Arthur [illegible] M.E.
Mines Branch,
Sept. 1915

CA. M. 6179

CANADA
DEPARTMENT OF MINES
HON. LOUIS CODERRE, MINISTER; R. W. BROCK, DEPUTY MINISTER.

GEOLOGICAL SURVEY

MEMOIR 58

No. 48, GEOLOGICAL SERIES

Texada Island, B.C.

BY

R. G. McConnell

OTTAWA
GOVERNMENT PRINTING BUREAU
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Texada Island, B.C.

CHAPTER I.

INTRODUCTION.

GENERAL STATEMENT.

The present report is intended to give a general description of the geology, and mineral and other resources of Texada island, B.C. The field work on which the report is based occupied 4 months of the season of 1908[1], and 2½ months in the season of 1909. A short time was also spent on the island in the autumn of 1912.

The writer was assisted in 1908 by Mr. Haughton, and in 1909 by Mr. A. O. Hayes. A collection of rocks made in 1908, illustrating the principal types found on the island, was examined in thin sections by Dr. G. A. Young, and a second collection made in 1909 was studied by Mr. A. O. Hayes. The names adopted in the report are the results of their determinations.

During the course of the work valuable assistance in the way of information and facilities for visiting the various mines was obtained from most of the property holders and mine managers on the island, especially from Mr. A. Grant and Mr. Eastman, superintendents, and Mr. W. Treloar, mine foreman at the time the work was done, of the Marble Bay mine, Dr. Tanzer, lessee of the Cornell and Copper Queen mines, Captain Lee, manager for the Puget Sound Iron Company, Mr. Planta, and James and Alfred Raper.

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[1] The delay in issuing this report is due to the prolonged illness of the topographer who had charge of the surveys in 1908-9 and his consequent inability to compile his work and furnish necessary plans. In 1912 the Iron range on the west coast and a small area on the east coast extending from Blubber bay to the Cornell mine were re-surveyed by Mr. Nichols of the topographic corps. The accompanying general map with the exception of these two areas is a compilation of old surveys.

PREVIOUS WORK AND BIBLIOGRAPHY.

The first observations on the geology of Texada island were made by Mr. James Richardson of the Geological Survey of Canada, in 1873. Richardson examined the Iron range on the west coast and published a short account of it in the Annual Report of the Survey for 1873-74, pages 99,100. He considered the magnetite to be a bedded deposit in limestone along its contact with the quartz diorite.

In 1885, the entire coast line of the island was examined by Dr. G. M. Dawson. The principal object of this work was to determine the presence or otherwise of coal-bearing Cretaceous strata. The magnetite lenses on the west coast were revisited, and are correctly classified as contact deposits due to the intrusion of diorite (Annual Report, Vol. II, pp. 36-37 B).

I. P. Kimball published in the American Geologist, Vol. XX, 1897, pages 13-27, an article on the character and origin of the magnetite lenses, and a description of the lenses by Mr. Fleet Robertson, Provincial Mineralogist, is given in the Annual Report of the Minister of Mines, B.C., for 1902, pages 225-228. References to the progress of mining on the island, also occur in the 1897, 1899, 1903, and other reports of the Provincial Mining Bureau, B.C.

A general survey of the island was made by Mr. O. E. LeRoy in 1906, and the results are included in a "Preliminary Report on a Portion of the Main Coast of British Columbia and Adjacent Islands," published by the Survey in 1908.

The origin of bornite ores on Texada island and other places is discussed by Mr. W. M. Brewer in the Journal of the Can. Min. Inst., Vol. VII, 1905, page 172.

An examination of the iron deposits of the island was made in 1907 by Mr. E. Lindeman of the Mines Branch, Department of Mines, Canada, and a description published in Report 47, pages 21-24.

TOPOGRAPHY.

Texada island is a partially submerged ridge paralleling the mainland at a distance of from 2 to 4 miles. It has a length of

30 miles, a maximum width of 5½ miles, and an average width of about 3 miles. The shore-lines are indented by few deep bays, and except at Long Beach on the east coast, and around Gillies bay and for some distance north on the west coast, consist mostly of low rock cliffs worn and broken by the incessant action of the ocean.

Relief.

Except for limited movements of elevation and depression, Texada island has not been noticeably disturbed since Cretaceous time at least, and the present topographic forms are the results of long continued erosion. The softer rocks represented by Cretaceous sandstones and shales, and limestones probably of lower Mesozoic age, have been worn down into basins and rough seaward sloping plains, while the more resistant rocks such as the porphyrites, project as hills and ridges.

The vertical relief in the southern portion of the island where the rocks consist largely of porphyrites, contrasts strongly with that in the northern portion, much of which is underlain by softer formations. The southern portion of the island consists of a single steep-sided, rock-crested ridge rising from the water edge on both shores and culminating at an elevation of 2,892 feet in a rocky point known as Mt. Shepherd. In the central part of the island, the highland which continues northward from Mt. Shepherd broadens out, becomes more irregular, and is interrupted on both slopes by wide depressions. The prominent elevations here are: Mt. Davies on the west coast, 2,484 feet; and Mt. Grant, 2,450 feet, and Pocohontas mountain, 1,800 feet, on the east coast.

North and west of Pocohontas mountain, the general elevation sinks abruptly several hundred feet, and from this point to the northern end of the island, the relief is comparatively low. The high rugged peaks and ridges which characterize the southern portion of the island are replaced by round-topped, although often cliff-bordered hills and ridges, none exceeding 1,000 feet in height, separated by low lying rough areas. Surprise mountain, a long ridge rising in steep often precipitous slopes from the west coast to a height of nearly 1,000 feet, is the most conspicuous elevation in the northern portion of the island. Comet mountain, south of Raven bay, attains a height of 750 feet, and other lower elevations occur at intervals.

With the exception of a few, comparatively small, heavily drift-covered areas mostly occupying depressions along the coast, the surface of Texada island is everywhere rough and broken. The low-lying portions are incised by shallow rock canyons and worn into hummocks and ridges which project above the thinly distributed boulder clays, and further diversity is added by the presence of numerous broken lines of low cliffs.

In the elevated districts, the slopes are steep and often consist of a succession of worn cliffs, and sloping terraces bare or lightly covered with drift. The summits vary from comparatively narrow crested ridges such as Mt. Shepherd, and rocky peaks like Mt. Davis, to broad hummocky uplands and rounded domes broken by ravines.

Notwithstanding the cliffy character of many of the slopes, the outlines of the elevated masses are seldom sharply angular. The edges of the cliffs, most of which are due to weathering along jointage planes, have been worn away and the surface generally smoothed and rounded by prolonged erosion.

Drainage.

As Texada island is nowhere more than 6 miles in width and is usually much less, the streams are necessarily short and small, and many of them are intermittent, drying up completely during the summer season. Probably the largest stream on the island is that emptying into Lower Gillies bay. It traverses the Gillies Bay Cretaceous basin and beyond it divides up into a number of branches which drain the surrounding highlands. The grade is steep and in winter it carries a considerable volume of water, but in summer the flow diminishes to less than 300 inches. Another stream of some importance is that draining Kirk lake. It follows a zigzag course across the island collecting on its way the waters of Priest and Emily lakes, then bending northward empties into Vananda bay. Small permanent streams each draining a few square miles, empty into Raven bay, Pocohontas bay, Northeast bay, and Anderson bay, on the east coast, and into Cook bay, Davis bay, and Gillies bay among others, on the west coast.

Most of the streams occupy shallow canyons or narrow rock-walled valleys seldom over 100 feet in depth and usually much less, sunk in the bottoms of wide depressions. The canyon character of the secondary valleys, as a rule, is well developed near the coast and diminishes and often disappears going inland. It is a general feature, and while more pronounced where the streams traverse the softer rocks, is also present in areas underlaid by hard porphyrite. The lower portion of the valley of Lower Gillies Bay creek consists of a canyon fully 150 feet deep in places, cut through soft Cretaceous shales and sandstones. About 3 miles from the coast, the canyon is replaced by a shallow depression sunk only a short distance below the general level. The stream falling into Cook bay furnishes an example of a valley cut through hard rocks near the coast and softer rocks farther up. The lower part of the valley is a narrow canyon from 50 to 75 feet deep, sunk through porphyrite. Half a mile from the coast, the stream enters and crosses a small Cretaceous basin. The valley is somewhat enlarged at first, but soon narrows and deepens and is bounded by steep, in places almost vertical walls. After crossing the soft Cretaceous area and in the case of some of the tributaries before doing so, the streams rise to the surface and the canyons are replaced by slight depressions.

The general deepening of the valleys near the coast is a post-Glacial feature, and is attributed to an uplift of the island which occurred at the close of the Glacial period. Beaches with marine shells are found at a number of points at elevations up to 428 feet above the present sea-level.

Lakes.

Lakes, ponds, and filled-up lake basins occur somewhat plentifully in the low northern portion of the island, and occasionally in the high ridgy southern portion. The larger lakes occupy depressions in wide pre-Glacial valleys and probably owe their existence in most cases to drift dams. Priest lake and its continuation Spectacle lake, situated in an east-west depression $1\frac{1}{2}$ miles south of Vananda, have a length of $1\frac{1}{2}$ miles and form the largest body of water on the island. They drain eastward into Emily lake and then northward into Vananda bay. Other lakes of some size are, Cranberry lake draining into Gillies bay, and Paxton and Myrtle lakes emptying northward into Raven bay on the east coast. Paxton lake is situated about a mile from the west coast and the depression in which it lies probably drained westward in pre-Glacial times. The depression extends to the west coast and the water is now prevented from flowing in that direction by a drift dam having a height of less than 21 feet above the low water level of the lake.

A group of small lakes, some of which appear to occupy rock basins, occur in the broken uplands south of Pocohontas mountain, and a lake half a mile in length was found high up on the east slope of Mt. Shepherd.

Some of the lakes, such as Paxton, Priest, and Spectacle lakes, are important as possible sources of water power, although, only on a small scale, as none of the basins are large. The precipitation on the island is heavy in winter and light in summer. A portion of the excessive winter rainfall could be stored with little expense in the lake basins, and its use distributed throughout the year. Paxton lake, situated at an elevation of 350 feet above sea-level, has already been surveyed for power purposes.

Coast Line and Harbours.

The coast of Texada island is characteristically bold and rocky, and consists for long stretches of low, broken cliffs worn irregularly into small bays and projecting rocky points. On the east side, the coast is generally rocky except for a 5 mile stretch of coarse gravel and boulders at Long Beach some distance south of Northeast point. On the west coast, the principal sand and gravel beaches occur at Gillies bay and vicinity, fronting a Cretaceous area. A short sand and gravel beach also skirts a portion of Blubber bay on the north coast.

PLATE I.

Limestone coast line; north end of Texada island, B.C.

Rock beaches sloping seaward and bounded on the landward side by low cliffs, are also uncovered at a few points in low water. They represent the work of the waves since the uplift at the close of the Glacial period. They are exceptional and occur mostly where granite and limestone areas reach the sea. The more resistant porphyrite cliffs are seldom affected and usually descend steeply into the water.

The principal bays of the island of sufficient size to afford harbourage to steamers are Blubber bay on the north coast, Sturt and Anderson bays on the east coast, and Gillies bay on the west coast.

Blubber bay, a rounded indentation about half a mile deep in the narrow northern end of the island, forms an excellent harbour for small steamers. It has good anchorage ground, and is sheltered from most of the prevailing winds. Sturt bay, the largest opening on the east coast, is a narrow, rock-walled inlet nearly a mile in length. In low water, the inner portion is a succession of pools separated by rock ledges. The outer portion is deep, but is exposed to easterly winds. Marble bay, a small opening to the south, is well sheltered. Vananda bay, a short distance south of Sturt bay, is at present the principal seaport on the island. It is small, not well protected, and cannot be used in severe storms. Anderson bay, near the southern end of the island, is a long, narrow, fiord-like inlet with steep rock walls possessing the characteristics of a flooded valley. It is exposed to storms from the south and east. Gillies bay, on the west coast, is a large shallow water bay about 2 miles wide, and a mile deep. It is not well sheltered but affords fair protection at various points from most of the prevailing winds. Other bays on the west coast are Lower Gillies bay, a long shallow imperfectly sheltered indentation, south of Gillies bay, and Crescent bay, somewhat similar in character, near the northern end of the island.

FOREST.

With the exception of the peaks and summits of some of the higher elevations, Texada island was originally well forested throughout its whole extent, and its timber resources are still considerable, although a large amount has been cut for commercial purposes and some areas have been ravaged by forest fires. The loss from the latter cause while considerable, is smaller than in most districts, as the forest is usually open and the heavy bark of the Douglas fir protects it even when fires pass along the surface. Living trees with trunks blackened below, are present everywhere and show that fires at one time or another have swept over most of the island.

The principal forest tree on Texada island is the valuable Douglas fir (*Pseudotsuga mucronata*). The ordinary trees of this species have a diameter of from 2 to 4 feet, and a height of about 100 feet. Occasional specimens attain a diameter of 6 feet and height of fully 150 feet. It furnishes an excellent timber, although the island variety mostly grown on rocky soil is stated to be harder and somewhat inferior in quality to that found on low moist lands along the coast. Other conspicuous trees of occasional occurrence are the hemlock (*Tsuga heterophylla*), the stately white pine (*Pinus monticola*), the black pine (*Pinus contorta*), the red cedar (*Chamaecyparis Nootkatensis*), a spruce (*Picea Sitchensis*), the yew (*Taxus brevifolia*), and a small cypress (*Juniperus scopulorum*). The broad-leaved varieties are represented by occasional maples (*Acer macrophyllum*), numerous specimens of the red-barked arbutus (*Arbutus menziesii*), a picturesque evergreen usually found along the coast, and the alder (*Alnus oregana*). The latter grows to a large size, occasional specimens attaining a diameter of from 1 to 2 feet.

While the forest is generally open and often park-like, the surface is usually covered with a dense underbrush, difficult in many places to penetrate. Among the most abundant shrubs are a blueberry (*Vaccinium oratum*) and the Salal bush (*Gaultthesia Shallon*). Other varieties less abundantly represented are wild roses, blackberries, and species of willow.

FAUNA.

The poverty of the fauna on Texada island is somewhat surprising, and is in strong contrast to the luxuriance of the flora. Only three of the larger mammals are represented, viz., the black-tailed deer (*Cervus Columbiana*), the Pacific coon (*Procyon Loter Pacificus*), and a land otter (*Taxidea Americana*). The deer are plentiful, but are smaller than on the neighbouring mainland. The limited range and consequent interbreeding is probably responsible for the deterioration in size and also in quantity. Bird life is also notable for conspicuous omissions. Grouse of all kinds are entirely absent, although berries and other food such as they ordinarily use are abundant. Efforts have been made to introduce them, but without success. Various species of duck and geese frequent the shores of the island in winter, but are seldom present in summer. Among the small birds robins, blackbirds, hummingbirds, and woodpeckers are frequently seen. Fish, principally trout, are abundant in some of the lakes, and salmon, sea trout, and cod of several varieties abound at certain seasons in the neighbouring waters.

PRINCIPAL INDUSTRIES.

The principal industries of the island are mining, lumbering, and agriculture. Of these, mining at present is much the most important.

Mining.

The mineral deposits of the island include important gold-copper sulphide ore bodies, numerous large masses of magnetic iron ore, and quartz veins carrying free gold. The copper deposits so far have yielded the best returns.

The Marble Bay mine, which has been continuously worked for over 14 years, and has now reached a depth of over 1,000 feet, produces about 1,200 tons a month, much of it high grade ore. The Cornell and Copper Queen have been worked by leaseholders and production has been intermittent. The known lenses have been practically exhausted, but the conditions at both mines warrant further explorations. Small shipments of copper ore have also been made from the Little Billy, Loyal Lease, and from the Iron Range on the west coast.

The magnetite deposits are not being worked at present, but will probably play an important part in the future history of the island. The magnetite occurs in lenses varying in size from small bunches up to great masses several hundred feet across. The ore is high grade, the iron contents usually exceeding 60 per cent, but is seldom free from iron and copper sulphides, and much of it will require roasting before treatment. Shipments of iron ore from the iron range on the west coast were made regularly for some years to the Irondale smelter, Washington, and the product shipped to San Francisco. On the east coast a considerable quantity has been mined and used as a flux at the Vananda smelter.

Gold quartz veins are numerous, especially on the northern end of the island, and have led to a number of excitements. The veins are mostly small, and the gold contents have proved to be exceedingly pockety. Work on them is now practically abandoned.

In addition to the metallic minerals, the limestones, marbles, clays, and sands of Texada island are important. The limestones at the northern end of the island, a bluish compact variety, are very pure and furnish an excellent lime. The supply is practically unlimited, and six kilns with a capacity of about 600 barrels a day have already been built. White, greyish, and reddish marbleized limestone occur on various parts of the island, and marble quarries have been opened up on Sturt and Anderson bays. Work on both of these has been suspended for some years. The crystalline limestones, while usually strongly jointed and fissured on the surface, include small areas which, judging from the surface exposures, are free or nearly so from these partings, and it is probable that a careful search for marble of a marketable quality would be rewarded with success. Clays and sands of glacial age occur at various points on the west coast, but so far have not been utilized or tested as to quality. A red clay bed at the base of the Cretaceous, evidently a residual deposit from the waste of the porphyrites in Pre-Cretaceous time, may possibly have some economic value.

Lumbering.

The lumbering industry on the island is represented at present by a sawmill at Vananda bay, and a logging camp on Lower

Gillies bay. A considerable proportion of the heavy forest, chiefly of Douglas fir, which originally covered the island, still remains uncut.

Agriculture.

The surface of Texada island is generally rocky, especially in the southern part, and the portions suitable for agriculture are confined mostly to isolated areas underlain by glacial deposits, most of which are still heavily timbered, and to occasional filled or partially filled-up lake basins. The aggregate amount is considerable, much larger than a cursory examination confined to the vicinity of the main roads would suggest. The soil is generally a rather light sandy loam, except in the flats where it becomes more or less peaty. A number of small ranches have been taken up in the northern part of the island, but many of them have been abandoned or neglected for various reasons. A few have been worked continuously for a number of years, and sufficient has been done to amply prove the suitability of both soil and climate for the production of numerous vegetables, some cereals, and fruits of various kinds. Small fruits such as strawberries, raspberries, and blackberries thrive well and mature fairly early, and cherries, apples, pears, and peaches are successfully grown.

CLIMATE.

The climate of Texada island, taken as a whole, is scarcely surpassed on the north Pacific coast. It is generally mild, dry in summer, but with the usual persistent rainfall in winter. The rainy season begins in October, and with occasional intervals of dry weather, continues until April. The precipitation occasionally takes the form of snow, but the fall is never heavy and soon disappears on the lowlands. Severe frosts are seldom experienced, the winter temperature usually ranging well above the freezing point. The spring is early, vegetation commencing in March and being well advanced in April. The summer season, lasting from May to September, with its occasional rains and long spells of dry sunny weather, is delightful. The heat is never excessive, as the island is narrow and exposed everywhere to the tempering ocean breezes.

CHAPTER II.

GENERAL GEOLOGY.

GENERAL OUTLINE.

The geology of Texada island, while not free from debatable problems, is simple, viewed broadly. The formations represented are few, are mostly of igneous origin, and if the glacial deposits are excepted, are confined to the central portion of the geologic column. The ages assigned the different formations are tentative only, as definite fossil evidence, except in the case of the Cretaceous, is wanting.

The greater portion of the island is underlaid by basic, massive, volcanic rocks, mostly porphyrites, all belonging to one period of eruption or intrusion, and probably of lower Jurassic age. Rocks older than the porphyrites are represented by a series of tilted tuffs, agglomerates, schists, amygdaloids, etc., at the southern end of the island, and by a number of small and large limestone areas, all evidently portions of one formation partially destroyed by the porphyrite invasion in the northern part. The tuff formation and the limestone are both considered to be lower Mesozoic in age. They were nowhere found in contact, and the greater age assigned the former is based on its more disturbed and altered condition.

The porphyrites were followed by an intrusion of quartz diorites. They occur in small stocks, irregular in shape and dimensions, and represent outliers of the great Coast Range granitic batholith of the neighbouring mainland. Later on in late Jurassic or early Cretaceous time, a number of small bosses and a widely distributed system of diorite dykes intruded the older rocks.

The dykes represent the last outbreak of vulcanism or even of disturbance on the island. Sedimentation occurred in the Cretaceous, but the beds laid down still preserve their horizontal attitude, and in places are scarcely indurated. The Cretaceous beds are distributed in small areas along the west coast. Some fossils were collected from an area situated a short distance east of Cook bay. The collection is small, but sufficient to correlate the beds with the Nanaimo group, the coal-bearing series of Vancouver island. Only the basal beds have been preserved on Texada island, and no coal seams of value were found in these.

During Tertiary time Texada island remained above sea-level, and vigorous erosion, the marks of which are everywhere apparent, was in progress. It was buried in ice moving southeastward during the Glacial period, and partially covered with boulder clays, silts, and sands in the lowlands, and scattered erratics in the uplands.

Recent deposits are represented by occasional accumulations of coarse angular debris at the foot of some of the steep slopes, small amounts of creek gravel, and peaty beds in the pond and lake basins.

The formations occurring on the island have been classified as follows, in descending order:—

Quaternary...	Recent............	Creek gravels, peat, etc.
	Glacial............	Boulder clays, sands, silts, etc.
Mesozoic.....	Upper Cretaceous...	Soft sandstones, sands, clays, and shales.
	Lower Cretaceous or upper Jurassic....	Diorites and diorite porphyrites in small stocks and dykes.
	Upper Jurassic (?)..	Quartz diorites referred to the period of Coast Range batholith.
	Lower Jurassic (?)..	*Texada group;* porphyrites. Texada group of LeRoy (in part).
	Triassic or Jurassic.	*Marble Bay formation:* limestone.
	Triassic............	*Anderson Bay formation:* schists, tuffs, agglomerates, amygdaloids, and marbles. Texada group of LeRoy (in part).

DETAILED DESCRIPTIONS.

ANDERSON BAY FORMATION.

This name has been applied to a group of rocks, mostly of volcanic origin, exposed around the southern end of Texada island.

DISTRIBUTION.

The rocks of the Anderson Bay formation extend from Point Upgood, at the southernmost point of the island, northward to the base of Mt. Dick, a distance of about a mile. They are replaced opposite Mt. Dick, on the west coast by the Texada porphyrites, but on the east side a band gradually narrowing to a few hundred feet in width outcrops along the coast for a distance of 8 miles. They are not found in other parts of the island, and the total area underlaid by them is less than 3 square miles.

GENERAL CHARACTER.

The Anderson Bay formation is the only distinctly bedded and banded formation on the island. It is made up of an alternating series of slates, quartzites, conglomerates, marbles, tuffs, agglomerates, amygdaloids, and reddish, lead-coloured and green schists. The beds and bands are highly tilted as a rule, dip to the west, and strike in a northerly direction. The different varieties have all been subjected to intense dynamic metamorphism, and nowhere occur in their original condition. Limestones have been altered into marbles, argillites, and fine-grained tuffs; into schists or quartzites, and even the massive flow rocks have been crushed in places into coarse schists.

PRINCIPAL ROCK VARIETIES.

Quartzites. The highest member of the series consists of about 800 feet of hard, greyish, slaty rocks, probably originally argillaceous sediments. They have been largely altered by silicification into fine-grained quartzites. In thin section they are seen to consist of microcrystalline quartz, associated with mica and varying quantities of carbonaceous dust. Some magnetite and crystalline pyrite are also present.

Tuffs and Agglomerates. The quartzites are exposed on the west coast and are overlaid, going eastward, by at least 1,500 feet of rather coarse, greyish tuffs and agglomerates in alternating bands. The fragments in the agglomerates are subangular, as a rule, and consist mostly of greenstones. These rocks are less altered than the other members of the series, but are silicified in places, and hold occasional jasperoid masses usually reddened with hematite scales.

Amygdaloids. Reddish vesicular flow rocks alternating with tuffs and schists occur in several thick bands near the centre of the section across the island. They are altered, coarsely schistose rocks holding considerable magnetite and hematite. The flattened vesicles are filled as a rule with calcite and quartz.

Reddish and Lead-coloured Schists. These rocks, associated with some green schists and enclosing a lens of limestone, underlie the amygdaloids near the east coast. They are argillaceous sediments metamorphosed into fine-grained, micaceous schists. The red coloration of the red variety is due to the presence of hematite.

Crystalline Limestone. Limestones occur near Henderson bay with altered argillaceous rocks, and on the west coast with dark slaty quartzites. They are coarsely crystalline rocks, greyish or light pinkish in colour, and in most of the sections occur in heavy beds or bands. Thin sections show large individuals of calcite in a fine-grained calcite groundmass. In the pink variety the large individuals are often bordered by films of hematite.

The Henderson Bay lens has a length of half a mile, a maximum surface width of 300 feet, and a thickness, measured at right angles to the dip, of 180 feet. The west coast lenses are much smaller and have also been partially destroyed by the intrusion of the Texada porphyrites.

Green Schists and Conglomerates. The lowest exposed beds of the formation consist of greenstones and greenstone agglomerates and conglomerates alternating above with slaty bands.

These rocks have been altered and are usually more or less schistose. They show in thin sections a large development of hornblende and in places pass into amphibolites. The rounded and subangular pebbles in the conglomerate members consist mostly of greenstone with some hard slate and limestone.

STRUCTURE.

The Anderson Bay rocks have a general north and south strike and westerly dip, usually at high angles. Small faults and folds occur in places, but there has been no repetition of the beds on a large scale. The thickness is estimated at about 3,500 feet.

The contact between the Anderson Bay beds and the Texada porphyrites is exposed at numerous points and is plainly intrusive in character. Numerous inclusions of the former occur in the porphyrites and the beds also become more altered and disturbed approaching the junction.

AGE AND CORRELATION.

Fragments of crinoid stems occur in the limestones of the Anderson Bay formation, but no determinable fossils were found, and its age and position in the geological scale is only known relatively. It is considered to be the oldest formation on the island. Both it and the Marble Bay limestones are intruded by the Texada porphyrites, but the latter, while crystalline, are only slightly deformed and evidently did not participate in the strong crustal movements necessary to tilt the Anderson bay beds into their present position.

The Marble Bay beds contain fossils which indicate, according to Dr. Kindle, a Triassic or Jurassic age. The older, but probably not geologically much older, Anderson Bay beds are, therefore, assigned to the Triassic.

In neighbouring districts the Anderson Bay formation closely resembles lithologically the Sicker[1] series, a subordinate member of the Vancouver group of Vancouver island. The Sicker series is referred by Clapp to the Triassic or Jurassic.

[1] Clapp, C. H., Memoir No. 13, p. 71, Geol. Surv., 1912.

ECONOMIC VALUE.

No metalliferous deposits of value have so far been found in the Anderson Bay formation. Some silicified shear zones have been prospected but proved practically barren.

The crystalline limestones near Henderson bay may have some value as marbles. A quarry was open on them some years ago, but is now idle. They contain considerable iron and dull quickly on exposure, but may be suitable for inside decorative purposes. The mottled and striped pink coloration of some of the bands is very striking.

MARBLE BAY FORMATION.

The Marble Bay formation on Texada island consists entirely of pure limestones. No siliceous or aluminous beds occur in the areas examined. The limestones have been partially destroyed by igneous invasions, and the portions remaining, except in limited areas, are all more or less completely crystallized.

DISTRIBUTION.

The limestones of the Marble Bay formation are confined to the northern portion of the island. They occur in two large and a multitude of small areas, some only a few feet across separated by igneous rocks. The largest area extends from the north end of the island in a band from 1 mile to 1½ miles in width, southeastward along the coast for a distance of 6½ miles, then bending southward crosses the island to the Iron range on the west coast. This area covers approximately 14 square miles.

A second considerable area occurs close to the west coast in the vicinity of Davis bay. Limestone is exposed here over an area about 4 miles in length following the direction of the island, and 1 mile in width. The country is mostly drift covered and the exact contact of the limestone with the bordering rocks is rarely seen. The limestone band is enclosed in porphyrite, except at the northern end, where it passes under Cretaceous beds.

In addition to the two large areas, numerous limestone inclusions, mostly too small to map, occur in the porphyrites from Davis bay northward to Crescent bay. The inclusions are variable in size and shape, ranging from angular shreds a few yards in length to rounded or lenticular areas traceable for a quarter of a mile or more. They are considered to be fragments of a limestone area which originally covered the island from Point Marshall south to Davis bay, and an unknown distance beyond, and was largely destroyed by the porphyrites.

ROCKS.

The Marble Bay formation as developed on Texada island consists entirely of limestone, mostly calcareous, but with some magnesian bands. Both varieties have been crystallized more or less completely by repeated igneous invasions, and the mineralizing agents which accompanied and succeeded them. The Davis Bay area, except around its boundaries, has suffered less than the larger northern area, and a small area at the north end of the island extending from Limekiln bay to Blubber bay, although cut by numerous dykes, still retains something of its original character. The limestone here is dark greyish in colour on a fresh fracture, fine-grained to compact in texture, and occurs in heavy beds from 1 to 6 feet in thickness. It is very pure and when burnt furnishes an excellent white lime.

Southeastward along the band, the limestones lose their dark coloration, become coarser in grain, and in the vicinity of Sturt bay and other places pass into whitish and greyish marbles, variable in texture and often made up, especially near the ore bodies, of large white calcite grains. A greyish, medium-grained saccharoidal variety is common in the extension of the band southward across the island.

The small limestone inclusions are always coarsely crystalline and are more impure than the large areas. Cherty layers are common, and some of the areas are rimmed, impregnated, and occasionally partially replaced with various contact metamorphic minerals both metallic and non-metallic.

PLATE II.

Vertical jointing in Marble Bay limestone, Texada island, B.C.

STRUCTURE.

The bedding planes of the Marble Bay limestone, except in a few comparatively unaltered areas and on the faces of occasional cliffs, are usually obscure and in places are entirely obliterated. The principal partings consist of strong jointage planes, vertical, or nearly so, in attitude. The joints are regular over short distances, are usually worn and gaping at the surface, and the rounded projecting limestone plates between closely simulate beds. In the less altered areas the beds plainly undulate in low folds, with an occasional sharp upturn near dykes and other igneous bodies. Faults are rare and seldom have a throw of more than a few feet.

The thickness of the formation was not ascertained, owing to the impossibility over the greater part of the area of clearly distinguishing the bedding planes. At the Marble Bay mine, a shaft has been sunk in it to a depth of nearly 1,200 feet. This probably indicates a minimum thickness of at least 1,000 feet, as the inclination of the beds in the vicinity, where recognizable, is low. At the mine the original structure has been obscured by recrystallization.

AGE AND CORRELATION.

No determinable fossils were found by the writer in the Marble Bay limestones, but a few imperfect forms were collected some years ago by Mr. Walter Harvey of Victoria, and were sent to the Survey for identification. Dr. Kindle reports on them as follows:—

"The imperfect state of preservation of most of the material together with the fact that it represents one of the undescribed faunas of Canada, make possibly only generic and provisional reference of species. These are as follows:—

Pentacrinus cf. *asteriscus* Meek
Terebratula sp.
Pleuromya ? sp.
Mytilus sp.
Pinna sp.

This is either a Jurassic or Triassic fauna, probably the former. This age determination is based chiefly upon the presence in the fauna of a species of *Pinna* and a joint of the column of a peculiar crinoid closely related to if not identical with *Pentacrinus asteriscus* Meek. The assemblage of species shown by this small collection strongly suggests that it represents a part of the Nicola series of Geo. M. Dawson."

Hitherto the Marble Bay limestones have been assumed to be of Carboniferous age.

On Vancouver island, the Sutton formation, a series of limestone lenses intercalated in the Vancouver Volcanics,[1] contain a fauna determined by Prof. H. W. Shimer to consist of lower Jurassic forms and is probably of nearly the same age as the Marble Bay beds. The deposition of the Sutton limestones was interrupted by periods of volcanism, while on Texada island, deposition was continuous and a much thicker mass of limestones was built up.

ECONOMIC VALUE.

All the important gold-copper ore deposits worked up to the present on Texada island, and most of the magnetite lenses occur in the large limestone area at the north end of the island, usually at or near its contact with various igneous bodies. No discoveries of proved importance have so far been made in the Davis Bay limestone area. The small limestone inclusions scattered through the porphyrites are often bordered by lenses of magnetite carrying variable quantities of pyrite and chalcopyrite.

In addition to their metalliferous contents, the limestones where unaltered are valuable as a source of lime on account of their purity. The altered limestones usually contain more or less material introduced as a consequence of various igneous intrusions, and are too impure as a rule to be used for this purpose. Areas may also be found suitable for the production of marble.

[1] Clapp, C. H., Can. Geol. Surv., Memoir No. 13, p. 68, 1912.

TEXADA FORMATION.

The Texada formation covers the greater part of Texada island. It consists mostly of basic, massive igneous rocks of varying composition and texture, but classed generally as porphyrites.

DISTRIBUTION.

The Texada formation is divided into two areas by a band of limestone which runs southward across the island from Vananda. The northern area extends along the southwest coast from Crescent bay southward to Welcome bay a distance of 7 miles, and includes Surprise mountain and a number of lower elevations. The southern area stretches continuously from Paxton lake southeastward to a point below Mt. Dick near the southern end of the island, and in most places covers the narrow island from coast to coast. Mt. Shepherd, Mt. Davis, Mt. Grant, and all the higher elevations on the island, occur in this area.

ROCKS.

The rocks of Texada formation include a number of related varieties differing greatly in appearance but mostly referable to the porphyrite group. They consist generally of a plagioclase feldspar, varying quantities of augite and hornblende, the former predominating, and usually considerable iron ore. They are badly altered as a rule at the surface and in places have a greenish tinge usually due to the development of epidote. The colour on fresh surfaces varies from grey to green and on weathered surfaces from grey to brown.

Two strongly contrasting types are apparent in the field. In certain areas, usually of limited extent, fresh or faded feldspar crystals, often arranged in stellar shapes, are prominent as phenocrysts. In the second type, augite is the principal phenocryst, but the porphyritic texture is inconspicuous as a rule in hand specimens, and the rock has the granular appearance of a medium-grained diorite.

In thin section, a porphyritic texture, although expressed sometimes merely by groups of large individuals, is always evident, and varietal differences, mostly due to changes in the relative quantities of the principal constituents, are more numerous. The principal types are classified by Mr. A. O. Hayes, who examined a large suite of slides representing collections from all over the island, as augite, hornblende, and diabase porphyrites, and basalts. The varieties grade into each other. They represent differentiations in the same magma, not distinct magmas, and are mapped together, as it was found impossible to separate them in the field.

Augite Porphyrite. This is the ordinary variety present along the whole length of the island. It is made up of phenocrysts of a plagioclase feldspar—usually andesine where determined but occasionally labradorite—and augite in a base of the same minerals. Iron ore in irregular grains and feathery flakes is usually abundant. The groundmass is holocrystalline and varies in texture from fine grained to moderately coarse. The feldspar in it occurs in small lath-shaped crystals occasionally showing an ophitic relationship to the augite. Alteration is usually pronounced with chlorite, calcite, epidote, and zoisite as the principal secondary minerals.

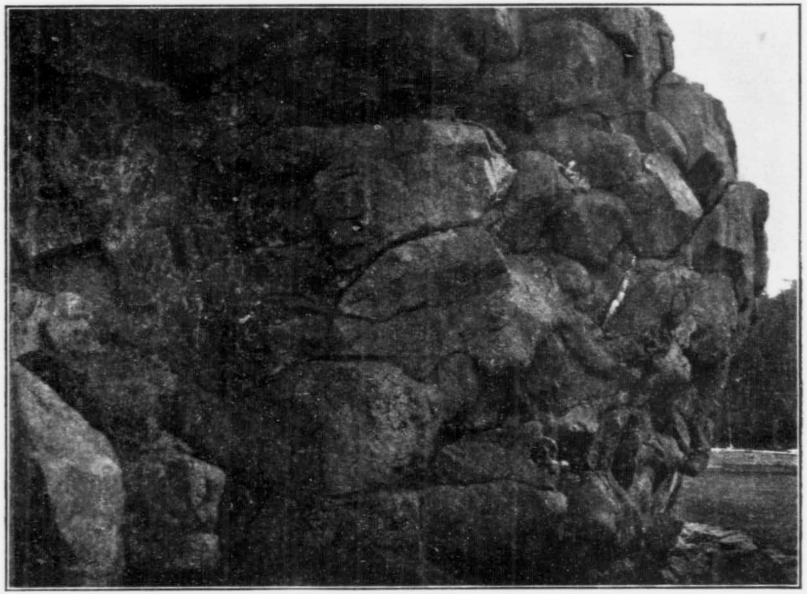
Vesicular varieties are not uncommon. In these the cavities are either filled with chlorite, or lined with chlorite and the filling completed with calcite epidote and more rarely quartz.

Hornblende Porphyrite. Porphyrites with hornblende as the principal dark mineral, occur in Pocohontas mountain and southward along the eastern side of the island to Long Beach. The phenocrysts in these are plagioclase, feldspar, and hornblende. The latter occurs in irregular forms and may be partially derived from augite. Some augite is usually present. The base is rather fine-grained and consists of small plagioclase laths, hornblendes, and alteration products, principally chlorite.

Diabase Porphyrites. Rocks with an ophitic structure occur on Mt. Shepherd and at Crescent and Davis bays. They do not differ greatly from the augite porphyrites as the latter occasionally show an ophitic structure in the groundmass and the minerals of both varities are similar. They are more uniform in

PLATE III.

Jointing in Texada porphyrites, Texada island, B.C.



Nodular structure in Texada porphyrites, Texada island, B.C.

texture as the groundmass is coarser and phenocrysts are fewer.

Basalts. Sections from Mt. Dick and from nodules in the nodular porphyrites of Cook bay and the area north of Surprise mountains have a basaltic character. They consist of altered labradorite and rather fresh augite phenocrysts in a turbid base which has the appearance of devitrified glass. Olivine is apparently absent.

STRUCTURE.

The porphyrites occur as a rule in a massive condition, but in a few places, especially near the quartz-diorite area, have been crushed over small areas into coarse schists. They are sparingly amygdaloidal in some areas. The cavities are globular or lenticular in shape, are occasionally an inch or more in length, and are filled with epidote, quartz, and calcite enclosed in a dark chloritic lining. They are nowhere numerous enough to give the rock the character of an ordinary amygdaloid.

Regular contraction joints simulating bedding over small areas, is a prominent feature of the porphyrites in some areas, while in others, they are almost wanting. Narrow fissures are common and moderate sized shear zones, from a few inches to 3 or 4 feet in width and traceable for a hundred yards or more, occur occasionally, especially in the northern portion of the island. The ordinary filling is quartz or quartz and calcite with some metallic minerals. In places, the porphyrite is spotted on the surface with rounded or lenticular areas usually from 3 to 6 inches in diameter, made up of quartz, calcite, and epidote. These probably represent replacements of the rock, not filled-up cavities.

One of the most notable features of the porphyrites is their nodular structure over wide areas. The nodules occur grouped closely together, sometimes interlocking and also distributed through the ordinary porphyrite. In the latter case, the rocks resemble and were at first mistaken for volcanic agglomerates. Subsequent work showed that the supposed agglomerate was intrusive in places into the limestone and possessed other characteristics, in certain areas at least, incompatible with a clastic origin.

The nodules, as a rule, are roughly spherical in shape with indented but rounded surfaces and are usually from 3 to 12 inches in diameter. Weathered cliffs where the nodules are packed closely together, resemble boulder walls. On Shelter island, the nodules have the form of uneven overlapping flattened masses 1 to 2 feet thick and 20 feet or more in length. They are harder than the interstitial material, weather out in ribs, and exposures at a distance have a roughly bedded appearance. A peculiar variety seen at Crescent bay and southward for a short distance along the west coast, has the "ropy" character of a surface volcanic flow. It is made up of a confused mass of irregular elongated cylindrical or flattened nodules, often interlocking and with numerous projecting knobs. A similar structure was observed by Dr. Dawson[1] on Lasqueti island and other places and was assumed by him to indicate a surface origin. This is the ordinary explanation and may be correct, but it is peculiar that the "ropy" nodular structure persists to a considerable depth, is only characteristic of small separated areas, and passes gradually into the ordinary massive, irregularly-jointed structure.

The nodules are usually harder than the enclosing rock and project on weathered surfaces. They are also finer grained and somewhat fresher. Their structure is homogeneous and in composition they are similar to the ordinary massive porphyrites. Rims of secondary minerals, principally quartz, are conspicuous in places.

The coarser interstitial rock is usually badly decomposed. Sections examined consisted largely of chlorite with some partially altered plagioclase and augite. The texture is more even-grained than in the nodules. In some instances, the interspaces are filled with small spheroids, altered and partially silicified.

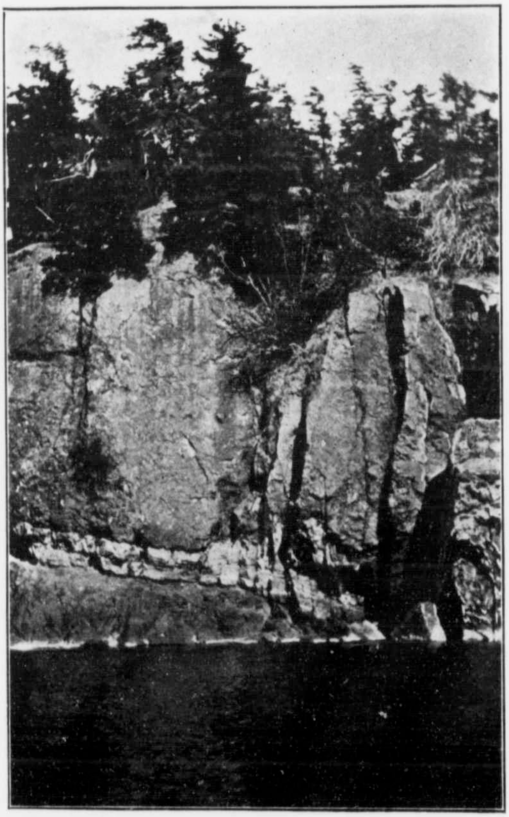
The nodular areas are irregular in shape and size and are surrounded and alternate with the ordinary massive porphyrite. The transition from one type to the other, while usually somewhat abrupt, is nowhere, in the sections observed, marked by sudden breaks, indicating different ages.

Nodular porphyrites are abundant in the Surprise Mountain area, and diminish in importance going south towards Mt.

[1] Annual Report, Geological Survey, Canada, 1886, p. 41 B.

Nodular structure in Texada porphyrites, Texada island, B.C.

PLATE VI.



Limestone band in Texada porphyrites, Texada island, B.C.

Shepherd. In many places where no distinct nodules can be detected, a tendency towards a nodular structure is indicated by rounded projections and hollows in cliff faces.

The nodules evidently developed during the consolidation of the porphyrites probably constituting the first centres of crystallization in the cooling magma. Where they are grouped closely together with little or no interstitial matter, the structure is somewhat akin to the ball and socket jointing in certain basalts and other lavas.

ORIGIN.

The porphyrites, while varying widely in texture, and appearance, are considered to form, viewed broadly, a single igneous body. Later dykes and small stocks intruding the main mass, occur in places, but owing to their lithological similarity to the older rocks and the obscuring of the boundaries by alteration, can seldom be satisfactorily differentiated.

No tuffs or agglomerates were definitely proved in the numerous sections examined. Flow rocks are not common, but probably occur near the southern end of Lower Gillies bay. A small bed of limestone overlaid and underlaid by porphyrites is exposed in a shore cliff at this point. It is only traceable for a short distance but is too regular for an inclusion and must have been deposited in its present position. Its presence apparently proves the effusive character of the overlying andesitic porphyrites and also indicates that deep sea conditions prevailed during a portion at least of the volcanic period.

The nodular and in places sparingly amygdaloidal structure of the Texada porphyrites ally them to rocks cooled without much overburden. They are, however, clearly intrusive in their relationship to the limestones of the Marble Bay formation and the volcanic and sedimentary rocks of the Anderson Bay formation wherever the contacts were seen. Inclusions of numerous angular zenoliths of limestone in the porphyrites at considerable distances from the present contacts, also show that large areas of the limestone have been destroyed.

The porphyrites have been exposed to erosion almost continuously since early Mesozoic time, and the original surface fragmental and flow rocks have been worn away with the exception of a few fragments of the latter. The rocks which now form the main mass of the island must have cooled at some depth, and represent the deeper-seated portions of the volcanic series.

AGE AND CORRELATION.

The Texada porphyrites are younger than the Marble Bay limestones, in which obscure fossils referred to the Triassic or Jurassic have been found, and are older than the upper Jurassic batholithic rocks of the Coast range. They are placed provisionally in the lower Jurassic. They probably belong to the same volcanic period as the Vancouver volcanics[1] of Vancouver island.

ECONOMIC CONTENTS.

The porphyrites are cut by a number of fissure zones usually of moderate size, carrying small quantities of iron and copper pyrites, galena, blende, and occasionally some free gold. They also hold occasional magnetite lenses usually situated near and occasionally partially replacing limestone inclusions.

BATHOLITHIC AND DYKE ROCKS.

The prolonged intrusions of the Coast Range batholithic period which commenced in upper Jurassic time and continued into the Lower Cretaceous, are recorded in Texada island by quartz diorite stocks and dykes, and a later set of diorite and diorite porphyrite stocks and dykes.

QUARTZ DIORITES.

The quartz diorites occur in small stocks and dykes intruding both the limestones of the Marble Bay formation and the porphyrites of the Texada formation. They are the equivalents

[1] Clapp, C. H., Memoir No. 13, Geol. Surv., Can., 1912, p. 50.

on the island of the ordinary Coast Range batholithic rocks of the neighbouring mainland and are probably connected in depth with them.

Distribution. Quartz diorite areas occur at a number of points along the northeast coast of Texada island, the two largest at Sevenmile beach, and south of Pocohontas bay. These areas extend eastward into the strait separating Texada island from the mainland and may possibly be the tips of spurs from the main batholithic areas of the mainland, as similar rocks outcrop on both coasts. From Pocohontas bay north nearly to Vananda bay, the coast is fringed with numerous small stocks cutting the porphyrites. None of these extend far inland and the majority are too small to outline on the general map.

No quartz diorite areas were found in the interior of the island. On the west coast a triangular area about 2 miles in length, occurs at the Iron range north of Gillies bay. A number of small satellitic stocks border the main area, and dykes of the same material are numerous in the vicinity.

Lithological Character. The quartz diorites are medium textured, light to dark grey rocks seldom showing a pronounced porphyritic structure. The essential minerals are a plagioclase feldspar usually andesine, quartz in irregular grains, hornblende, biotite, and occasionally some augite. Orthoclase occurs in a few sections; and apatite in small prisms, and magnetite are common accessories.

Structure. The quartz diorites, like the other post-porphyrite intrusives on the island, are massive rocks, showing no sign of having been subjected to any strong dynamic action. Horizontal and inclined contraction joints are prominent in a number of the areas.

Economic Relationship. The ore bodies at the Little Billy mine formed in limestone near its contact with an acid quartz diorite. Numerous magnetite lenses also occur around the borders of the area on the west coast.

SYENITE PORPHYRITE.

This is an uncommon type on the island and was only found in two dykes cutting the porphyrites of the Texada formation near the Commodore mine. In it plagioclase occurs only in subordinate amounts and orthoclase is the dominant mineral both as phenocrysts and in the groundmass. Elongated areas filled with chlorite and calcite probably represent original hornblende. The principal accessories are apatite, sphene, and magnetite.

AUGITE SYENITE.

The rocks from a small area near the Prescott mine, classed in the field with the quartz diorites, proved on examination in thin sections by Mr. Hayes, to be made up mostly of orthoclase, and augite with some biotite.

The syenitic rocks are rare and probably represent variations from the normal quartz diorite type. The field relationships are the same and the latter usually hold some orthoclase and occasionally both orthoclase and augite.

DIORITES.

The rocks classed as diorites occur in small stocks often less than 100 yards across, intruding limestones and porphyrites in the northern part of Texada island. They are closely related to the quartz diorites and certain areas cannot be referred with certainty to either group.

The diorites were nowhere found in contact with the quartz-diorites, and the higher position assigned them is due to finding small inclusions of quartz diorite in a small diorite area on Sturt bay, and to the further fact that dykes occurring as apophyses from the diorite areas are similar lithologically to dykes cutting the quartz-diorites.

Distribution. The diorites, so far as known, are confined to the northern portion of Texada island, and occur mostly on or close to the east coast. A line of small areas extends from the Cornell mine to the Security, a distance of three-quarters of a mile. A number of small areas outcrop also in the vicinity of the Marble Bay mine, around Sturt bay, and at the Paris group of claims near the northern end of the island. Other areas, all of small size, occur near the Commodore mine, at the Surprise, and other places.

A small area outcropping north of Sturt bay and on an island in the bay, is referred doubtfully to this group, but may represent a basic phase of the quartz diorites.

Lithological Character. The diorites are massive rocks darker in colour and less uniform in grain than the quartz diorites. They have also suffered greater surface alteration and usually weather to a greenish shade. On a fresh fracture the colour is a dark grey. The texture is variable, ranging from moderately fine to medium. Rapid gradations from the fine-grained varieties to the coarse one occurs in most of the stocks.

In hand specimens, the principal minerals seen are faded feldspars, dark augite, and hornblende. The augite occurs in places in stout prismatic crystals, giving the rock a porphyritic appearance.

Dr. Young furnishes the following description of their microscopic character: "The rocks here classed as diorites are not of a normal type and might with perhaps equal propriety, be classed as gabbros. They consist essentially of plagioclase feldspar with but little quartz or orthoclase, accompanied by varying amounts of biotite with hornblende or augite, or both of the latter minerals. Magnetite is always present and usually is abundant. A few individuals of apatite frequently appear in the sections. In one instance it seemed quite possible that the sulphide was secondary."

"As in the quartz diorites, the plagioclase feldspars are usually zonal and at least rudely idiomorphic. Quartz when present, occurs in small formless grains. Biotite is present in nearly every section, the flakes are shaleless and when fresh, of a brown colour. The mica is always accompanied by hornblende or pyroxene or both of these minerals and they possess the same characteristics as in the quartz diorites. The magnetite and coloured bisilicates vary in amount from section to section, sometimes these minerals are very abundant, sometimes they are nearly lacking."

"The great abundance of the plagioclase feldspar and the lath-like form of the individuals, gives a characteristic appearance to the thin sections. At times the rock possesses a porphyritic texture due to the presence of larger feldspars or crystals of augite."

Structure. The diorites like the quartz diorites are massive rocks showing no signs of crushing. Jointing is prevalent in the larger areas, while the smaller ones are only slightly affected. None of the areas are strongly fissured.

Economic Relationship. The diorites are very important economically, as a number of rich ore bodies, including those in the Cornell and the Marble Bay mines, have formed at or near their contact with the enclosing rocks.

DIORITE PORPHYRITES.

The diorite porphyrites are the dyke forms of the diorites. They also occur in the peripheral portions of the diorite stocks and as apophyses from them. The dyke period commenced before the deposition of the principal ore bodies and continued for some time after their formation. At the Lake mine, a large magnetite lens is intruded by a comparatively fresh dyke.

Distribution. Diorite porphyrite dykes varying in width from a few inches to 20 feet or more, occur over practically the whole of Texada island except in the Cretaceous areas. Their distribution is very uneven. At the northern end of the island, also north of Paxton lake and east of the northern end of Spectacle lake, they are especially large and numerous and cover a considerable portion of the surface. They are less common in the porphyritic areas as a rule than in the limestone, but numerous examples occur cutting the former along a portion of the eastern coast south of Northeast point. In the Marble Bay mine, dykes are absent in the upper levels but occur in increasing numbers with depth.

Lithological Character. The dyke rocks as a whole are more even textured than the stocks, and in hand specimens are seldom strongly porphyritic. In thin sections the most common variety is found to consist essentially of phenocrysts of plagioclase feldspar and hornblende in a groundmass of the same minerals.

Augite and less frequently biotite replace the hornblende in some sections. Orthoclase and quartz are often present in small quantities. The accessory minerals include magnetite, ilmenite, apatite, and sphene.

In a few sections the ferro-magnesian minerals are inconspicuous and the rock consists mainly of plagioclase, with usually some orthoclase and quartz and might be classed as a felsite.

A number of the dykes are comparatively fresh, but most of them show some alteration with a development of the ordinary secondary minerals chlorite, epidote, calcite, etc.

Economic Relationship. Ore bodies are occasionally associated with the dykes. The most conspicuous example occurs at the Copper Queen mine where large bodies of rich ore rested on a diorite porphyrite dyke. Small ore bodies with dykes as footwalls also occur at the Rose and Belle and other claims. It is probable that deeply buried stocks exist at these points and that the ore solutions ascended from the stocks along the dykes. Somewhat similar conditions obtain at the Marble Bay mine where a stock was encountered in the deep workings underlying a rich bornite ore body.

QUARTZ PORPHYRY.

This rock is represented by one dyke situated near the Paris mine at the northern end of the island. The dyke cuts a small area of diorite porphyrite and is probably the youngest intrusive on the island. It consists essentially of orthoclase in large idiomorphic crystals, and rounded quartz in a fine-grained groundmass of the same minerals.

CRETACEOUS.

Cretaceous rocks in isolated basins occur at various points along the west coast of Texada island from Gillies bay southeastward to Cook bay. The different occurrences originally formed parts of one large area, which probably extended westward across the Strait of Georgia to Vancouver island. The beds were laid down on an uneven surface of porphyrites, have been greatly eroded, and only those portions which occupied basins in the old floor have been preserved.

DISTRIBUTION.

The largest area of Cretaceous on the island, occurs in the neighbourhood of Gillies and Lower Gillies bays where they occupy a wide depression which extends inland a couple of miles. The area has a length of about 5 miles and a maximum width of 2 miles. Its outline was not precisely defined as the country is heavily drift covered and contacts with the bordering porphyrites are rarely seen even in the valleys. It was not found in place north of Gillies Bay creek, but probably extends for some distance in that direction under the drift deposits as the country is flat and angular sandstone fragments occur in the drift.

A second Cretaceous area represented by a single outcrop of conglomerate occurs at Davies bay. The area is small, the porphyrites coming to the surface a short distance away.

Red clays usually found at the base of the Cretaceous are exposed at intervals for a distance of half a mile, on a creek some distance below Davies bay. No outcrops of the higher beds were seen.

Farther south, a small area well exposed on a branching creek which falls into Cook bay occurs about half a mile inland from the beach. The Cretaceous beds, here, occupy a well-defined basin, sunk in the porphyrite. The area covered does not exceed a square mile.

ROCKS.

Lower Gillies Bay Area.

Lower Gillies Bay creek affords the best sections of Cretaceous rocks examined. The lower part of the valley is a steep-sided canyon from 75 to 125 feet deep, and exposures occur along it at short intervals for a distance of 2 miles. The basal beds of the formation consist of an irregular layer of red clay resting on decomposed porphyrites of the Texada formation. The clays are never more than a few feet thick, and are considered to be a residual deposit derived from the waste of the underlying rocks. They are coarsely bedded in places, but frequently pass gradually into the unsorted decomposed material below. The transition zone is usually marked by numerous soft porphyrite cores.

The red clay beds are akin in origin to the laterites generally considered to be a product of tropical or semi-tropical arid districts. Their presence on Texada island in a region of moderate temperatures and excessive rainfall during a considerable portion of the year indicates a great change in climatic conditions since they accumulated.

The red beds are overlaid by conglomerates made up of rounded pebbles mostly of porphyrite enclosed in a sandy matrix. The conglomerates have a thickness of about 100 feet, occur in heavy beds, and are occasionally interstratified with yellowish feldspathic sandstone.

Descending the creek, the conglomerates soon disappear and are replaced and overlaid by dark greyish or bluish, slightly indurated, coarse shales, so soft in places that they might properly be called bedded clays or sandy clays. These are the highest beds exposed. They contain occasional nodules of clay ironstone often 3 to 4 feet in diameter. The thickness was not definitely ascertained, but is estimated at from 300 to 400 feet.

About half a mile from the mouth of the creek, heavy beds of yellowish sandstones occur at the base of the section, interstratified with the shales. These probably represent the upper part of the lower siliceous portion of the formation, and if so, the beds have a general synclinal attitude. No conglomerates are exposed and farther down the rocks are concealed by drift.

Exposures of sandstone, conglomerate, coarse shales, and bedded clays occur in the main valley and in tributary valleys of the stream falling into Gillies bay. The section exposed across the Cretaceous basin on this line, is less complete than that on Lower Gillies Bay creek.

Davies Bay Area.

An outcrop of hard, massive conglomerate and sandstone 15 feet thick, occurs at Davies bay, 200 feet from the beach. The Cretaceous area here must be quite small as porphyrites are exposed on the beach and also a short distance inland.

Red Clay Creek Area.

The Cretaceous exposures here consist of a few thin outcrops of red clay overlaid in places by a soft reddish agglomerate made up mostly of decomposed porphyrite pebbles. Red clay is exposed in the bed of the creek at intervals, for a distance of 250 yards from the beach, and is then replaced by porphyrite. The country bordering the creek is drift covered and the exact length of the area could not be determined. It is probably less than half a mile as porphyrite outcrops on the beach a short distance above and below the mouth of the creek.

Cook Bay Area.

This area differs from the others in being situated half a mile from the beach behind a porphyrite ridge. It is well exposed along branches of Cook Bay creek. Sections along these show that it occupies a basin one-half a mile long and 1,400 feet wide, rimmed all round with porphyrite. The rock section is similar to that on Lower Gillies Bay creek and consists below of irregular deposits of red clay and agglomerate, sometimes absent and never more than a few feet thick, passing downwards into decomposed porphyrites. Above the red beds are 50 feet of conglomerate followed by 50 feet of yellowish sandstone, sands, and sandy clays passing upwards into bluish bedded clays. The total thickness of the beds in the basin is probably less than 200 feet. Numerous fossils occur on the east branch in the sands and sandy clays above the conglomerates.

STRUCTURE.

The Cretaceous beds have not been affected materially by crustal movements. While they are seldom horizontal, the dips rarely exceed 5 degrees, are very irregular, and are probably due largely to the uneven surface on which the beds were deposited. The general dip in the Gillies Bay area is seaward, and in the Cook Bay area is towards the centre of the basin.

AGE.

The fossils collected were submitted to Mr. Lawrence Lambe for examination who reports as follows:—

"The fossil mollusca collected by Mr. McConnell, during the summer of 1909, from an outlier of Cretaceous rocks half a mile east of Cook bay, Texada island, are all pelecypods and belong to nine species of seven genera. The majority of the specimens are poorly preserved casts of the interior of the shells, but specific determinations have been rendered possible through comparison with better preserved material from the same locality already in the possession of the Geological Survey. This latter material consists of a collection made in 1901 by Mr. Walter Harvey of Vancouver, who was the discoverer of the Cretaceous outlier at Cook bay. His specimens are well preserved and were described by Dr. Whiteaves in 1903 in part V of the first volume of Mesozoic fossils. They represent in all one species of brachiopod, four of gasteropods, and twelve of pelecypods. The beds at Cook bay, Texada island, from which these seventeen species were obtained, were considered by Dr. Whiteaves to belong to the Nanaimo group of Vancouver island which includes Divisions A-D of Richardson's Comox section, and Divisions A and B of his Nanaimo section. The Nanaimo group belongs to the Upper Cretaceous, it is synchronous with the Chico group of California, and its fauna bears some resemblance to that of the Pierre-Fox Hills or Montana formation."

"Mr. McConnell's collection of 1909 includes the following species":—

"1. *Meretrix nitida*, Gabb. A poorly preserved cast of the interior, shewing the muscular scars with the palial lines and sinus, and to some extent, the character of the hinge dentition. This species is recorded from Texada island (Harvey collection). It is known from Division D (Middle Shales) of the Comox area; and from a number of localities in both the Comox and Nanaimo areas in the Productive Coal Measures (Division A). Dr. Hector has recorded it from Departure bay, Vancouver island, below the lignite.

"2. *Trapezium* sp. A genus not hitherto known from the Vancouver Island Cretaceous. The specimen is a cast of the interior, and indicates a species, thought to be undescribed, differing from *T. carinatum*, Gabb, from the Cretaceous of California, in its proportionate greater height. Indications of a radiating sculpture are seen in the Texada specimen.

"3. *Astarte couradiana*, var. *tuscana*, Gabb. A cast of the interior revealing the principal characters necessary for its determination. The species was obtained by W. Harvey at Texada island. It occurs in Division A (Productive Coal Measures) of the Comox and Vancouver areas.

"4. *Trigonia intermedia*, Fahrenkokl. The anterior half of a left valve shewing the characteristic sculpture. A small example of this species, a mould of the exterior of the shell, was collected by W. Harvey at the Texada locality in 1901. A second specimen in Mr. McConnell's collection apparently belongs to this species but it is too imperfect for definite determination. This species is recorded by Dr. Whiteaves from Division C (Lower Shales and Sandstones, with coal) of Dawson's Queen Charlotte Island section, which division is supposed to represent a lower geological horizon in the Cretaceous than the Productive Coal Measures of the Nanimo group. It is probable that *T. intermedia* has a somewhat extended vertical range in the Cretaceous.

"5. *Trigonia tryoniana*, Gabb. A right valve, in which the inner layer only of the test is preserved, appears to be referable to this species. Without the surface ornamentation the species represented cannot be determined with certainty. *T. tryoniana* occurs at Northwest bay, V.I., in the Productive Coal Measures, Division A of Richardson's Comox section.

"6. *Pentunculus veatchii* (Gabb). This species, abundant in the Texada Island beds, near Cook bay, is represented in Mr. McConnell's collection by a cast of the interior. Two small casts of the interior may be immature examples of this shell. The species is recorded from Division D of the Comox area, and from Division A of the Nanaimo coal-fields.

"7. *Inoceramus digitatus*, Schmidt. Moulds of the exterior portions of a strongly ribbed shell which are regarded as referable to this species. The species is found in Divisions A and B of the Vancouver Cretaceous.

"8. *Anomia linensis*, Whiteaves. A mould of the exterior of the upper valve of a specimen shewing well marked concentric lines of growth, and radiating sculpture. The characters exhibited agree in all particulars with those of the type specimens from Lina island, Queen Charlotte islands, from the Lower Shales and Sandstones (Division C) of the Queen Charlotte Island formation.

"Mr. McConnell's collection adds five species to the previously recorded faunal list of Texada island, bringing the total number of known species up to twenty-two. Of these, seventeen occur in the Nanaimo group, three are found also in the Coal Measures (Division C) of the Queen Charlotte Islands formation, and two (one being a new species) are known only from Texada island. It is thus seen that the faunal relation of the Texada Island beds at Cook bay with those of the Nanaimo group is a most intimate one and leaves little doubt as to the correctness of the previously published opinion (Whiteaves) that the Texada beds at Cook bay form part of this group as developed on Vancouver island.

"Further, an analysis of the occurrence of Texada species in the different divisions of the Nanaimo group goes far to prove that a basal position in the group is to be assigned to the Cook Bay outlier. Of the seventeen species of the Texada fauna occurring in the Nanaimo group, thirteen are found in the Productive Coal Measures (Division A), of which a few are represented as well in Divisions B and D. That three species are common to the Texada beds and to Division C of the Queen Charlotte Islands formation strengthens the idea that the Texada beds belong to the earlier part of the Nanaimo group. Richardson in the Report of Progress for 1876-77 expressed the opinion that the Cretaceous rocks (plant bearing), exposed at Gillies bay near the northwest end of Texada island, seemed to be at the base of the Productive Coal Measures. It appears probable, on the evidence of their fossil remains, that the rocks composing the outlier at Cook bay are also properly assignable to a low position in the Nanaimo group at or near the base of the Productive Coal Measures or Division A of that group."

The following fossils were collected by Mr. Walter Harvey from the Cook Bay Cretaceous outlier in 1901, and are reported on and the new species described by Mr. J. F. Whiteaves in Vol. 1, part V, Mesozoic Fossils, published by the Geological Survey of Canada, 1903.

Gasteropoda

Vanikoro pulchella var., Whiteaves
Lysis suciensis var. carinferos, Whiteaves
Helcion tenuicostatus, Whiteaves

Pelecypoda

Panopaea concentrica, Gabb
Cymbophera ashburneri, Gabb
Meretrix nitada, Gabb
Meretrix arata ?, Gabb
Cymprimeria lens, Whiteaves
Crassatella conradiana, Gabb
Crassatella conradiana var., Tuscana
Pectunculus veatchii, Gabb
Mytilus pauperculus, Gabb
Pecten traskii, Gabb
Lima suciensis, Whiteaves
Anomia vancouverensis, Gabb

Brachiopoda

Terebratella harveyi, Whiteaves

ECONOMIC VALUE.

The fossils collected at Cook Bay creek indicate an Upper Cretaceous horizon, and correlate the beds there with the Nanaimo or coal-bearing series of Vancouver island. The Gillies Bay rocks while destitute of fossils, resemble those at Cook bay in every respect and are referred with little hesitation to the same period.

No coal seams of value were found in either area, although good sections from the base upward are available for study, and it is doubtful if any exist. A bore-hole put down some years ago near Gillies bay failed to discover coal. The greater part of the formation has been destroyed locally by erosion, and the beds preserved are apparently below the coal-bearing horizon.

The red hematitic clay beds at the base of the formation have a thickness in places of 15 feet. Several claims have been located on them, on the assumption that the material may be of value in the manufacture of paints.

SUPERFICIAL DEPOSITS AND GLACIATION.

GLACIAL DEPOSITS.

The Glacial deposits of Texada island consist of two boulder clays separated by about 200 feet of sands and silts referred to an interglacial period. The upper boulder clay is overlaid by a few feet of sands and gravels above which are occasional large angular rock fragments probably sea borne.

The distribution of the Glacial deposits is very irregular. Heavy boulder clays occur in a few places along the coast, but in the interior of the island, except in one area north of Pocohontas mountain, they are usually thin and over the greater part of the island are absent altogether. They were found up to an elevation of 1,200 feet. Above that point, the Glacial deposits are represented by scattered erratics only. These persist to the tops of the highest peaks showing that at the time of the maximum glaciation the whole island was buried in ice. Striæ and groovings preserved at a few points, indicate a general southwesterly movement of the glacier, nearly parallel to the long direction of the island.

The lower boulder clay occurs at Limekiln and Crescent bays resting on glaciated rocks, and also at the wharf at the Iron range on the west coast. At the latter point the base is not exposed. It is a greyish rather silty clay, holding a few scattered pebbles and scratched boulders and was probably deposited under water.

The interglacial beds are well exposed on the west coast about 2 miles north of Gillies bay and also on Harwood island north of

Texada island. At the former place, they consist of 150 feet of greyish and yellowish sands, holding at one point, a thin bed of clay pebbles. On Harwood island they have an exposed thickness of 185 feet. Near the top of the section, they include a bed of clay 2 feet thick, and occasional layers of small pebbles.

Similar deposits of stratified sands occur on a number of islands in the Gulf of Georgia, and also at intervals along the mainland coast and the coast of Vancouver island. It is probable that after the first retreat of the ice, the wide basin occupied by the gulf was silted up to a height of about 200 feet above the present sea-level. Subsequently, the whole widespread sheet of soft sediments, with the exception of a few sheltered patches, was destroyed.

The upper boulder clay occurs overlying the interglacial beds on Harwood island and north of Gillies bay. It is a typical, hard, compact boulder clay filled with granite and greenstone boulders. Many of the granite boulders are soft and crumbly from decomposition. The upper boulder clay bed is thin measuring only from 4 to 15 feet in thickness in the sections examined.

The boulder clay in the interior of the island bears a closer resemblance to the product of the second period of glaciation, as developed on the coast, than to the first, but the absence of interglacial beds makes it impossible to definitely classify it.

The upper boulder clay is a typical ground moraine laid down on land. After or during its deposition, the island was depressed and the low lying portions up to a height of about 500 feet above the present sea-level, were submerged. This is shown by the presence of occasional patches of gravels and beach sands up to that elevation. Marine shells were found near the Lake mine at a height of 380 feet, near the Sentinel claim at a height of 413 feet, and south of Cornell mine at a height of 424 feet above sea-level. Large boulders dropped by icebergs overlie the old beach sands at places along the coast at an elevation of over 200 feet. After the final retreat of the ice the land rose to its present position and changes in level ceased. Occasional wide rock beaches cut by the waves in hard quartz diorite and limestone show that the island has remained at the same elevation for a long period.

The changes in elevation must have been gradual without prolonged breaks as no well marked elevated rock-cut terraces were observed on the island. Rough terraces cut out of drift occur at a few points.

RECENT DEPOSITS.

The small island streams have weak carrying power and as most of them discharge directly into deep water, no conspicuous delta deposits have been built up. In the interior of the island, a number of lakelets and small depressions have been filled up with impure peaty accumulations and occasionally converted into valuable agricultural land.

HISTORICAL GEOLOGY.

Texada island affords no records of the Pre-Cambrian or Cambrian ages. Its geological history commenced in early Mesozoic or possibly late Palæozoic time and was ushered in by a volcanic outbreak resulting in the deposition of the tuffs, agglomerates, and amygdaloids of the Anderson Bay formation, some thousands of feet in thickness. The volcanics are associated with bands of limestone and aluminous sediments showing that they were laid down in a sea of some depth, and that the eruptions were intermittent.

The volcanic period was followed—probably after a lengthy interval as meanwhile the beds of the Anderson Bay formation were first hardened and then folded into their present almost vertical attitude—by a subsidence during which the massive limestones of the Marble Bay formation were deposited. These beds have yielded a few imperfect shells which indicate an upper Triassic or lower Jurassic age.

The placing of the limestones above the Anderson Bay fragmentals is based on indirect evidence, as the two formations are nowhere found in contact. The limestones away from igneous bodies are only slightly altered, and such deformation as they have undergone is manifested only in light rolls. The Anderson Bay rocks, on the other hand, are often highly altered, and their steep attitudes show that they have been affected by strong orogenic movements.

The tranquil deep sea conditions of the Marble Bay Limestone period was interrupted by a second period of vulcanism, during which the porphyrites, the most important rock mass on the island, were erupted or intruded. The porphyrites broke through and partially destroyed the Marble Bay limestones and the Anderson Bay volcanics, and probably broke out in volcanoes at the surface. No direct evidence of this is obtainable as the original surface rocks have been long since removed by erosion.

The age of the porphyrites is probably lower Jurassic. They are younger than the Marble Bay limestones and older than the Coast Range batholith, generally referred to the upper Jurassic.

The great intrusion of granitic rocks in the upper Jurassic along the Pacific coast, is recorded on Texada island by the presence of a number of quartz-diorite areas mostly confined to the east coast. A second intrusion bringing up more basic material, followed closely. The products of this consist of a number of small diorite stocks and a widely distributed system of diorite-porphyrite dykes.

At the close of the dyke period, or shortly afterwards and probably as a consequence of it, mineralization on an extensive scale took place and numerous lenses of magnetite and copper and iron sulphides were formed. The limestones were also crystallized over considerable areas and occasionally partially replaced by garnet, epidote, and other contact metamorphic minerals. The quartz veins cutting the porphyrites probably date from nearly the same period.

Vulcanism ceased on the island with the formation of the ore deposits and henceforward its history is practically one of continuous waste.

In Upper Cretaceous time, the island was partially submerged and beds of conglomerate, sandstone, and shale formed along the western shores. A subsequent elevation brought these above the surface and they have since been destroyed except in a few isolated and sheltered basins.

In the long interval between the Upper Cretaceous and the Glacial period, no additions were made to the mass of the island. Degradation was in active progress and the present topographic forms gradually evolved. The relatively soft northern portion of the island was worn down to within measurable distance of sea-level, and the more resistant southern portion sculptured into peaks and ridges still considerable in height.

During the Glacial period, the island was depressed and interglacial sands, silts, and clays were deposited in places along the coast. At its close, an elevation of about 500 feet took place. At the time of maximum glaciation, the island was entirely submerged in ice moving in a southeasterly direction.

Since the close of the Glacial period, the island has remained practically stationary and sloping rock beaches, often of considerable width, have been cut by the waves at various points around the coast.

CHAPTER III.

ECONOMIC GEOLOGY.

MINERAL DEPOSITS.

Texada island with the exception of the few small areas covered by Cretaceous deposits, is more or less mineralized throughout its whole extent. The mineral occurrences, while numerous and widely distributed, are mostly small and the proved important deposits are confined to two areas, one near Vananda on the east coast and the other almost directly south on the west coast. The island is easily accessible, and has been prospected pretty thoroughly from end to end. Hundreds of claims have been staked, mostly on the northern portion, and a large amount of work in the aggregate has been done on them. Of the claims staked, many have been abandoned. A considerable number are still held but are idle, and a few have reached the status of producing mines.

The character of the croppings has proved an uncertain guide in regard to the value of the deposits. The island has been subjected to nearly constant erosion since late Mesozoic time, and thousands of feet of massive and sedimentary rocks with their enclosed mineral contents have been worn away. The lenses of ore are irregular in shape and size, occur at varying depths, and the point at which they are intersected by the present surface is purely accidental. Small lenses cut through their widest part may make a better surface showing than large lenses, with only the tips exposed. Numerous disappointments and an occasional agreeable surprise have resulted from this cause. The Marble Bay mine is a notable example of the latter. Started on an indifferent showing, a lens of good ore was soon encountered and a succession of lenses have since been followed down to the present level of 1,170 feet.

Mineral discoveries are still being made, notwithstanding the continuous prospecting of the last two decades, and the possibilities of the island are still by no means exhausted.

CLASSIFICATION.

The mineral deposits of the island consist of replacement deposits of the contact metamorphic type and a few quartz veins. The former are the most important and may be subdivided into deposits worked principally for their copper contents and those worked for iron.

The groups are not sharply divided as the magnetite lenses invariably contain more or less chalcopyrite, and magnetite in some quantity occurs with the copper ores.

The iron and copper deposits usually occur in irregular lenses, bunches, and large masses, but in broken ground occasionally assume elongated vein-like forms evidently determined by fissures. At the Raven mine the ore, mostly magnetite and chalcopyrite, has formed along a well-defined line of fissuring.

The quartz veins contain the same metallic minerals as the irregular replacement deposits, but in much smaller quantities and in different proportions. The minerals common to both include pyrite, chalcopyrite, galena, magnetite, blende, molybdenite, and free gold.

COPPER DEPOSITS.

DISTRIBUTION AND GEOLOGICAL RELATIONSHIP.

All the proved important copper deposits occur at the northern end of the island, usually in limestones at or near contacts with the later dioritic intrusives. The long porphyrite-lime contact is occasionally lightly mineralized but seldom holds workable ore bodies.

The Marble Bay, Cornell, and Loyal Lease mines are all situated near small diorite porphyrite stocks, while the Copper Queen ore bodies follow a diorite porphyrite dyke. The Little Billy occurs near an acid quartz-diorite stock, and the small chalcopyrite lenses along the Iron range on the west coast, have all formed in limestone near contacts with quartz-diorite except at the Lake mine, where the bordering intrusive is a porphyrite.

A number of magnetite lenses, all holding some chalcopyrite, occur in the porphyrite along the east coast from Pocohontas mountain northward. The lenses in most instances partially replace small limestone inclusions in the porphyrite. In a few of the occurrences no limestone is present and the lenses appear to have formed in the porphyrite. The absence of lime may, however, be due to the complete replacement of small inclusions by magnetite and other secondary minerals.

South of Pocohontas mountain the island is only lightly mineralized, and no bodies of workable ore have so far been discovered. Porphyrite is the principal rock, and diorite stocks occur only at a few points along the east coast.

The Davis Bay limestone area on the west coast is bordered along its contact with the encircling porphyrites by occasional lenses of magnetite and sulphides, none of proved importance.

GENERAL CHARACTER.

The copper deposits in the principal mines consist of irregular-shaped bodies made up of bornite and chalcopyrite in grains, small aggregates, and narrow bands usually enclosed in a gangue of garnet, epidote, and diopside, occasionally of calcite and tremolite. In a few lenses chalcopyrite is the only copper mineral present.

The ore bodies vary in size from small bunches up to masses some hundreds of feet in length. The largest bodies of pay ore so far found occur in the Marble Bay mine, where a continuous wide lens often 100 feet or more in length was followed from the 260-foot level downwards for a distance of over 500 feet. Other lenses succeeded this down to the present level of 1,173 feet. The Copper Queen ore body, mined out before the present investigation was undertaken, is reported to have been followed almost continuously for a distance of over 700 feet. The ore bodies at the Cornell and Little Billy proved less persistent.

In the principal copper mines the iron sulphides and oxides occur only in small quantities and the copper sulphides, bornite and chalcopyrite, intimately commingled, form the bulk of the metallic minerals present. Molybdenite occurs in small quantities in the Marble Bay mine, and galena at the Loyal Lease.

The ores in the Marble Bay, Cornell, and Copper Queen carry considerable gold values, the shipments from the former averaging about $10 per ton, and occasional shipments from the Cornell and Copper Queen are stated to have yielded over an ounce per ton. Free gold is reported from both these mines. Native silver in plates and heavy pellets occurs in the Marble Bay and other mines and is especially abundant in some of the lower levels far below the zone of surface circulation. It is usually associated with bornite and appears to be in large part at least of primary origin.

AGE AND ORIGIN.

The ore bodies in their irregular shape, sporadic distribution, constituent metallic and non-metallic minerals, and geological relationship, form typical examples of contact metamorphic deposits now generally admitted to be of magmatic origin, and directly due to heated gaseous or liquid emanations holding various metals in solution rising from a cooling intrusive. The Texada deposits date from the closing stages of the great period of vulcanism which produced the Coast Range batholiths. The intrusives of this period on the island consist of quartz diorite stocks and a later more basic series of diorite porphyrite stocks and dykes. Copper ores occur in connexion with both rocks, but the principal deposits followed the intrusion of the later series. The mineralizing solutions ascending from the still liquid lower portion of the intrusive stock follow closely as a rule the contact between the upper solidified portion and the bordering crystalline limestone. The solutions acted mainly on the limestones, and large irregular areas have been more or less completely replaced by various metallic and non-metallic minerals. The diorites, while less affected than the limestones, often exhibit considerable replacement along the contact and in limited areas have also been converted into ore.

It is noteworthy that the limestone in which most of the ore bodies formed is remarkably free from siliceous and aluminous impurities, and with the exception of lime the material for gangue as well as ore minerals must have been largely derived from the ascending magmatic solutions.

DESCRIPTIONS OF PRINCIPAL COPPER MINES AND PROSPECTS.

MARBLE BAY MINE.

The three principal copper mines on the island are the Marble Bay, Copper Queen, and Cornell. Of these the Marble Bay has yielded the largest tonnage of ore and is the only one producing at present (1912). It was located in 1898 on ground owned by Mr. Sturt, and subsequently sold to J. J. Palmer of Toronto, who opened it up and explored it down to the 4th level at a depth of 260 feet. The ore at this point apparently giving out, it was sold to the Tacoma Steel Company in 1902. Exploratory work by this company soon revealed the presence of a large ore body below the 260-foot level, which persisted down to a point 18 feet below the 9th level, 778 feet below the surface. Other lenses were found below this, and a considerable body of good ore is exposed on the present or 13th level, 1,160 feet below the surface.

The writer was afforded every facility for the examination of the mine by the management, and his thanks for many courtesies and much information are due to Mr. A. Grant and Mr. Treloar, superintendent and mine foreman respectively, at the time the work was done, and to Mr. Eastman, formerly secretary and mine manager, now superintendent.

Situation.

The mine is conveniently situated close to the east coast, a short distance west of Sturt bay, at an elevation of 55 feet above sea-level. A tram line about 2,000 feet in length connects the mine with the ore bunkers on Sturt bay, the shipping point.

Development.

The mine is worked from a vertical shaft down to the 10th level at a depth of 860 feet. In the upper levels ore occurs on both sides of the shaft, and drifts have been run in northwesterly and southeasterly directions from it. The ore bodies pitch to

PLATE VII.

Marble Bay mine, Texada island, B.C.

the northwest at an angle sufficient to carry them all across the shaft at the 7th level and the workings below that are all northwest of the shaft.

The main shaft terminates at the 10th level, and the 11th and 12th levels are worked from a vertical winze situated 180 feet northwesterly along a drift from the foot of the shaft. The extension of this winze to the 13th level is now in progress (1912).

Geology.

The rocks exposed in the vicinity of the mine consist of limestones intruded by diorite porphyrite stocks and dykes.

The limestones, ordinarily fine-grained and dark in colour, have been altered into moderately coarse white or banded marbles. They are brecciated in places and crossed by a number of fracture planes trending in different directions, but are otherwise quite massive, the original bedding planes having been obliterated during recrystallization.

The fracture planes in most cases originated after the crystallization of the limestones. The walls are often slickensided and faulting on a small scale occurs at a couple of points.

The most persistent fissure exposed in the workings is known as the Mud-slip. It is situated a few feet east of the shaft except between the 7th and 8th levels, where it zigzags across it and is traceable from the surface down to the 10th level and probably extends considerably farther. No ore occurs in connexion with it, and the occasional spaces between the walls, seldom more than 2 inches in width, are usually filled with a plastic clay. Considerable surface water descends into the mine through this fissure, and in the rainy season several large pumps are needed to counteract the flow.

Immediately west of the Marble Bay mine are three small basic stocks lying closely together but separated from each other on the surface by narrow bands of limestone. The rocks in the stocks are classed as diorite porphyrites, but are closely related to the gabbros. They consist essentially of a plagioclase feldspar and augite, with some hornblende and considerable ilmenite. They are badly altered, the augite usually showing more or less uralitization, and in extreme cases it is represented by chlorite and epidote.

The limestones bordering the basic stocks are replaced in places by garnet, epidote, and diopside, usually holding scattered grains of chalcopyrite and bornite. A replaced area formed near the easterly tip of the most southerly of the three stocks constituted the croppings of the mine. The easterly side of this stock is very steep, as it is not touched in the workings, although the main shaft is sunk close to the surface outcrops.

A small mass of diorite porphyrite, probably an independent stock terminating in depth, but possibly a spur from one of those reaching the surface, was encountered between the 11th and 12th levels. On the 13th or lowest level the stock has a width of 30 feet, and is exposed on the workings for a length of 60 feet. A large body of high grade ore formed directly above this diorite porphyrite mass, and in places between the 11th and 12th levels, rested directly on it.

Diorite porphyrite dykes are numerous in the lower levels of the Marble Bay mine. The upper three levels are free from them, the first one encountered occurring on the 4th level. In the 6th, 7th, and 8th levels a dyke about 4 feet in width known as the main dyke cuts the ore body. It is highly altered as a rule and occasionally is almost completely replaced by ore and gangue minerals. In the 9th, 10th, and 11th levels the workings are crossed by numerous dykes from a few inches to over 6 feet in thickness, trending in various directions. They probably represent apophyses from the buried stock, terminating above the 12th level.

Mineralogy.

Metallic Minerals.

Gold. The Marble Bay ores carry average gold values of about $10 per ton, and some shipments have yielded over $15 per ton. The gold occurs mostly in connexion with the copper sulphides. Visible free gold is reported, but is rare.

Silver. Native silver is found throughout the mine, but was especially abundant in the rich ore body on the 11th level at a depth of over 900 feet below sea-level, and consequently far below the zone of present and probably any past surface circulation. It occurs in thin scales, and small rounded nuggets usually associated with bornite. It is considered to be in large part at least of primary origin. The silver tenor of the ores usually ranges from 3·50 ounces to 6 ounces per ton.

Magnetite. Magnetite, usually abundant in contact metamorphic deposits, is not common in the Marble Bay mine, and nowhere forms large masses.

Pyrite. Pyrite occurs only in small quantities, usually as scattered grains in the altered intrusives. A small mass in limestone is exposed in the workings on the 11th level.

Pyrrhotite. A small quantity of pyrrhotite occurs near a dyke on the 7th level. It was not recognized in the other levels.

Chalcopyrite. This is the more abundant metallic mineral in the mine, although in places the quantity of bornite present is probably greater. It occurs in grains and small aggregates, intimately associated with bornite scattered through a garnet-diopside, occasionally a calcite gangue. In places the bornite and chalcopyrite have a banded arrangement.

Bornite. Bornite occurs in quantity on all the levels, but is relatively more important in the lower than in the upper levels. No evidence of its derivation from chalcopyrite was obtained, and there is little doubt that it is a primary mineral deposited practically simultaneously with the chalcopyrite.

Tetrahedrite. Grey copper, probably tetrahedrite, is reported to have been found between the 8th and 9th levels.

Molybdenite. Small molybdenite bunches occur on all the levels. It is reported to have been somewhat abundant between the 3rd and 4th levels. Small quantities have been saved and shipped.

Gangue Minerals.

Garnet. The lime garnet andradite is exceedingly common, both as a gangue mineral in the ore bodies and in the bordering limestones. It occurs occasionally in crystals, but usually forms masses often entirely replacing the limestone.

Pyroxene. Diopside is abundant as a gangue mineral in all the levels, and as a rule is more closely associated with the ore minerals than the garnet. It forms large green masses in the limestones, usually holding some brown garnet and aggregates of ore minerals. The diopside is subject to exceedingly rapid decomposition on exposure.

Tremolite. Tremolite was practically absent from the ore bodies in the upper levels, but is common in the lower levels. It occurs in radiating groups of well-formed bladed crystals, often holding bornite in the interstices, and was evidently one of the first minerals to crystallize out.

Epidote. Considerable epidote occurs in places associated with the garnet and diopside.

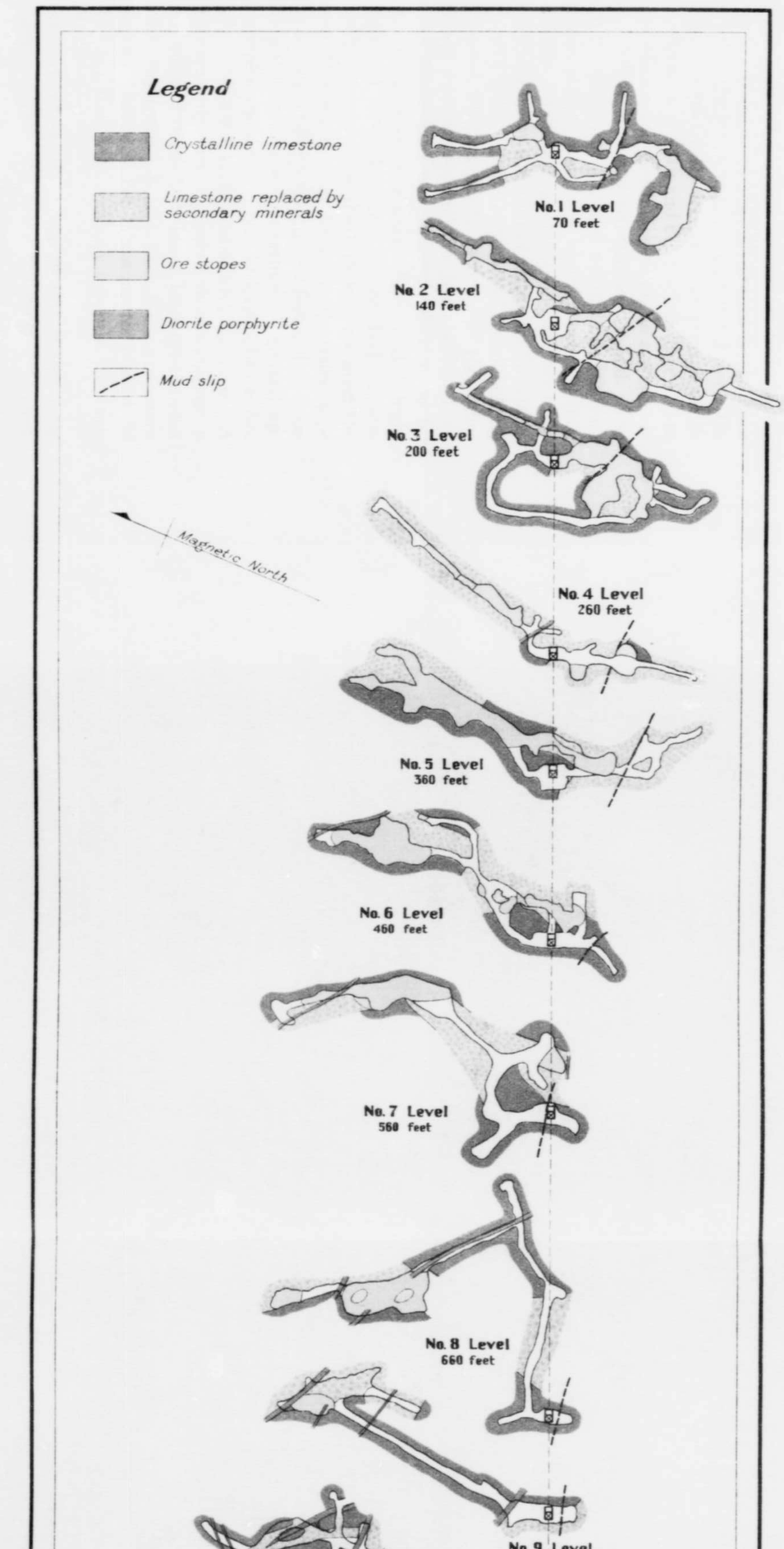
Quartz. The limestones show partial silicification in places, but no quartz veins or stringers were observed.

Calcite. Coarse calcite is a common gangue mineral in the ore bodies, and associated with garnet and diopside is also common in the bordering barren areas.

Ore Bodies.

While copper minerals in some quantity are distributed all through the altered and replaced limestone areas at the Marble Bay mine, they only occur in portions of them in commercial quantities. Ordinarily one side of the replaced areas is rich in copper minerals, ending somewhat abruptly against massive crystalline limestone, and the other is comparatively lean, the pay minerals fading away gradually in a garnet-diopside gangue. Occasionally the replaced areas are ore-bearing throughout and the stopes are bordered on both sides by limestone walls. The paying portions or ore bodies are not dependent on fissures and are extremely irregular, pinching, widening, and branching with little warning. Often the same replaced area on one level contains several pay shoots of different sizes separated by barren stretches of gangue minerals and the whole mass requires exploration.

The ore bodies in the upper four levels are scattered erratically through a large area of secondary minerals replacing the



Geological Survey, Canada

1346

Plans of Levels, Marble Bay Mine, Texada Island, B.C.

(From surveys by management)

To accompany memoir by R. G. McConnell, 1912

limestone and are smaller and more irregular than those encountered below. Their shapes and sizes are shown in the accompanying plan. The 280-foot or 4th level proved comparatively barren, but immediately below it, at a depth of 16 feet, the workings exposed a large ore body, the largest copper ore body so far found on the island. It persisted through several levels down to a point 18 feet below the 9th, a total distance of 502 feet. On the 5th level it has a length of 220 feet, with an average width of about 15 feet. Between the 5th and 6th levels it divided into two branches, the smaller one continuing down as a workable ore body to the 7th level and a short distance beyond. The main branch from the 6th to the 8th level varied in length from 80 to 120 feet, and in places attained a width of over 40 feet. Below the 8th level it diminished gradually in size, and terminated a short distance below the 9th in nearly pure limestone.

The 10th level, with the exception of a narrow streak holding some scattered mineral, was practically barren, and the future of the mine when the workings reached this depth was far from promising. Further exploration was, however, decided on by the management, and a winze was sunk which reached high-grade ore at a depth of about 40 feet. The ore body rapidly lengthened out with depth, and on the 11th level assumed the shape of a flattened V, the two arms known as the main stope and the extension having a total length of 190 feet and an average width of about 15 feet. It was subsequently followed upwards several floors past the drift on No. 10 level. Below No. 11 level it rapidly contracted and became very irregular. A spur from the southeasterly arm continued downwards for a distance of 50 feet, where it opened out into a large ore chamber floored with diorite porphyrite. A spur from the northeastern arm wound downwards through the limestone to a point 50 feet below No. 12 level, then bent suddenly upwards, terminating on the 12th level.

No ore was encountered on the lower 50 feet of the winze connecting the 12th and 13th levels, but the working 120 feet northwest from the foot of the winze exposes and follows a small ore-shoot for a distance of 50 feet. The central portion of this shoot measures about 8 by 12 feet, and is bordered on all sides by limestone.

The workings in the Marble Bay mine show that the line of ore bodies followed pitches steeply but steadily to the northwest at an angle of approximately 17 degrees, and that while the ore bodies occur in an interrupted manner, the garnet-diopside-tremolite mass which accompanies and often encloses them is practically continuous from the surface down to the top of the small diorite-porphyrite stock encountered above the 12th level, and extends down the northwestern side of this as far as exploration has gone.

The effect of the appearance in depth of this stock on the future of the mine is difficult to predict. It is now in the low levels in the same position geologically as the Cornell in the upper levels where the ore bodies rest against the sides of an intrusive stock which reaches the surface. It is probable that the line of ore bodies followed above will continue down the sides of the stock for some distance at least, but the difficulty and expense in finding and following them will doubtless be considerably increased.

Ore.

The Marble Bay ores consist of intimately associated bornite and chalcopyrite, often in nearly equal quantities, enclosed in a gangue of secondary minerals mostly garnet, diopside, tremolite, and calcite. The iron sulphides and oxides are present only in small amounts. The ores hold good values in the precious metals, especially in gold. Native silver is common, and the amount present has increased with depth down to the 11th level at least.

The relative importance of the two copper sulphides has also changed to some extent with depth, the proportion of bornite, contrary to what would naturally be expected, having materially increased. There is little doubt that the bornite is a primary mineral deposited with and at the same time as the chalcopyrite. In the 13th or lowest level, at a depth of 1,127 feet below sea-level, small stringers of nearly pure bornite, and nearby others of unchanged chalcopyrite, occur, penetrating the limestone walls bordering the ore body.

The distribution of the copper minerals through the gangue is very irregular, good ore often enclosing areas of low grade and even waste material, all of which must necessarily be mined. The ores are hand sorted before shipment and divided into two grades known as the "coarse" and "fine." The annual shipments usually range from 12,000 to 15,000 tons.

The following smelter returns of shipments, obtained from the management, show the grade of the ore at various levels:—

Stope between 460 feet and 560 feet. Shipped 1904.

	Tons.	*Gold.*	*Silver.*	*Copper.*
Coarse...........	110	0·39 oz.	4·15 oz.	7·38%
Fines............	257	0·169	2·06	3·64

Stope between 460 feet and 560 feet. Shipped 1905.

	Tons.	*Gold.*	*Silver.*	*Copper.*
Coarse...........	127	0·706 oz.	3·69 oz.	7·69%
Fines............	152	0·265	2·60	4·44

Stope between 560 feet and 660 feet. Shipped 1906.

	Tons.	*Gold.*	*Silver.*	*Copper.*
Coarse...........	137	0·66 oz.	4·62 oz.	9·27%
Fines............	145	0·125	1·17	2·67
Waste............	116	0·02	0·18	0·30

Stope 960 feet. Shipped 1909.

	Tons.	*Gold.*	*Silver.*	*Copper.*
Coarse...........	59	0·517 oz.	05·81 oz.	11·27%
Fines............	166	0·107	01·25	4·07

These returns appear to indicate that while the gold values in the ores have fluctuated, the tenor in both copper and silver has increased with depth.

Equipment.

Steam power is used and the mine is well equipped with the machinery necessary for working it in an economical manner. This includes a powerful Lidgerwood hoist operating at the main shaft and two smaller ones at the winze in the lower levels; two compressors, one of ten and one of five-drill capacity, four pumps with a total capacity of about 40,000 gallons per ton, and an electric lighting plant. Water is obtained by gravity from Priest lake.

The stopes in the Marble Bay mine are practically dry and very little water enters the workings except through the Mud-slip, previously described as following and roughly paralleling the shaft. Most of this water is caught at No. 5 and No. 7 levels, and pumped back to the surface, and the small quantity which escapes is pumped up from No. 10 to No. 7 and thence to the surface. During the wet season a large volume of water descends the Mud-slip and the pumps are taxed to their full capacity to throw it back. In the dry season the amount diminishes to less than 10,000 gallons per day.

CORNELL MINE.

History.

The Cornell[1] croppings were staked by James Raper about 1898, on land owned by the VanAnda Copper and Gold Company. It was opened up by the VanAnda Company and worked by them until 1901. A shaft was sunk to a depth of 260 feet, drifts run out at the 80-foot and 160-foot levels, and most of the ore above the latter level taken out. In 1901–2 it was operated under lease by the Northwest Company, an American syndicate, and from 1902 to 1905 was under bond to an English company. The latter company, under the management of Mr. T. R. Vaughan-Rhys, continued the shaft down to the 560-foot level, and did a large amount of exploratory drifting on the 160, 260, and 360-

[1] The writer is indebted to Mr. James Raper of Vananda for details in regard to the history of the Cornell and Copper Queen mines.

foot levels. They also took out the ore on what is known as 4 B Stope on the 260-foot level. In 1906 the mine was leased for a short time by an American company, and from 1908 to 1910 was worked under lease by Dr. Tanzer of Seattle. A short extension of the 360-foot level by him resulted in the discovery of a large body of rich ore. In 1912, a local syndicate unwatered the mine and did some exploratory work.

Situation.

The Cornell is situated near the head of Emily lake, about 1¼ miles southeast from Vananda bay on the east coast, at an elevation of 239 feet above sea-level. The shipping point is on Vananda bay, and is connected with the mine by a tram line built on an easy grade down the outlet of Emily lake.

Workings.

The principal workings consist of a shaft 560 feet deep with long exploratory branching drifts to the east following closely the lime-diorite-porphyrite contact at the 80-foot, 160-foot, 260-foot, 360-foot, and 460-foot levels. Over 2,000 feet of drifting has been done on the 360-foot level. The 80-foot level is connected with the surface by a tunnel, mostly through diorite-porphyrite.

Geology.

The rocks in the vicinity of the mine consist of light-coloured crystalline limestone cut by a small stock of diorite porphyrite and by diorite porphyrite dykes. The limestone is massive, seldom showing more than traces of the original bedding. It is fissured in various directions and in places brecciated. Near the intrusive area it is replaced in places by garnet and diopside, associated with chalcopyrite, bornite, and other secondary minerals.

The dioritic stock cutting the limestones is small, having a length of 1,300 feet to Emily lake, and a maximum width of 460 feet. The surface boundaries are fairly regular except at the southeast end where the stock terminates in two points. In depth, the southern contact with the limestone, as shown in the workings, is somewhat ragged. It is very basic consisting mostly of augite and a basic plagioclase feldspar. No orthoclase nor quartz were detected in the sections examined. Some hornblende is present, mostly uralitic in character, also varying amounts of biotite and dark iron ore. The texture is uneven, the rock varying in this respect from an even, moderately fine-grained condition to a coarsely porphyritic one, with augite as the principal phenocryst.

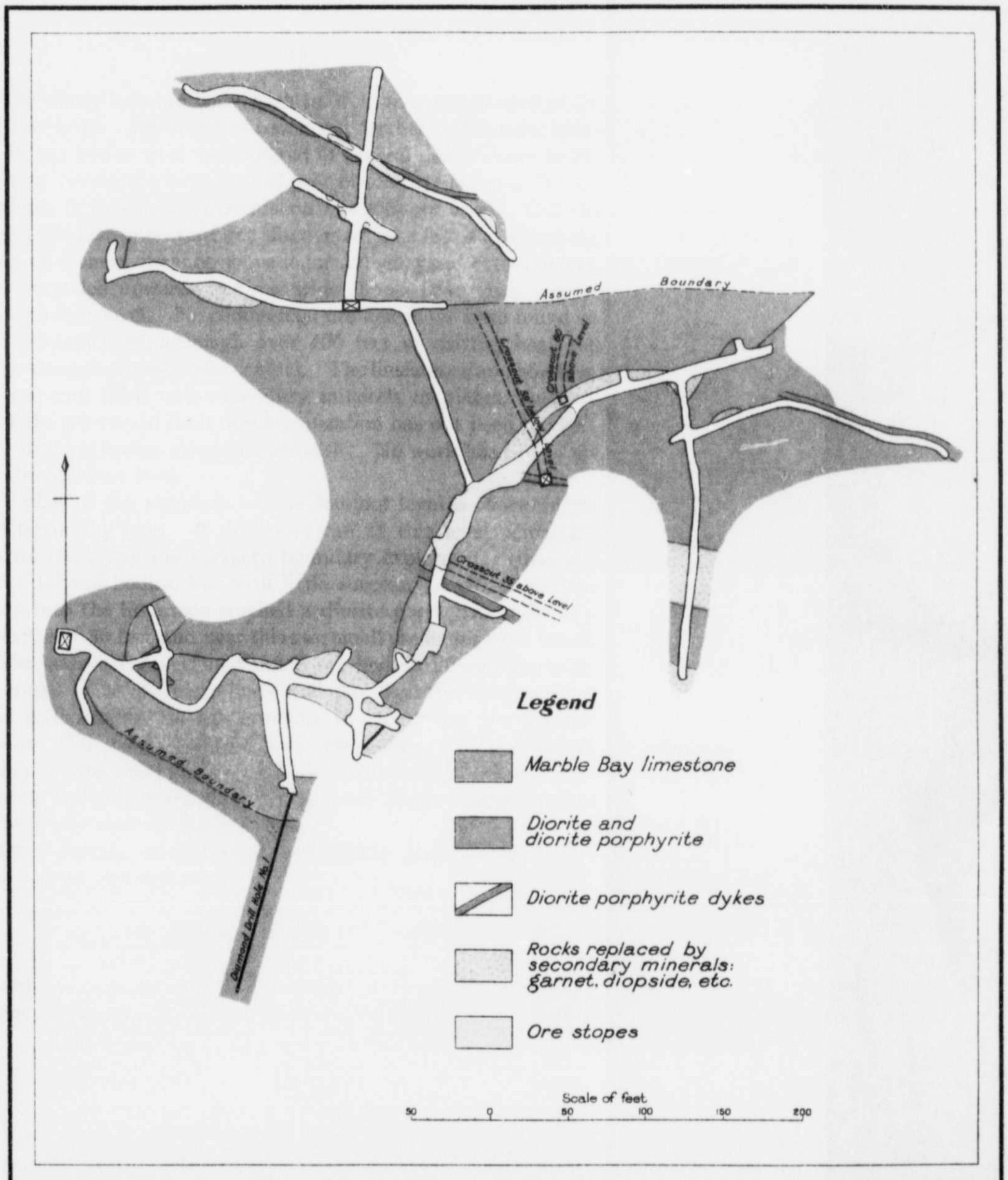
Mineralogy.

The ore and gangue minerals in the Cornell are very similar to those at the Marble Bay mine. Chalcopyrite and bornite intimately commingled are the principal metallic constituents of the ores. Pyrite and magnetite occur in small quantities and some molybdenite, tetrahedrite, and native silver are also present. The gangue minerals are mainly diopside, garnet, calcite, and epidote. The diorite bordering the replaced limestone areas is usually altered and in places passes into serpentine.

Ore Bodies and Ores.

The ore bodies in the Cornell occur along a diorite-lime contact, mostly in the lime but occasionally replacing the diorite. They are smaller and even more irregular and systemless in their distribution than in the Marble Bay mine.

Two ore bodies outcropped on the surface, one at the shaft and the other 480 feet eastward along the contact known as the Glory hole ore body, and both are continued downwards by interrupted lines of lenses. The shaft ore body pitching slightly to the east was followed down to the 160-foot level. A stringer from it led to the Coney ore body, an important mass of high grade ore about 30 feet across extending from the 160-foot to the 260-foot level. East of it between the same levels is the smaller 4 B stope. No. 8 ore body occurred a short distance east of the shaft on the 260-foot level, and was followed down to a point 25 feet above the 360-foot level.



Geological Survey, Canada 1348

Plan of 360-foot Level, Cornell Mine, Texada Island, B.C.

(From surveys by Management)

To accompany memoir by R. G. McConnell.

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The Glory hole ore body, with its rich ores, terminated at the 80-foot level. Below it but somewhat farther to the east, lower grade ore bodies were encountered at several points down to the 260-foot level and a large body of good ore occurred almost directly beneath it looking northwards on the 360-foot level. This ore body, the last important one discovered, was followed along the level or a short distance above it for a distance of over 150 feet, and extended upwards in three wide shoots about half way to the 260-foot level. No commercial ore has so far been found on the 460-foot level, although over 400 feet of drifting has been done along the lime-diorite contact. The limestones are, however, altered and filled with secondary minerals in places, evidence that the downward limit of mineralization has not been reached, and that ore bodies may exist beneath. No work has been done on the 560-foot level.

A plan of the workings on the 360-foot level is shown in the accompanying plan. A drift was run at this level across the diorite stock and the northern boundary explored for some distance for ore bodies, but with little success. A drift from the stock into the limestone reached a diorite porphyrite dyke at a distance of 80 feet and near this two small ore lenses were found.

The ores in the various Cornell ore bodies differed markedly in grade. The shaft ore body and No. 8 on the 260-foot level held little bornite and ran low both in copper and the precious metals. The Glory hole ore body, the Coney, 4 B, and the ore bodies on the 360-foot level held bornite as the principal copper mineral and shipments often yielded over 10 per cent copper and occasionally over an ounce in gold.

The following smelter returns show the grade of the ore in No. 1 stope 360-foot level.

	Tons.	*Gold.*	*Silver.*	*Copper.*
Coarse...........	110	0·72 oz.	3·82 oz.	9·35%
Fines............	112	0·36	1·92	4·66

COPPER QUEEN.

History.

The Copper Queen, one of the three large copper producers of the island, was first opened up by E. Blewell in 1895. It was subsequently acquired by the VanAnda Copper and Gold Company and mined by them down to the 500-foot level. Work by this company ceased in 1901. From 1902 to 1905, the mine was operated under bond by an English company, a winze was sunk 180 feet below the 500-foot level, and a large tonnage of high grade ore taken out. In 1906 it was leased to the Trimetallic Company of New York. The winze was extended by them 60 feet along the ore shoot and a corresponding amount of ore scooped out. In 1907, it was leased to Mr. E. M. Cox, who extended the shaft from the 500-foot to the 600-foot level and did some drifting. In 1908, it was leased to Dr. Sawyer, and some exploratory work on the 500-foot level was done by him.

Situation.

The Copper Queen is situated about three-quarters of a mile southeast from Vananda bay on a low wide ridge separating the Emily Lake drainage valley from the coast. Its elevation at the shaft is 275 feet above sea-level. It is connected by a short tram line and ore chute with the tram line leading from the Cornell to Vananda bay, the shipping point for both mines.

Workings.

The Copper Queen workings consist of a single compartment shaft sunk to a depth of 600 feet with drifts run at various levels down to 500 feet. From the 500-foot level a winze situated 150 feet west from the shaft has been sunk on the ore body to a farther depth of 240 feet.

Rocks.

The rocks in the vicinity of the mine consist of greyish and light-coloured crystalline limestones cut by a few diorite porphyrite dykes and by an occasional quartz diorite dyke. No intrusives outcrop as stocks in the immediate neighbourhood, or within a distance of 2,000 feet from the cropping. It is possible, however, that the mineralizing solutions may have originated from a buried stock similar to the one reached in the lower workings of the Marble Bay mine.

Mineralogy.

The ore and gangue minerals at the Copper Queen are very similar to those at the Marble Bay and Cornell mines. Bornite and chalcopyrite are the principal copper minerals, and garnet, diopside, and calcite, with some epidote, are the prevalent gangue minerals. Less common minerals included tetrahedrite, molybdenite, native silver, and visible free gold.

Ore and Ore Bodies.

The Copper Queen croppings consisted of a limestone area about 50 feet across, mostly replaced by garnet and diopside, but showing in one place copper sulphides partially altered to carbonates. The sulphide shoot enlarged in depth and was followed nearly vertically to the 300-foot level, below which it gave out. It varied in size but seldom exceeded 40 feet in length. A break in the continuity of the ore of about 50 feet occurred between the 300-foot and 400-foot levels. A second ore shoot situated somewhat farther to the west was picked up 20 feet above the 400-foot level and this persisted to the bottom of the workings, a total distance of 360 feet. Between the 400-foot and 500-foot levels it measured for some distance 40 feet in length by 30 feet in width. Lower down it lengthened out to 100 feet in places, but became much narrower. The bottom of the stope is reported to be still in ore. Dykes occur in connexion with both ore bodies, and the lower one rests throughout on a large diorite porphyrite dyke dipping steeply to the south. The dyke is altered near the ore body and partially replaced by secondary minerals, including the copper sulphides. Some fissuring occurs between it and the enclosing crystalline limestones, both rocks being fractured parallel to the course of the dyke.

The Copper Queen ores like those of the Cornell and Marble Bay mines, are made up of bornite and chalcopyrite in a gangue of garnet, diopside, and calcite. The gold tenor is reported to have been higher than in the other mines, some shipments averaging over $25 per ton. The range in copper values is given at from 6 per cent to 12 per cent, and in silver from 4 to 6 ounces.

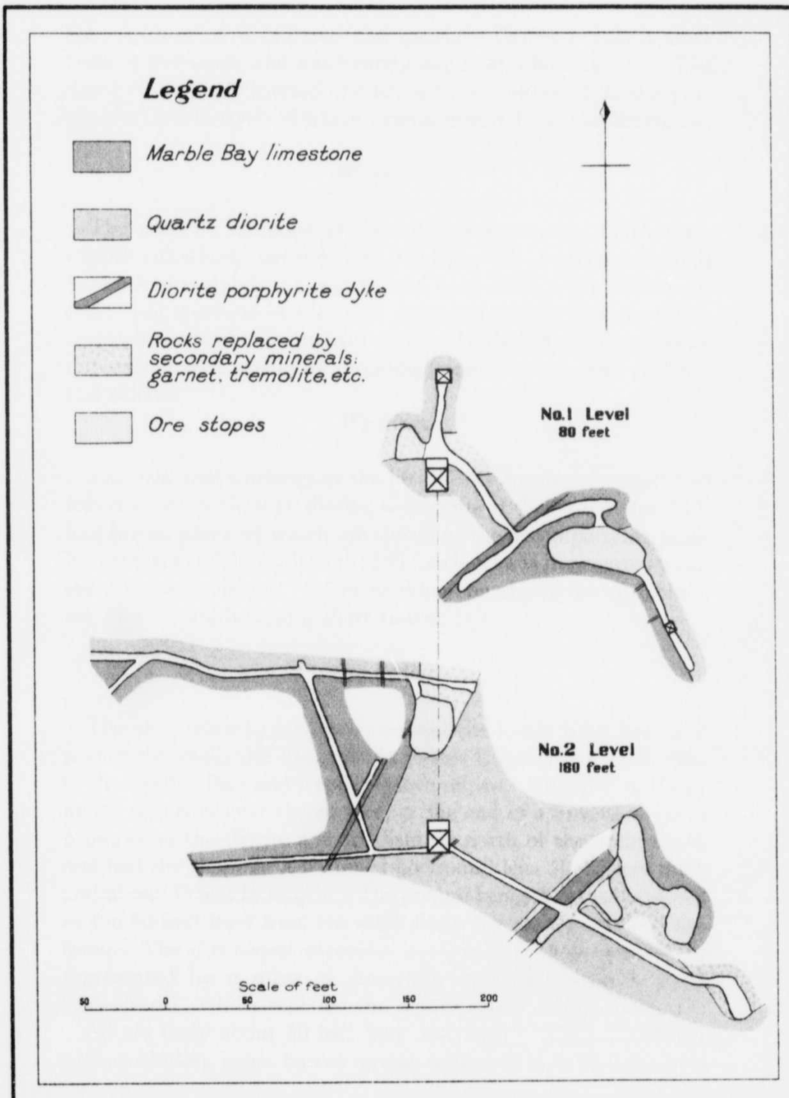
The Copper Queen mine has suffered from lease holders even more than the Cornell. Development worked stopped at the 500-foot level. Below this the ore body was followed down by a winze situated 155 feet west from the shaft, and the ore scooped out as far down as it could be mined at a profit. A considerable body of good ore is reported to exist at the bottom of the present workings 740 feet below the surface, but a new shaft will probably be required to reach it.

LITTLE BILLY.

The Little Billy croppings were discovered in 1880, and work has been carried on at intervals ever since. The property belongs to the VanAnda Copper and Gold Company, but is worked at present (1912) under lease. It is situated close to the east coast, about one-half mile southeast of Vananda bay.

Geology.

The rocks near the mine consist of the crystalline limestones of the Marble Bay formation, traversed by diorite porphyrite dykes and cut by a rather coarse-grained, light-coloured quartz diorite. The latter outcrops in a narrow irregular strip along the coast, and may possibly be a spur extending across the Strait of Malaspina from the Coast Range batholith of the mainland. It is of an acid type and is made up mostly of plagioclase feld-



Geological Survey, Canada

1347

Plans of Levels, Little Billy Mine, Texada Island, B.C.

(From surveys by Management)

To accompany memoir by R.G. McConnell.

spar, with some orthoclase, and quartz. Biotite occurs in portions of the mass, and more rarely augite and hornblende. The diorite is strongly jointed and is cut by a number of diorite porphyrite dykes, some of which extend into it from the limestone.

Mineralogy.

The metallic minerals at the Little Billy consist of the two copper sulphides, bornite and chalcopyrite, occasional small bunches of molybdenite, pyrite, and magnetite. The latter mineral is not common in the three mines previously described, but occurs in considerable quantities in the Little Billy The gangue minerals include andradite, diopside, tremolite, actinolite, epidote, and calcite.

Workings.

The principal workings at the Little Billy consist of a shaft 180 feet deep sunk through diorite, with drifts at the 80-foot and 180-foot levels, plans of which are shown in the accompanying plan. An extension of the shaft to the 280-foot level was in progress when the mine was visited. Other workings on the property include two shallow shafts and a short tunnel.

Ore Bodies.

The ore bodies so far discovered on the Little Billy are comparatively small, and the grade in copper is somewhat lower than in the Marble Bay and Copper Queen mines. The first ore body mined occurred near the surface, at the end of a limestone point penetrating the diorite a short distance north of the main shaft, and had the shape of a flattened horizontal lens 10–15 feet thick and about 35 feet in length. The ground beneath it was explored at the 80-foot level from the main shaft, but no ore was encountered. The downward extension on this level may possibly be represented by a mass of secondary minerals including some chalcopyrite, which replaces the diorite north of the shaft.

An ore body about 50 feet long and from 15 feet to 20 feet wide, including some barren areas, occurs on the 80-foot level near the lime-diorite contact about 100 feet east of the shaft. It has been stoped upwards for 35 feet but has not been sunk on.

In the 180-foot level a drift to the southeast through light greyish quartz diorite reached at a distance of about 65 feet a large dark-coloured diorite porphyrite dyke dipping at a high angle to the southeast and bordered on both sides by a band of contact metamorphic minerals. A drift along the dyke exposed in a short distance a small magnetite mass holding some copper sulphides, and farther on an important ore body about 75 feet in length was reached. This has been followed upwards for a distance of 30 feet and will be undercut by a drift from the shaft at the 280-foot level. The ore in the southeastern portion of the ore body is of good grade and consists mostly of bornite in a tremolite gangue. In the northeastern portions chalcopyrite is the principal copper mineral, and garnet and diopside the predominant gangue minerals.

A second rounded ore body about 30 feet across occurs in the 180-foot level, 50 feet north of the shaft. It consisted mostly of bornite and tremolite below, but passed upwards into magnetite sprinkled with chalcopyrite. A drift from this ore body westward for a distance of 200 feet along the lime-diorite contact exposed a continuous band of secondary copper and gangue minerals from 1 to 5 feet in width rich enough in places to constitute ore.

The Little Billy ores usually carry from 4 per cent to 8 per cent in copper, but the precious metal tenor is much lower than in the other mines, seldom exceeding $3. As a rule, copper ore bodies on the island lying against quartz diorite stocks carry less gold and silver than those bordering the more basic diorite porphyrite stocks.

Equipment.

The equipment at the mine includes a 60 horse-power boiler, a Canadian Rand 3 drill compressor, a 25 horse-power hoist, and an electric lighting plant. There is in addition a good machine shop and a small sawmill.

LOYAL MINE.

The Loyal mine is included in the large group of claims on the island held by the VanAnda Copper and Gold Company. It has been worked in a desultory manner for a number of years, mostly by lease holders.

It is situated at the northern end of the island near the east coast, and is connected with the coast by a short tram line. A wagon road about a mile in length has also been built to Blubber bay.

The belt of limestone in which the Marble Bay, Cornell, and Copper Queen mines occur extends northward along the east coast to the head of the island, and forms the country at the Loyal Lease. The croppings occur in the limestones near diorite porphyrite dykes. Small stocks of diorite outcrop on the coast at a distance of about 400 yards. The limestone bordering these has been altered into a coarsely crystalline condition, but this has not been accompanied as usual by the development of any large mass of secondary minerals, on the surface at least.

The Loyal croppings are traceable at intervals for a distance of 300 yards, and consist of irregular areas of limestone and occasionally dyke rock replaced by secondary minerals, largely garnet and epidote with some copper sulphides, galena, pyrite, and magnetite. The copper minerals are occasionally concentrated into lenses of good ore, but no large persistent ore body has so far been found.

The workings consist of a shaft at the northeast end of the croppings reported to be 300 feet in depth and several shallow shafts, all sunk on small ore bodies. The geological conditions are very similar to those at the Vananda mines, and further exploration for payable ore bodies seems warranted. A drift along the line of lenses and altered limestones and dyke rocks at a depth of 100 feet or more, would afford a good test.

Small shipments of rich copper ore have been made from the Loyal, but none in recent years. The ore consists of bornite and chalcopyrite, with some galena, iron pyrite, and magnetite in a garnet-epidote or calcite gangue. The bornite and chalcopyrite and bornite and magnetite occur at times in thin, short, alternating bands. The silver tenor is high, reaching 20 ounces to the ton. This is probably due to the presence of galena, a mineral not found in the principal producing mines.

PARIS GROUP.

The Paris group of claims are situated a short distance south of Blubber bay, at the north end of the island. No work has been done on them for some years. The rocks on the claims consist of the Marble Bay limestones intruded by two small diorite stocks and numerous diorite-porphyrite dykes. The stocks are highly altered and blotched everywhere with green epidote areas. The most southerly one is cut by a strong, comparatively fresh quartz porphyry dyke.

The workings consist of 3 shafts from 50 to 60 feet in depth, the most southerly of which is connected with the surface by a tunnel 250 feet in length.

The shafts have been sunk on moderate-sized, magnetite lenses formed along the diorite-lime contacts. The magnetite contains some irregularly distributed chalcopyrite, and also pyrite, pyrrhotite, and occasional grains of zinc blende. The principal non-metallic impurities are garnet, epidote, and actinolite. At the central shaft about 200 tons of magnetite carrying considerable chalcopyrite have been mined. No shipments have been made.

CANADA GROUP.

The Canada Group of claims, situated about a mile south of the Loyal mine, are owned by the Tacoma Steel Company. The croppings consist of the usual assemblage of contact metamorphic metallic and non-metallic minerals developed along a line of diorite porphyrite dykes intruding the Marble Bay limestones. Considerable stripping was done during the summer of 1912 along the line of dykes. The bordering limestones and in places the dyke rocks proved to be altered and mineralized at intervals, but no discoveries of commercial ore bodies were made.

VOLUNTEER.

The Volunteer is situated about one-half mile west of the Marble Bay mine near the southeastern end of a long diorite-porphyrite stock, the longest on the island. The croppings consist of three magnetite lenses from 30 to 50 feet in length and 10 to 15 feet in width, which have formed along the contact of the intrusive with limestone. The central lens rests below on limestone. It has been partially mined out and shipped as a flux. Some chalcopyrite is present, but the percentage is small.

RED CLOUD.

The Red Cloud mine, formerly the Raven, is situated about one-quarter mile west of Spratt bay and 3 miles southeastward along the coast from Vananda. The croppings occur in the Texada porphyrite near a quartz diorite stock which outcrops in a narrow band around the bay. They consist mainly of magnetite containing some iron and copper pyrites and are distributed irregularly along a fissured zone from 1 to 8 feet in width, traceable along the surface for a distance of about 150 feet.

The workings on the Red Cloud include a shaft said to be 175 feet in depth and two drifts at levels of 25 feet and 75 feet below the collar of the shaft. The lower drift extends from the sloping surface near Raven creek into the hillside for a distance of 254 feet, but does not reach the shaft. No ore is exposed along it. The upper drift extends from the surface to the shaft, and continues past it, following the lead for a distance of 70 feet. Magnetite occurs along it and a considerable amount has been stoped out and shipped as a flux. A band of chalcopyrite ore from 1 to 15 inches in thickness rests at one point on the footwall of the lead. It is overlaid by magnetite.

The Red Cloud magnetite showing is a replacement deposit, but differs from the ordinary type on the island in having formed along a narrow fissure zone bounded by definite walls. Garnet and the usual contact metamorphic minerals occur with the ore although not in large quantities, and in addition some cobalt bloom is also present.

GOOD HOPE FRACTION.

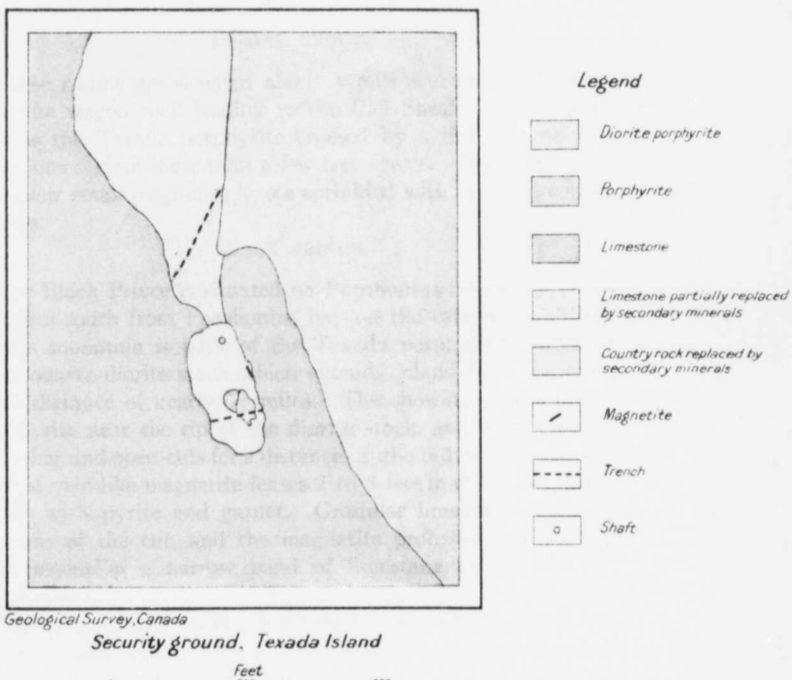
This claim, staked recently by H. Wolburn, is situated on the south side of Raven bay about 250 feet from the coast, and at an elevation of 115 feet above sea-level. The country rock is porphyrite cut by a few quartz diorite dykes. A magnetite lens 100 feet in length and from 5 to 15 feet in width has formed apparently in the porphyrite, but may replace a lime inclusion. The magnetite contains some pyrite and a small percentage of chalcopyrite, but is freer from impurities than most of the lenses in the vicinity.

SECURITY.

The Security ground is situated a short distance north of Emily lake, about midway between the Cornell and Copper Queen mines, at the top of a small diorite porphyrite stock which intrudes both the Marble Bay limestones and the Texada porphyrites. The limestones and diorite rocks are both intensely altered near their contact, and are replaced over a large area by contact metamorphic minerals, principally garnet, diopside, epidote, and magnetite. The exploratory work consists of three trenches across the mineralized area and two shafts. Several small lenses of magnetite sprinkled with iron and copper pyrites occur on the property, but no workable copper ore bodies have so far been found notwithstanding the favourable conditions. Chalcocite in small quantities, evidently secondary, occurred in the upper portions of one of the shafts. The surface showing on the Security looks promising enough to warrant further exploratory work.

CAP SHEAF.

The Cap Sheaf is situated 2 miles south from Spratt bay, and is connected with it by a rough wagon road about 3 miles in length. It is included in a group owned by the Duluth and Texada Mining Company. The Texada porphyrites holding occasional limestone inclusions and intruded in places by diorite porphyrites outcrop in the vicinity. The croppings consist of a



Geological Survey, Canada

Security ground, Texada Island

To accompany Memoir by R. G. McConnell

magnetite lens formed in one of the inclusions near its contact with the porphyrite. A shaft has been sunk to a depth of 90 feet and some drifting done. The mine has been idle for some years and the workings at present are filled with water. Dump specimens of the magnetite show some disseminated iron and copper pyrites. The grade in copper is not high.

DE OAR GROUP.

These claims are situated about a mile south of Spratt bay, near the wagon road leading to the Cap Sheaf. The country rock is the Texada porphyrite crossed by a line of limestone inclusions seldom more than a few feet across. Bordering these are a few small magnetite lenses sprinkled with iron and copper pyrites.

BLACK PRINCE.

The Black Prince is situated on Pocohontas mountain, about 1½ miles south from Pocohontas bay on the east coast. Pocohontas mountain is built of the Texada porphyrites, intruded by a quartz diorite stock which extends inland from the coast for a distance of nearly 1½ miles. The showing occurs in the porphyrite near the tip of the diorite stock, and is exposed by stripping and open-cuts for a distance of about 150 feet. It consists of vein-like magnetite lenses 2 to 3 feet in width, banded in places with pyrite and garnet. Granular limestone occurs in portions of the cut, and the magnetite probably represents a replacement of a narrow band of limestone enclosed in the porphyrite.

The magnetite at the Black Prince is low grade in copper, but contains some gold values, a small shipment made some years ago yielding about $13 per ton.

A number of magnetite lenses occur in different portions of Pocohontas mountain, but all those examined were small, had a low copper tenor, and contained numerous impurities.

ROSE AND BELLE CLAIMS.

These claims are situated near the centre of the island, about 300 yards east of the forks of the Gillies Bay and Iron Mine roads.

The country rock is an uneven textured crystalline limestone traversed by a few diorite porphyrite dykes. A garnetized area in the limestone constitutes the croppings. A shaft sunk on this reached a small body of ore resting on a dyke at a depth of 28 feet. The shaft has been extended down with the steeply dipping dyke as a footwall, to a depth of 150 feet, and some drifting done along the dyke. The limestone bordering the dyke is replaced at intervals by areas of garnet, diopside, and epidote, with some copper sulphides, and at the 130-foot level some bornite ore came in but did not persist. No commercial ore body has so far been found.

SENTINEL GROUP.

The Sentinel group, owned principally by R. Swan, is situated near the centre of the island, a short distance south of the Gillies Bay road, and north of Paxton lake. The croppings occur in the Marble Bay limestone a short distance from its contact with the Texada porphyrites.

The limestones here are dark greyish in colour and are fine-grained to saccharoidal in texture. The original bedding planes as usual have been obscured by recrystallization. The limestone is strongly fissured in a north and south direction, and in places shows brecciation. Narrow branching calcite veinlets and irregular blotches of calcite are numerous. Occasional diorite porphyrite dykes, some of large size, traverse the limestone.

The mineral deposits at the Sentinel differ from the ordinary types prevalent on the island. They consist of iron and copper pyrites, galena, tetrahedrite, and blende in grains, small aggregates, and veinlets scattered irregularly in small quantities through a wide band of the fissured and broken limestone. The ordinary contact metamorphic minerals with the exception of calcite and quartz are almost entirely absent.

The workings consist of a few shallow pits and cuts, all showing mineral, and a shaft sunk to a depth of 17 feet. The latter follows an oxidized zone from 10 to 15 inches in width holding considerable galena. The bordering limestones are also lightly impregnated with pyrite, chalcopyrite, and galena.

While the limited amount of work so far done on the Sentinel group has not exposed any large mass of commercial ore, further exploration is desirable. Only a few of the numerous known mineral occurrences have been tested, and these only superficially. The presence of the rich silver-bearing mineral tetrahedrite, even in small quantities, is important.

WOODPECKER AND BUTTERFLY.

The porphyrites extending from Raven creek, Spratt bay, northwestward for a mile or more to the main Marble Bay limestone area are intruded near the coast by numerous small quartz diorite stocks, and hold numerous limestone inclusions seldom more than a few feet across. Many of the inclusions are partially replaced by secondary minerals and in a number magnetite lenses have developed. Among the best known claims in the district are the Woodpecker and Butterfly. The Woodpecker is opened up by a shaft and some open-cuts, all showing impure magnetite in small lenses. A shaft now filled with water has also been sunk on the Butterfly to develop a magnetite lens 60 feet in length and from 4 to 6 feet in width.

The magnetite in all the lenses contains considerable pyrite and some irregularly distributed chalcopyrite. Other impurities present are epidote, garnet and calcite. The copper sulphide occurs in insufficient quantities, except in limited areas, to constitute commercial ores. A magnetite lens situated on the coast was mined some years ago and used as a flux.

MALASPINA MINES COMPANY.

This company controls a large group of claims covering part of Comet mountain, east of Raven creek, and extending eastward to the coast a distance of over 3,000 feet. Comet mountain and the surrounding district are underlaid by the massive porphyrites of the Texada formation, cut by a few diorite porphyrite dykes, quartz diorite intruding the porphyrite outcrop in narrow stocks along portions of the coast. Small inclusions of the Marble Bay limestone occur in places in the porphyrite.

The croppings consist of a few magnetite lenses, the largest seen measuring about 100 feet in length. The magnetite contains some pyrite and small quantities of chalcopyrite, but is too low grade in copper to be considered an ore. A shaft sunk on the largest lens showed no increase in the copper tenor with depth.

In 1909 a tunnel starting at the coast a few feet above sea-level, intended to pierce Comet mountain at a depth of 700 feet, was commenced by the Malaspina Mines Company, but has not been completed. The scattered low grade surface showings on the mountain scarcely justified the expensive undertaking.

CHARLES DICKENS.

This claim recently staked is situated a short distance south of the Marble Bay mine, near the forks of the Gillies Bay and Blubber Bay wagon roads. A small lens of chalcocite enclosed in limestone was exposed by road construction work. A shaft sunk on the lens passed through the chalcocite at a depth of less than 6 feet. Below it, the minerals present consist of zinc blende, chalcopyrite, and pyrite.

The chalcocite is evidently secondary, and the showing affords one of the few examples on the island of surface enrichment.

COMMODORE.

The Commodore is situated on the Iron Mine road, near the centre of the island. The croppings occur along the contact of the main limestone area of the island with porphyrite.

Two varieties of porphyrite occur at this point, a greyish conspicuously porphyritic variety bordering the limestone and farther in a brownish weathering nodular variety. It is probable that the former is intrusive into the latter, but the field evidence on this point is not clear. Several small irregular limestone inclusions occur along the junction of the two varieties. The more recent intrusives are represented by a branching area of syenite porphyrite, which cuts both the porphyrites and the limestone.

A large amount of work was done on the Commodore in the early days of mining on the island—more than the character of the croppings seems to have warranted. An incline 140 feet in length at an angle of 60 degrees was sunk along the lime-porphyrite contact, and from the foot of this, drifts, according to report, were run in a westerly direction for 750 feet and in an easterly direction for 250 feet. Some pyrite, chalcopyrite, and galena were found, but no ore bodies of importance. The mine has been shut down for some years and the workings are inaccessible.

In 1908, a shaft 60 feet deep was sunk on Commodore ground in limestone about half a mile from the porphyrite contact. Some galena occurs at the foot of the shaft disseminated through the limestone.

The conditions here are somewhat similar to those at the Sentinel. The limestone is crystalline and is fissured and cut by occasional diorite porphyrite dykes, but there is no large development of garnet and the other secondary minerals which accompany the metallic minerals at the principal deposits.

IRON RANGE COPPER ORES.

Chalcopyrite occurs along the iron range near the west coast of Texada island in lenses usually of moderate size embedded in limestone near their contact with intrusives and also disseminated in small quantities through most of the magnetite masses. Bornite, abundant in the Vananda mines and in other parts of the island, is entirely absent.

At the Lake mine, near the eastern end of the iron range, a vein-shaped lens of chalcopyrite 2 to 5 feet in width and 60 feet long occurred wedged in between altered porphyrite and crystalline limestone. It became lean at a depth of 30 feet. An incline shaft at an angle of 70 degrees, has been sunk along the contact to a depth of 80 feet, and a drift run from the foot of it northward into the limestone for a distance of 120 feet. A buried lens of magnetite was pierced by the drift, but no copper ore bodies of importance were found.

Chalcopyrite also occurs at the Lake mine in disseminated grains and small bunches, associated with magnetite and pyrrhotite, along the contact of the northern boundary of the main magnetite mass with the limestone. The workings here consist of a short tunnel driven under the most promising croppings, and some pits. The ore areas explored proved to have little persistence.

Some copper mining has been done on the iron range a short distance north of the Paxton mine. The limestone terminates here in a triangular tongue bordered on the east by porphyrite and on the west by quartz diorite. A number of small lenses of high grade chalcopyrite ore occurred in the limestone along both contacts and have been mined out and shipped. No exploratory work has been done in depth.

The lenses are seldom more than a few feet across and soon terminate in depth. Only the exposed ores have been worked and it is probable others would be found if the workings were carried down along the contact.

Some of the lenses consist almost entirely of chalcopyrite surrounded on all sides by crystalline limestone. In others, pyrite and magnetite are also present as well as variable quantities of garnet, actinolite, diopside, and epidote.

A lens of copper ore is stated to have been found while sinking a shaft to explore the magnetite mass at the Prescott mine. Like the other lenses along the range, it proved to be small.

IRON DEPOSITS.

The principal iron deposits of Texada island occur on the west coast about 3 miles north of Gillies bay, and are owned by the Puget Sound Iron Company, with headquarters at San Francisco. This company acquired the property in 1875 and has been in continuous possession ever since. Between 1883 and 1893, considerable development work was done on the Prescott ore body, the most northerly of the large magnetite masses in the range, and several thousand tons of ore was mined and shipped to a smelter at Irondale, Wash., for treatment. Since that date mining has been limited to occasional shipments of surface ore, mostly from the Lake mine ore body, and a few attempts, the latest in 1908, to work the copper deposits occurring in places along the range.

The iron ore occurs in the form of magnetite lenses of various sizes, distributed irregularly over an area about $1\frac{1}{2}$ miles in length and half a mile in width. The magnetite belt roughly parallels the coast at a distance from it of from a quarter to half a mile, and most of the occurrences outcrop at elevations of from 300 to 500 feet above sea-level. The sloping surface is drift covered in places up to an elevation of about 350 feet, but over most of the area, the hummocky rocks are bare or only lightly covered and the geological boundaries are easily traceable. The magnetite lenses often project as low hills.

ROCKS.

The rocks represented in the iron range, consist of limestones intruded successively by porphyrites, quartz diorite in stocks and dykes, and diorite porphyritic dykes.

Limestones.

The limestones occupy an irregular area along the northern elevated part of the range. Ordinarily, they are light to dark grey rocks with a compact to saccharoidal texture, but in places, especially near the intrusive masses, have been altered into coarse whitish crystalline marbles. The bedding planes have mostly disappeared and the principal partings consist of well developed cleavage planes inclined at high angles. The cleavage planes are emphasized on the surface by numerous solution furrows, and, in places, by lines of small pits and hollows worn out by the descending surface drainage.

The limestones here, as elsewhere on the island, are remarkably free from impurities, except for the development of secondary minerals and occasionally some chert along the contacts with the intrusives. They occupy the most elevated portion of the district and in places have the appearance of overlying and being younger than the porphyrites. The actual contact of the two rocks is usually marked by a hollow partially filled with debris and is seldom seen, but at a few points unmistakable evidence of the intrusion of the porphyrites into the limestone is clearly exhibited.

Porphyrites.

The porphyrites occupy a small area at the southwestern corner of the area and a large one indented by a limestone spur from the north at the eastern end of the mineralized area. They are greyish, medium-grained, holocrystalline rocks, cooled at varying distances from the surface, and while classed generally as porphyrites in some of their phases they resemble andesites, and in others, diorites. They are made up chiefly of a plagioclase feldspar and augite or hornblende, rarely biotite. A porphyritic arrangement of the minerals is usually apparent in hand specimens.

The porphyrites are always more or less altered, usually with a development of epidote, but nowhere to such an extent as to obscure their origin, and except along occasional shear zones exhibit little evidence of dynamic deformation.

Quartz Diorites.

The quartz diorites are intrusive into both the limestones and porphyrites. They are distributed over an irregular roughly triangular area, stretching inland from the coast for a distance of about a mile. In addition to the main area, a number of dykes and small stocks cut the bordering limestones and porphyrites.

The quartz diorites are greyish, irregular-textured but seldom coarse rocks, very similar in composition to the principal variety in the Coast Range batholith. They consist essentially of a plagioclase feldspar usually andesine, with some orthoclase and quartz, and hold biotite as the principal dark material. Hornblende, and less frequently augite, replace the biotite in some areas. Secondary minerals, principally epidote, garnet, and magnetite, occur abundantly in the quartz diorites, near their contacts with the bordering rocks and occasionally replace them altogether over small areas.

The quartz diorites, like the porphyrites are massive throughout and show no evidence of much crushing. Contraction joints are prominent in places.

Diorite Porphyrites.

The diorite porphyrites, the latest intrusives in the area, occur in the form of dykes, ranging in size from a few inches up to 40 feet in width, and occasionally attaining a length of over 1000 feet. They are common in the limestones, especially east of the area mapped, and less frequent in the quartz diorites and porphyrites. They consist essentially of moderate sized phenocrysts of plagioclase feldspar, hornblende, and augite separately or together, and occasionally, biotite enclosed in a fine to medium grained groundmass of the same minerals. Small amounts of orthoclase and quartz occur in some sections. The accessory minerals include abundant magnetite, ilmenite, apatite and sphene. The porphyritic texture is seldom pronounced in hand specimens but is always apparent in thin sections.

Diorite porphyrite dykes were intruded both before and after the mineralization of the district. An example of a later dyke occurs at the Lake mine. At this point a comparatively fresh dyke about 3 feet in width, crosses the magnetite ore body and bordering altered rocks. Mineralogically, this dyke differs from the majority of those examined in being more basic, in having augite as the principal phenocryst in place of plagioclase, and in the flow-like arrangement of the lath-shaped plagioclase crystals in the groundmass. Gradations, however, occur from this type to dykes nearly destitute of dark minerals, and consisting mainly of plagioclase. The older dykes in the vicinity of ore bodies are altered and often wholly or partially replaced by ore and gangue minerals.

CLASSIFICATION AND DISTRIBUTION OF DEPOSITS.

The iron and associated copper ores in the area reported on, are typical examples of contact metamorphic deposits. The ore occurs in bodies of all sizes up to great masses several hundred feet in length and 100 feet or more in width. The large masses have the irregular outlines characteristic of the members of this group, and the magnetite is associated with and in most instances surrounded by an aureole of the usual contact metamorphic minerals, principally epidote, andradite, augite, and varieties of amphibole.

The distribution of the magnetite lenses is exceedingly erratic. They occur along the lime-diorite contacts, the lime-porphyrite contacts, the porphyrite-diorite contacts, and enclosed in all three formations at considerable distances from their boundaries. In two instances, lenses have formed at the ends of quartz-diorite dykes. No constant relationship was detected between the size and freedom from sulphides of the lenses and the contacts along which, or the rocks in which, they form. The Paxton ore body, the most pyritic of the large masses, occurs at a diorite porphyrite contact and the Lake ore body, the freest from pyrite, at a lime-porphyrite contact. Small lenses of nearly pure ore occurs in both the porphyrites and limestones.

AGE OF DEPOSITS.

The age of the magnetite deposits is considered to be Lower Cretaceous. They originated during the closing stages of the Coast Range batholithic invasion, an invasion which commenced in the Jurassic and continued into early Cretaceous times. Mineralization and igneous activity ceased on the island before the deposition of the Upper Cretaceous rocks of Gillies bay and other places along the west coast.

MINERALOGY.

METALLIC MINERALS.

The metallic minerals occurring in the West Coast Iron range are limited to the iron oxides and sulphides and the common copper sulphide, chalcopyrite.

Magnetite. This is the principal mineral in the range. It occurs in numerous bunches and masses, mostly situated along the borders of the intrusive areas. The masses in several instances, attain a length of over 200 feet. The magnetite is seldom pure, usually including numerous small areas of dark silicates, mostly garnet and epidote and some iron sulphides, accompanied occasionally by a small quantity of chalcopyrite. The percentage of iron in the large masses averages about 61 per cent.

The magnetite in the large Prescott ore body is usually rather coarsely crystalline, and in places, the crystals are separated by a thin film of calcite. In the Lake mine, the crystallization is much finer, and in a few of the smaller masses the crystals are barely observable with the naked eye. As a rule, the proportion of sulphides is larger in the coarser-grained than in the finer-grained varieties.

Besides its occurrence in large clearly secondary masses, magnetite is present as an accessory mineral in both the quartz diorites and porphyrites, and in the diorite porphyrite dykes.

Hematite. The specular variety of hematite occurs sparingly in some of the altered areas associated with magnetite, epidote, and garnet. It does not form large masses and, so far as known, does not occur in the large magnetite masses.

Marcasite. Tabular crystals and aggregates of crystals of a yellowish sulphide are prominent in the magnetite ore body of the Prescott mine. These have been identified by Mr. Harvey, acting mineralogist, as marcasite partially altered to pyrite. The marcasite crystals often have a radial arrangement and in places are crowded into short elongated vein-like areas. They are contemporaneous in origin with the magnetite in which they are embedded.

Pyrite. Pyrite in crystals and small aggregates is common all along the iron range, but nowhere forms large masses, and the proportion present in the large magnetite masses except in limited areas, is usually small. With the exception of a few small secondary veinlets and where pseudomorphous after marcasite, the pyrite crystallized out at the same time as the magnetite. Its tenor in the previous metals is low.

Pyrrhotite. This mineral occurs in bunches and lenses of considerable size in the Lake mine, associated with magnetite and chalcopyrite. It has developed mainly between the magnetite ore body and the bordering limestones.

Siderite. Small bunches of siderite occur in the limestones bordering the altered area at the Lake mine. It is not common

Chalcopyrite. Chalcopyrite has been mined at the Prescott and Lake mines and at several points along the border of a limestone tongue which extends southward towards the Paxton mine. It occurs in small and moderate-sized lenses all developed, except the one at the Prescott mine, in limestone. Occasional specks of chalcopyrite also occur in most of the magnetite lenses.

NON-METALLIC MINERALS.

The common non-metallic minerals, associated with the metallic varieties include epidote, garnet, varieties of pyroxene and amphibole, quartz, and calcite.

Epidote. Epidote is widely distributed along the iron range. It occurs in bunches and scattered crystals usually associated with andradite and magnetite replacing the original rocks over considerable areas, usually partially surrounding or in close proximity to the large magnetite masses. It has developed in both the limestones and the intrusives, but is especially abundant in the latter. Dykes of quartz diorite situated at some distance from the main altered areas are found partially replaced by epidote, and green blotches representing epidote areas are frequent over the whole porphyrite area.

Garnet. The lime iron garnet andradite is common all along the range in both the limestones and the older intrusives. It forms with magnetite and epidote, the bulk of the secondary minerals.

Pyroxene. The greenish pyroxene diopside is common in the limestone, especially near the chalcopyrite lenses. It occurs occasionally in narrow sharply bounded zones simulating dykes.

Amphibole. Dark green to black actinolite occurs sparingly with the other secondary minerals, but nowhere forms large masses.

Quartz. Quartz is not common. It occurs in small quantities in the Prescott mine associated with garnet and other minerals filling cavities in the magnetite.

Calcite. Calcite, probably recrystallized limestone, occurs as a gangue in some of the pyrite and chalcopyrite deposits, and also occasionally in small quantities in the magnetite.

PARAGENESIS.

The iron oxides and iron and copper sulphides on the evidence of polished surfaces, crystallized out practically simultaneously. Field observations also indicated that the metallic minerals as a rule formed after the non-metallic. Veinlets of magnetite often cross areas of garnet and epidote enclosed in the magnetite mass, and are also found traversing the zone of secondary minerals bordering the magnetite.

While the main mass of the metallic minerals probably formed after the non-metallic ones, there is reason to believe that the deposition of both kinds was taking place at the same time in different parts of the mineralized area, and that small quantities of non-metallic minerals continued to form until deposition finally ceased. Small areas, manifestly cavities formed in the magnetite during its crystallization, were subsequently filled with secondary minerals. A number of these cavities are with garnet with good crystal faces projecting inwards, and the interior is filled with calcite and quartz holding occasional well-formed crystals of epidote, and cubes of pyrite.

The evidence in regard to the order of deposition of the non-metallic minerals is also conflicting. The pyroxene, probably formed first as a rule at any particular point, followed by epidote and garnet, and later by small quantities of quartz and calcite. This order is, however, not constant, and overlapping both in the case of the gangue and metallic minerals undoubtedly occurred.

PRINCIPAL MAGNETITE OCCURRENCES.

PRESCOTT MINE AND VICINITY.

The Prescott mine is situated near the western end of the iron range. The outcrops occur on a steep sidehill at elevations of from 300 to 580 feet above sea-level. The main ore body is connected with the coast by a tramway about 1,000 feet in length.

The Prescott ore bodies have formed along a ragged, quartz diorite contact with limestones and replace both rocks. They are enclosed in a roughly lenticular-shaped area, about 600 feet in length with a maximum width of 380 feet, in which, with the exception of a few diorite and limestone cores, the original rocks are entirely replaced by magnetite, garnet, epidote, and other secondary minerals.

Workings.

The Prescott mine has been idle since 1893. The work done on it includes three large surface cuts on the principal magnetite lenses, and a shaft 150 feet deep sunk at the southerly tip of the mineralized areas. From the foot of the shaft a tunnel was driven in a northerly direction, through diorite, towards the main ore body which it reached at a distance of 215 feet. It was continued into the ore body for a distance of 65 feet, and subsequently extended southwards to meet the sloping surface. A second short tunnel has been driven into the magnetite 250 feet higher up.

Ore Bodies.

The main magnetite mass is roughly crescentic in outline, has

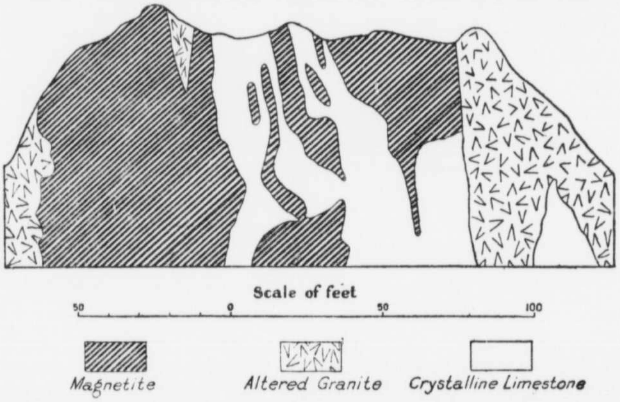


Figure 1. Sketch section across upper part of Preston mine ore bodies.

a length of 300 feet, an average width of about 80 feet, and has been proven by a tunnel to extend downwards for a distance of

430 feet below the highest outcrop. The dimensions in depth are not known as the tunnel ends in ore after penetrating it for a distance of 75 feet.

In addition to the main mass, several smaller lenses occur in the same altered area, two of which have been opened up by surface cuts. The largest of these outcrops is a rounded mass about 75 feet in diameter. It has formed entirely in limestone and is separated from the main ore body by coarse crystalline limestone in which a number of small irregular bunches of magnetite have formed.

The third ore body opened up has a width of 20 feet, a length of about 100 feet, and has formed in the quartz diorite. Diorite cores only slightly altered occur in its vicinity.

Character of Ore.

The workings on the main ore body have exposed at the southern end, an imposing face of magnetite fully 50 feet in width by 75 feet in height. The magnetite is coarsely crystalline, breaks with a rough fracture, and is seldom free from impurities. Marcasite in thin short radiating plates concentrated in places along narrow bands resembling veinlets, is conspicuous from its contrasting colour although the percentage present is small. Some pyrite is also present, and occasionally garnet and chalcopyrite. The non-metallic impurities include dark areas made up mostly of epidote, garnet, and hornblende, and a number of small light-coloured areas filled mainly with calcite and quartz. The latter are considered to be cavities formed during the crystallization of the magnetite and subsequently filled up. They are usually lined with garnet and contain some epidote and occasional cubes of pyrite in addition to the main calcite-quartz filling.

A rough sample taken from the exposed face and along a short tunnel driven into it, and assayed at the Mines Branch for iron, copper, and sulphur, gave: iron 64·30 per cent, copper 0·14 per cent, and sulphur 0·303 per cent. The small, light-coloured areas were not included in the sampling. A second general sample taken along the 75 feet of magnetite exposed in the lower tunnel, yielded: iron 55·20 per cent, copper 0·14 per cent, and sulphur 0·266 per cent.

The larger part of the magnetite shipped from the Prescott mine was taken from a small lens north of the main ore body, and entirely separated from it. The percentage of sulphides in this is considerably less than in the larger body.

West of the Prescott mine, a number of magnetite lenses of moderate sizes occur along the diorite-lime, and farther on the porphyrite-lime contacts, the larger having a length of 90 feet and a width of 20 feet. Lenses have also formed at a few points along the small outlying diorite stocks and dykes. A lens 57 feet long and 20 feet wide, occurs at one point forming the continuation of a diorite dyke. The magnetite in this lens is remarkably free from both sulphides and non-metallic impurities. It contains a small percentage of manganese. It yielded on assay, iron 68·20 per cent, copper, none, sulphur, trace, manganese 0·08 per cent.

North of the Prescott mine, the lime-diorite contact is exceedingly irregular, consisting of a succession of spurs and bays. Three large and several small lenses of magnetite occur in one of the limestone bays. The most westerly and largest of these has formed entirely in limestone at a distance of 100 feet from the tip of the diorite spur. It has a length of 250 feet and an average width of about 50 feet. The second lens has a length of 160 feet, a width of 40 feet, and has formed along the contact. The third lens has developed partly in diorite and partly in limestone, and has a length of 200 feet and a width of about 70 feet. The diorite southeast of this lens is altered and replaced for some distance by epidote, garnet, and grains and bunches of magnetite. No work has been done on these lenses except the excavation of a small pit at one point. The ore judging from the surface exposure is of superior quality, and the percentage of sulphides present is very small.

Southwest of the Prescott a mineralized area in the quartz-diorite about 75 feet across, is exposed in a cut on the tramway from the mine to the coast. The area contains a narrow lens of magnetite, but consists mainly of epidote, garnet, and small bunches of magnetite. The percentage of sulphides present, mostly iron pyrite, is high.

PAXTON MINE AND VICINITY.

The Paxton ore body situated at the eastern boundary of the quartz-diorite stock, ranks next to the Preston ore body in size. It has a length of 290 feet, a maximum width of 200 feet, and an average width of about 150 feet. It has developed entirely in the quartz-diorite near its contact with porphyrite.

The southern part of the ore body outcrops on a steep slope about 60 feet in height, the lower part of which is diorite, and the upper part magnetite. Two short open-cuts about 80 feet apart through the diorite, expose the diorite-magnetite contact. A tunnel 40 feet in length has been driven from the end of the most easterly of the cuts through the solid magnetite. The attitude of the magnetite lens is nearly vertical.

The diorite south of the ore body is traversed by a number of narrow fissures some of which show movement, but is not regularly jointed. Near the ore body it is filled with grains of pyrite and magnetite, but otherwise is little altered and the transition from unmistakable diorite to magnetite is very abrupt.

The Paxton ore is coarse grained, contains the usual small areas of dark secondary minerals and a larger percentage of sulphides, mostly iron pyrite, than usual. Part of the ore mined from the tunnel some years ago and since exposed to the atmosphere has crumbled into grains owing to the decomposition of the numerous pyrite crystals. An assay of a sample taken along the tunnel yielded, iron 59·40 per cent, copper 0·30 per cent, sulphur 1·07 per cent.

The Paxton ore body occurs at the southern extremity of a long altered area consisting mainly of epidote, garnet, and magnetite in grains and bunches, situated on the south along a diorite-porphyrite contact. To the north, the two intrusives are separated by a limestone spur and the altered area divides into two portions, the easterly one following the porphyrite and the westerly one the diorite. The latter spreads southward at one point into the diorite for a distance of 500 feet. It contains several lenses of magnetite of good quality from 50 to 75 feet in length. The easterly branch also holds some moderate sized magnetite lenses and near its termination small lenses of chalcopyrite, several of which have been mined, occur in the limestone.

The lime-diorite contact farther to the north is marked at intervals by small magnetite lenses and areas of alteration, and at one point the diorite at some distance from the contact is completely replaced by a mass of secondary minerals. The replaced area is crescentic in shape and has a length of 300 feet. It contains two magnetite lenses, each about 60 feet in length, and numerous small aggregates and bunches associated mainly with epidote and garnet.

The porphyrite east of the Paxton extends northwards as a spur from the main body penetrating the limestone. East of the tip of the spur a rounded mass of magnetite about 90 feet across, has formed in the limestone, and several smaller lenses, one at the porphyrite-lime contact, occur to the south. The mineralized area here is cut across by a large diorite-porphyrite dyke.

LAKE MINE AND VICINITY.

An important body of magnetite occurs at the Lake mine, situated near the eastern known limit of the iron range. A magnetite mass measuring 180 feet in length with an average width of 130 feet, has formed here in the porphyrite, at the bottom of an angular limestone bay. The magnetite is bordered on three sides by porphyrite and has apparently developed mostly in that rock. Limestone occurs on the north but is separated from the magnetite mass by an irregular area consisting mostly of garnet and epidote. Pyrite, pyrrhotite, and magnetite in scattered grains and bunches are also present and the latter in two places forms small lenses. The boundary between the replaced area and the unaltered limestone is marked along nearly its whole course by copper stains, and a lens of good chalcopyrite ore about 60 feet in length situated near the eastern end of the zone, has been mined.

The magnetite in the Lake mine ore body is finer grained than in the other large masses and is freer from iron and copper sulphides. These have developed in considerable quantities in the altered zone lying between the main magnetite mass and the unaltered limestone, and occur only in scattered grains and minute aggregates in the magnetite itself. Non-metallic impurities, principally epidote and garnet, and less frequently actinolite, calcite, and quartz are fairly abundant. A rough general sample taken from the faced magnetite cliff and assayed in the laboratory of the Mines Branch, yielded, iron 57·50 per cent, copper trace, sulphur 0·046 per cent.

A buried lens of magnetite about 30 feet in width, was cut through in the copper workings at the Lake mine, 250 feet north-east of the main magnetite ore body. The lens is overlain by crystalline limestones practically free from secondary minerals.

A line of narrow magnetite lenses about 1000 feet in length, simulating an interrupted vein, occurs south of the Lake mine in the porphyrite at a considerable distance from both lime and diorite contacts. The conditions are unusual as the porphyrite near the magnetite shows little alteration and non-metallic secondary minerals are rare. The most northerly lens, the longest one, measures 220 feet in length with a width of from 10 feet to 20 feet. Two other lenses measure respectively 84 feet and 50 feet in length with widths of from 10 to 20 feet. The other lenses are comparatively small.

The magnetite in all the lenses is fine grained and remarkably pure. Some epidote and garnet occurs scattered through it, but the quantity is small and only occasional grains of pyrite were noted. An assay of a sample from the long lens, yielded, iron 69·40 per cent, copper, none, sulphur 0·01 per cent.

The total quantity of ore in the various outcrops is difficult to estimate as practically no development work has been done below the surface except in the Prescott. The ores are replacement deposits formed as after effects of the quartz-diorite intrusion but subsequent to its solidification on the surface. They belong to the contact metamorphic group, and as such, are characteristically irregular and uncertain in outline. Furthermore, the district has been subjected to almost continuous erosion since Cretaceous times, the lenses have been partly destroyed, and the portions remaining may represent either the roots or the tips of large masses.

For the purpose of making a rough estimate, it is assumed that the lenses extend downwards for a distance equal to their exposed surface length. The Prescott ore body with a surface length of 300 feet has been proven to extend downwards for a distance of 430 feet, and at the low level is still strong and must descend considerably farther.

The tonnage in the main Prescott ore body above the lower tunnel is estimated at 1,366,400 tons. The three large lenses in the limestones northeastward from the Prescott, assuming that they persist to a depth equal to their surface length, would yield 993,600 tons. The Paxton ore body yields 1,607,200 tons and the Lake ore body 504,000. The total tonnage in the six ore bodies, estimated on the basis adopted, amounts to 4,521,200 tons.

No account is taken in this estimate of the numerous small lenses from 20 to 100 feet or more in length occurring along the range. Some of these are surrounded by large areas of intense alteration and mineralization and the concealed portions may be much larger than the small outcrops appear to indicate.

It is also unlikely that the lenses cut by the present surface represent the lowest tier formed. It is more probable that they are followed in depth along the contacts by other lenses and the tonnage given above may be multiplied several times before the iron resources of the district are exhausted.

GENERAL CHARACTER OF ORE.

The magnetite lenses vary greatly in the amount of impurities they contain, more especially in regard to the sulphides. The rocks in which the lenses formed, appear to have had some influence on the character of the ore, as those in the porphyrite are the purest on the whole and those in the diorite the most impure. The lenses formed in the limestone are variable, some being nearly free from sulphides while others contain large percentages.

The following assays of the three principal lenses were made in the laboratory of the Mines Branch of the Department from samples collected by Mr. Lindeman, who examined the range in 1907.[1]

[1] Bulletin No. 47, Mines Branch, Department of Mines.

	Prescott ore body Lower tunnel	Paxton ore body 45-ft. tunnel	Lake ore body average of ore
SiO_2	4·37	4·47	8·33
Fe	63·27	64·48	59·57
Al_2O_3	1·18	0·66	1·71
CaO	2·58	1·32	3·82
MgO	1·05	1·13	1·05
Cu	0·09	0·22	0·08
S	0·347	1·866	0·137
P_2O_5	0·013	0·005	0·057

These assays are probably fairly representative of the general run of the ore in the large masses. The phosphorus content in these and in numerous other recorded assays is low, usually well below the Bessemer limit. The copper content is also small as a rule, but in limited portions of the Prescott ore body and possibly in other lenses the amount present rises to over one per cent. Sulphur derived from the iron sulphides, pyrite, marcasite, and pyrrhotite, and the copper sulphide, chalcopyrite, is the principal deleterious impurity. The Paxton ore body is impregnated throughout with sulphides in grains and small aggregates. In the Prescott ore body the distribution is more irregular, some areas carrying considerable percentages while others are nearly free. The Lake mine ore body is exceptionally free from sulphides except along its northern border.

The small lenses vary from nearly pure magnetite to masses made up largely of sulphides. A sample from the line of lenses south of the Lake mine, assayed over 69 per cent iron with no copper and only 0·001 per cent sulphur. A sample from a moderate sized lens west of the Prescott mine proved almost equally pure. It contained 68·20 per cent iron with no copper and only a trace of sulphur.

The comparatively high percentage of sulphur in the Paxton ore body and in portions of the Prescott, will necessitate washing the ore before treatment. The percentage in the Lake ore body, in portions of the Prescott, and in a number of the smaller lenses is low, and a preliminary washing will not be required.

TRANSPORTATION AND MINING FACILITIES.

The ore bodies are all exceptionally well situated for cheap mining and transportation. They outcrop as large masses on the seaward slope of a ridge, roughly paralleling the coast. The distances from the coast, of the principal masses, range from a few hundred feet to a mile, and the elevation above sea-level from 300 feet to 800 feet.

The exposed portions of the masses can be quarried out and transported to the coast by short trams. The buried portions in the western part of the range can easily be reached by tunnels as the hillside is steep. In the eastern part, the country flattens out and shafts would be necessary if the lenses persist to any considerable depth.

MAGNETITE LENSES ON THE EAST COAST.

Numerous small and medium sized magnetite lenses occur near the east coast of Texada from Pocohontas mountain north to the head of the island. Most of these contain considerable quantities of iron and copper sulphides and attempts have been made to work them for copper.

Magnetite lenses occur at the Paris group of claims near Blubber bay and at the Volunteer south of Sturt bay. Shipments from the latter have been used as a flux at the Vananda smelter. Farther to the south, numerous lenses occur in the porphyrite area north and south of Raven creek on Comet mountain and at several points on Pocohontas mountain. The lenses are usually associated with small limestone inclusions in the porphyrite. They are seldom free from sulphate impurities and with the possible exception of a few areas near the coast, could not be profitably mined for iron.

South of Pocohontas mountain, the lenses disappear and the known mineral occurrences consist of a few small veins.

The Davies Bay limestone area on the west coast about midway up the island, is bordered along its contact with the surrounding porphyrites by occasional magnetite lenses all so far as known of small size. With the exception of occasional diorite porphyrite dykes, none of the later intrusives occur in the vicinity.

QUARTZ VEINS AND FISSURE ZONES.

Quartz veins and silicified fissure zones occur at a number of points on the island, mostly cutting the porphyrites. They are all small, seldom exceeding 3 or 5 feet in width, and have not proved very productive. Discoveries of quartz rich in free gold have been the cause of several excitements, but the values have invariably proved to be spotty. Besides the free gold, they contain pyrite, chalcopyrite, sphalerite, magnetite, and galena.

The veins probably mark the final stage of mineralization on the island. They contain the same minerals as the contact metamorphic deposits, although in different proportions, and also grade into them in other ways. The Raven deposit, made up mostly of magnetite with some chalcopyrite, follows a fissure zone and has the shape of a vein, and the Leamington near Comet mountain, a similar linear lead, contains both magnetite and quartz with some pyrite, chalcopyrite, and bornite. Quartz occurs on the iron range, associated in formless masses with the other contact metamorphic minerals and also in tiny veinlets cutting them. It is thus contemporaneous with at least the later secondary minerals, and continued to crystallize out after the deposition of the latter had ceased.

DISTRIBUTION.

Quartz veins occur cutting all the formations from the Anderson Bay formation up to and including the diorite porphyrite dykes. No examples were found in the Cretaceous areas. The larger veins and practically all those developed occur in the porphyrites.

The veins are nowhere numerous and are somewhat sporadic in their distribution. A number occur along the northern base of Surprise mountain, and others near Kirk and Spectacle lakes. Several have been opened up around Comet mountain, and occasional examples are met with around Pocohontas mountain, south of Long Beach, and in the tuffs of the Anderson Bay formation at the southern end of the island.

DEVELOPMENT.

A number of shafts ranging in depth from a few feet to several hundred feet, have been sunk on the most promising veins and some drifting has been done. With the exception of occasional pockets of gold quartz, very little ore capable of being extracted at a profit was encountered, and work on them has now practically ceased.

PRODUCTION.

The total production from the veins has not exceeded $20,000. This has been derived principally from small pockets or shoots of rich gold quartz in the veins on the Marjorie, Golden Slipper, Nutcracker, and Potasa.

PRINCIPAL OCCURRENCES.

Marjorie.

The Marjorie is situated north of Spectacle lake, in the porphyrite near its contact with the Marble Bay limestone. Two veins, 26 feet apart and dipping towards one another, have been opened up. The larger has a width of 2½ feet, and is traceable for 120 feet. A shaft has been sunk on this to a depth of 65 feet and some drifting done. Free gold occurred in the croppings and about $6,500 worth was taken out, according to Mr. W. S. Planta, the discoverer, from a rich surface pocket 7 feet long and about 6 feet deep. Below the pocket the values dropped to about $1 per ton.

Victoria.

The Victoria is situated a short distance east of the outlet of Kirk lake. Two quartz veins occur here about 60 feet apart. A shaft 100 feet deep has been sunk on one and a cross-cut from the bottom of this driven to the other. Some free gold was found, down to a depth of 25 feet, and about $1,000 is reported to have been taken out. In the lower part of the shaft, the values were very small.

Nutcracker.

The showing on this claim consists of a fissure zone 3 to 4 feet wide, seamed with small veins mostly quartz, but including a few of calcite. The zone traverses a brownish porphyrite sprinkled with dull feldspar crystals and blotched with rounded areas filled with quartz, calcite, and epidote. It has been opened up by a shaft 35 feet deep, and an open-cut 30 feet long. Free gold to the value of $2,000 is said to have been taken out mostly from near the surface. Galena in small quantities and occasional specks of chalcopyrite occur in the quartz.

Laurendale.

The Laurendale is situated near the old wagon road from the Iron Mine road to the Victoria mine. The country is a porphyrite similar to that at the Nutcracker. The porphyrite is fissured and partially replaced in places along the fissure zone by quartz. A small production of gold is reported. The gold is stated to have been of a wiry character, and to have occurred mostly in the country.

Golden Slipper.

This claim acquired considerable notoriety at one time owing to the presence on it of a small auriferous calcspar vein. It is situated near the southern end of Surprise mountain. The country is a greyish porphyrite traversed in an east-west direction by a fissured and shattered zone 10 feet in width. The individual fissures are all small and have quartz and less frequently calcspar as a filling.

Free gold to the value of over $5,000 was obtained according to report from a small calcite vein from 1 to 4 inches in width. The shoot had a length of 9 feet and has been followed downwards by an open-cut and shaft to a depth of 70 feet. The gold was all pounded out in a mortar at the mine by the owner Mr. Miller.

Other workings on this claim include an exploratory tunnel

350 feet in length, and a short cross-cut tunnel. The latter cuts a strong fissure zone 8 feet wide, seamed with small quartz and calcite veins and holding considerable pyrite. A general sample collected by the writer and assayed in the laboratory of the Mines Branch, yielded only small values in gold.

Copper King.

A number of claims, including the Copper King, Surprise, Silver Tip, and Smuggler, have been staked northeast of Surprise mountain and considerable development work has been done on some veins or veined fissure zones on them, with poor results. The country is a rather coarse, greenish porphyrite usually spotted with greyish feldspar crystals. It contains a few rounded vesicles filled mostly with chlorite and calcite, and is cut at one point by a small diorite porphyrite stock, very similar to the one at the Cornell.

The Copper King is the most easterly of the series of claims. The workings on it consist of a shaft 68 feet deep sunk on a shear zone 8 to 10 feet wide. A few inches of this yielded good gold values near the surface. Other minerals present are chalcopyrite and pyrite. No shipments were made.

Surprise.

The Surprise is situated a short distance northwest of the Copper King. A shaft reported to be 360 feet deep has been sunk on this claim and some drifting done. The lead followed consisted of a lightly silicified shear or fissure zone containing some chalcopyrite in places and reported to carry some gold values.

Silver Tip.

The Silver Tip, situated about one-half mile northwest of the Surprise, was explored in 1897 by Mr. James Findlay acting for a St. John, New Brunswick, syndicate. A fissure zone filled with small often reticulating quartz stringers and reported to be traceable for 900 feet, occurs on the claim. The zone strikes in a northwesterly direction, has an almost vertical attitude, and varies from 1 to 4 feet in width. The workings consist of two shafts sunk on the lead at an interval of 200 feet along the strike to depths of 145 feet and 150 feet. Some drifting was done from the foot of the latter, and also at the 50-foot station. The lead, while small, proved persistent and contained average values, according to Mr. Findlay, of $11 per ton, mostly in gold. Other minerals present include pyrite, small quantities of chalcopyrite and galena, and considerable zinc blende. The gold occurred both in the quartz and associated with the blende.

No work has been done on the Silver Tip for some years, and the substantial mine buildings erected when it was in operation have been destroyed by fire.

Smuggler.

The showing on the claim consists of a fractured silicified zone, in places 8 feet in width, holding some chalcopyrite and pyrite. Only surface work has been done on it, and the reported values are low.

The strike of the silicified zone on the Smuggler is south-southwest, while the general direction of the leads on the other claims along Surprise mountain is north-northwest.

Potasa.

This claim is situated on the west coast, north of Davies bay. A small fissure zone containing free gold is exposed on the beach. Some work was done on this in 1896, and a shipment of one ton made which is reported to have yielded $800 in gold.

Comet and Pocohontas Mountains.

Small veins and fissure zones similar to those along Surprise mountain occur in places on Comet and Pocohontas mountains and in their vicinity. Some surface work has been done on a few of these, but so far no lodes of sufficient promise to warrant serious development have been located.

South of Pocohontas mountain claims have been staked on a wide, shear zone, the widest seen on the island, traversing the porphyrites in a north and south direction. The porphyrites, usually massive, have been crushed into coarse sheets for a width in places of over 100 feet. Some silicification has taken place, accompanied by a deposition of pyrite and small quantities of bornite and chalcopyrite. The percentage of copper is low in the portions of the shear zone explored.

The veins and shear zones examined in the southern part of the island gave no indication of economic importance.

STRUCTURAL MATERIALS: LIME AND CLAY.

MARBLES.

Marble quarries have been opened up at Sturt bay near Vananda, and at Anderson bay near the southern end of the island. Work has been stopped at both quarries for some years.

The Sturt Bay marble consists of the altered and recrystallized Marble Bay limestones, the main limestone formation of the island. The rock worked is a medium-grained white to light greyish crystalline limestone, cut by occasional strong jointage planes and traversed by numerous small irregular fractures. The quarry is situated near an intrusive area, and the shattering of the rock is probably an effect of the intrusion. Better material may be found at a distance.

Surface exposures of white, even-grained, marbleized limestone were noted at a number of points in the wide limestone band which crosses the island from Vananda to the iron range. No work has been done on them, but they are worth investigating if the market for marble becomes important.

The marble at Anderson bay occurs as a lens about half a mile long and 180 feet thick, enclosed in lead-coloured and pink schists belonging to the Anderson Bay formation. The lower part of the lens consists of a nearly massive band 40 feet thick of whitish, coarsely crystalline limestone, irregularly marked in places with yellowish lines. This is overlaid by 33 feet of pinkish marble showing some distinct partings parallel to the dip of

PLATE VIII.

Limestone quarry, Tacoma Steel Co., Limekiln bay, Texada island, B.C.

the lens. This rock is made up of lens-shaped areas of pink marble, usually from 1 to 3 inches in thickness and 2 to 6 feet in length, separated by narrow bands of the white variety. The smaller pink lenses have wavy courses, and are often outlined in the surface by micaceous lines. The upper part of the lens is more shaly, and is too broken up to be of commercial value as a marble.

The most valuable part of the lens is the central variegated pink and white band. The colouring of this rock is very effective, but is due to reddish hematite scales, and this will probably restrict its use to inside work, as surfaces exposed to the weather soon tarnish.

The quarry is situated 100 feet above sea-level and about 900 feet from the head of Henderson bay. A tramway was built to the coast and some buildings erected when work was in progress, but these are now in a ruinous condition.

LIME.

The limestones of the Marble Bay formation afford an almost unlimited supply of material for the manufacture of lime. The less altered varieties, as a rule, are the freest from deleterious impurities.

The lime industry at present is centred around Blubber and Limestone bay, at the north end of the island. The limestone worked is a light to dark bluish grey, fine-grained variety, breaking with a splintery fracture. It occurs in heavy beds undulating in easy rolls. The bedding planes are often obscure, and strong, nearly vertical jointage planes constitute the principal partings. Diorite porphyrite dykes are numerous, and in places the limestone adjoining them is impregnated for a short distance with siliceous and aluminous impurities.

Three companies have erected kilns at the north end of the island. The Tacoma Steel Company have 4 kilns with a total capacity of about 400 barrels a day on Limekiln bay south of Point Marshall. The kilns are situated on the shore just above high water mark, and the face of the quarry is being carried back on a level with their tops and is connected with them by a short tram. The limestone used is very pure, carrying over 98 per cent calcium carbonate, and burns into an exceedingly white lime. A barrel and stave factory is operated by the company in connexion with the industry.

The Pacific Lime Company have their kiln on the shore-line of Blubber bay, and have the advantage of an excellent harbour. A band of magnesian limestone 75 feet thick, overlaid and underlaid by the ordinary nearly pure calcareous variety, occurs on the property of this company. The two varieties have the same greyish blue coloration, occur in heavy beds, and are practically indistinguishable in the field.

Partial analyses of the two varieties by Mr. H. A. Leverin of the Department of Mines gave the following results:—

	Magnesian limestone.	*Ordinary variety.*
Calcium carbonate.........	(1) 85·00	(1) 98·39
Magnesium carbonate......	(2) 11·32	(2) 0·71
Ferric oxide and alumina...	2·16	0·30
Insoluble matter..........	1·26	0·20
	99·74	99·60
Equivalent to lime CaO....	(1) 47·60	(1) 55·10
Magnesia MgO	(2) 5·42	(2) 0·34

A third company, the Texada Development Company, owns a limestone area on Blubber bay east of the property of the Pacific Lime Company. A kiln with a daily capacity of 120 barrels, and the necessary wharf, warehouse, and other buildings were constructed in 1909, but the plant has never been put in operation. The present available market is limited and is fully supplied by the product of the older companies. The following analysis of the limestones of this company made by J. Wanselm, Sweden, shows that it contained more magnesia than ordinary, but is otherwise very pure.

Lime CaO	53·320
Magnesia MgO	2·200
Iron oxide FeO	0·230
Alumina Al_2O_3	0·030
Manganese oxide MnO	0·140
Silica SiO_2	0·110
Phosphorus P	0·006
Sulphur S	0·045
Loss in burning	44·010
	100·091

Limestones suitable for the manufacture of lime, occur also in the Davies Bay limestone area, but so far have not been utilized for that purpose.

MAGNESIAN LIMESTONE.

The limestones of the Marble Bay formation carry as a rule only small quantities of magnesia, but in occasional bands, such as the one occurring on the property of the Pacific Lime Company at Blubber bay, referred to above, the percentage present exceeds 5 per cent. Magnesian limestone strongly crystalline in character also occurs at Sturt bay on ground owned by the Tacoma Steel Company. This rock is in demand for the manufacture of sulphites in connexion with the paper industry, and regular shipments are made from both points across Malaspina strait to Powell river, where a large wood pulp and paper plant has recently been established.

CLAYS.

Glacial clays occur along the shore-line of the northern part of Crescent bay and also at the Lake mine wharf, about 2 miles north of Gillies bay. The deposit is concealed except along the coast and its extent is not known. It is a boulder clay, but contains only a few scattered pebbles. A test of it was made by Mr. Joseph Keele, who reports as follows:—

"This clay is very gritty, slightly calcareous, but has a fairly good plasticity when tempered with water. The air shrinkage is rather too high, being 8 per cent. On burning to Cone 010—the temperature that most common bricks are burned at—the clay has a good hard body of light red colour. The fire shrinkage is zero, and the absorption 16 per cent. When burned to Cone 06 the clay develops a good red colour and steel hard body, but the absorption is rather high, being 15 per cent. At Cone 03 the body is dark red in colour and almost vitrified. The shrinkage at this temperature is 4 per cent. This is a good common brick clay, but is not suitable for the manufacture of vitrified wares, as the shrinkage is too great, and the softening point too low."

The Cretaceous beds in the Lower Gillies Bay area include 300 to 400 feet of greyish slightly indurated clays passing into coarse shales in places, and a few feet of reddish hematitic clays occur as a rule at the base of the formation. The latter is a residual deposit due to the decomposition of the underlying prophyrites and often contains partially decayed rock fragments. A sample assayed in the laboratory of the Department of Mines, contained 16·20 per cent of iron.

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LIST OF RECENT REPORTS OF GEOLOGICAL SURVEY

Since 1910, reports issued by the Geological Survey have been called memoirs and have been numbered Memoir 1, Memoir 2, etc. Owing to delays incidental to the publishing of reports and their accompanying maps, not all of the reports have been called memoirs, and the memoirs have not been issued in the order of their assigned numbers, and, therefore, the following list has been prepared to prevent any misconceptions arising on this account. The titles of all other important publications of the Geological Survey are incorporated in this list.

Memoirs and Reports Published During 1910.

REPORTS.

Report on a geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont.— by W. H. Collins. No. 1059.

Report on the geological position and characteristics of the oil-shale deposits of Canada—by R. W. Ells. No. 1107.

A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories—by Joseph Keele. No. 1097.

Summary Report for the calendar year 1909. No. 1120.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 1. *No. 1, Geological Series.* Geology of the Nipigon basin, Ontario —by Alfred W. G. Wilson.

MEMOIR 2. *No. 2, Geological Series.* Geology and ore deposits of Hedley mining district, British Columbia—by Charles Camsell.

MEMOIR 3. *No. 3, Geological Series.* Palæoniscid fishes from the Albert shales of New Brunswick—by Lawrence M. Lambe.

MEMOIR 5. *No. 4, Geological Series.* Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district, Yukon Territory—by D. D. Cairnes.

MEMOIR 6. *No. 5, Geological Series.* Geology of the Haliburton and Bancroft areas, Province of Ontario—by Frank D. Adams and Alfred E. Barlow.

MEMOIR 7. *No. 6, Geological Series.* Geology of St. Bruno mountain, Province of Quebec—by John. A. Dresser.

MEMOIRS—TOPOGRAPHICAL SERIES.

MEMOIR 11. *No. 1, Topographical Series.* Triangulation and spirit levelling of Vancouver island, B.C., 1909—by R. H. Chapman.

Memoirs and Reports Published During 1911.

REPORTS.

Report on a traverse through the southern part of the North West Territories, from Lac Seul to Cat lake, in 1902—by Alfred W. G. Wilson. No. 1006.

Report on a part of the North West Territories drained by the Winisk and Upper Attawapiskat rivers—by W. McInnes. No. 1080.

Report on the geology of an area adjoining the east side of Lake Timiskaming—by Morley E. Wilson. No. 1064.

Summary Report for the calendar year 1910. No. 1170.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 4. *No. 7, Geological Series.* Geological reconnaissance along the line of the National Transcontinental railway in western Quebec—by W. J. Wilson.

MEMOIR 8. *No. 8, Geological Series.* The Edmonton coal field, Alberta—by D. B. Dowling.

Memoir 9. *No. 9, Geological Series.* Bighorn coal basin, Alberta—by G. S. Malloch.

Memoir 10. *No. 10, Geological Series.* An instrumental survey of the shore-lines of the extinct lakes Algonquin and Nipissing in southwestern Ontario—by J. W. Goldthwait.

Memoir 12. *No. 11, Geological Series.* Insects from the Tertiary lake deposits of the southern interior of British Columbia, collected by Mr. Lawrence M. Lambe, in 1906—by Anton Handlirsch.

Memoir 15. *No. 12, Geological Series.* On a Trenton Echinoderm fauna at Kirkfield, Ontario—by Frank Springer.

Memoir 16. *No. 13, Geological Series.* The clay and shale deposits of Nova Scotia and portions of New Brunswick—by Heinrich Ries, assisted by Joseph Keele.

MEMOIRS—BIOLOGICAL SERIES.

Memoir 14. *No. 1, Biological Series.* New species of shells collected by Mr. John Macoun at Barkley sound, Vancouver island, British Columbia—by William H. Dall and Paul Bartsch.

Memoirs and Reports Published During 1912.

REPORTS.

Summary Report for the calendar year 1911. No. 1218.

MEMOIRS—GEOLOGICAL SERIES.

Memoir 13. *No. 14, Geological Series.* Southern Vancouver island—by Charles H. Clapp.

Memoir 21. *No. 15, Geological Series.* The geology and ore deposits of Phoenix, Boundary district, British Columbia—by O. E. LeRoy.

Memoir 24. *No. 16, Geological Series.* Preliminary report on the clay and shale deposits of the western provinces—by Heinrich Ries and Joseph Keele.

Memoir 27. *No. 17, Geological Series.* Report of the Commission appointed to investigate Turtle mountain, Frank, Alberta, 1911.

Memoir 28. *No. 18, Geological Series.* The geology of Steeprock lake, Ontario—by Andrew C. Lawson. Notes on fossils from limestone of Steeprock lake, Ontario—by Charles D. Walcott.

Memoirs and Reports Published During 1913.

REPORTS, ETC.

Museum Bulletin No. 1: contains articles Nos. 1 to 12 of the Geological Series of Museum Bulletins, articles Nos. 1 to 3 of the Biological Series of Museum Bulletins, and article No. 1 of the Anthropological Series of Museum Bulletins.

Guide Book No. 1. Excursions in eastern Quebec and the Maritime Provinces, parts 1 and 2.

Guide Book No. 2. Excursions in the Eastern Townships of Quebec and the eastern part of Ontario.

Guide Book No. 3. Excursions in the neighbourhood of Montreal and Ottawa.

Guide Book No. 4. Excursions in southwestern Ontario.

Guide Book No. 5. Excursions in the western peninsula of Ontario and Manitoulin island.

Guide Book No. 8. Toronto to Victoria and return *via* Canadian Pacific and Canadian Northern railways: parts 1, 2, and 3.

Guide Book No. 9. Toronto to Victoria and return *via* Canadian Pacific, Grand Trunk Pacific, and National Transcontinental railways.

Guide Book No. 10. Excursions in Northern British Columbia and Yukon Territory and along the north Pacific coast.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 17. *No. 28, Geological Series.* Geology and economic resources of the Larder Lake district, Ont., and adjoining portions of Pontiac county, Que.—by Morley E. Wilson.

MEMOIR 18. *No. 19, Geological Series.* Bathurst district, New Brunswick—by G. A. Young.

MEMOIR 26. *No. 34, Geological Series.* Geology and mineral deposits of the Tulameen district, B.C.—by C. Camsell.

MEMOIR 29. *No. 32, Geological Series.* Oil and gas prospects of the northwest provinces of Canada—by W. Malcolm.

MEMOIR 31. *No. 20, Geological Series.* Wheaton district, Yukon Territory—by D. D. Cairnes.

MEMOIR 33. *No. 30, Geological Series.* The geology of Gowganda Mining Division—by W. H. Collins.

MEMOIR 35. *No. 29, Geological Series.* Reconnaissance along the National Transcontinental railway in southern Quebec—by John A. Dresser.

MEMOIR 37. *No. 22, Geological Series.* Portions of Atlin district, B.C.—by D. D. Cairnes.

MEMOIR 38. *No. 31, Geological Series.* Geology of the North American Cordillera at the forty-ninth parallel, Parts I and II—by Reginald Aldworth Daly.

Memoirs and Reports Published During 1914.

REPORTS, ETC.

Summary Report for the calendar year 1912. No. 1305.

Museum Bulletin No. 2: contains articles Nos. 13 to 18 of the Geological Series of Museum Bulletins, and article No. 2 of the Anthropological Series of Museum Bulletins.

Prospector's Handbook No. 1: Notes on radium-bearing minerals—by Wyatt Malcolm.

MUSEUM GUIDE BOOKS.

The archæological collection from the southern interior of British Columbia—by Harlan I. Smith. No. 1290.

MEMOIRS—GEOLOGICAL SERIES.

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Memoirs and Reports in Press, October 30, 1914.

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Summary Report for the calendar year 1913.

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Canada

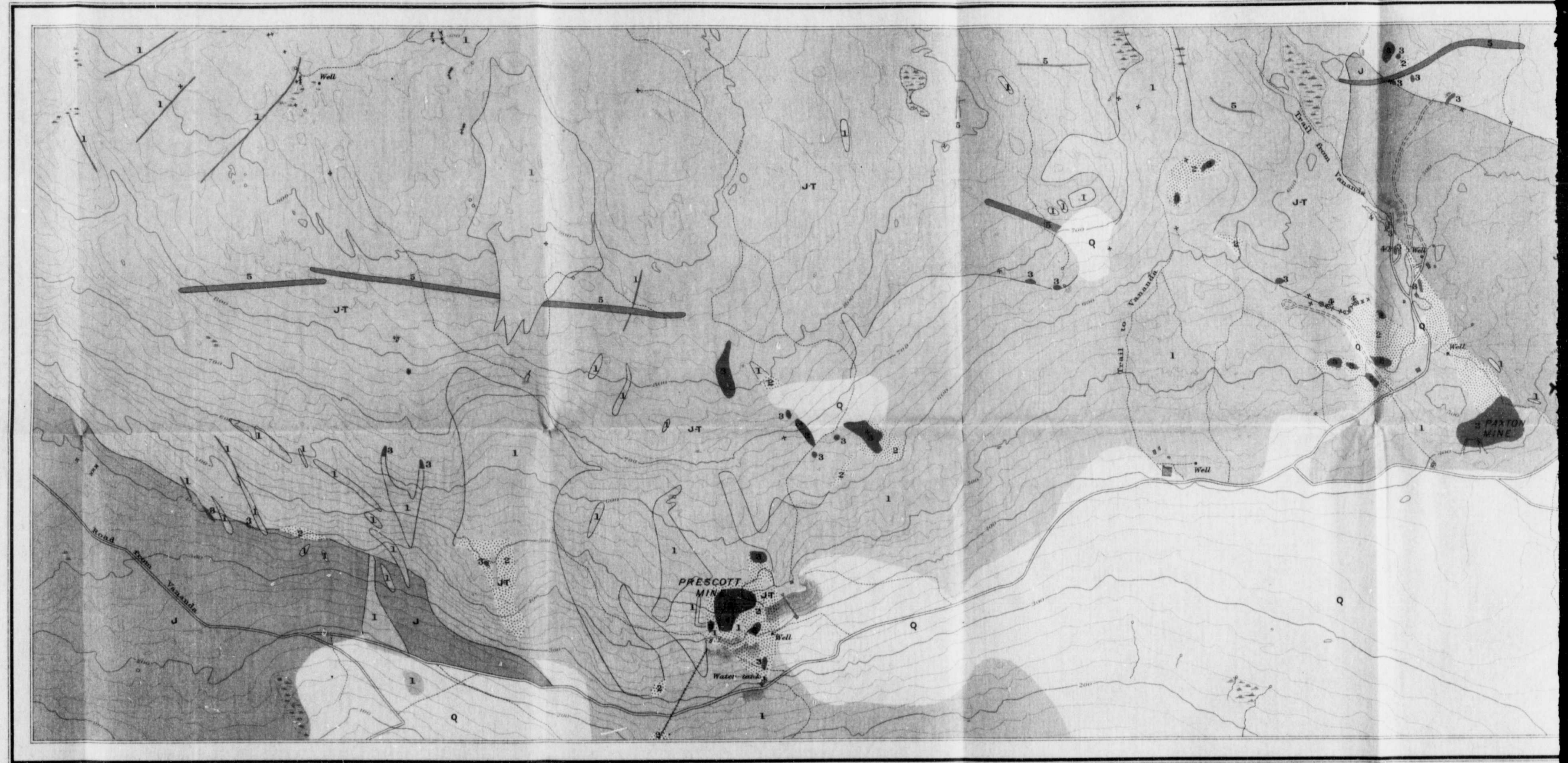
Department of Mines

HON. L. CODERRE, MINISTER; R.G. M^C CONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY

LEGEND

QUATERNARY	PLEISTOCENE	Q	Superficial deposits
MESOZOIC	CRETACEOUS (?)	5	Diorite Porphyrite dyke
		4	Copper deposit
		3	Magnetite
		2	Rock replaced by secondary minerals, epidote, garnet magnetite, etc.
	JURA-CRETACEOUS	1	Quartz Diorite
	LOWER JURASSIC (?)	J	Porphyrite
	LOWER JURASSIC OR TRIASSIC	J-T	Marble Bay limestone



C.O. Senécal, *Geographer and Chief Draughtsman*
S.G. Alexander, and A.S. Jost *Draughtsmen*

Scale, 35 Miles to 1 Inch

MAP 110 A
(Issued 1915)

PRESCOTT, PAXTON AND LAKE MINES

TEXADA ISLAND

BRITISH COLUMBIA

Scale, 1/4800

Feet: 400 200 0 400 800 1200

Metres: 100 0 100 200 300 400

400 FEET TO 1 INCH

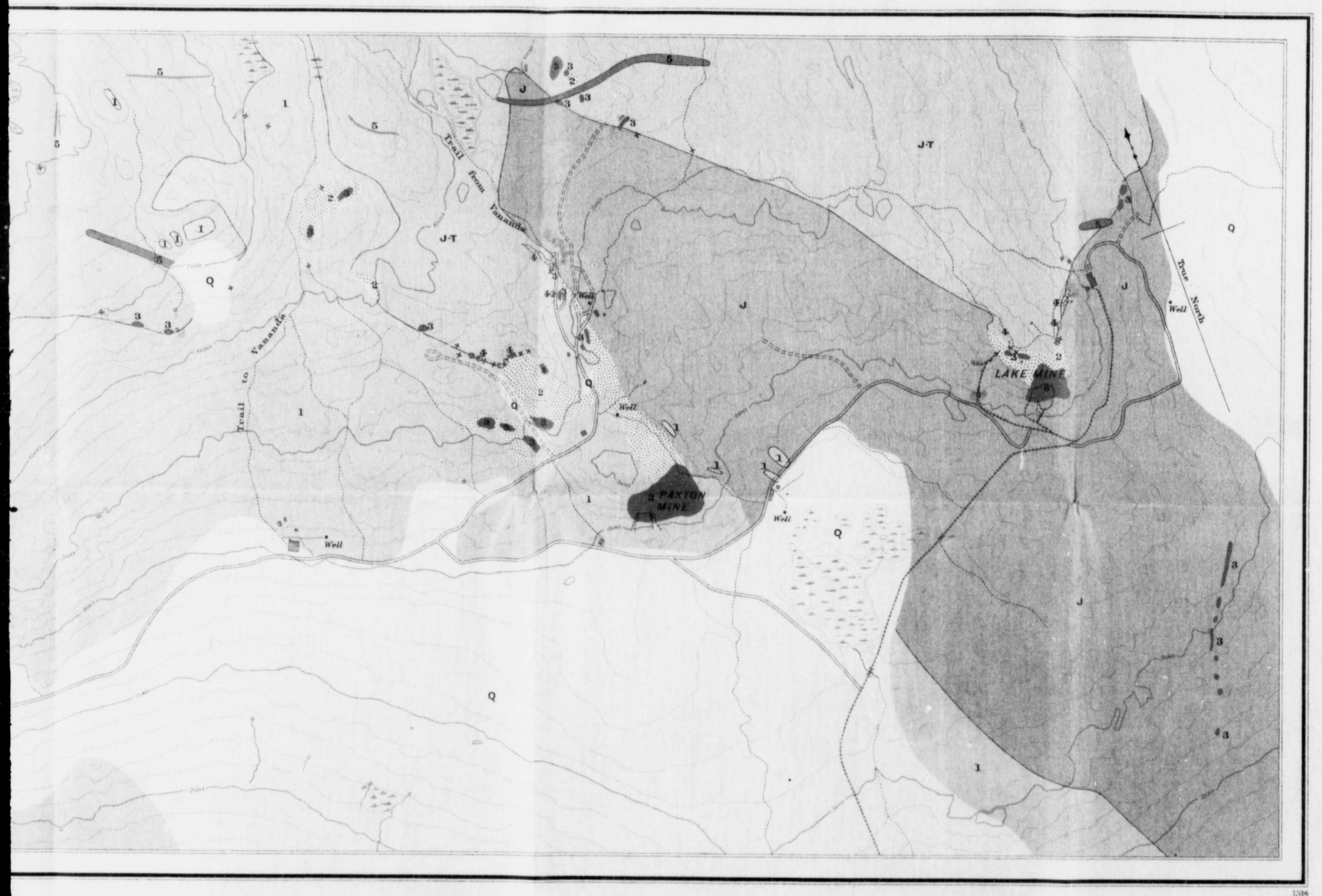
To accompany memoir by R.G. M^c Connell

Canada

Department of Mines

...ODERRE, MINISTER; R.G. M^C CONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY



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MAP 110 A
(Issued 1915)

...PAXTON AND LAKE MINES

TEXADA ISLAND

BRITISH COLUMBIA

Scale, 1/4800

400 FEET TO 1 INCH

GEOLOGY

R.G. M^C CONNELL 1909, 1912.

TOPOGRAPHY

D.A. NICHOLS, (IN CHARGE) 1912.
E.E. FREELAND, 1912.

LEGEND

Culture

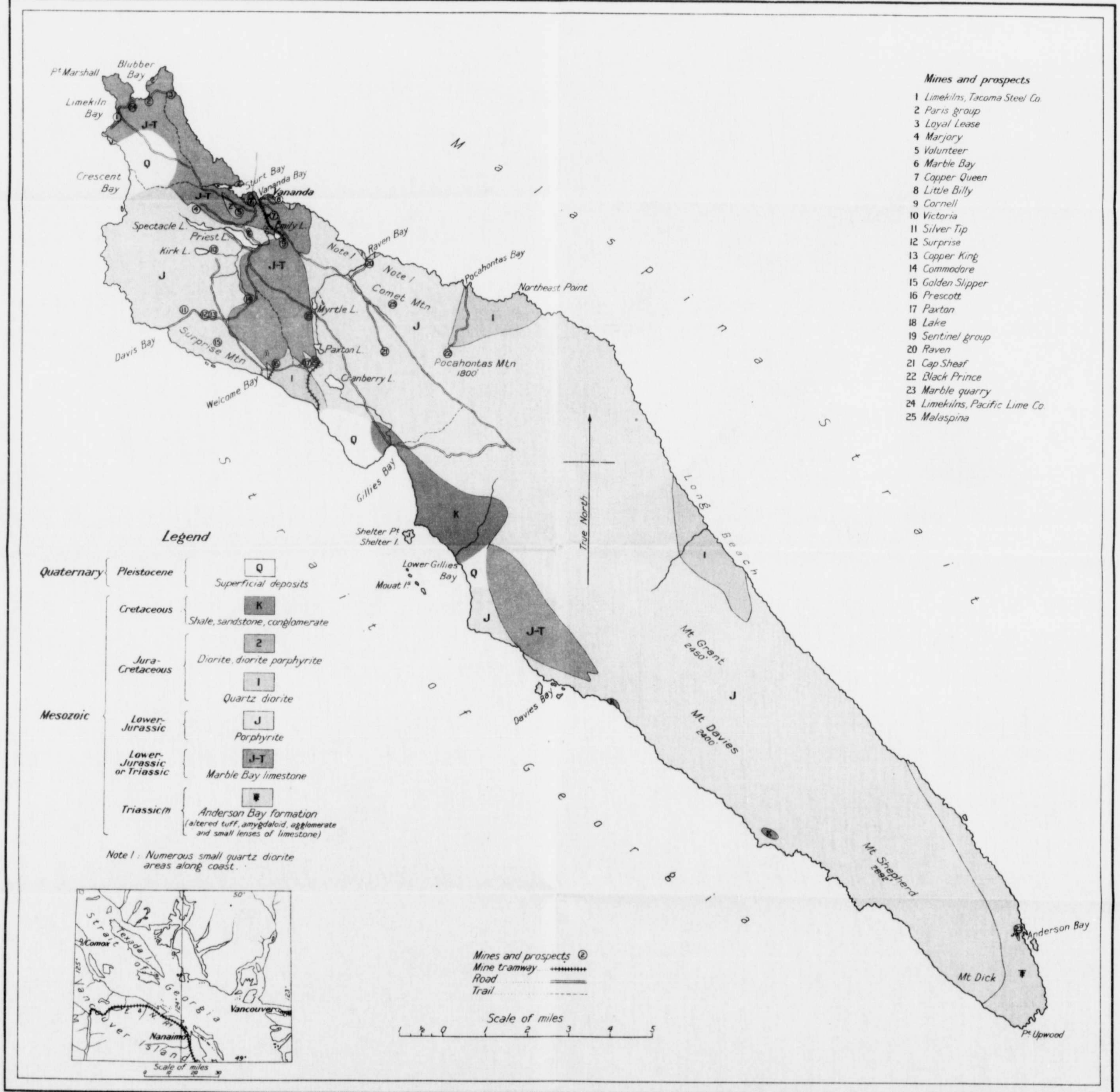
- Roads and buildings
- Roads *(not well defined)*
- Trails
- Mine tramways
- Bridges
- Shaft houses
- Shafts
- Tunnels
- Prospects
- Open cuts

Water

- Watercourses *(with intermittent flow)*
- Springs
- Marshes

Relief

- Contours *(showing land forms and elevations above sea level) Interval 20 feet*
- Depression contours
- Mine dumps



Geological Survey, Canada.

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Diagram showing the geology of Texada Island, British Columbia.

To accompany memoir by R.G. McConnell 1912