp in most places. On the south side of Gavel Lake the contact can be located to within 1 foot or 2 feet. There it is a fault represented by a gouge zone 6 inches to 1 foot wide. The sequence across the contact is from clean granodiorite through slightly foliated granodiorite, highly sheared granodiorite which is changed to a quartzofeldspathic gneiss, the gouge zone, to rusty weathering dark micaceous quartzite and biotite schist. The contact, which is concordant, there dips about 70 degrees east. North of Gavel Lake the granodiorite is in sharp contact with light grey weathering, thinly bedded quartzite with thin biotite schist layers. Direct evidence of faulting is less there but the metasedimentary beds are crumpled and dragged southward. Farther north, east of Ecstall River, the contact appears to be fairly sharp. A few elongate inclusions appear in the granodiorite at the contact only, and the metasediments consist of finely laminated pyritiferous schist and gneiss. Whether the contact there is a fault is uncertain. If it is, the whole of the eastern contact of Ecstall Pluton in Douglas Channel map-area is probably a fault.

<u>Butedale Pluton (southern part)</u>: Most of this rock is a medium- to coarse-grained, hornblende>biotite granodiorite. Between Butedale and Canoona Lake is a poorly defined area of granodiorite where biotite is the dominant mafic mineral. In most specimens the mafic minerals form 15 to 20 per cent of the rock, K-feldspar 5 to 10 per cent, and quartz 10 to 20 per cent, except between Whalen and Butedale Lakes where it forms only 5 to 10 per cent of the rock. Here and there K-feldspar forms conspicuous megacrysts. Although not abundant, sphene was observed in nearly all outcrops. Epidote is rare. The rock contains unusually widely spaced joints, and even large outcrops are commonly

free of breaks. In most places the rock is massive or only faintly foliated - northwesterly trends parallel with the elongation of the pluton prevail except at the northwest end where northeasterly trends appear, conforming to the limits of the pluton. Inclusions are rare or absent. No distinct contacts were observed. On Whalen Lake the granodiorite appears to grade westward into quartz diorite (8b) which differs megascopically only in being somewhat darker, better foliated and in containing fairly numerous drawn out inclusions and thin layers (2 to 6 inches wide) of fine-grained diorite and amphibolite. At the eastern margin south of Butedale the granodiorite grades into a very streaky, commonly gneissic diorite (5b). Fifty-two specimens of the southern part of Butedale Pluton have a mean specific gravity of 2.70.

Butedale Pluton (northern part): Butedale Pluton crosses Princess Royal Channel northwest of Butedale and underlies a large part of the area between the channel and Gardner Canal. Like the southern part of the pluton the rock is a hornblende>biotite granodiorite and contains 10 to 20 per cent mafic mineral, 5 to 10 per cent K-feldspar and 10 to 20 per cent quartz, but unlike it, epidote is ubiquitous and in places abundant. A massive leucocratic phase of the granodiorite, which approaches a quartz monzonite in appearance, underlies most of the area between the headwaters of Paril and Triumph Rivers. Sphene is common in this phase of the granodiorite. Except in the areas flanking Klekane Inlet and along the northeast margin of the granodiorite, the rock shows no or only faint foliation. The foliation trends generally northwest except south of the head of Triumph River where it trends northeast. On Princess Royal Channel the foliation strikes N25°E and dips vertically, but a later northwest shearing parallel with the channel has developed. The contact between the granodiorite and the quartz diorite (8b) to the east was not observed but is thought to be gradational as it involves only a decrease in K-feldspar. The contact with the metasedimentary rocks is exposed in Klekane Inlet and nearby on Princess Royal Channel. In both places a transition zone (5b) about 2,500 feet wide separates the typical granodiorite from the metasedimentary rocks (2b). The transition is initiated by the appearance of *schlieren*, and a more conspicuous foliation in the granodiorite, and increases in the mafic mineral content, hornblende-biotite ratio, and sphene. *Schlieren* become more and more abundant, the granodiorite becomes darker, more dioritic looking and more gneissic, and agmatitic zones appear. The gneiss contains K-feldspar megacrysts and alternating quartz-rich and quartz-poor layers, and is interrupted here and there by zones of massive granodiorite. Close to the contact dark zones very rich in biotite become numerous. The actual contact with marble and quartzite of the metasedimentary unit is fairly sharp and dips vertical to steeply east. Thirty-five specimens of the northern part of Butedale Pluton have a mean specific gravity of 2.71, not significantly different from the southern part of the pluton.

The northern part of Butedale Pluton extends across Ursula Channel to Gribbell Island where its character is much the same as on the mainland. Biotite however, is more abundant and about equal to hornblende in most places. Most specimens of the granodiorite contain both sphene and epidote. A few wispy *schlieren* appear in many outcrops, and locally 'schools' of dark, elongate, amphibolitic inclusions were recorded. An extensive network of aplitic and pegmatitic veins cuts the granodiorite and is particularly conspicuous in the southern part of the granodiorite on Gribbell Island. The northwest contact against the narrow metasedimentary screen (2b) is sharp. The southwest contact is gradational against a migmatite (1) that is characterized by *lit-par-lit* and agmatitic complexes.

Sleeman Creek: The Sleeman Creek granodiorite is exposed over a width of about 4 miles and extends from the northern end of Maitland Island southeastward to Barrie Reach on Gardner Canal. The rock is mainly a coarse-grained, hornblende>biotite granodiorite. It contains 10 to 20 per cent mafic minerals, 10 to 30 per cent K-feldspar and 10 to 20 per cent quartz. Sphene is common between the medial line and the southwest contact of the belt, and rare elsewhere. South of the head of Falls River is a core area wherein the granodiorite is more leucocratic and sufficiently richer in K-feldspar that it locally grades into quartz monzonite in which K-feldspar megacrysts are common. The granodiorite is massive in the core area but moderately foliated in most other places and strongly foliated in the contact zones. Inclusions are rare in the core, but increase in abundance toward the margin of the granodiorite, where they commonly form screens of gneiss rather than the lensoid spherical shapes more common far from the contacts.

The granodiorite forms part of the core of Foch Antiform that extends from near the head of Sleeman Creek west-northwest across the northern tips of Loretta and Maitland Islands, and continues northwesterly to beyond the north border of the map-area. Northwest of Douglas Channel, however, the rock in the core of the antiform is quartz diorite (8b, 8e) rather than granodiorite, a change that may be related in some manner to the Hawkesbury Warp. The antiform is interrupted southeast of the head of Sleeman Creek by a southerly plunging synformal structure that underlies the upper part of Falls River. Because Foch Antiform has a steep southwesterly limb and a gently dipping northeasterly limb the northeastern contact of the granodiorite with the gneiss belt is much more irregular than the southwestern contact although both contacts are gradational in many places. The zone between clean granodiorite and the gneiss unit (1) to the southwest is about 4,000 feet wide. As exposed on the northeast end of Hawkesbury Island and southern part of Loretta Island the transition zone includes the following phases. In the gneiss unit, which consists of about one-third biotite gneiss, one-third banded gneiss and the remainder a complex of agmatite and pegmatitic stockwork, zones appear in which the banding dissolves into a nebulitic granodiorite. These zones gradually become more abundant and finally dominant, at which state the contact has been drawn. The granodiorite, however, contains screens of gneiss and nebulitic banding in decreasing abundance for the next 3,000 feet. The nebulitic banding is formed by narrow parallel trains of randomly oriented hornblende and biotite. In places, intricate folds of formerly existing contorted gneisses are clearly preserved. Little is known about the northeastern contact but the transition zone is only several hundred feet wide on the east side of Douglas Channel, and less on Barrie Reach of Gardner Canal. At the latter place the contact is, however, somewhat arbitrarily located along the west side of a substantial band of gneiss that farther east gives way to a gneissic terrane containing abundant quartz diorite which with some justification could be considered a phase of the granodiorite.

The mean specific gravity of 43 specimens of the granodiorite is 2.71.

Map-unit 9d

This unit is a narrow band of complex, sheared rock that trends northwesterly across the head of Porcher Inlet. It is less than a mile wide in most places, and in the map-area has a length of about 6 miles, the northern part lying beyond the north edge of the map-area.

The unit consists of a peculiar sheared garnet-biotite-quartz-feldspar rock of granodiorite or quartz diorite composition. The garnets are small and not everywhere present. In places the rock is a gneiss with dark elongate inclusions and ribbons. It appears to have been a granodiorite or quartz diorite that was extensively sheared and later recrystallized. Locally it contains zones of coarse-grained hornblende pegmatite and irregularly shaped masses of aplite. Both east and west contacts are probably faults. At the eastern contact schist and limestone of unit 2a are highly contorted and cut by minor north-trending shears that show small right-hand offsets.

Garnet-bearing quartz monzonite (unit 10d) appears to occupy the extension of the sheared zone to the south.

Map-unit 9e

South of middle part of Dala River: This small granodiorite pluton is distinctive because of its rather fine grain size and even 'salt and pepper' texture. It contains about 20 per cent mafic minerals, including both hornblende and biotite in an undetermined ratio. Finely disseminated K-feldspar forms about 20 per cent and quartz about 15 per cent of the rock. Small elongate inclusions and rare bands of greenstone make up about 1 per cent of the pluton. Moderate foliation, which was observed in places, strikes east-northeast and dips moderately to the north. Pink hydrothermal alteration is conspicuous locally. Near the southern contact with a small quartz monzonite pluton (10a) the mafic minerals are chloritized and epidote is abundant. The contact was not actually observed but the alteration of the granodiorite indicates that the quartz monzonite is younger.

Six specimens of the granodiorite have a mean specific gravity of about 2.66.

Map-unit 10

Quartz monzonite underlies about 6 per cent of the land-area and forms comparatively small scattered stocks. Like most other rock-units, these bodies are mainly elongated northwesterly parallel with the regional trend. Most of the quartz monzonite is leucocratic and practically free from inclusions. Foliation is rarely well developed.

Map-unit 10a

North of head of Dahlaks Creek: This body is the most distinctive of the several plutons lying between Dala and Kildala Rivers. It consists of a coarse-grained, pinkish, leucocratic, biotite quartz monzonite. Biotite forms about 2 to 5 per cent of the rock, K-feldspar varies from about 20 to 40 per cent, and quartz, which is a conspicuous grey, forms about 30 per cent. Small round dark inclusions make up less than 1 per cent of the pluton. The quartz monzonite is massive, and cut by abundant pegmatite veins. Pink hydrothermal alteration was observed locally. Stringers from the quartz monzonite cut the greenstone along the sharp southeastern contact.

Campania Island: The core of Campania Island consists of clean, massive, medium- to coarse-grained biotite quartz monzonite. The exposed part of the pluton is slightly smaller but similar in shape to the island. The quartz monzonite exhibits a faint pinkish colour that is less distinct than that of the quartz monzonite pluton at the head of Dahlaks Creek in the northeast part of the map-area. In places quartz forms large abundant (up to 40 per cent) conspicuous grey crystals, in other places it is medium grained and less distinct. In contrast, biotite froms tiny disseminated crystals ranging from 2 to 10 per cent of the rock, but less than 5 per cent in most places. Muscovite is present in an undefined zone crossing the pluton about a mile north of Mount Pender. Epidote was recorded in the quartz monzonite in Weinberg Inlet. Inclusions are very rare. Near the margin the rock is faintly foliated with moderate northeast and easterly dips along the east side, and northwesterly dips on the west side. A northwest-trending vertical fault separates the quartz monzonite from the granodiorite on the west. The fault, which coincides with the east side of Jewsbury Peninsula, is marked by considerable shearing.

The quartz monzonite yielded a K-Ar age on biotite of 115±6 m.y. which is comparable with the 133±22 m.y. age, obtained on hornblende from the diorite on Gil Island. Alteration of the diorite on Campania Island by the quartz monzonite indicates that the diorite is older. It may be much older, in which case the isotopic ages do not reflect relative ages of intrusion but a common period of cooling owing to uplift and unroofing.

South of Kitkiata Inlet: This small pluton on the west side of Douglas Channel lies within the Ecstall belt of metasedimentary rocks. It consists mainly of medium- to coarse-grained biotite quartz monzonite. The mafic mineral content ranges from 2 to about 15 per cent, and quartz appears to be abundant, possibly as high as 40 per cent. Epidote and sphene are common. A fine-grained aplitic phase characterized by muscovite and garnet underlies a considerable area near but not at the southern contact. On the south side of Kitkiata Inlet the quartz monzonite grades into medium- to coarse-grained, biotite>hornblende granodiorite with abundant sphene and some epidote. In most places the rock is massive or only faintly foliated, but near the north and south contacts it is intensely sheared. Except near the northern contact where angular blocks of quartzite in the granodiorite form a diffuse agmatite, inclusions are rare. One large block of biotite-hornblende-feldspar schist about 50 feet long was observed along the west side of Douglas Channel. The shearing near the margin of the pluton, but not in the adjoining rocks, indicates that the body may have been in a more or less solid state at the time of intrusion.

Hawkesbury Island: This body consists mainly of a leucocratic biotite quartz monzonite. The grain size varies from less than medium- to coarse-grained, and the mafic mineral content from 2 to 15 per cent. Along the shore of Douglas Channel biotite forms well-defined streaks, but where examined inland it imparts only a faint foliation to the quartz monzonite. The southern contact is roughly a 100-foot-wide zone in which rusty weathering paragneiss containing about 20 per cent random stockwork of quartz monzonite passes into a sharply banded *lit-par-lit* complex with 2-inch to 20-foot-wide granitic layers which farther on coalesce, forming clean homogeneous quartz monzonite. The eastern contact is a broad zone of large-scale angular agmatite part of which is well exposed on the spinal ridge of Hawkesbury Island. As in the adjoining quartz diorite (8b) epidote is common, the mafic minerals are chloritized and the feldspar is altered to chalky white material.

Map-unit 10b

Banks Island: The central spine of Banks Island is underlain by a very white weathering massive coarse-grained biotite>hornblende quartz monzonite. In many places biotite is the only mafic mineral but exposures along Banks and Waller Lakes commonly exhibit appreciable hornblende. The mafic minerals are partly chloritized in most outcrops. Minor sphene was observed. Inclusions are rare. A 'salt- and pepper'-textured aplitic phase dominates the exposures of Kooryet Lake and the west part of the unit exposed on Waller Lake. The aplite in places contains K-feldspar poikiloblasts up to 1 inch across, and, in the northern part of the body, scattered garnets. The aplitic phase has sharp contacts with the coarse-grained phase. The latter in contrast grades into the surrounding granodiorite (unit 9c) and the contacts are located on the basis of K-feldspar content as determined by specimen staining and specific gravity (mean of 2.65 for the quartz monzonite, and 2.69 and 2.73 for the granodiorite on the west and east sides respectively). Although no parallel mineral orientation was observed, the quartz monzonite exhibits a north-trending fracture system related possibly to Principe-Laredo Fault.

Map-unit 10c

Near the head of Aaltanhash Inlet (east side of Princess Royal Channel) is a small body of leucoquartz monzonite or granite. The leucoquartz monzonite is sugary textured at the western contact but coarse grained in most other places. The east contact was not observed but the west contact is sharp against nebulitic quartz diorite (unit 8b), but nearby, east of the contact, the rock passes through an agmatite into a heterogeneous diorite then sharply back into the main mass of coarse-grained leucoquartz monzonite. The limits of body north and south of the inlet are not known but the quartz monzonite was not seen on the adjoining ridges. Another small exposure of this rock was observed on the east side of Klekane Inlet about 8 miles to the northwest.

Map-unit 10d

On Pitt Island quartz monzonite (10d) extends from Sylvia Lake to north of Wyndham Lake and forms two bands at the north end of the island. It is irregular in texture and characterized by small red garnets. Around Wyndham Lake most of the rock is medium- to coarse-grained biotite quartz monzonite, but aplitic phases are common. Biotite forms from 2 to 10 per cent of the rock. In the finer grained phases biotite forms conspicuous 'buttons'. Hornblende is present here and there but subordinate. Epidote is locally abundant, and sphene is rare. Most of the quartz monzonite is massive but it is well foliated near the eastern contact with unit 5b. The western contact with granodiorite (9c) appears to be gradational. Except for a few elongate inclusions the quartz monzonite is in most places clean and massive. On the ridge north of the eastern part of Wyndham Lake the quartz monzonite grades into fine-grained garnet-biotite-quartz gneiss. In many places the quartz monzonite grades into the granodiorite.

The quartz monzonite is similar at the north end of Pitt Island and on the east side of Grenville Channel.

Map-unit 11

Basalt flows were recorded on Bonilla Island, on a small group of islands southeast of Gurd Island, and on Porcher Island at the head of Kitkatla Inlet. The age of these rocks is not known, but they have been assigned a Tertiary age because they are only slightly deformed and because of their comparatively fresh appearance. A much older age is, however, possible.

Bonilla Island: The entire island consists of dark grey massive pillow basalt commonly containing epidote and quartz-filled vugs, and stringers of epidote. The pillows are well exposed in some of the sea cliffs. No stratification was observed. In thin section the basalt is seen to consist of about equal amounts of plagioclase which forms in narrow laths and augite which forms an interstitial matrix. The rock is fresh except for minor chloritization and epidotization.

The basalt is not metamorphosed and apparently not appreciably deformed. It is thought to be Tertiary, but in outcrop the rock resembles parts of the Upper Triassic Karmutsen Formation on Vancouver Island. If this older age were confirmed a pre-Upper Triassic age for the highly metamorphosed and deformed septa of unit 2 on nearby Banks Island would be strongly supported.

Southeast of Gurd Island: About 2 miles southeast of Gurd Island is a small group of islands made up of a more heterogeneous volcanic rock than that of Bonilla Island. A blackish fine-grained basalt with tiny amygdules is overlain by a greenish grey very fine grained andesite or basalt. Locally the underlying basalt is vesicular, although the vesicles are mostly filled with calcite or radiating crystals of zeolite. The contact is roughly horizontal at one place and vertical at another. The apparent attitudes are confirmed by poor vertical and horizontal columns. As there is no other evidence of severe deformation, the vertical contact may be accounted for as the wall of a feeder dyke.

These volcanic rocks are tentatively correlated with the Bonilla Island basalt although they lack the well-developed pillows that characterize that island and are not lithologically identical.

Porcher Island: The west side of the small peninsula jutting into the head of Kitkatla Inlet is underlain by brown weathering, dark green basalt flows. Most of the basalt is fine grained but there are thin coarser layers. These, in addition to local columnar jointing and rare thin layers of vesicles, indicate dips as high as 55 degrees, but no consistent direction.

STRUCTURAL GEOLOGY

Most of what is known about the structure of the area is mentioned in the description of the individual units. Several major structures, however, are of regional importance.

The fundamental grain of the region trends northwesterly conforming in the map-area with the trend of the Coast Crystalline Belt, but when traced to the northwest the main units are seen to trend slightly more westerly than the axis of the belt. This obliqueness brings rocks equivalent to unit 2 from the central part of Douglas Channel map-area to the coast in the northwestern part of Prince Rupert map-area.

The northwesterly-trending fold axes are the oldest structures that can be recognized in the map-area. Although crests are rarely seen, steep easterly dips and tight isoclinal folding appears to dominate the terrane west of the Hawkesbury Warp.

Foch Antiform with its steep easterly dipping west limb and gently easterly dipping east limb illustrates overturning toward the southwest. The east limb of this anticline lies east of the belt of tight folding and was not involved in it, but whether the antiform is older, coeval or younger than the tight folds is not known. The northwesterly-trending structures mainly involve units 1 and 2 and are cut in places by the major plutons which, nevertheless, are commonly elongated parallel with the regional trend. The relationship between deformation and granitization of units 1 and 2 is more difficult to establish than that between deformation and intrusion. Where schist and layered gneiss grade into foliated granitic rock (a common relationship in the area) the foliation of the latter, which conforms even with minor folds in the metamorphic rocks, seems to have been derived from the pre-existing rock rather than superposed on it by forces acting on both. It is concluded that both granitization and intrusion of plutons were later than the main deformation of units 1 and 2.

Some evidence for older northeast structures is described by Baer (1967) in the Bella Coola map-area to the southeast. In Douglas Channel map-area, however, substantial northeast-trending structures are present only in the northeastern part of the map-area and their relationship to the northwest-trending structures is not known, but may be related to development of the Hawkesbury Warp.

In the western part of the map-area the regional trend is emphasized by a number of essentially vertical, northwesterly-trending faults. The more important of these are the Grenville Channel, Kitkatla and Principe-Laredo Faults. The rocks bordering Grenville Channel have recrystallized since most or possibly all of the movement along that fault took place. In contrast the rocks adjacent to the Kitkatla and Principe-Laredo Faults, especially some of the granitic rock on Banks Island, are commonly highly shattered, indicating later movement and/or a higher structural level. Little is known about the direction of movement along these faults but right-hand displacement was recorded on several small parallel faults on Banks Island. Right-hand offset and drag of major rock-units seems to exist adjacent to the southeastern end of Principe-Laredo Fault in Laredo Sound map-area. This sense of movement on the major faults would conform to that of most transcurrent faults in the western Cordillera, and is thought to be probable but not certain.

Later than the northwest folding is the Hawkesbury Warp. It is reflected in structural trends across the entire map-area and appears to be the result of forces that were more regional than those associated with the adjacent intrusions. The lines of weakness underlying Grenville Channel and Princess Royal Channel which probably were once '*en ligne*' now conform with the warp. The Hawkesbury Warp seems therefore to post-date the main period of Grenville Channel faulting. Renewal of this faulting, however, after the warp was created may account for the shearing in the Bear Lake lineament (*see* Fig. 10). Although it is tempting to consider the Hawkesbury Warp as a regional drag fold, this implies a left-hand sense of movement which is contrary to that of the major transcurrent faults on the Pacific margins of the continent.

Both of the northeasterly-trending Hazelton Group rocks and the Gil Island circular area of basic rocks may be related to the framework of the Hawkesbury Warp but the relationship is not evident from known data. The simplest concept, that the northeast-dipping Hazelton Group is a remnant of the northwest limb of a large northeasterly-trending antiformal structure caused by the warp and that the Gil Island centre of basic rocks lies on the axis of the complementary synformal zone cannot be substantiated by the recorded attitudes.

CONCLUSIONS

The Douglas Channel-Hecate Strait map-area is extraordinarily difficult to map on a reconnaissance scale. Owing to the heterogeneity and complexly gradational contacts of many of the rock-units their limits are to a degree arbitrary, resulting in lines on the map where none appear in the field. The complexity of the geology thus often fails to persist through the cartographic process, and the resulting map is simplified much more than it would be in an area dominated by stratified rock units.

Isotope age determinations in the Coast Crystalline Belt between latitudes 52° and 55°N, while sparse, suggest that the rocks on the west (as old as about 140 m.y.) actually did cool before those on the east (as young as about 40 m.y.). It is thought that the cooling is more closely related to general uplift than to emplacement of individual plutons because the isotopic determinations correspond more closely to position in the Coast Crystalline Belt than to rock composition. Present age determinations suggest a grouping of ages in northwesterly-trending belts, possibly separated by faults, but additional determinations will probably reveal a more complex pattern. Much critical evidence bearing on the interpretation of isotopic age determinations in the Coast Crystalline Belt is unfortunately not available. The determinations reflect only the last time of cooling through a temperature below which radiogenic argon is retained. It is not definitely known whether the cooling was sequential to a minor thermal event, regional metamorphism, fusion, upward intrusion, or simple unloading after uplift.

The fundamental problem of any area in the Coast Mountains is the origin of the plutonic rock. Granitization on a massive scale is evident at many places in both the dioritic complexes on the west and the more acid gneiss belt to the east. Intrusion and plastic deformation is common, but whether the mass plasticity was the result of partial melting or the presence of a tenuous hydrous vapour phase is not known. The difference is not merely academic as vastly different temperatures may be involved. Although complex, and commonly nearly unmappable, the heterogeneous migmatitic areas are more easily decipherable than clean massive plutonic rock such as found in parts of Ecstall and Butedale plutons. As the thermal effects of these latter rocks differs in no way from those of clearly granitized origin, the writer doubts that the massive plutons were emplaced magmatically, and, although much more work is required to resolve the matter, favours the concept of emplacement as crystalline diapirs as concluded for the plutonic rocks of the Vancouver area (Roddick, 1965) and Adamant pluton (Fox, 1969).

Figure 10. View northeast from over east side of Campania Sound showing the Bear Lake lineament crossing the picture in the near background. Terrain is higher and more rugged northeast of lineament. (B.C. Government Air Photograph 501:77)

Some model of the evolution of the Coast Crystalline Belt is possibly warranted, even though rapid reconnaissance mapping does not provide a sound basis for an adequate model, as it does provide some limits to speculation, principally the general character of the plutonic rocks and their distribution. Most of the plutonic rocks are heterogeneous throughout the area, but they are more dioritic and commonly more heterogeneous in the western part of the map-area, yet some very acidic plutons (for example, the quartz monzonite on Campania Island) are present in the west. No explanation of this distribution can be made without certain assumptions, and some are made here: namely, that the fundamental differentiation of sialic material from simatic (oceanic crustal) material is effected not by magmatic differentiation but through the action of the hydrosphere (including the atmosphere) on the lithosphere and subsequent solution, sedimentation and accumulation of eugeosynclinal piles; metamorphic processes are capable not only of converting eugeosynclinal material to granitoid rock but also of effecting massive redistribution of components according to slowly changing thermal patterns in the pile; in places fusion may occur but in the writer's opinion, it is a less effective mechanism for large scale component redistribution, and not a prerequisite for intrusion.

The presence of more basic plutonic rock in the west suggests more basic parent material there than farther east. This may be accounted for by postulating a greater abundance of basic volcanic material in the eugeosynclinal pile, or that part of the oceanic crust beneath the pile was involved in the plutonism. Neither explanation accounts very satisfactorily for the presence of acid plutons in the west. In the western United States where the quartz diorite line separates basic plutonic rocks in the west from more acid varieties in the east, it has been suggested that the line represents the junction between an eugeosyncline and miogeosyncline (Bateman and Eaton, 1967). This explanation is not applicable to the Coast Crystalline Belt as no miogeosyncline existed in the eastern part of the belt.

The hypothesis favoured by the writer is based on the postulate that the Canadian Shield extended to very near the present continental margin, and that the eugeosynclinal pile was deposited on it rather than on oceanic crust. With full development of the pile, the parts that were wet and over about 350°C became granitized, commonly incompletely. Given a mass plasticity by means of a thin but pervasive hydrous intergranular fluid (gaseous), parts of the granitized pile became mobilized and moved upward as diapiric intrusions. Parts of the deeply buried shield were also mobilized, possibly aided by the penetration of hydrous fluids from the overlying eugeosynclinal rocks. Finally the whole belt was uplifted exposing not only intrusions but granitized terranes as well. The results in the west were three types of plutonic terranes: dioritic complexes showing little differential movement; diorite, quartz diorite and granodiorite intrusions, representing mobilized eugeosynclinal materials; and quartz monzonite intrusions, representing mobilized shield. East of the diorite line, mainly shield material is exposed owing either to great uplift there or a thinner original eugeosynclinal cover. The transition between the base of the eugeosynclinal pile and the Canadian Shield terrane is thought to be somewhere in unit 1, but granitization of the base of the pile and plastic deformation of both this and the underlying shield, itself containing gneisses, has obliterated the unconformity.

ECONOMIC GEOLOGY

At present no mineral property in the map-area is in production. In past years, however, significant production was obtained from Surf Inlet Mine on Princess Royal Island and Drum Lummon Mine on Douglas Channel. A number of prospects have long histories of sporadic exploration but none promise production in the near future.

Most of the properties fall into one of two types, namely, gold-bearing pyritized quartz veins such as the Surf Inlet Mine, and sulphide replacements of skarn or schist, in which copper and/or gold represented the main values, such as the Gibson Island prospect.

Gold-bearing Pyritized Quartz Veins

Surf Inlet Mine (14)[1]

References: B.C. Min. Mines, Ann. Rept.: 1902, pp. 51-53; 1913, pp. 100-103; 1914, pp. 150-151; 1915, p. 69; 1917, pp. 38-42; 1918, pp. 45-46; 1919, pp. 40-41; 1920, p. 37; 1921, p. 40; 1922, p. 43; 1923, p. 45; 1924, p. 45; 1926, pp. 68-69; 1933, p. 41; 1934, pp. 5-6; 1935, p. 25; 1936, p. 57; 1939, pp. 67-68; 1942, p. 54; 1943,

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[1]Number in brackets refers to number of property on map.

p. 54; Geol. Surv. Can. Summ. Rept., 1921, Pt. A, pp. 30-34A; 1948, Structural Geology of Canadian Ore Deposits, Can. Inst. Mining Met., pp. 99-104.

Surf Inlet Mine is located on Princess Royal Island about 5 miles north of the head of Surf Inlet. It is the most important of the two mineral deposits in the map-area which have yielded more than trial shipments of ore, the other being Drum Lummon Mine on Douglas Channel.

The original discovery was made about the turn of the century by tracing white quartz 'float' from the bottom of the valley which enters Bear Lake from the east, up to where the veins outcrop on the north and south sides of the valley. The veins have a northerly strike and dip moderately (45 degrees) to the west. They are in a fault zone made up of several shears that has been traced about 3 miles horizontally and more than 3,000 feet vertically. The veins lie near the east side of a northerly-trending screen of hornblende gneiss that is 1,000 to 2,000 feet wide and enveloped in hornblende>biotite quartz diorite (unit 8b). The veins, which range from 100 to 1,000 feet in length and from 2 to 40 feet in width, appear to fill subsidiary tension fractures opened by movement along the main shears. Striae plunging about 45 degrees north and abundant other evidence indicate a resultant left-hand offset, in which the west or hanging-wall moved upward and southward.

Along with very fine gold the milky quartz veins contain pyrite (up to 25 per cent) chalcopyrite, ankerite, and minor amounts of calcite, chlorite and molybdenite. Most of the gold appears to be in fractured pyrite, but visible gold is extremely rare.

Trial shipments of the ore were first made in 1902, and although these yielded excellent values in gold (about 5 oz. per ton) and copper (about 3 per cent), subsequent work was discouraging. Serious doubts arose as to the average value of the ore, and activity on the property remained at a low level until 1912 when a more vigorous development program began. This led to large scale production beginning in 1917 and ending in 1926. During this period 836,500 tons of ore were mined and yielded 322,297 oz. of gold, 176,734 oz. of silver, and 5,244,772 pounds of copper for a total value of nearly eight million dollars at the then current metal prices.

A new company, Princess Royal Gold Mines Limited was organized in 1933 and reorganized as Surf Inlet Consolidated Gold Mines Limited in 1935. Production was intermittent and on a small scale until 1943 when the property was finally closed down. During this period the property produced 166,546 tons of ore valued at $2,324,103.

Western Copper Group (16)

References: B.C. Min. Mines Ann. Rept.: 1924, p. 45; 1925, p. 66; 1926, pp. 69-70; 1927, pp. 60-61; 1928, pp. 67-68; 1929, p. 71; 1932, pp. 37-38.

This property is situated on the east fork of Khutze River about 4 1/2 miles from the head of Khutze Inlet. It was originally staked in 1908 by A. McLeod of Vancouver, and by 1910 considerable work had been done. This consisted of open-cuts along the vein, some tunnelling, and a 2 1/2 mile light railway up the valley from tidewater. About 48 Crown-granted claims comprised the property when it was taken over Messrs. Martin and Shannon of Vancouver. The property was idle until 1925 when it was bonded to E.W. Scully who formed Khutze River Mines Limited. This company reconditioned the camp and tramline, and did a little work on the mineralization, then allowed the bond to lapse. In 1926 the property was purchased by the Revenue Mining Company who did some preliminary work. Detroit Western Syndicate bought the property in the same year and retained the former owners to administer the development work. Most of the effort in 1927 was spent in constructing a permanent camp and a new railway, 5 miles long, extending from the inlet to the base of the hill below the main workings. Construction began also on a 3,000-foot aerial tramway to connect the railway with the tunnel site. In 1928 attention was belatedly turned to exploration work. The tunnel was started about 12 feet below the vein in the footwall, and when driven in a few feet, was swung over to the vein. There the vein unfortunately had pinched to a few inches of quartz and sulphide and was then cut off by a fault that outcropped on the surface. Further exploration was directed to other parts of the property and although about 100 tons of ore was mined from surface cuts nothing encouraging was found. During 1929 a small shipment of the ore was made and work continued on a shaft. In November operations ceased. Ownership passed to Western Copper Venture, a Vancouver syndicate, but according to the last report in 1932 no further work had been done.

The main mineral deposit occurs in a long, gently dipping quartz vein, striking N70°E and dipping 20 to 30 degrees south, which occupies a well-developed joint plane in biotite>hornblende granodiorite (unit 9b). The vein outcrops on a precipitous mountain side and crosses several steep-walled gullies. It varies in width from an inch or two to four or five feet. In places it is mineralized with pyrite and chalcopyrite, and in those places it carried gold. The reported assays show erratic values varying from trace to as high as 7 ounces per ton gold, and 10 ounces per ton silver. Rich ore is restricted to small isolated lenses which would make mining difficult.

Hunter Group (15)

References: B.C. Min. Mines, Ann. Rept.: 1930, p. 65; 1932, pp. 34-37; 1933, p. 41; 1939, p. 68; 1940, p. 53; 1941, p. 55.

This group is situated at 950 feet elevation on the east side of a north branch of the north branch of Khutze River, about 8 1/2 miles north of the Western Copper camp. It was first staked in 1927. Further discoveries were made on the west side of the river between elevations 1,200 and 2,750 feet in 1929 and 1930. In 1930 the property was owned by C.W. Meldrum and associates of Vancouver. Up to 1932 little work had been done on the property, most of the effort having been spent on cutting a trail to the claims. In 1933 about 3 tons of ore from surface workings was shipped. The property was optioned in late 1939 to P.W. Racey of Seattle who, with a small crew of nine men, sank a 150-foot shaft and drove 50-foot drifts from each side of it. Little work has been done since.

The deposit consists of narrow discontinuous quartz veins mineralized with gold-bearing pyrite in erratically distributed lenses. The country rock is reported to be biotite quartz diorite. The quartz veins are very narrow, ranging from a fraction of an inch to about 18 inches wide, and as they cut aplite and pegmatite dykes they represent the latest stage of hydrothermal activity in the area. The sulphide mineralization is restricted to quartz veins except for rare instances. Besides pyrite minor chalcopyrite is present. Selected mineralized samples of the veins yielded from 0.2 to 6.7 ounces of gold per ton, and minor silver.

Donaldson Creek (Henrietta, Margaret) (5)

Reference: B.C. Min. Mines, Ann. Rept.: 1930, p. 68.

The property is situated about a quarter mile up Donaldson Creek from Patsy Cove, on the northeast side of Banks Island about three miles northeast of Mount Gransell. In 1930 the property was reported as consisting of a group of old claims (Henrietta and Margaret) on which a crown grant was issued in 1907. It was then owned by E.J. Smith of Victoria.

The deposit is a 20- by 60-foot pod of massive sulphide enclosed by an envelope of barren milky quartz which is in turn enclosed in unmineralized quartz diorite. The deposit appears to be a replacement of a large inclusion of metasediments in the quartz diorite. G. Woodsworth examined the property in 1968 and reported that the mineralization consists mainly of pyrrhotite and lesser amounts of magnetite, chalcopyrite and pyrite. A large chip sample collected by Woodsworth yielded 0.58% copper, and traces of gold, silver and nickel.

Rowe Claims (2)

References: B.C. Min. Mines, Ann. Rept.: 1922, pp. 43-44; 1925, p. 67; 1926, p. 71; 1927, p. 61; 1929, p. 75; 1930, p. 69; 1932, p. 49.

These are situated on Pitt Island, on the west slope of Noble Mountain at 1,400 feet elevation. The claims were staked in 1920 by J.E. Hallpy of Prince Rupert, and again in 1925 by J. Costello and C.O. Rowe of Prince Rupert. A short tunnel was started that year, but most of the work was by open-cuts during the period 1926 to 1932. The prospect consists of a well-defined quartz vein 4 to 6 feet wide and traceable for about 700 feet. It trends northerly and dips moderately to the east. The veins contain sparse lenses and pods of pyrite that bear variable amounts of gold. Minor chalcopyrite is also reported.

Golden Crown Group (9)

References: B.C. Min. Mines, Ann. Rept.: 1899, p. 656; 1900, p. 787, 1901, p. 992; 1907, p. 74; 1928, p. 69.

This deposit is in the canyon wall of Wathl Creek about 4 1/2 miles east of Kitimat Mission on the east shore of Kitimat Arm. The property was staked in 1899 by Messrs. Steele and Dunn and explored by trenching in 1899, 1900, and 1901. By 1907 a 155-foot tunnel had been driven. The property was abandoned sometime after 1909. It was restaked in 1928 for the Cal-Brit Exploration Company which immediately went into liquidation and ownership passed to the Big Slide Mining and Development Company, Limited. The last report (1928) mentions that the new owners did not examine the property. Economic interest was mainly in a 20-foot quartz vein containing some value in copper, gold and silver.

Payroll Claims (12)

References: B.C. Min. Mines, Ann. Rept.: 1920, pp. 38-39; 1921, p. 40; 1922, p. 45; 1929, p. 69.

These are situated on the south shore of Kiltuish Inlet about 1 1/2 miles from the head. They were staked by J. Hickey of Prince Rupert in 1920. A little work was done on the property that year and during the following two years. The claims were later allowed to lapse and were restaked as the High Tide Group by L.W. Patmore of Prince Rupert in 1929. No appreciable work, however, was done on the property. The main exposure, on the beach, consists of a 6-foot-wide quartz vein in hornblende schist. It is heavily mineralized with pyrrhotite, pyrite and a little chalcopyrite. Assays yielding low gold and copper values were not encouraging.

Cordila Group (13)

References: B.C. Min. Mines, Ann. Rept.: 1921, p. 40; 1922, p. 43; 1923, p. 45; 1926, p. 71.

This group is situated on the west side of Drake Inlet (Princess Royal Island) near where it joins Cornwall Inlet (referred to in the older reports as Rivers Bight). It was staked by D. Cordila and J. Koski of Butedale in 1920, and bonded to Rivers Bight Syndicate. A 300-foot-long tunnel was driven along the mineralized shear zone but the results were not satisfactory and the bond lapsed in 1922. A little additional work was done up to 1926 the date of the last report. The deposit consists of small lenses of pyritized quartz lying in a shear zone in quartz diorite (unit 8b). Assays yielded only low values in gold and silver.

Sulphide Replacement of Skarn or Schist

Ecstall (7)

References: B.C. Min. Mines, Ann. Rept.: 1900, pp. 788-789; 1901, p. 991; 1902, p. 47; 1916, p. 50; 1917, p. 45; 1918, p. 47; 1919, p. 42; 1920, p. 40; 1923, p. 46; 1942, pp. 81-84; 1958, pp. 7-9; 1966, p. 54.

This property is situated on Red Gulch Creek, a minor tributary of Ecstall River, about 2 miles west of Johnston Lake. It is thought to be the oldest property in the map-area, having been discovered some years prior to 1900 when it was purchased by Mr. John Bryden of Victoria who organized the British Columbia Pyrites Company. Economic interest was in the pyrite as a source of sulphur. Considerable tunnelling was done on the property in 1901 and 1902 and a trail shipment was made to Victoria Chemical Works. Interest then waned until 1916 when the property was bonded to Lewisohr Bros. of New York. About 750 feet of diamond drilling was done on the property in early 1917. Granby Consolidated Company, who took an option on the property in the fall of 1917 did further drilling on it in 1918 and 1919. Not encouraged by the results of several thousand feet of drilling, the company relinquished its option in 1920. Three years later Granby took up the option once again, did some exploratory work, then once more dropped the property. In 1937 the property was acquired by Northern Pyrites Limited and after some preliminary drilling that year underground development began in 1938. By 1940 the new workings consisted of 3,500 feet of tunnelling and a 600-foot raise to the surface. The property was idle until 1952 when Northern Pyrites Limited was reorganized as Sulgas Properties Limited. The extensive exploratory program of this company resulted in 1,378 feet of surface drilling, 8,880 feet of underground drilling, geophysical survey of the known deposits and a geological reconnaissance of the surrounding territory. The property was acquired by Texas Gulf Sulphur Company who did further geophysical work in 1957 and 1958.

The mineral deposits are massive sulphide replacements of quartz-biotite-chlorite schist, quartz-hornblende-chlorite schist, quartzite grading to quartz-mica schist, minor black argillite and granitoid gneiss, the entire assemblage being part of unit 2a. The main deposits are two tabular bodies known as North Lens and South Lens. On examining some polished sections of the ore, G. Woodsworth reported the pyrite which is by far the most abundant mineral, forms cubic crystals which are closely packed but separated from each other by thin gangue layers. This accounts for the rather friable nature of the ore that causes outcrops of it to rapidly disintegrate. Interstitial among the pyrite crystals are minor amounts of sphalerite, marcasite, galena and chalcopyrite. His assay of a sample collected across 20 feet of the South Lens yielded 0.02 oz. gold, 0.6 oz. silver, 0.18% copper and 3.02% zinc.

Gibson Island (1)

References: B.C. Min. Mines, Ann. Rept.: 1914, pp. 149-150; 1917, pp. 44-45; 1926, p. 71; 1929, pp. 72-74; 1952, pp. 79-80.

Mineralized rock was discovered on Gibson Island, which lies in the northern entrance of Grenville Channel, some years before the First World War by prospectors living in Prince Rupert. The several claims staked made up the Wild Goose Group. Granby Company took an option on the property in 1914 and it was renamed the Standard Group which covered practically the whole island. By 1917 a 40-foot shaft and some crosscuts had been completed but the vein yielded only low values and the work was discontinued. Until 1927 only enough assessment work was done to keep the claim from lapsing. The property became open in 1928 and was restaked by Frank Cole and George Keys of Prince Rupert as the Gibson Girl. The new owners discovered a second mineralized zone that looked promising, and Granby Company again took up an option. After some inconclusive surface work, however, the company again relinquished the property. Near the end of 1929 it was bonded by Consolidated Mining and Smelting Company but with the onset of the Depression the property was dropped with little further work. In 1951 Gibson Girl Mines Limited, a company headed by K.J. Springer, was formed to explore the property. Twenty-two holes, totalling 5,279 feet, were diamond drilled but failed to indicate an economic deposit.

The mineralized zone lies along an altered contact between crystalline limestone (unit 2c) and schist (2a). Quartz-feldspar-biotite, chlorite, and hornblende-muscovite-garnet are the dominant varieties of schist. Mineralized rock extends for at least 1,500 feet but is discontinuous. Most of the sulphide is restricted to narrow siliceous bands and schistose partings. G. Woodsworth who examined polished sections of the ore reported, in order of abundance, chalcopyrite, sphalerite, galena, pyrrhotite, marcasite and pyrite. The chalcopyrite forms massive segregation in calc-silicate rocks and narrow bands of dispersed grains in schist. The sulphides have replaced pre-existing material rather than filled open space. W.R. Bacon collected 15 samples in 1952 for assay. The average 0.84 oz. silver, nil gold, 2.15% copper, 2.6% zinc, and 1.4% lead.

Hepler Lake Property (6)

Reference: B.C. Min. Mines, Ann. Rept.: 1963, pp. 21-23.

This property is situated midway between Banks and Waller Lakes on the much smaller, Hepler Lake. The first claims, based on an exposure of auriferous, siliceous and pyritized skarn, were staked in 1960.

Falconbridge Nickel Mines Limited explored the mineralization in 1963 by drilling 23 holes totalling 7,050 feet, the deepest of which penetrated mineralized skarn at 350 feet.

The mineralization forms a lens in a screen of metasedimentary rock that is rarely more than 1,000 feet wide and consists chiefly of crystalline limestone, skarn and slate. The rocks form an isoclinal syncline striking N20°W to N40°W. Faults, evident in the screen, form a lineament that extends the full length of the island. The skarn is brecciated, silicified and mineralized with pyrrhotite, pyrite, chalcopyrite, arsenopyrite and minor galena and sphalerite. In places widths up to 50 feet are mineralized. The main values are in gold. G. Woodsworth, who examined polished sections of the ore, reported average assays of about 1.3 oz. gold and about 2.6 oz. silver.

Marble Bay (3)

Reference: B.C. Min. Mines, Ann. Rept.: 1929, p. 75.

This property, situated on the northeast shore of Banks Island 5 1/2 miles from the north end, was staked originally in 1929 by P.M. Ray, J.L. Jollymore and associates of Prince Rupert, and has attracted sporadic interest up to recent years. According to G. Woodsworth who visited the property in 1968 and examined some polished section of the mineralization, the deposit formed along the contact between a screen of intercalated crystalline limestone and chloritic and quartz diorite (unit 8b). The limestone near the contact is altered to epidote-garnet-chlorite skarn, which bears the heaviest sulphide mineralization. The sulphides consist mainly of pyrite and chalcopyrite with minor amounts of molybdenite. In spite of repeated efforts through the years the mineralized skarn zone has not been traced more than 100 feet. A chip sample collected by Woodsworth of the best mineralization assayed 0.01 oz. gold, 0.3 oz. silver, 1.36% copper and 0.02% molybdenum.

Kingkown Lake (4)

This small deposit is situated on the north shore of the west end of Kingkown Lake. Falconbridge Nickel Mines Limited drilled two holes (totalling 125 feet) in mineralized skarn in 1963. The deposit is a partial replacement of a 10-foot-wide screen of crystalline limestone and limy schist that have been partly altered to a skarn of quartz, garnet, epidote, and hornblende. G. Woodsworth reports the mineralization is mainly chalcopyrite followed by pyrite and magnetite, with minor sphalerite and molybdenite.

Empress and Copper Cliff Groups (11)

References: B.C. Min. Mines, Ann. Rept.: 1901, p. 992; 1905, pp. 85-87; Geol. Surv. Can., Summ. Rept., 1921, Pt. A, p. 39.

These two adjacent properties, which lie at about 1,200 feet elevation near the southeast corner of Gribbell Island, were staked in 1899; the Empress Group by Canadian-American Mining Company, and the Copper Cliff Group by the Gribbell Island Copper Company. Between 1900 and 1906 considerable exploration work was conducted, resulting in several hundred feet of tunnels and crosscuts, and a short shaft, but owing to the low value and discontinuity of the ore the project failed.

The main deposit occurs in an east dipping (60 degrees), 20- to 30-foot bed of crystalline limestone intercalated with schist (unit 2b) and cut by diorite (unit 7b). Skarn minerals, garnet, epidote and diopside have developed in the limestone. Associated with these minerals are impregnations of chalcopyrite, bornite, chalcocite and covellite. Samples yielded only low values in copper, gold and silver.

Kildala Claims (10)

References: B.C. Min. Mines, Ann. Rept.: 1928, pp. 69-70; 1929, p. 70.

These are situated on a small point which juts out from the north side of Kildala River flats. The property was staked in 1928 on the basis of a little chalcopyrite and pyrite in a narrow bed of crystalline limestone. Assay values for gold, silver and copper were negligible and the property is only worth mentioning because the owners claimed to have had assays yielding 1.7% tin. The claim could not be confirmed by later assays made in Victoria by the B.C. Department of Mines.

Unclassified Mineral Deposits

Drum Lummon Mine (8)

References: B.C. Min. Mines, Ann. Rept.: 1908, p. 58; 1909, p. 56; 1916, p. 50; 1917, pp. 42-43; 1918, p. 46; 1919, pp. 41-42; 1920, p. 39; 1921, p. 41; 1922, p. 45; 1923, p. 46; 1924, p. 46; 1925, p. 67; 1926, p. 71; 1928, p. 70; 1929, pp. 70-71; 1930, pp. 66-67; Geol. Surv. Can., Summ. Rept. 1921, Pt. A, pp. 35-38.

This property is located about a mile from the shore of Drumlummon Bay, a small cove on the northwest shore of Douglas Channel beside the outlet of Foch Lagoon.

It was first staked in the fall of 1907 by Messrs. Sloan and McLennan. A small test shipment of the ore was sent to the Ladysmith smelter in 1909, and yielded high copper (9.2%), some silver (3.84 oz.), and minor gold (0.01 oz.). Drum Lummon Copper Mines Limited was formed to develop the property. Work proceeded slowly partly because the original intent to finance development by concurrently hand picking high grade ore pockets proved unfeasible. By 1918 a small mill was in operation but the erratic nature of the ore prevented steady production. The company was reorganized in 1921 as Drum Lummon Mines Limited (deleting the product from its name) but in the face of continuing financial difficulties ceased operation in 1923 and went into bankruptcy the following year. In 1925 the property was transferred to a new company Paisley Point Mines Limited which conducted a small exploration program that summer. No encouraging results were obtained. In the fall of 1927, Los Angeles-Vancouver Mines Limited was incorporated to take over and operate the property. After three years of fruitless underground work, the company ceased operation in September 1930, and, being without funds or credit, left their employees stranded on the property. Little interest has been shown in Drum Lummon Mine since.

The mineralization consists mainly of bornite and chalcocite with some chalcopyrite which contains minor gold and silver. It is concentrated mainly near the margins of irregularly shaped masses of pegmatitic quartz and feldspar which have developed in the coarse-grained hornblende>biotite quartz diorite that forms the country rock. Sulphides are concentrated in erratically distributed, irregularly shaped pods that locally penetrate the quartz diorite. In the upper levels of the workings minor native gold and silver were recorded.

Mica Group

References: B.C. Min. Mines, Ann. Rept.: 1932, p. 50; 1934, p. 10; 1935, p. 30; 1940, p. 99.

This group is on the north shore of Baker Inlet (exact location not known) off Grenville Channel. The property originally owned by Harry Scott of Prince Rupert, and later, from 1934, by P.M. Ray of Prince Rupert. The deposit is reported to consist of good grade sericite lenses in a pegmatitic zone in metasediments of unit 2a. The lenses are erratically distributed. Exploration of the deposit was limited to open-cuts which exposed a discontinuous zone

TABLE I

MAIN CONSTITUENTS OF THE THERMAL SPRINGS

Spring[1]	Cl ppm	Cl %	Na ppm	Na %	SO_4 ppm	SO_4 %	Mg ppm	Mg %	Ca ppm	Ca %	K ppm	K %
1 Brim River	52	18.5	43	15.3	78	27.8	12	4.3	17	6.0		
2 Gardner Canal	60	4.9	259	21.1	546	44.5	5	0.4	67	5.5	29	2.4
3 Bishop Bay	32	8.0	92	22.9	179	44.5		-	18	4.5		
4 Ursula Channel	24	6.1	81	20.5	174	44.1		-	22	5.5		
5 Klekane Inlet	4,600	53.5	2,523	29.3	717	8.3	179	2.1	385	4.5	82	1.0
Normal Sea Water[2]	19,630	55.8	10,770	30.6	2,701	7.7	1,298	3.7	408	1.2	387	1.1

Spring[1]	HCO_3 ppm	HCO_3 %	CO_3 ppm	CO_3 %	SiO_2 ppm	SiO_2 %	FeO+ Al_2O_3 ppm	FeO+ Al_2O_3 %	Total dissolved solids in ppm	Temp. °F
1 Brim River	40	14.2			36	12.8	3	1.1	281	~100
2 Gardner Canal	167	13.6			90	7.3	5	0.4	1,228	>>112
3 Bishop Bay	4	1.0	7	1.7	65	16.2	5	1.2	402	>>112
4 Ursula Channel	2	0.5	10	2.5	59	14.9	23	5.8	395	>>112
5 Klekane Inlet	58	0.7				-	58	0.7	8,602	>112
Normal Sea Water[2]	116	0.3	12	-					35,161	

[1] These numbers refer to identification of spring on map.

[2] Rubey, W.W. Geologic history of sea water. An attempt to state the problem: Bull. Geol. Soc. Am., vol. 62, pp. 1111-1148, 4 figs., 1951.

more than 600 feet long, and 2 to 7 feet wide. About 80 tons of crude sericite were marketed in Vancouver in 1940, and some further shipments were made in 1941.

Thermal Springs

The five thermal springs in the area were discussed by Dolmage (1922) and more recently in a comprehensive compilation of mineral and thermal waters in Canada by Souther and Halstead (in press). In addition to the above five springs, others, undiscovered or unreported, probably exist in the project area. The known springs are: 1. Brim River - near the southeast bank about 200 yards above the mouth; 2. Gardner Canal - on the north side of Gardner Canal in the small cove between Shearwater and Europa Points; 3. Bishop Bay - off Ursula Channel, near head of bay; 4. Ursula Channel - on east side of channel about 2 3/4 miles north of Goat Harbour; 5. Klekane Inlet - at head of inlet. Except for the Brim River spring all are within a few feet of tidewater, warmer than 112°F, and situated in or near the mainland (that is, northern) part of Butedale Pluton. All issue from granodiorite (unit 9c) or quartz diorite (unit 8a) except the Gardner Canal spring which emerges from chloritic schist (unit 1).

The spring waters are thought to have a meteoric origin and to have been heated by passing through deep seated joints. Except for the Klekane Inlet spring, all are of the sodium sulphate type (*see* Table I). Oxidation of pyrite may account for the sulphate. The Klekane Inlet spring discharges a sodium chloride water which is much higher in total dissolved solids than that issuing from the other springs. Comparison of the main constituents of this spring with that of normal sea water (*see* Table) reveals such a close similarity that contamination of the meteoric by sea water can scarely be doubted.

REFERENCES

Baer, A.J.
1967: Bella Coola-Laredo Sound map-area, British Columbia; *Geol. Surv. Can.*, Paper 66-25, 13 pp.

Bateman, P.C., and Eaton, J.P.
1967: Sierra Nevada Batholith; *Science*, vol. 158, pp. 1407-1417.

Dolmage, V.
1922: Coast and islands of British Columbia between Burke and Douglas Channels; *Geol. Surv. Can.*, Sum. Rept. 1921, Pt. A, pp. 22-49.

1923: Coast and islands of British Columbia between Douglas Channel and the Alaska Boundary; *Geol. Surv. Can.*, Sum. Rept. 1922, Pt. A, pp. 9-34.

Duffell, S.
1959: Whitesail Lake map-area, British Columbia; *Geol. Surv. Can.*, Mem. 299, 119 pp.

Duffell, S., and Souther, J.G.
1964: Geology of Terrace map-area, British Columbia; *Geol. Surv. Can.*, Mem. 329, 117 pp.

Fox, P.E.
1969: Petrology of Adamant pluton, British Columbia; *Geol. Surv. Can.*, Paper 67-61, 101 pp.

Holland, S.
1964: Landforms of British Columbia; *Brit. Columbia Dept. Mines, Petrol. Resources*, Bull. 48, 138 pp.

Hutchison, W.W.
1967: Prince Rupert and Skeena map-area, British Columbia; *Geol. Surv. Can.*, Paper 66-23, 27 pp.

Money, P.L.
1959: Geology of Hawkesbury Island; unpublished M.Sc. Thesis, Univ. Brit. Columbia.

Read, P.B.
1958: Ecstall Mine to Skeena River area, British Columbia; unpublished report for Texas Gulf Sulphur Co.

1963: Geology of the southwestern portion of the Whitesail Lake map-area, British Columbia; unpublished report for Texas Gulf Sulphur Co.

Roddick, J.A.
1965: Vancouver North, Coquitlam and Pitt Lake map-areas, British Columbia; *Geol. Surv. Can.*, Mem. 335, 276 pp.

Roddick, J.A., Baer, A.J., and Hutchison, W.W.
1966: Coast Mountains Project; *Geol. Surv. Can.*, Paper 66-1, pp. 80-85.

Souther, J.G.
1964: Coast Range Project; *Geol. Surv. Can.*, Paper 64-1, pp. 24-25.

Souther, J.G., and Halstead, E.C.
(in press): Mineral and thermal waters of Canada; *in* Symp. on Genesis of mineral and thermal waters; *XXIII Intern. Geol. Congr.*, Prague, Czechoslovakia, 1968.

Stacey, R.A., and Stephens, L.E.
1969: An interpretation of gravity measurements on the west coast of Canada; *Can. J. Earth Sci.*, vol. 6, pp. 463-474.

Stuart, R.A.
1960: Geology of the Kemano-Tahtsa area, British Columbia; *Brit. Columbia Dept. Mines, Petrol. Resources*, Bull. 42, 49 pp.

White, W.H.
1959: Cordilleran tectonics in British Columbia; *Bull. Am. Assoc. Petrol. Geologists*, vol. 43, No. 1, pp. 60-100.