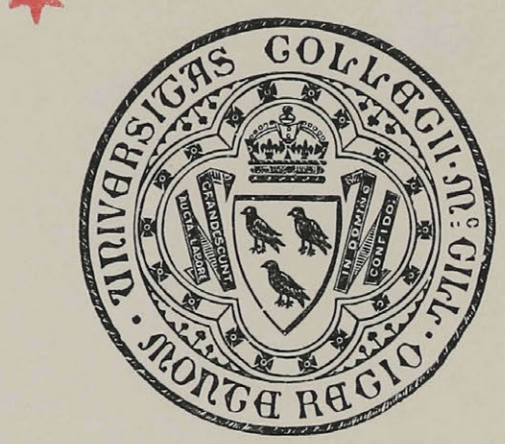
# PETROGRAPHY OF SOME OF THE IGNEOUS ROCKS OF TEXADA ISLAND



# THE PETROGRAPHY OF SOME OF THE IGNEOUS ROCKS OF TEXADA ISLAND

by

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## INTRODUCTION.

Texada Island is composed chiefly of igneous rocks comprising extrusive, intermediate and intrusive varieties. The volcanic rocks, including the hypabyssal type, are the most widespread, while plutonic and dike rocks are well represented.

It is proposed in this paper to refer briefly to the geography, topography, and general geology of the island, and then to describe the various types of igneous rocks, including some pyroclastic rocks which are intimately associated.

### Geography.

The island lies in the Gulf of Georgia, its south-eastern extremity being forty-seven miles from Vancouver. It has a length of about thirty miles and a maximum width of six and one half miles.

### Previous Work.

Reports of geological examinations have been written by the late Mr. James Richardson*, the late Dr. Geo. M. Dawson**, and Mr. O. E. Leroy***. Mr. R. G. McConnell made a detailed study of the geology of the island during 1908-9, the writer acting as his assistant during the summer of 1909. Mr. McConnell's report has not yet been published. Dr. G.A.

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* Report of Progress, Geol. Sur. of Can. 1873-4, 1876-7.

** Annual Report, Part B, Geol. Sur. of Can. 1886.

*** Preliminary Report on a Portion of the Main Coast of British Columbia and Adjacent Islands, Geol. Sur. of Can. 1908.

Young, of the Geological Survey of Canada, has made a study of the sections of specimens secured by Mr. McConnell during the summer of 1908.

The writer wishes to acknowledge the assistance received from Mr. McConnell and Dr. Young in the preparation of this paper.

## Topography.

The topography of the island is rough and mountainous. The coast rises abruptly from the water's edge and there are very few beaches. A range of hills lies near the coast and follows it very closely around the southern part of the island, leaving a broken depression in the interior. The highest elevations are attained near the southern extremity of the island where Mt. Shepperd rises to over 3000 ft.

To the south-east, from the base of Mts. Dick and Shepperd, the land slopes away more gently, forming a half moon shaped area of comparatively low elevation which extends to the coast. To the westward and north-westward from Pocohontas Mountain the elevations decrease and the country becomes much less rugged.

The surface of the island has been completely glaciated and the mountains present everywhere the rounded, flowing outlines produced by the smoothing action of an ice flow.

Glacial striae are found in various localities and are particularly well developed along the rugged coast of Henderson Bay. This bay is a miniature fiord, scarcely half a mile in length and two to three hundred yards in width, similar in character to the larger fiords found on the mainland. The general strike of the striae is a few degrees east of north, the gladiation being everywhere influenced by the topography.

The island, as a whole, presents the appearance of a large roche moutonée. The gradual increase in elevation from

north to south culminates in Mts. Shepperd and Dick, beyond which precipitous declines bring the surface to sea level within a very short distance.

There are a number of lakes occupying basins in the northern part of the island. Most of these empty into Melaspina Strait on the north-east coast.

Small streams are numerous in all parts of the island, those emptying into the Strait of Georgia to the southwest, being much shorter than the ones running north-eastward. They cut small V shaped valleys and occupy tortuous channels.

## Geology.

The rocks of Texada Island are largely of igneous origin, including the volcanic, ~~intermediate~~ basic and plutonic varieties. They have a wide range in composition from acid to basic. The volcanic rocks have a much greater distribution than the plutonic.

Agglomerates closely associated with the volcanic rocks are wide-spread. Agglomerates of different character, associated with schists and tuffs, have a locally important development.

Sedimentary rocks are found in areas of considerable size in many parts of the island. They include limestones, conglomerates, sand, gravels and boulder clay.

The rocks making up the country between Mts. Dick and Shepperd and the south-eastern coast are made up of agglomer-

ates, schists and tuffs. An area of crystalline limestone is included in the schists near Henderson Bay. These rocks are probably the earliest on the island, but they have not been correlated with the limestones farther north since they are completely isolated. They may be of the same age as the Marble Bay formation, and have been placed in the Upper Palaeozoic.

A large area of limestone occurs in the northern part of the island extending along the coast from Crescent Bay to a point about half way between Sturt Bay and Raven Bay, and across the island towards Welcome Bay and Gillies Bay. A smaller area of limestone is found at Davis Bay and smaller occurrences are found in various parts of the island. These rocks are known as the Marble Bay formation and have been placed in the Upper Palaeozoic. A few fossil corals found in the limestone at Van Anda, near Mr. Grant's residence, by Mr. J. A. Bancroft, have been determined to be lithostrotian ^ Candelnse either of Devonian or Carboniferous age. There is, however, an almost entire absence of fossils of determinable age. The limestones are all highly metamorphosed.

The volcanic rocks are of later age and often include the limestones. They are porphyritic rocks which exhibit many variations in structure. Their mineralogical composition is fairly uniform, however, and they have all been included under the names of porphyrite and andesite. The greater part of them are of an hypabyssal character, and some are true surface lavas. The rocks of this series, together with the agglomerates associated with them, have been placed

in the Triassic period.

Some of the plutonic rocks have been referred to the present Coast Range batholith, considered to be of Upper Jurassic age. These vary in composition from quartz diorites to gabbros.

Subsequent to this intrusion, dioritic rocks in small stocks and a wide-spread invasion of dikes cut all the older rocks. These have been placed in the Lower Cretaceous period.

The Cretaceous rocks lie in basins in the volcanic rocks and agglomerates. They are conglomerates, soft sand stones, sands, clays and shales. Their distribution is limited to a few small areas near the south-west coast at Gillies Bay, Davis Bay and Cook's Bay, of which the Gillies Bay area is the largest.

The stratified sands and gravels, boulder clay, etc. of Pleistocene age have a limited development in the vicinity of Crescent Bay.

The geological sequence of the rocks is as follows:-

| | |
|---|---|
| Pleistocene:- | Stratified sands and gravels, boulder clay. |
| Cretaceous:- | Soft sand stones, sands, clays, and shales. and conglomerates. |
| Lower Cretaceous:- | Diorite and diorite porphyrite, in small stocks and dikes. |
| Upper Jurassic?:- | Quartz diorites, referred to present Coast Range batholith. |
| Triassic?:- | Porphyrites and agglomerates (Texada Group of Leroy). |

Upper Palaeozoic:- Limestones (Marble Bay formation), schists, tuffs, agglomerates with included marble at Henderson Bay. (Texada Group of Leroy.)

## PETROGRAPHY.

In the following descriptions the rocks are taken in the order of their geological age from older to younger. The pyroclastic and sedimentary rocks of the Upper Palaeozoic period and those of Cretaceous and later age are not referred to again, but the agglomerates which are associated with the volcanic rocks of Triassic age are described. The plutonic rocks referred to the Upper Jurassic and Lower Cretaceous periods are not separated, but are taken together, in the order of their mineralogical composition. The dike rocks are treated similarly.

### Volcanic and Hypabyssal Rocks.

The rocks covering the larger part of the surface of Texada Island, lying between a large area of limestone in the northern part and a fringe of agglomerates, schists and tuffs at its southern extremity, are of the nature of porphyrites. They vary in character from hypabyssal rocks to true surface flows, passing gradually from one type into the other. The surface flows, where they have been studied, are classed as andesite, but no strict rules of nomenclature can be followed. The prevailing color of the rocks is a dark green or greenish drab, weathering to shades of dark green and greenish brown.

Under the microscope they are found to be composed essentially of plagioclase feldspar, hornblende and augite. Black iron ore is nearly always a characteristic accessory constituent, and various secondary minerals have developed.

The following list includes the minerals composing this

series.

| Essential. | Accessory. | Secondary. |
|---|---|---|
| Plagioclase Feldspar | Black Iron Ore | Chlorite |
| Hornblende | | Epidote |
| Augite | | Calcite |
| | | Zoisite |
| | | Quartz |
| | | Black Iron Ore |
| | | Hematite |
| | | Pyrite |
| | | Kaolin |
| | | Sericite |
| | | Tremolite |

Plagioclase feldspar is the most abundant mineral, andesine and labradorite* being the most common varieties. It is always well twinned according to the albite law, and usually carlsbad twins are found, but pericline twinning and zonary banding are rarely, if ever, present.

The augite is colorless or pale yellow and occurs in stout prismatic forms.

The hornblende is green. It usually assumes irregular forms with ragged outline which occur in a mat or aggregate. In the contact zone caused by later intrusive rocks, the augite sometimes entirely disappears, being replaced by hornblende. Some original hornblende is undoubtedly present, but it is probable that augite was primarily the most abundant bisilicate constituent.

*Determined from a number of specimens by F. E. Wright's method of oils.

The rocks have a definite porphyritic structure, with plagioclase feldspar and the bisilicate constituents as phenocrysts, although in some cases the latter are in very subordinate amount.

The groundmass is made up of small laths of feldspar with granular hornblende and augite, having ophitic structure. The texture varies from moderately coarse to very fine. In some of the rocks an ~~vesicular~~ amygdaloidal structure has developed, the vesicles being filled by one or more secondary minerals. Some areas resembling ~~vesicles~~ amygdales, are undoubtedly due to the replacement of the normal constituents of the rock by alteration products, but sufficient evidence of ~~vesicular~~ amygdaloidal structure is present to prove the amygdaloidal character of some of the rocks of this series.

An attempt to classify the porphyrites according to the dominant bisilicate constituent has been made. The result is not wholly satisfactory since the character of the rock may change within comparatively small areas. It has been found generally, however, that along the north-eastern coast hornblende is more plentiful than augite, while augite predominates in other parts of the island where these rocks occur. A possible explanation of this distribution may be that the plutonic rocks have a greater distribution in the north-east part of the island and the augite has suffered a greater change by uralitization than elsewhere.

Augite Porphyrite: Augite is the dominant colored constituent, hornblende being in very subordinate amount. This type is found in the southern, western and north-western parts

of the island, the sections examined representing the following localities:- A mountain ridge two miles south of the Long Beach area of quartz diorite at an elevation of 2000 feet; half way up Mt. Dick on the south-east side; at several points along the south-west coast, and inland, east of Crescent Bay.

Plagioclase feldspar, augite, and occasionally a subordinate amount of hornblende occur as phenocrysts in a fine grained groundmass of the same minerals.

Black iron ore is always present and is sometimes abundant. It assumes granular and irregular forms and sometimes is in feathery flakes which are probably secondary.

Chlorite is the most abundant secondary mineral. Epidote, calcite and zoisite are present in varying amounts.

The groundmass varies in grain from coarse to very fine, and is characterized by ophitic structure.

The phenocrysts of plagioclase are made up of individual crystals and also of aggregates of lath shaped forms.

The augite is colorless and in stout prismatic individuals.

The hornblende where present is green in color and occurs in irregular forms with ragged outline.

Augite Andesite:- The rocks lying between Lower Gillies Bay and Davis Bay are amygdaloidal, containing ~~vesicles~~ amygdales, some of which are filled with quartz in aggregates large enough to be easily distinguished in a hand specimen. The ~~vesicles~~ amygdales usually contain chlorite, partially or completely filling them. Occasionally it occurs as a border lining the ~~vesicle~~ amygdale, within

which calcite and zoisite are sometimes found, and quite frequently quartz, in aggregates of grains, fills the centre. Oval and irregular shaped areas resembling ~~filled vesicles~~ amygdales are also found, which in reality are pseudo-~~vesicular~~ amygdaloidal, being formed by the replacement of the original constituents of the rock by secondary minerals. Chlorite usually nearly fills these areas, ~~in which~~ Aggregates of epidote and zoisite occur embedded in the chlorite, and, In one instance secondary tremolite, with radial structure, was so found.

The plagioclase of the phenocrysts in these ~~vesicular~~ amygdaloidal rocks was found to be labradorite, and since they are evidently extrusive lava flows, they should be named andesites. Their mineralogical composition is similar to that of the augite porphyrites.

At the southern extremity of this series, in the vicinity of Mt. Shepperd, also near the area of limestone at Davis Bay and at Crescent Bay, augite andesites of a somewhat different character occur. They consist essentially of plagioclase feldspar and augite having ophitic structure. Very few large phenocrysts are found, and the texture varies from fine to coarse.

In some sections there are areas resembling devitrified glass. These contain small needles resembling feldspar, but they are so fine that they were not proved to be so and may be zeolites. Chlorite and carbonates are present. This suggests a question as to whether these portions of the rock are poorly crystallized or highly altered.

At the base of Mt. Shepperd on the south-east side a rock of this type occurs which has a different structure from those described.

The rock is holocrystalline and is made up of long, narrow laths of plagioclase around which the augite has formed, frequently assuming a radial structure. Micrographic intergrowths of the augite with the feldspar have also taken place, giving a striking appearance to the section.

A section from a rock taken from the top of Mt. Dick deserves attention since there is a ~~striking~~ marked resemblance between it and the inclusions found in the agglomerate to be described later.

Plagioclase feldspar and augite as phenocrysts occur in a groundmass which has the appearance of devitrified glass.

The phenocrysts of plagioclase are large individuals, often much decomposed. They are labradorite.

The augite is quite fresh and usually colorless or pale yellow. It occurs in stout prisms with idiomorphic outline.

The groundmass is of a turbid brown color. Radiating or arborescent forms have developed throughout, which appear to be augite, some small crystals showing an approximate extinction of 25°.

Hornblende Porphyrites:- Rocks of this type are found on the eastern side of the island, extending as far south as the area of quartz diorite at Long Beach. The sections examined represent the rocks from Pocohontas Mountain,

six miles south-east of Pocahontas Mountain, and in the vicinity of the quartz diorite area at Long Beach.

They consist essentially of plagioclase feldspar and hornblende, with, in some instances, a small amount of augite. Black iron ore in small grains is always present and is usually abundant.

Chlorite occurs plentifully as an alteration of the hornblende, and the usual secondary minerals characteristic of these rocks are found.

The plagioclase phenocrysts were determined to be labradorite. With albite lamellation is sometimes associated twinning on the carlsbad law.

The hornblende is green in color, often exhibiting a lifeless appearance. It occurs in shapeless forms in mats or aggregates, and is probably largely of secondary origin.

The augite is colorless or pale yellow and occurs in very subordinate amount.

The porphyrite near the contact of the intrusive areas of quartz diorite exhibits a somewhat different structure. It is not so definitely porphyritic but is almost even grained and of medium texture. The plagioclase is in lath like crystals, surrounded by hornblende in somewhat smaller lath-shaped forms. The hornblende is more abundant than the plagioclase. It is probable that the original rock has been entirely recrystallized.

## Pyroclastic Rocks.

Agglomerates:- Associated with the porphyrites there is a wide-spread occurrence of agglomerates. These rocks outcrop in areas varying in size from a few square yards up to dimensions in the order of square miles. Their outlines are very irregular and there is no distinct line of contact between them and the porphyrites.

Dr. G. M. Dawson* mentions them in his description of the coast rocks of Texada Island from Marshall Point to Gillies Bay, as follows: -"Southward from the last limestone exposures to within ten miles of Gillies Bay, hard greenish and grey, much altered amygdaloids occupy the shore, till replaced near the point above defined (at which the houses of the Texada Iron Mine are situated) by agglomerates. These volcanic rocks evidently underlie the limestones, and at the mine are abruptly cut off by a granitic mass, half a mile in width on the shore." Again, in his description of the coast south-east of Gillies Bay:- "Shelter Island consists of grey green, altered volcanic rocks, chiefly a rather rough agglomerate , which is overlain by an amygdaloid. The dip is about S 45° E ∠ 25°. The remaining portion of the shore of Texada Island to the south-eastward is composed of greyish green and bluish grey, hard altered volcanic rocks, chiefly or entirely agglomerates or amygdaloids, but in many places so much altered as to be scarcely recognizable as such. They form, for the most part, a bold rocky shore, and a few small rocky islets lying off are of the same materials. The strike is generally nearly

*Annual Report.Part B, Geol.Sur.of Can.1886,Vol. II,pg. 35 B.

parallel to the shore, with south-westward dips at angles of 15° to 30°."

Mr. O. E. Leroy* also describes these rocks in the following words:- "The agglomerates are massive without any traces of bedding. They are composed of angular and subangular fragments of basic igneous rocks,- now largely altered and silicified,-and angular grains of feldspar and quartz in a matrix of chlorite, calcite and epidote. In places the rock becomes more uniform, and passes into a coarse tuff in which there are few large fragments. On exposed surfaces the fragments weather in relief, and the whole rock assumes a dirty brownish grey color. The agglomerates are well developed on Texada Island, forming hills nearly 1000 feet high."

From a macroscopic study of the rock, it appears to be composed of a highly altered,greenish matrix in which dense textured inclusions of a greyish purple color occur. The matrix is often characterized by little spheroids outlined by siliceous material. It is generally comparatively soft and easily broken up. The fragments appear to be quite fresh and hard and are of all sizes up to a foot or more in length. In shape they are angular, rounded and irregular, sometimes assuming elongated forms rudely resembling a dumb-bell in outline.

From a microscopic examination the rock appears to be a palagonite tuff, containing fragments of plagioclase feldspar and augite, and also large inclusions of an andesitic lava.

Sections of the rock from the following localities have been studied:- The coast at Crescent Bay; three-quarters

* See footnote ***, p. 1.

of a mile north-west of the Iron Mine Landing; Cook's Bay, and in the vicinity of the Commodore Mine.

Surrounding the large inclusions of andesite is a green colored, isotropic palagonite glass. Oval and irregular shaped areas are outlined in this glass by brown colored calcite in aggregates of small round grains, sometimes associated with chlorite. Plagioclase feldspar and augite, sometimes with good crystal forms but usually much broken up, occur as fragments in the glass.

Quartz in aggregates of small grains and a subordinate amount of black iron ore are present.

Chlorite, calcite, epidote and zoisite occur as secondary minerals.

Needles of hornblende are sometimes found in the isotropic glass and occasionally assume fairly large forms, probably of smaragdite.

The plagioclase is largely altered to sericitic mica, kaolin and calcite as saussurite, and, except in a few instances where albite lamellation may be discerned, is too much altered to study. A few of the phenocrysts were determined to be andesine.

The inclusions of andesite consist essentially of plagioclase feldspar and augite, occurring as phenocrysts in a groundmass having the appearance of a devitrified glass.

The plagioclase of these inclusions has been determined to be labradorite, and is much decomposed.

The augite is colorless or pale yellow and occurs in stout prismatic forms.

The groundmass is of a turbid brown color. Radiating or arborescent forms have developed throughout, which appear to be augite, some crystal forms showing an approximate extinction of 25°.

## Plutonic Rocks.

Intrusive dioritic rocks have cut through the limestone and have intruded the series of volcanic and agglomerate rocks, forming many small areas and giving rise to numerous dikes. The plutonic rocks are found in the northern half of the island, principally on or near the coast. Some areas appear to be of earlier origin than others, but no attempt will be made to classify them according to geological age. The earlier intrusions have been referred to the Coast Range batholith and placed provisionally in the Upper Jurassic, and the later intrusive rocks and dikes in the Lower Cretaceous.

All of the plutonic rocks occurring in areas and small stocks are medium to coarse grained in texture and usually have a granitoid structure.

A part of the plagioclase feldspar is often idiomorphic towards the other minerals, which otherwise follow the normal order of crystallization. They range from medium acid to basic. Quartz is always in very subordinate amount and usually it is absent.

At the contact of some of the intrusive areas with the volcanic rocks, a contact zone has developed, the intrusive usually becoming more basic. This phenomenon is well devel-

oped in the Long Beach area of quartz diorite.

Very few normal rock types are found, all transitions from a true gabbro to a quartz diorite being met with, and in one instance an augite syenite has developed.

The following list includes most of the minerals found in these rocks:-

| Essential. | Accessory. | Secondary. |
|---|---|---|
| Orthoclase | Quartz | Chlorite |
| Plagioclase | Orthoclase | Epidote |
| Quartz | Apatite | Calcite |
| Augite | Sphene | Zoisite |
| Hornblende | Zoisite | Hornblende |
| Biotite | Black Iron Ore | Kaolin |
| | Titaniferous Iron Ore | Sericite |
| | | Leucoxene |
| | | Black Iron Ore |
| | | Brown Iron Ore |
| | | Pyrite |

Plagioclase feldspar is the most abundant mineral. Orthoclase is found in a few of the rocks in subordinate amount. In one instance it is the predominating feldspar, but usually it is absent. Next to the plagioclase, hornblende is most plentiful, and augite is nearly as common. Biotite does not occur in all the rocks and is always in subordinate amount compared with the other colored constituents. Quartz occurs in varying amounts and is sometimes absent.

The plagioclase usually occurs both in stout tabular

and slender lath forms. It is invariably characterized by albite twinning in varying breadth of lamellae, indicative of the character of the feldspar. Carlsbad and pericline twinning are also of frequent occurrence. Zonary banding is very common, a series of zones, basic alternating with less basic feldspar, usually occurring. ——————————— Occasionally a gradual shading indicates that the feldspar becomes progressively more acid from the centre outwards. The feldspars are rarely perfectly fresh, but are usually more or less turbid by alteration to kaolin, sericite and calcite.

The augite is colorless or pale yellow, occurring in fairly large individuals of stout prismatic form. It is frequently surrounded by uralitized hornblende. Although hornblende is, on the whole, more abundant in these rocks than augite, it seems probable that augite originally predominated, and that a great part of the hornblende is secondary, having been derived from the augite by uralitization. Chlorite is a common alteration product of the augite.

The hornblende is green in color and occurs in aggregates or mats of irregular forms with ragged outline. It is usually more or less altered to chlorite. Secondary hornblende frequently occurs fringing the augite, sometimes entirely replacing it and retaining its original form. This has not been observed in the quartz diorite or diorite rocks.

Biotite is not of frequent occurrence. When fresh it has a deep brown color, but it is nearly always partially or wholly altered to chlorite.

Quartz when present is in irregular grains of varying size.

Quartz Diorite:- The intrusive areas at Long Beach, Pocahontas Bay Raven Bay and the Little Billy Mine,on the north-east coast of the island, and at the Iron Mine,on the south-west coast, and inland, are of the nature of quartz diorites.

These are medium coarse grained rocks, consisting essentially of plagioclase feldspar, quartz, hornblende,augite and biotite. The bisilicates are not always all present together. Orthoclase feldspar in small amount, small prisms of apatite and black iron ore in irregular grains are accessory minerals. Chlorite and epidote are common alteration products.

The plagioclase feldspar is very abundant and some of it has developed idiomorphically towards the other constituents. Albite lamellation is invariable and twinning on the carlsbad and pericline laws is frequent. Zonary banding is well developed in most of the sections.

The quartz occurs in irregular grains in varying amount. It is never very abundant.

Hornblende is the most plentiful colored constituent in some cases, while biotite predominates in others. The hornblende is green in color and occurs in irregular forms of varying size. The biotite has a deep brown color when fresh and occurs in ragged flakes. It is largely altered to chlorite. Augite when present is in subordinate amount. It is

colorless or pale green.

The intrusion near the Iron Mine and north-east of Welcome Bay is made up of several small areas, some of which though of the same general character vary considerably in composition. In one instance orthoclase feldspar predominates, and with it are augite and biotite. Plagioclase feldspar is almost entirely absent. Black iron ore in small grains is scattered through the rock. Prisms of apatite and a few individuals of sphene occur as accessory constituents.

The orthoclase is largely altered to saussurite.

The augite is in large fresh individuals.

The biotite is almost wholly chloritized, and epidote has developed in the chlorite.

Diorite:- Intrusive rocks containing little or no quartz or augite are found cutting the limestone in a small area at the Paris Mine, near Blubber Bay, and in a larger area at the Cornell Mine, about one mile south-east of Van Anda.

They are of medium coarse texture, consisting essentially of plagioclase feldspar and hornblende, usually accompanied by some biotite mica and a little augite.

Apatite is usually present, and black iron ore is abundant. Most of the iron ore is titaniferous, having partially altered to leucoxene.

Chlorite and epidote occur as secondary minerals.

Some of the plagioclase crystals have developed idiomorphic outlines. They are usually turbid from a develop-

ment of saussurite.

The hornblende is similar in appearance to that of the quartz diorites, being in green, shapeless forms.

Hornblende Gabbro:- Rocks which usually have predominant amounts of augite, but the composition of which varies considerably as regards the bisilicate constituents, are found in the following localities:- On the coast north-east of Blubber Bay, at Loyal Lease Mine, on an island in Sturt Bay, and inland east of Priest Lake, and between the head of Sturt Bay and the Volunteer Mine.

These are coarse grained rocks, consisting essentially of plagioclase feldspar and augite, with varying amounts of hornblende.

Black iron ore, some of which is titaniferous, occurs in all sections, and in some, pyrite is present. Apatite is also an accessory constituent.

The plagioclase is in large crystals and in aggregates of laths. The albite lamellations are broad. Carlsbad and pericline twinning are common.

The unstable character of the augite is shown by its marked tendency to become altered to hornblende. In some sections no hornblende occurs, but this is true only where the sections are from especially fresh rocks. In most cases considerable uralitization has taken place, and in a few sections no augite appears. Some original hornblende may be present, but it is probable that, for the most part, it is secondary after augite.

Intrusive areas near Marble Bay Mine.

Three small areas of hornblende gabbro cut the limestone south-east of Sturt Bay. The ore deposits of the Marble Bay Mine appear to be genetically related to these intrusions.

They exhibit the same general characteristics described for the hornblende gabbro from other parts of the island, consisting essentially of plagioclase feldspar and augite with some hornblende.

Black iron ore is fairly abundant.

The plagioclase occurs in large individuals and in smaller lath like forms. A few individuals are idiomorphic and have zonary banding as well as the usual twinning.

The augite is more abundant than in the types previously described. It is usually in large forms of pale green color, and is generally bordered by uralitized hornblende. Frequently the augite has been doubly altered, first to hornblende, and afterwards the hornblende has been changed to chlorite and epidote.

Fresh augite and some apparently original hornblende is present, but as a general rule chlorite and epidote have replaced them, retaining the original form of the mineral in many cases.

The larger individuals of black iron ore exhibit parting typical of ilmenite. Leucoxene has developed as an alteration product, frequently entirely replacing the ilmenite, and in some instances it has retained the form and parting of

the original mineral.

Gabbro:- A typical gabbro is found on the coast extending northward from Sturt Bay.

It is a coarse grained rock with granitoid structure, consisting of plagioclase feldspar and augite. A small amount of orthoclase and black iron ore in large grains are present as accessory constituents. A little chlorite occurs as an alteration of the augite.

The plagioclase is twinned on all three laws, the pericline variety having a remarkable development.

The augite is colorless or pale greenish yellow, in large crystals.

No hornblende is present.

## Dikes.

A great many dikes occur in the northern part of the island and very few south of the areas of plutonic rocks. They cut all except the later (Lower Cretaceous?) plutonic rocks. There is no evidence of igneous action in the Cretaceous and later rocks.

Some of the dikes are directly connected with areas of plutonic rocks, and most of them appear from their composition to be genetically related to the diorites.

The paucity of dikes in the southern part of the island coincides with the absence of plutonic invasion there.

The greater part of the dikes have been classed as diorite porphyrites. A few aplite dikes are found over a wider

area, cutting the older plutonic rocks and the tuffs at Henderson Bay.

Diorite Porphyrite:- The diorite porphyrites consist essentially of plagioclase feldspar, augite and hornblende as phenocrysts in a groundmass of the same minerals. Biotite is rarely present and orthoclase feldspar sometimes occurs. Quartz is occasionally an important constituent. Black iron ore is usually present and pyrite also occurs. Apatite and sphene are sometimes found. Calcite, chlorite and epidote are usual alteration products.

The plagioclase is usually well twinned and sometimes exhibits zonary banding.

The hornblende is of a green color and in large irregular forms.

Augite is in stout prisms and is usually colorless.

The groundmass is of fine to medium texture and consists of plagioclase in laths and stouter forms, often showing twinning and zonary banding. The augite and hornblende are in small grains.

A description of the dikes, which from their field relations appear to be contemporaneous with the areas of plutonic rocks, shows a marked similarity to them in composition. These sections are from dikes in the Marble Bay Mine and near the Marjorie Mine.

They consist essentially of plagioclase feldspar and hornblende. Black iron ore, in varying amount, occurs as an

accessory constituent. Chlorite, epidote, calcite and zoisite are present as alteration minerals, and pyrite is also probably secondary.

The plagioclase and hornblende occur as large phenocrysts in a fine to medium textured groundmass of the same minerals.

The plagioclase is twinned on the albite, carlsbad and pericline laws, and zonary banding is well developed.

The hornblende is green in color and somewhat altered to chlorite.

The phenocrysts vary in shape from slender to stout prismatic.

The groundmass is usually granular. Lath shaped and stouter crystals of plagioclase, and grains of hornblende with grains of black iron ore, are its principal constituents. The hornblende alters to chlorite.

Two dikes, varying in width from 25 to 50 feet and cutting the massive agglomerates, volcanic rocks and the large areas of limestone, are found about a quarter of a mile southwest of the Commodore Mine. They appear to emanate from an area of plutonic rocks which lies a few hundred yards west of the Commodore shaft, and, though wider than the average dikes, are typical of many in this vicinity.

They consist of orthoclase and plagioclase feldspar as phenocrysts in a fine grained groundmass. Chlorite and calcite entirely fill well defined areas having the outline of large lath shaped individuals of hornblende, which was

evidently the original colored constituent. A limited amount of quartz in small grains, apatite, sphene, and black iron ore are present as accessory constituents.

The groundmass is made up of small, stout, platy forms of orthoclase, with fewer lath like forms of plagioclase.

The phenocrysts of orthoclase predominate, and saussurite has developed generally in the feldspars.

Other dikes of this general type cut many of the plutonic rocks along the north and north-east coast. The sections examined are from dikes cutting the diorite east of Blubber Bay and the quartz diorite at Long Beach.

They contain large phenocrysts of plagioclase, augite and hornblende in a fine grained groundmass. A variable amount of orthoclase feldspar and quartz is present. Sphene is fairly abundant and black iron ore in small grains is common.

There is an almost entire absence of zonary banding in the plagioclase.

The hornblende is in slender forms and irregular grains.

Augite is not so abundant as the hornblende.

Chlorite and epidote have formed as secondary minerals.

The groundmass is made up of small laths of plagioclase, some stouter forms of orthoclase and granular hornblende and augite.

A few more acid dikes are found which also cut plutonic rocks.

Aplite:- These are of medium grained texture and con-

sist of orthoclase and plagioclase feldspar, quartz, and a very subordinate amount of biotite mica.

The plagioclase is in subordinate amount and characterized by albite twinning in thin lamellae.

Micrographic structure characterizes the feldspar and quartz, and beautiful intergrowths are common.

The biotite occurs in ragged flakes and has been the first mineral to crystallize. It is pale brown in color.

The sections are from very fresh rocks and contain no secondary minerals.

Felsite:- These dikes consist almost entirely of plagioclase feldspar which has crystallized in two generations. The groundmass is fine grained in comparison with the phenocrysts.

Biotite and hornblende occur in small amount. Accessory black iron ore, accompanied by leucoxene, is in subordinate amount, and chlorite, epidote and calcite are the secondary minerals which have developed.

The plagioclase shows remarkable twinning on all three laws as well as zonary banding.

The hornblende and mica are usually quite fresh, but in some instances are altered to chlorite. The hornblende is in small, lath shaped forms of a green color. The biotite is in brown flakes with ragged outline.

Quartz Porphyry:- Only one quartz porphyry dike was found on the island. This cuts a small stock of intrusive rock and the limestone at the Paris Mine, near Blubber Bay.

Large rounded phenocrysts of quartz and phenocrysts of orthoclase and plagioclase feldspar occur in a fine grained groundmass.

The plagioclase, which is characterized by albite lamellation, is in comparatively small amount, most of the feldspar being orthoclase.

The groundmass exhibits micrographic structure with a tendency towards the microspherulitic.

## General Remarks on Essential and Secondary Minerals.

Essential Minerals:- There is a general similarity in composition characterizing nearly all varieties of the igneous rocks of Texada Island. Their essential constituents, with a few exceptions, are limited to plagioclase feldspar, augite, hornblende and biotite mica, with occasionally quartz and orthoclase feldspar. The character of these minerals as they are found in different rock types also remains fairly uniform, except the plagioclase feldspar, which occurs in a fairly wide range from acid to basic, in the plutonic rocks.

Secondary Minerals:- With the exception of the quartz diorites and to a less extent the diorites, the augite, hornblende and biotite have been especially subject to alteration. The feldspars have frequently become turbid from the development of secondary minerals such as kaolin, sericitic mica and

calcite, generally in the form of saussurite, but they have suffered comparatively little change.

As a general rule augite occurs more plentifully in sections from fresh rocks, since it has a tendency to become uralitized. It is probable that original hornblende is in very subordinate amount and that augite was the predominant colored bisilicate before the process of alteration commenced.

Chlorite is the most abundant alteration product, and is found partially or wholly replacing augite, hornblende and biotite, and sometimes occupying portions of the rock where the feldspars originally were found as well. A general alteration of the normal constituents of the rock to chlorite is frequently found in the fine grained groundmass of the volcanic and dike rocks.

Epidote and calcite are also important secondary minerals. The epidote occasionally occurs in grains within feldspar crystals, and also replaces the colored bisilicates. When abundant, it forms clusters which are scattered through the rock. It is sometimes found in small veins, suggesting impregnation from a foreign source.

Calcite has a general slight development from the alteration of the feldspars and to a less extent from the other minerals. It is ~~often~~ frequently found traversing the section in irregular veins, and often develops locally in small areas. It is sometimes very abundant and is probably in large measure of foreign origin.

Secondary hornblende occurs quite frequently. Much

of it is derived from augite by uralitization, but quite frequently it is in fibrous and other forms derived from other sources.

Black iron ore is an invariable accessory constituent and quite often it is found in powdery forms, which are probably secondary.

Pyrite is seldom abundant. It is usually found near the contact of an intrusive rock and often occurs in small veins which are undoubtedly of secondary origin. A few grains are often found, however, especially in the dike rocks which are primary.

# Geological Map* of TEXADA ISLAND BRITISH COLUMBIA.

To illustrate Paper by A.O. HAYES, B.Sc. 1910.

Scale: 4 statute miles to 1 Inch

1 ½ 2 2½ 3 3½ 4

124° 30' 124° 15'

49° 45'

49° 30'

HARWOOD ISLAND

NANAIMO MINING DIVISION

Rebeca I

Blubber Bay

Lime Kiln Bay

Paris Mine

Loyal Lease Mine

Pt. Marshall

Crescent Bay

Sturt Bay

Marble Bay

Venanda Bay

Lillie Billy Mine

Marjorie Mine

Marble Bay Mine

Priest Lake

Raven Bay

Cornell Mine

Pocahontas Bay

Davis Bay

Comodore Mine

Welcome Bay

Prescott Iron Mine

Pocahontas Mount.

STRAIT OF GEORGIA

TEXADA ISLAND

Gillies Bay

Shelter Pt.

Lower Gillies Bay

Mouat Is.

Davies Bay

Long Beach

Cooks Bay

Sabine Channel

Mount Shepherd

Henderson Bay

Mt. Dick

NELSON ISLAND

HORNBY ISD.

LASQUETI ISLAND

STRAIT OF GEORGIA

## LEGEND

MEZOZOIC

- Cretaceous
- Lower Cretaceous? (Later Intrusives)
- Upper Jurassic? (Coast Range Batholithis)
- Triassic? (Porphyrites etc.)

UPPER PALAEOZOIC

- Limestone (Marble Bay Formation)
- Agglomerate Shists etc.

*This map has been compiled from various sources and is subject to correction. A complete topographical and geological map of Texada Island is being prepared by the Geological Survey of Canada.