THE GEOLOGY OF THE CENTRAL MINERAL BELT OF NEWFOUNDLAND

A COLLATION & CONTRIBUTION

DEPOSITED BY THE FACULTY OF
GRADUATE STUDIES AND RESEARCH

IxM .1SG7.1928

McGILL
UNIVERSITY
LIBRARY

ACC. NO. UNACC. DATE 1928

BOUND BY McGILL UNIVERSITY BINDERY

THE GEOLOGY

of

THE CENTRAL MINERAL BELT OF NEWFOUNDLAND:

A COLLATION AND CONTRIBUTION.

Being

A THESIS

Submitted to

The Faculty of Graduate Studies and Research, McGill University, in partial fulfilment of the requirements for the degree of Master of Science,

May, 1928.

By ALFRED KITCHENER SNELGROVE, B.Sc.

List of Contents.

List of Contents (continued)

List of Illustrations.

"Concerning the inland commodities, as wel to be drawen from this land (Newfoundland) there is nothing which our East and Northerly countries of Europe doe yeelde, but the like also may be made in (it) as plentifully by time and industry: Namely, rosen, pitch ... metalls, and many moe. All which the countries will aford, and the soyle is apt to yeelde. ...For besides these alreadie recounted and infinite moe, the mountains generally make shew of minerall substance: Iron very common, lead, and somewhere copper. I will not auerre of richer metalls: albeit ... more then hope may be concieued thereof."

---Narrative of Captain Hayes,
second in command to Sir Humphrey
Gilbert's Expedition, 1583.
From Hakluyt.

INTRODUCTION.

The investigations set forth in the following pages were made in the field in Newfoundland during the summer of 1927, and later in the laboratories and library of McGill University, and in the library of the Canadian Geological Survey at Ottawa, with the purpose of collating and adding to our knowledge of the geology of an area roughly wedge-shaped in outline, and nearly nine thousand square miles in extent, stretching across the centre of the island of Newfoundland, from the southwest to the northeast coasts. To the description of this district, which contains most of the known mineral occurrences of Newfoundland, the term 'mineral belt' is here introduced.

The northeastern part of this belt, hereinafter referred to as the Central Mineral Belt of Newfoundland, is already familiar to the mining industry by reason of having produced, in the past, copper ore from Notre Dame Bay, which ranked the island sixth among the copper producing countries of the world during the 'eighties. At the present time, interest is again being attracted by the development of new copper-lead-zinc deposits occurring at Red Indian Lake, in the centre of the belt.

The remainder of the Central Mineral Belt of Newfoundland, is, however, still largely a terra incognita to the geologist and the prospector, and the author presents this work with the hope that it may serve, to some extent, as a basis and encouragement to further exploration and exploitation.

CHAPTER 1.

Since one of the aims of this work is to systematize the present knowledge of the geology of the area designated as the Central Mineral Belt of Newfoundland, the observations of previous writers will be reviewed at length in a succeeding chapter. It will suffice to give here a short synopsis of the data available, both published and unpublished.

Previous Work.

(a) Published.

The first geological description of any part of the belt is that by W. E. Cormack (6)[1], who crossed the island of Newfoundland from the east to the west coast in the summer of 1822, with the purpose of ascertaining whether the interior was still inhabited by the Beothuck aborigines. Mr. Cormack was a mineralogist as well as an explorer, and his account includes many references to the rocks which he encountered on his journey of discovery.

In 1839, the government of Newfoundland, realizing the importance of a geological survey as a means to open up the country for development, engaged the services of a noted young English geologist, James Beete Jukes (24,25). After spending two years in examining the coasts, with occasional trips inland, and strangely enough without discovering any mineralization of note, and not a single fossil, Jukes returned to England in 1842.

It was not until 1864 that the Geological Survey of Newfoundland was resumed. In that year, Alexander Murray

(1) Numbers in brackets refer to bibliography, at the end.

of the Canadian Geological Survey, was sent to Newfoundland by the director, Sir William Logan, at the request of the Newfoundland authorities. Murray laboured on the island until 1883, when he was succeeded by his assistant, James Patrick Howley, who continued the work until 1909. To these pioneers we owe most of our present knowledge of the geology of the island. The official geological map of Newfoundland, and the annual reports of progress, issued from 1864 to 1909 (12) are the fruit of their investigations.

Shortly before Murray went to Newfoundland, the discovery of copper ore in Notre Dame Bay in 1857 by Smith McKay introduced a long period of successful mining activity. Mr. McKay's visit to this region was not, according to Rev. M. Harvey (16), by mere accident, but rather "at the suggestion of Sir William Dawson, the eminent geologist of Canada ... who predicted that copper and other ores would be found in the serpentines." Unfortunately, however, the amount of geological information which has found its way into the literature as a result of these operations is very scant. Wadsworth (65) examined the bay in 1884, and described many of the rocks and minerals which he found; and Garland (11) and Marett (31) contributed papers on the Tilt Cove mines. The Geological Survey also devoted several seasons to this area.

At the southern end of the Central Mineral Belt, on the south coast, a little exploratory work has been done on various lead, copper and gold occurrences, but this enterprise, which was confined to the immediate vicinity of the shores, has left no record in the literature.

Of the more recent work, the most important is that of Professor Edward Sampson of Princeton University, (54), who in 1923 described the Ferruginous Chert Formations of Notre Dame Bay. This paper was a report on a portion of the field work carried out by the Princeton University Geological Expeditions to Newfoundland.

During the present year, Mr. Hans Lundberg (30) described recent results in electrical prospecting in Newfoundland, and the present writer (59) gave a history of mineral exploration in Newfoundland during the decade 1917-1927.

(b) Unpublished.

One of the latest chapters in the history of the development of this area is that of the efforts of the Natural Resource Department of Mines & Forests (Newfoundland) Limited, a subsidiary of the Reid Newfoundland Company, Limited, late operators of the Newfoundland Railway and Steamship Services. This organization, during the past ten years, has performed considerable work in an endeavour to resuscitate the copper industry of Notre Dame Bay, and in addition to making an examination of most of the old properties of that region, has mapped geologically the extensive land lots which they own, some of which occur within the Central Mineral Belt. It was the author's privilege to serve for several summers as an assistant on these surveys. Such is the paucity of the published work on areas occurring within the extensive province of this thesis, that the author would hesitate to attempt it, were it not that the private records of the Natural Resource Department have been kindly placed at his disposal.

The present field work.

The field work performed by the writer in the season of 1927 includes geological traverses of Hind's River and Lake and vicinity, between Grand Lake and Red Indian Lake, in the interior; of the Newfoundland Railway between Grand Falls and Kitty's Brook, a distance of sixty-seven miles, which gives a base line for correlation and interpolation between the productive districts of Notre Dame Bay and Red Indian Lake; and of the Badger-Hall's Bay Road, thirty-five miles in length, and for the most part in the copper bearing formations. In addition, studies of the local geology of the new Red Indian Lake properties and some of the Notre Dame Bay mines were made. Unfortunately, time does not permit of a full description of all this field work in the present paper.

Method and Scope of Investigation.

The method adopted in treating the material at hand consists first in defining a mineral belt, delimiting the Central Mineral Belt of Newfoundland, and describing the types of deposits; following which is an account of the physiographic features. Under the chapter entitled General Geology will be found a survey of the observations of previous workers, as collected from their various publications, many of which are long since out of print and extremely rare. Then follow descriptions of the geology and petrography of various areas examined during the past summer. A bibliography which is believed to be comprehensive is appended.

Acknowledgments.

The author wishes to express his sincere thanks to the following who have facilitated his work: The Canada-Newfoundland Syndicate of Montreal, for permission to use most of the information and material collected by him for them during the past summer; Mr. Loyal Reid, of the Reid Newfoundland Company, Ltd., for numerous ore specimens and for access to the records of the Natural Resource Department, and also Mr. H.B.Hatch, late chief geologist of that company; Mr. Williams, manager, and Dr. W.H.Newhouse, geologist, of the American Smelting & Refining Company, (Buchan's Mining Company) for courtesies extended during a visit to their property; Messrs. Weeks and Corlett of the Porcupine Goldfields & Finance Company, for rock specimens and geological map of their property, Red Indian Lake; Hon. W.J.Walsh, Minister of Mines, Newfoundland for his cooperation; Mr. Hans Lundberg of the Swedish-American Electrical Prospecting Company, for many suggestions; Mr. Thos. E. Wells, for ore specimens from Great Gull Lake Copper Property; Dr. F.H.Sexton, for information concerning the Rose Blanche property; Mr. W.F.Joyce, chief engineer, Newfoundland Railway, for maps; Mr. Tipping, manager, Newfoundland Pulp & Paper Company, Grand Lake, for maps; the officials of the Peter Redpath Library, McGill University, and of the Canadian Geological Survey and Library, Ottawa; and finally, Professors Graham, O'Neill, Adams, Bancroft, Clark and Erlenborn of McGill University, to whose instruction, criticism and advice is due whatever merit this dissertation may possess.

CHAPTER 2.

MINERAL BELTS IN GENERAL.

THE CENTRAL MINERAL BELT OF NEWFOUNDLAND DEFINED.

TYPES OF DEPOSITS.

Mineral Belts in General.

The term mineral belt is of very common occurrence in geological literature, and has been applied in describing groups of deposits of widely different characterictics. An essential feature, common to all mineral belts, however, appears to be a more or less continuous horizontal distribution of mineralization over an area greater in length than breadth, and comprising deposits which stand in either genetic or structural relationship with one another.

The definition of mineral belt given by Weed,(67), viz., "The strip, or zone, of mineralized territory in a given formation or district," is it will be observed as largely geographical as geological; and it is in this wide sense that the term is used in this work.

A mineral belt, in its more obvious import of a circular or elliptical arrangement of deposits, is exemplified by the nickel-copper deposits bordering the Sudbury basin of Ontario; but by an extension of meaning, it is generally used to connote any linear distribution of deposits over a tract narrow in proportion to its length. Thus Lindgren (28, p.558) refers to the Leadville-Boulder mineral belt of Colorado, a district about eighty miles long by twenty miles wide; and Spurr (60, p.481) illustrates the east-northeast ore belt of Utah.

Relation to Metallographic Province:

In comparatively recent years, the study of metallogenetic epochs, as first developed by de Launay; and of metallogenetic or metallographic provinces, as elaborated by Spurr (60) has been fruitful of many important results which are of present interest. Spurr defines a metallographic province as one "in which the metals possess a unity, a blood relationship, distinctive of that province." In North America he finds "various ... straight mineral zones ... some northeast and some northwest; these are believed to represent some geometrical blocking out of the metalliferous under-earth, and to be ultimately related to the geometric forms of the earth's face." The present writer construes a mineral belt to be a special case of a metallographic province, in which the deposits exhibit a more or less perfect linear alignment.

Relation to Metallogenetic Epochs.

In the Appalachian province of eastern North America, the relation of which to the Central Mineral Belt of Newfoundland will be referred to later, there have been two main metallogenetic epochs:

(1) In the pre-Cambrian, in which iron, copper, nickel, gold and silver deposits of igneous affiliations, and of high temperature and deep-seated types were formed;

(2) In the Paleozoic, when appear

(a) gold-quartz deposits, genetically connected with granitic intrusions of early Paleozoic to Carboniferous age. These ores are found from Nova Scotia to Alabama.

and (b) pyrite and chalcopyrite deposits of less definitely determined age and relations.

A third and minor epoch is that accompanying Triassic vulcanism, when ores principally of copper were deposited. (28).

At the present stage of our knowledge, insufficient information is available to permit of correlating the deposits of the Central Mineral Belt of Newfoundland with any one of these metallogenetic epochs. It is possible, however, that the effects of both the Pre-Cambrian and the Paleozoic epochs may be represented.

The Central Mineral Belt of Newfoundland Defined.

The Central Mineral Belt of Newfoundland is defined arbitrarily as follows: The shores of Notre Dame Bay, on the northeast coast of the island, between Partridge Point on the west, and the eastern end of New World Island on the east, representing a width of eighty miles; and the tapering prolongation of this zone for two hundred and ten miles in a direction south thirty degrees west across the island to the southwest coast between Rose Blanche Bay and Cinq Cerf Bay, a width of about twenty-five miles.

The reason for narrowing the boundary of the belt thus to the southwest is made apparent by examining the official geological map of the island. Along a practically rectilinear coast line running east-west for over one hundred and fifty miles, the only known metallic mineralization is confined to the strip between Rose Blanche Bay and Cinq Cerf Bay. This is considered as evidence for a definite 'mineral zone' in the area outlined.

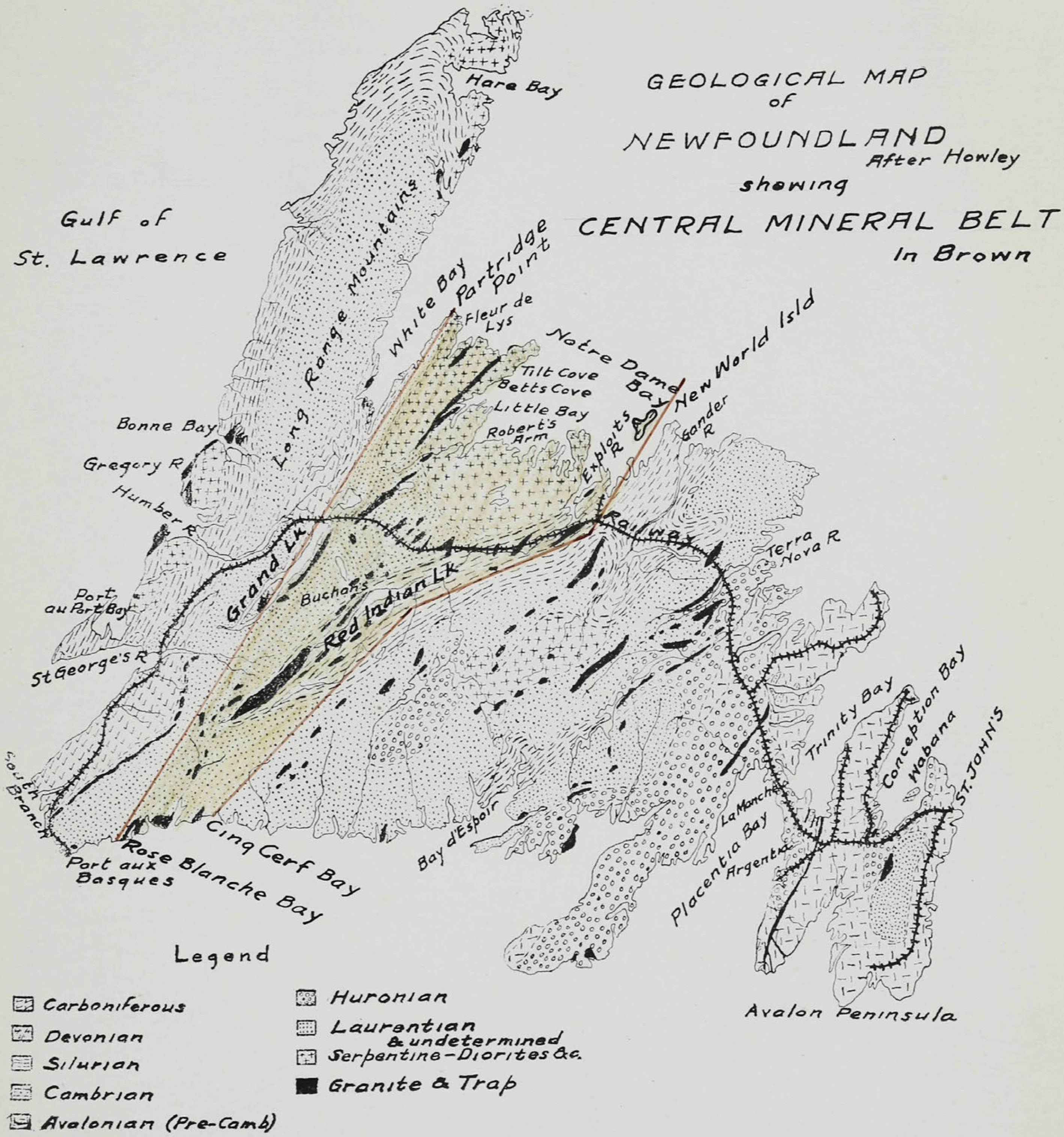

GEOLOGICAL MAP
of
NEWFOUNDLAND
After Howley
showing
CENTRAL MINERAL BELT
In Brown
Gulf of
St. Lawrence
Hare Bay
Long Range Mountains
White Bay
Partridge Point
Fleur de Lys
Notre Dame Bay
New World Isld
Tilt Cove
Betts Cove
Little Bay
Robert's Arm
Exploits R
Gander R
Bonne Bay
Gregory R
Humber R
Grand Lk
Buchans
Red Indian Lk
Railway
Terra Nova R
Port au Port Bay
St George's R
South Branch
Port aux Basques
Rose Blanche Bay
Cinq Cerf Bay
Bay d'Espoir
Placentia Bay
La Manche
Argentia
Trinity Bay
Conception Bay
Wabana
ST. JOHN'S
Avalon Peninsula
Legend
Carboniferous
Devonian
Silurian
Cambrian
Avalonian (Pre-Camb)
Huronian
Laurentian & undetermined
Serpentine-Diorites &c.
Granite & Trap

Figure 1.

Within the boundaries of the Central Mineral Belt as delimited above, there occur metallic deposits comprising ores of copper, sulphur (pyrite), iron, lead, zinc, molybdenum, antimony, arsenic, silver, gold and manganese. To date all exploratory and development work on these deposits has been confined largely to three districts, viz.; (1) Notre Dame Bay District, (2) Red Indian Lake District, in the interior, and (3) The Southwest Coast District. Outside of these three areas, very little is at present known of the economic geology of the belt, due both to lack of exploration and to the mantle of drift which in many places conceals the bedrock. Several seams of coal are also known to occur in the west central part of the belt, but these will not be treated in this work.

Of the metallic mineral deposits of Newfoundland found outside of the Central Mineral Belt, the most important are the sedimentary iron ores of Wabana (Bell Island), certain lead deposits in sediments classified as Huronian in Placentia Bay, on the east coast, and various copper and lead ores on the west coast. In these several occurrences the deposits are, for the most part, isolated, and none of them exhibit the features of a mineral belt such as are shown so strikingly in the Central Mineral Belt.

TYPES OF DEPOSITS IN THE CENTRAL MINERAL BELT.

Comparatively little detailed work has as yet been done on the deposits, but even with the meagre amount of information available it is possible to propose a tentative classification of the main types represented.

(1) NOTRE DAME BAY DISTRICT.

General Geology: The general geology of this district is summarized by Sampson (54) thus, (in part):-

"Throughout the whole district the structure is exceedingly complex. Faulting is highly developed, but folding is not conspicuous and is seldom observed, although dips are high, often vertical. Several series of rocks can be recognized, the oldest being volcanic.

Cambrian (?)

"One great series is composed very largely of andesitic pillow lava with minor amounts of basic breccia and tuffs of variable composition. Ordinary sediments appear to be lacking. Chert is often found in the spaces between the pillows, and also with heavy beds associated with tuffs. In places there are exposed great sections of tuffs, breccias, and flows which show no pillow structure. Such sections do not contain chert. These sections are not simply different facies of the pillow lava series, but are thought to represent a distinct series. As to the age of these two series, evidence is scanty. That the first mentioned series containing chert is considerably older than the Upper Ordovician is indicated by the relative degree of metamorphism, and particularly by the finding of its characteristic green chert in conglomerates of Upper Ordovician age. This series is probably of Cambrian age. As to the other series which does not contain pillow lavas or chert, we can only say that it is intermediate in age between that of the old pillow lavas and the Middle Ordovician.

Ordovician.

"The known Ordovician rocks are represented in the lower sections by volcanics and shales. The volcanics are principally pillow lavas of andesitic composition and tuffs which are mostly acid. Throughout Notre Dame Bay rhyolite flows are practically absent, the rhyolite eruptives being clastic and represented principally by tuffs which show somewhat waterworn fragments. Thin beds of chert are often found associated with these tuffs. In some places, the volcanics are wanting, and shales containing beds of chert take their place, though a persistent black graptolitic shale fixes the age of these rocks as contemporaneous with sections showing volcanic products. The graptolites are of Llandeilo age. In the higher sections, there are sandstones and some conglomerates, both of which are commonly red. In places on the east side of New World Island, limestones of Caradoc age are associated with pillow lavas and volcanic breccias, some of which breccias have a lime cement. At Burnt Arm, branching from Goldson Arm, a pillow lava was seen with fossiliferous limestone in the spaces between the pillows. The lime mud must have been caught up when the lava was extruded. Here, at least, the evidence for the subaqueous nature of the pillow flows is clear.

Silurian.

"The Silurian rocks are principally sandstones and conglomerates, usually red. Very thick sections are exposed, those studied being in the extreme south of the bay and on the Exploits River. They are in places highly fossiliferous. Volcanic rocks are almost entirely absent in the known Silurian. No chert has been found in the Silurian or in the upper part of the Ordovician.

"Intrusive igneous rocks are abundant and varied and greatly complicate the structure of the region, ..."

Hatch (17) finds these intrusive rocks to range from diorites to olivine basalts. Mention should also be made here of the granite batholiths shown on the official geological map of the island as occurring parallel to the western shores of Notre Dame Bay. The possibility is here suggested that the basic dikes and other small intrusive masses, which have evidently been responsible for localizing the ore deposits in many places, are differentiates of the magmas of the granite batholiths. The writer can find no reference as to the age of these intrusive rocks, but the inference is that they are post-Silurian.* In order to establish a connection between the Notre Dame Bay District and the Red Indian Lake District, it may be stated here that in the interior part of the Central Mineral Belt, between Grand Lake and Red Indian Lake, a granite batholith is exposed, apparently striking in the same northeast-southwest direction, and in alignment with the main batholith of the northeast portion of the belt, i.e., the one paralleling the western shores of Notre Dame Bay. The age of the intrusion in the interior is considered as pre-Carboniferous, and possibly pre-Cambrian, because of a striking parallel with the pre-Cambrian rocks of the northern Ontario mining districts. (See Chapter 5, p. 58). If, however, the batholith-invaded

* Prof. Sampson in a personal communication (77) states that the intrusive rocks of Notre Dame Bay are later than any of the sediments.

lavas of the interior are of early Paleozoic age, as are those of the Notre Dame Bay region, the age of the granitic intrusions will have to be assigned to a later period, possibly Devonian, as in Nova Scotia (51, p. -) or even later.

Types of Deposits in the Notre Dame Bay District.

Hatch (17) classified the ore deposits of the Hall's Bay-Green Bay peninsula, in Notre Dame Bay, in two types:

> "(1) Veins, with chalcopyrite in a quartz gangue. These deposits are not of great importance.
>
> and (2) Disseminated ore in chloritic schist or 'killas.' This type is a combination of replacement and injection along planes of schistosity and fissures in the chloritic schist. Generally the ore occurs as disseminations through the schists, as stringers of variable length and width, and as masses of solid chalcopyrite in fissures. These deposits were formed at intermediate depth.

In both types, oxidation is generally absent, and there is no zone of secondary enrichment." In a subsequent classification, he stated that "The ore of the Green Bay (Notre Dame Bay) copper area is chalcopyrite occurring in three distinct types:

> "(1) Solid lenticular masses of cupriferous pyrite. This type is represented by the East Mine of Tilt Cove.
>
> (2) Lenticular masses of chalcopyrite in metamorphosed amygdaloidal basalt. This rock is locally known as 'killas' and is chloritic schist. This type is represented by the Bett's Cove and Little Bay deposits.
>
> (3) Veinlets, small irregular lodes, and disseminations of chalcopyrite in well-defined shear zones of the chloritic schist. This type is also represented by the Bett's Cove and Little Bay mines."

A more comprehensive classification for the whole of Notre Dame Bay District is here advanced, as follows:

(A) High temperature deposits.

(a) Veins.

(i) Gold-quartz-magnetite veins; example, Ming's Bight gold property.

(ii) Molybdenite-pyrrhotite-quartz-calcite veins; example, Fleur de Lys molybdenum property.

(b) Replacements.

(i) Chalcopyrite-bornite (with malachite) in calcareous gneiss (possible Grenville); example, Fleur de Lys copper property.

(ii) Pyrrhotite-magnetite-pyrite-chalcopyrite lenses in schisted diabase; intrusive rock not located; type, Great Gull Lake copper property.

(B) Middle vein zone and related replacement deposits.

(a) Chalcopyrite and pyrite in lenses in chloritic schist; example, Bett's Cove copper property.

(b) Chalcopyrite-pyrite-quartz in chloritic schist, adjacent to and genetically connected with (?) diorite-porphyrite dikes; examples, Little Bay and Whalesback copper deposits.

(c) Chalcopyrite and pyrite in a quartz gangue; country rock hard amygdaloidal basalt; example, Robert's Arm copper property.

(d) Impregnations of chalcopyrite and pyrite in joint and cleavage planes of intrusive 'Olivine basalt;' example, West Mine, Tilt Cove.

(e) Massive lenses of copper-bearing pyrite in 'Olivine basalt;' example, East Mine, Tilt Cove.

(f) Pyrite and copper-bearing pyrite, lenticular replacement deposits in talcose and chloritic schists; example, Pilley's Island pyrite property.

(Unclassified: Antimony, Moreton's Hr.; Iron, Fortune Harbour; Pyrite, Cobb's Arm; etc. etc.)

The deposits(A)-(a)- (i) Ming's Bight gold property,
(A)-(a)- (ii) Fleur de Lys molybdenum property
and (A)-(b)- (i) Fleur de Lys copper property
are probably connected genetically with granitic or other acid plutonic intrusions. The Ming's Bight deposit is near the border of a small (12 x 2 miles) granite batholith.

(2) RED INDIAN LAKE DISTRICT.

In the Red Indian Lake district, two mineral deposits have been known for some years. The more important of these, the Buchan's lead-zinc-copper property, is now being extensively developed by the American Smelting & Refining Company; and the second deposit, Victoria copper property, on the opposite (southeast) side of the lake, is also receiving further attention.

Geology: The geology of this district will be discussed in Chapter 6, but it may be noted here that there are two series of rocks present, an older one of andesitic and basaltic lavas and pyroclastics, which strike northeast and dip northwest, with a later intrusive series of granite, quartz porphyry and diabase.

Types of deposits in the Red Indian Lake District.

The Buchan's ore is an intimate mixture of lead-zinc-copper sulphides, in a barite gangue. (30). The orebodies occur as lenses and irregular masses in the pyroclastics adjacent to quartz porphyry stocks, and also in the quartz porphyry itself. In the latter case, there is less replacement of the walls. These deposits are evidently replacements, formed at intermediate depth.

In the Victoria mine area, the same general conditions as those found at Buchan's prevail. A zone of scattered small lenses and stringers of pyrite and chalcopyrite is found in schistose lavas and pyroclastics, intruded by small masses of quartz porphyry. The ore and gangue minerals are pyrite and chalcopyrite, very little sphalerite, some chlorite, quartz, siderite and garnet. These deposits apparently possess the features of deep intermediate zone replacements.

(3) THE SOUTHWEST COAST DISTRICT.

Several mineral discoveries have been made in this district in the past, but none has as yet attained importance.

The most noteworthy is the Rose Blanche Gold deposit. This property was examined some twenty years ago by Dr. F. H. Sexton, president of Nova Scotia Technical College, and he has kindly furnished a brief description (57). "The area is mainly composed of ancient schists and gneisses with irregular intrusions of granodiorite. The vein at Rose Blanche is a very large deposit of about one hundred and fifty feet thick and twelve hundred feet long, of white quartz very sparsely mineralized with pyrite. This vein can be traced for a distance of about three miles on the same strike. The quartz contains a little gold."

At Cinq Cerf, near the eastern boundary of the Central Mineral Belt, chalcopyrite-galena-quartz veins occur striking east-west (magnetic) or about north thirty degrees east (true). Several shafts have been sunk on these veins but no information is available as to the extent or richness of the deposits.

Criteria for Mineral Belt.

The numerous deposits found in the Central Mineral Belt of Newfoundland exhibit, on the whole, a notable parallelism in strike. Thus, the strike of the long axes of eight of the more important worked-deposits, mostly lenses in the Notre Dame Bay and Red Indian Lake districts varies between north thirty degrees east and north fifty-one degrees east, with an average of north thirty-nine degrees east (Astronomical). Moreover, the schistosity of the rocks, the strike of the sedimentary formations, the long axes of the intrusive batholiths, and the major faulting observed in the various mines conform broadly with this general northeast-southwest alignment. It is on the basis of the relationship of the deposits to the structural features that the step of applying the term mineral belt to this region is taken.

These physical features of the belt are believed to be intimately related to the Appalachian structure of the eastern part of the North American continent. Moreover, on physiographic grounds, Twenhofel (64) finds that the slope of the Cretaceous peneplain -- common also to the Appalachian province -- which is traceable across the entire island, with greatest elevations on the west coast and least on the east, is probably due to tilting that has occurred with uplift; and that this uplift does not appear to have blocks acting as units, of which the Long Range Mountains on the west coast is perhaps the most conspicuous. The possible coincidence of the Central Mineral Belt with one or more of these units seems suggestive to the present writer.

Paleogeographic Relations.

In a work of more recent date than that of Twenhofel, Schuchert (50) shows that the New Brunswick geanticline which was in existence very early in the Paleozoi and continued up to the close of the Devonian as the highland between the Acadic and St. Lawrencic geosynclines, and which included the granitic area of eastern Connecticut and Rhode Island and the White Mountains of New Hampshire, strikes across Maine into northern New Brunswick and southern Newfoundland. Schuchert's map, with which the present write was unfamiliar when he delimited the Central Mineral Belt of Newfoundland, represents this New Brunswick geanticline with a present average width of one hundred miles, as passing through Newfoundland in an area which is practically identica with that outlined as the province of this work.

CHAPTER 3.

PHYSIOGRAPHY.

General Features of Newfoundland.

The island of Newfoundland as a whole exhibits low relief, with maximum elevations in the Long Range Mountains on the west coast of less than 2600 feet, decreasing to about 700 feet on the east coast. The major topographic feature is the marked parallelism of the peninsulas, bays, lakes, rivers and ridges, all of which approximate a direction of about north twenty eight degrees east (64).

The interior is a peneplain having a gentle slope downward to the north and east, and dissected by several extensive river systems, chief among which are the Exploits, the Gander and the Terra Nova, flowing to the northeast; and the shorter La Poile and Bay d'Espoir rivers draining to the southwest. The monotony of the sky line in the hinterland is broken mainly by comparatively low, parallel ridges. In places, however, higher isolated monadnocks, of roughly elliptical outline, stand out prominently. The most westerly series of uplands, the Long Range, constitutes the backbone of the island, and assumes the proportions of a mountain range. Cutting across this range are two antecedent rivers, the Humber and the St. George's, whose westward flow is in marked contrast with the general northeast-southwest drainage of the remainder of the island. Indeed this is not the only anomaly presented by the general physiographic features, for despite the gentle slope of the island to the eastward, none of the major rivers drain to the east.

This, however, is possibly to be accounted for by considering the northeast-southwest drainage as mature 'subsequent.' In support of this view is the evidence, though not yet well substantiated, of the former eastward drainage of the narrow west-east trending Gander Lake into Bonavista Bay, rather than northeast into Notre Dame Bay as at present.

Twenhofel (64) was the first to point out that if the lowlands of Newfoundland were to be filled to the levels of the bordering highlands, the result would be a plain highest in the west, where it attains an elevation of 2540 feet in the Long Range Mountains, and sloping gradually to a height of about 700 feet at the east coast. He showed that this plain was developed on various structures and on rocks of various degrees of hardness, and concluded that it represented a peneplain which was probably developed in the Cretaceous.

The broad topographic features of Newfoundland to-day are mainly the result of erosion following the uplift and tilting of this Cretaceous base level, possibly accompanied by faulting; the softer rocks and weaker structures have been rapidly cut into, forming the lowlands, while the highlands are underlain by more resistant structures or by rocks of superior hardness.

Superimposed upon these earlier topographic features are the modifying effects of at least two glacial advances (74) now evidenced by the U-shapes of some of the upper valleys, the polishing and striations of the rock ridges, and the abundant deposits of glacial drift which blanket much of the island.

<u>Physiographic Province.</u>

The physical features of an island 42,000 square miles in area, separated at its nearest point by only nine miles from the North American continent, as is Newfoundland, might reasonably be expected to show a definite relationship to those of one or another of the physiographic provinces into which the mainland is naturally divided. Such is the difference of opinion in the meagre literature on the subject of the physiographic affinities of Newfoundland, that the present occasion seems opportune for reviewing the evidence, in order to justify the present writer's conclusions.

At first glance, the striking rias coast line topography of the island, with its long parallel peninsulas and deeply penetrating bays, corresponding in a general way to anticlinal and synclinal folds, respectively, indicates a projection of the northeast axes of the Appalachian system which borders the Atlantic seaboard from Alabama, United States, to Nova Scotia, Canada; although there is evident here a reversal of the structural relations generally found in the Appalachian Mountains, where synclines underlie the highlands and anticlines occupy the lowlands. On the other hand, and in view of the essential unity always to be found between geologic and physiographic conditions (4), the proximity of the Laurentian plateau, immediately to the northwest, and the equivalence in age (pre-Cambrian) of the rocks constituting much of Newfoundland with those of that major Canadian province, may be construed as evidence for the coincidence of Newfoundland with the vast Laurentian physiographic province of Canada. Moreover, Reudemann, in a paper published in 1922, (75), with the purpose of delineating and correlating the structures of the various pre-Cambrian areas of the world, came to the conclusion that the pre-Cambrian folds of North America exhibit a grand and simple curvature, which in the eastern part of the continent have a northeast direction.* The question naturally arises as to whether this structural feature of the Canadian shield or Laurentian plateau is sufficient to account for the configuration of Newfoundland.

The first attempt at a physiographic correlation of Newfoundland with North America, is apparently that of Wilson (71), who in his paper on The Laurentian Peneplain, included most of the island within that physiographic province, which is known to have been reduced to a peneplain by Cretaceous time, although most of the levelling occurred in pre-Cambrian times. Twenhofel, however, in a work (64), that is a standard reference on this subject, correlates the peneplanation of Newfoundland with that of the Appalachians, both as to the period of development and the close of the cycle (Cretaceous).

It is noteworthy, in this connection, that the planation of both the Laurentian Plateau and of the Appalachians is referred to the Cretaceous; and if, as

*Cf also Schuchert (50), pp.549-550. "The general east-northeast trend of the basement structures doubtless reveals the axial relations of the Archeozoic mountain ranges.

O'Neill suggests (44), the summits of the Monteregian hills of the St. Lawrence lowland bridge these two provinces, the distinction between them loses weight somewhat, insofar as the present discussion is concerned.

Nevertheless, because Newfoundland has shared in the Appalachian revolution, which began here some time late in the Paleozoic (55), it seems logical to regard the island as an outlier of the Appalachian physiographic province.

Physiography of the Central Mineral Belt.

The most prominent topographic features of the Central Mineral Belt are the isolated, roughly elliptical and often steep-sided monadnock hills and ridges which occur in the central and southern regions. Among these, several are over 2,000 ft. high, e.g., Hodge's Hill (2200 feet) and Annieopsquolch Mountains (2043 feet); while many exceed 1,500 feet, viz., Blue Hills of Coteau (1093 feet), Red Indian Lookout (1875 feet), Main Topsail (1829 feet), Anderson Lookout (1690 feet), Old Harry (1630 feet), Lobster House (1570 feet), Notched Mountains (1555 feet) and Mizzen Topsail (1550 feet). These are the land marks of the central plateau, the average elevation of which is probably little over 1,000 feet.

For purposes of topographic description, the Central Mineral Belt may be divided into the following districts: (1) The Exploits River or Northern Drainage Basin, (2) The Notre Dame Bay Region, (3) The Western Drainage Basin, and (4) The Southern Drainage Basin.

(1) The Exploits River.

This extensive river system lies almost wholly within, and drains a major portion of, the Central Mineral Belt. Its headwaters extend to within twenty-five miles from the south coast of the island, where several small mountain torrents flow into King George IV Lake, with an area of about eight square miles and at an elevation of 1237 feet. The outlet of this small lake skirts for almost thirty miles the northwest side of the Annieopsquolch Mountains, expanding meanwhile into the long and narrow Lloyds Pond (elevation 620 feet), and finally emptying into Red Indian Lake (elevation 481 feet), which has an area of about sixty-four square miles, and is the second largest body of water in the central plateau. The west shore of Red Indian Lake is bordered by the abruptly-rising extension of the 'trap' ridges of the Annieopsquolchs. The east shore of the lake, however, is considerably lower, and receives the waters of Victoria River, which after rising on the south of the Annieopsquolch Mountains, only a few miles from the headwaters of the main river, pursues an almost parallel course towards Red Indian Lake. At the outlet of this lake, the Exploits River proper swings somewhat to the east, receives the waters of several large tributaries, chief among which are Harpoon, Noel Paul's and Badger Brooks, and then wends its way with many rapids and falls over the low Silurian plain to the sea at Notre Dame Bay.

(2) Notre Dame Bay Region.

The Bay of Notre Dame exhibits in a striking manner the features of a drowned shore line. The axes of the ridges of the mainland are prolonged in the Notre Dame Bay archipelago, the islands of which have in general a northeast elongation. These islands are low-lying and in many instances are almost barren, due to the action of wave and wind. The rugged coast line at the south of the bay is an extremely sinuous one; but the western shores are bluff and rectilinear, and are broken only by small transverse valleys which are the site of fishing villages and of some old mines.

The hinterland in this vicinity is also barren in many places, apparently due in part to the inimical influence of magnesian rocks, such as serpentine and talc, upon plant life. On the other hand, extensive tracts of good pulpwood timber are met with in the valleys and on the slopes of many of the rugged ridges with which this district abounds. The inland country may be described as a drift covered plateau, about 400 feet above sea level.

The chief rivers of the Notre Dame Bay mainland are Indian Brook, whose headwaters are separated by only a few miles from some of those of the westward-draining Humber system; and South Brook, both emptying into Hall's Bay. Some of the tributaries of the latter have their source in the desolate granite terrain of the Topsail Mountains.

Of the peninsula between White Bay and Notre Dame Bay, which may be considered as an extension of the central plateau, little is known at present.

(3) The Western Drainage Basin.

The Central Mineral Belt, as defined in the preceding chapter, embraces a part of the Humber system, which flows to the west coast, and includes Grand Lake, the largest body of water on the island. In the opinion of Perret (47) the basin of this lake is a prolongation of the synclines of the Bay of Fundy and of Prince Edward's Island, Canada.

The shores of Grand Lake rise fairly abruptly to over 1000 ft., and from the flat-topped highlands on the southeast side an excellent panorama is obtained of the topography which is typical of much of the interior. The plateau level, with its barrens, swamps and 'flashets,' -- small,shallow ponds -- is interrupted only by comparatively low northeast trending ridges, and by isolated monadnock 'tolts' or knolls, on the sheltered slopes of which scrub vegetation and small trees are found. At least some of these knolls, e.g., Lobster House, present from a distance an outline which is strongly suggestive of "craig and tail" topography.

As evidence of the uplift of the island of Newfoundland Twenhofel (64) cites the terraces which are found both on the coast and around some of the interior lakes. At Grand Lake he notes three, at about 5, 15 and 60 feet above lake level. In recent years this lake has been raised by artificial damming to 22 feet above its original level of 255 feet above sea level. As a consequence, the first two levels mentioned cannot now be observed; but at the mouth of Hind's Brook, on the east side of the lake, what appears to be the third was recognized. Much more conspicuous, however, and at the same place is a terrace in bowlder material at a level determined barometrically as 105 feet above the present level of Grand Lake -- or in other words, about 352 feet above sea level -- and extending about one-half mile back to the foothills.

The comparatively unknown Hind's Lake, which empties into Grand Lake by way of the torrential Hind's River, in a steep sided gorge, is fringed by a beach of bowlders which average between one and two feet in diameter. These bowlders are of widely different petrologic types, and are believed to be of morainic origin, although their present roundness is probably due to lacustrine wave action. The beach rises to about five feet above the summer level of the lake and in many instances forms a barrier or ice rampart at the mouth of the small tributary brooks and ponds.

Further south in the Central Mineral Belt, the St. George's River drains a small section, south of Grand Lake and west of Red Indian Lake.

(4) The Southern Drainage Basin.

In consequence of the northerly slope of the central plateau, only a small part of the belt is drained southwards, by way of the LaPoile River and its tributaries. This river, at a distance of but twenty miles from the south coast of the island, has its headwaters in the

Fig. 2.- View looking east from south bank near mouth of Hind's River, Grand Lake, showing remnant of uplifted and tilted Cretaceous peneplain in background; and terrace at 105 feet above lake level, on north bank of river.

Fig. 3 - Nearer view looking east from south bank of Hind's River, quarter mile upstream from Grand Lake, showing terrace at 105 feet above lake level.

mountainous country south of Red Indian Lake, one of the least known portions of Newfoundland. As Perret said (47) in 1913, "The hinterland of LaPoile Bay is as little known as the centre of Africa." Bellairs, who traversed this region in 1868, refers to it as "a desolate wilderness of rocky ridges alternating with vast savannas and marshes, cut by a network of torrents which run through rugged gorges towards the fiords which carve the south coast. It is bleak granite country." (Quoted by Perret, 47).*

---

* Translation by the present writer.

CHAPTER 4.

GENERAL GEOLOGY OF THE CENTRAL MINERAL BELT OF NEWFOUNDLAND.

COLLATION OF PREVIOUS WORK.

"There can be nothing more fatiguing to the mind, when it is engaged on so comprehensive a subject as that of developing the resources of an unknown region like Newfoundland, to be fettered and embarassed with the shackles of dry detail; and yet, if the reader of such a work does not obtain all the information which it is in the power of the author to give or to collect, he turns away from it with disdain, and observes that more might have been done, 'considering the time and opportunities of the writer.' "

-- Sir R.H.Bonnycastle, (3)
"Newfoundland in 1842."

It is proposed to review in some detail in this chapter the work of the various geologists, travellers, and writers who have directed their attention to the geological features of that part of Newfoundland which is here designated as the Central Mineral Belt. This purpose is not only desirable, in order to interpret the previous results, and to correlate the present findings with them; but it is rendered essential by reason of the extreme rarity of some of the earlier publications in which the observations in question are recorded.

The Work of Cormack, (1822 and 1827).

The earliest recorded exploration of note in the interior of Newfoundland is that made by W. E. Cormack, who in 1822 crossed the island from the east coast at Trinity Bay to the west coast at St. George's Bay, in order "to see the rocks, the deer, the beavers, and the Red Indians, and to tell

King George what was going on in the middle of that country," as he explained to one of the mountaineer Indians whom he encountered. Mr. Cormack's track, as indicated on the official geological map of Newfoundland, passed through the Central Mineral Belt in the vicinity of the watershed between the Exploits and LaPoile rivers, near the south coast. Referring in his narrative (6) to the general features of the western interior he states, "The western territory is entirely primitive. No rocks appear but granitic. The only soil is peat, which varies in quality according to situation. In the valleys some patches are very similar to the savanna peat in the eastward, but as the peat ascends, it becomes shallower and lighter until it terminates at the summit of the mountains in a mere matting."* Cormack's geological notes are plotted on a map made twenty years later by the first geological surveyor of the island, Jukes, although as Bonnycastle points out (3) "Jukes, when putting Mr. Cormack's discoveries on the map of the island, forgot that that gentleman saw and stated the positions of the metallic rocks in the part of the interior he passed over, as well as the red sandstones and serpentines, the sienites and greenstones." A photograph of part of this rare map will be found on page

After reaching the west coast in an exhausted condition and still suffering from the effects of his arduous sixty-five day journey, Cormack returned by ship along the south coast to Fortune in order to take passage back to England. On his coastal voyage he noted that "the prevailing rock

*Cf also Pirsson (50, p166)

(at Seal Island) is mica slate," while at Cingserf (or, more properly, Cinq Cerf) "trap rock prevails." Summarising his observations along the south coast, some of which refer in particular to places within the Central Mineral Belt as at present defined, he notes, "The rock formation of the coast between Cape Ray and Bay of Despair (Bay d'Espoir) may be noticed in a general view as follows: red sandstone of the coal formation is found next to the trap rock, six or eight miles east of Cape Ray. Then we come to primitive rocks, mica slate, gneiss, and granite; next are trap and old red sandstone alternating, which, with the granite rocks, form the coast all the way eastward, presenting little else than most barren and precipitous hills, half clad with stunted firs, and indented everywhere with harbours, bays, and rivers. Few of the harbours have any soil at those parts nearest the sea, there being merely debris in small patches. At the head, however, of most of the harbours and bays, and along the margins of the waters that discharge into them, some good soil and spruce are to be found. Rock crystal of different colours are stated by the inhabitants to occur in qualtities at Harbour le Cou and Diamond Cove in that neighbourhood. Several of the inhabitants possessed transparent specimens as curiosities." These latter remarks relate, no doubt, to the extensive quartz veins, in places auriferous, which occur between Rose Blanche and Harbour le Cou, as already mentioned on page 21.

On a subsequent journey, undertaken in 1827, Cormack entered the country by the northwest arm of the River of Exploits, crossed to Hall's Bay through "an almost uninterrupted forest," pushed forward westward to the mountains south of

White Bay, and returned to the sea coast by way of Red Indian Lake and the River of Exploits, having covered over 220 miles in thirty days. The only reference to geology in his account of this journey is as follows, "One of the specimens of mineralogy which we found in our excursion, was a block of what is called Labrador feldspar (Labradorite), nearly four and a half feet in length by about three feet in breadth and thickness."

The Work of Jukes,(1839-40).

The first geological work to be carried out in Newfoundland under government auspices was performed by J. B. Jukes, M.A., F.G.S., of St. John's College, Cambridge, during the years 1839-40. Mr. Jukes published the following reports (24, 25):-

(1) Report on Geology of Newfoundland, 29 pp. St. John's, 1839; In part, Edinburgh New Philosophical Journal 29: 103-111 (1840).

(2) General Report of the Geological Survey of Newfoundland during the years 1839 and 1840, (Map) London, 1843

(3) Excursions in and about Newfoundland during the years 1839 and 1840; London, John Murray, 1842 (Including General Report of Geol.Survey of Nfld 1839-40).

Jukes, after an investigation extending over two years and confined chiefly to the shores of the island, divided the sedimentary rocks of Newfoundland into the following formations:

1. Coal Formation - - - - (a.Upper Portion
)b. Lower or Red Portion

1a.Magnesian Limestone
2. Upper Slate Formation -(a.Belle Isle shale & gritstone
)b.Variegated slates
3. Lower Slate Formation (a.Signal Hill sandstone
)b.St. John's slate
4. Gneiss & Mica Slate Formation.

Very wisely, he refrained from using terms which might have a theoretic import, at a time when the succession in Canada had not yet been worked out, and in the absence of fossils with which to correlate the formations with those of Europe. The map of Fig. 4 page 40 shows the distribution of these formations in the neighbourhood of the Central Mineral Belt.

"As regards the relative age of the igneous rocks," Jukes observes, "it appears that the granites are generally newer than the mica slate and gneiss, which repose upon them. It is also evident that the large mass of porphyritic granite on the south coast is more modern than some of the shales, flags and schists about LaPoile, inasmuch as these latter are penetrated by veins from the granite." (Cf. page).

As might be expected from the restricted nature of his reconnaissances, and the limited time at his disposal, Jukes has little of importance to add to the present discussion. One can, however, join with Perret (47) in saying "Jukes has left an admirable work, clear, methodical and precise. To be sure, modern work has much to add to that of Jukes, but it has nothing to subtract; and I think that no scientist could wish greater praise."*

The Work of Bonnycastle, (1842).

Sir R. H. Bonnycastle, Lt.-Col. in the corps of Royal Engineers, published in 1842 a work entitled "Newfoundland in 1842," (3), in which pp. 179-222 are devoted to the geological relations of the island. Himself a military writer who "neither pretends to abstruse geognostic knowledge,

---

* Translated from the French by the present writer.

Portion of
MAP OF THE ISLAND OF NEWFOUNDLAND
By J.B.Jukes, M.A., F.G.S.,&c.
Geological Survey of Newfoundland
in the Years 1839-40,

showing

Earliest Attempt to depict the geology
of the area herein designated as The
Central Mineral Belt of Newfoundland.

Fig. 4

-Position of Beds of Coal.
COAL FORMATION

G Granite
S Sienite
P Porphyry
T Trap
B Basalt
Sp Serpentine
H Hypersthene
g Greenstone

'a' Belle Isle Shale &c UPPER SLATE FORM'N

Signel Hill Sandstone LOWER SLATE FORMATION

Gn Gneiss
M Mica Slate
C Chlorite Slate
Q Quartz Rock

Primary limestone

nor to anything more than having advantageously pursued enquiries into the formations of Canada and the Gulf of St. Lawrence," Bonnycastle's chapter on the geology of the island is largely confined to a review and criticism of the labours of Cormack and Jukes. He "fears, or rather hopes ... that Mr. Jukes has been, as most young authors are, a little too hasty in his generalization of dividing the island into two sections ... by a line drawn from Cape Ray to the head of the Bay of Exploits ... on the south of which all is hopeless and barren, while to the north of it there is a land of promise, not flowing with milk and honey, but abounding in forest and fell, in coal and iron, in limestone and gypseous deposits."

"On the shores extending to Notre Dame Bay," he finds, "the rocks are sandstone and slate, of an early class, few or no fossils appearing amongst them, intermixed with trap rocks and with granites and serpentines, with mica schist, and in fact with all the early mineral masses; excepting that there is a deficiency of limestone, and a superabundance of the igneous classes, as might be expected; whilst the alluvial or diluvial covering is arenaceous, intermingled with a few boulders, and spread over with shallow peat bogs, of very small depth, but of great consistency."

The Work of the Geological Survey, under Murray and Howley, (1864-1909).

In 1864, Alexander Murray began his geological labours in Newfoundland, at first under the direction of Sir W. E. Logan of the Canadian Survey. Thus was instituted the first serious attempt at a systematic and detailed official survey of the island. Murray engaged as an assistant James P. Howley, in 1869, and together they examined most of the country until 1883, from which date Howley continued the work independently until 1909. The records of this survey are to be found in the Annual Reports of the Geological Survey of Newfoundland, issued between 1864 and 1909, and in the official geological map of the island (12).

During this period, several seasons were spent in the region of the Central Mineral Belt, the north end of which, Notre Dame Bay, began an era of copper production which, strangely enough, was practically coextensive with the lifetime of the geological survey.

Following is a summary of the work of the survey that is of interest in the present connection: In the first year of his investigations, Murray described portions of Hall's Bay and Notre Dame Bay; and in the next season, the valley of Indian Brook, Hall's Bay, as well as the country surrounding Grand Pond (Lake). The report for 1867 is entitled "Survey of Tilt Cove, and the Neighbouring Country, on North Shore of Notre Dame Bay; with a Description of The Union Mine, &c." In 1871, a survey was made by Murray of Exploits River and Red Indian Lake, while Howley examined the coast of Exploits Bay. This work was continued in 1875, the report being on a "Survey of the Upper Waters of the Exploits River -- Mineral and Other Resources of Notre Dame Bay, &c." The survey was diverted to topographic work in the Notre Dame Bay district in 1877 and 1878, and elsewhere in succeeding years. It was not until 1888 that the region of present interest was reentered by Howley on a survey across country by way of the Bay d'Est River, Noel Paul's and the Exploits; and later, in 1890, on a preliminary survey across the island from the Exploits Valley to the West Coast, for the purpose of ascertaining the feasibility of constructing a railway to connect the eastern and western sections of the country. This was followed in 1894 by a geological exploration along the Northern and Western Railway. The succeeding years of the survey's activities were taken up by coal boring operations, mineral statistics, etc.

It is regrettable that the detailed maps which were made in connection with the above investigations are no longer available, they having been destroyed by fire in the Crown Lands Office, St. John's. And even the written descriptions are buried in two large, unindexed volumes.

Synopsis of Areal Geology of the Central Mineral Belt, based on official geological map of Newfoundland.

The formations represented within the area to which the descriptive term Central Mineral Belt is here applied, are as follows, as shown on the current geological map of Newfoundland by Howley (Reprinted in 1925), (12).

	(4)	Carboniferous
PALEOZOIC....	(3)	Silurian
	(2)	Cambrian & Cambro-Silurian
ARCHEAN......	(1)	Laurentian & Undetermined.

together with the following "Igneous & Metamorphic Rocks," listed in a separate column in the legend; the relative age of which is left to the reader's inference from their distribution:

(C) Serpentine, Diorites, Dolerites, &c.
(B) Trap, Greenstone, &c.
(A) Granite, Syenite, Porphyry, &c.

Reviewing each of these in turn, it may be noted that:

(1) The "Laurentian and Undetermined" occupies much of the western central and the extreme southern parts of the belt. Since much of this region is as yet practically unexplored, it is probable that on further investigation this classification will have to be revised in the future.

It should be pointed out here that the connotation of the term 'Laurentian' as used in the above classification is that in which it was first employed by Logan, viz., to describe "a vast series of gneisses and other crystalline rocks," which underlie unconformably the oldest fossiliferous formations of North America. Nowadays the Laurentian is restricted to the first of the two series of granitic intrusions into the older strata of Archeozoic and Early Proterozoic time. (50, p.555).

(2) Cambrian and Cambro-Silurian rocks are represented in an area only a few square miles in extent, on the western flanks of the Annieopsquolch Mountains, in the southern interior of the belt.

(3) The Silurian is shown as stretching inward from Notre Dame Bay for a distance of about 130 miles, in the shape of an embayment less than 20 miles wide. The sediments comprise red sandstones, bluish and black slates and fine conglomerates,

with some quartzite, according to Howley, who in his report for 1894 (20, pp. 300-301) described the section of this formation exposed along the railway, from Gander Lake to Lake Bond.* At the latter place "they become considerably disturbed and altered ... and dioritic intrusions are of frequent occurrence"(ibid. p301). The only fossils noted by Howley in this section are graptolites of the genus Namosus which were found at Little Red Indian Lake Fall, in black, plumbaginous slates. "The late Mr. Billings, Paleontologist of the Dominion (Canadian) Survey, pronounced these organisms Middle and Upper Silurian."

In a rare map of earlier date, Murray represented this embayment as consisting of the Utica, Hudson River and Medina formations, with some Clinton on the north. In Murray's nomenclature, of course, the rocks which are now classified as Ordovician were termed Lower Silurian.

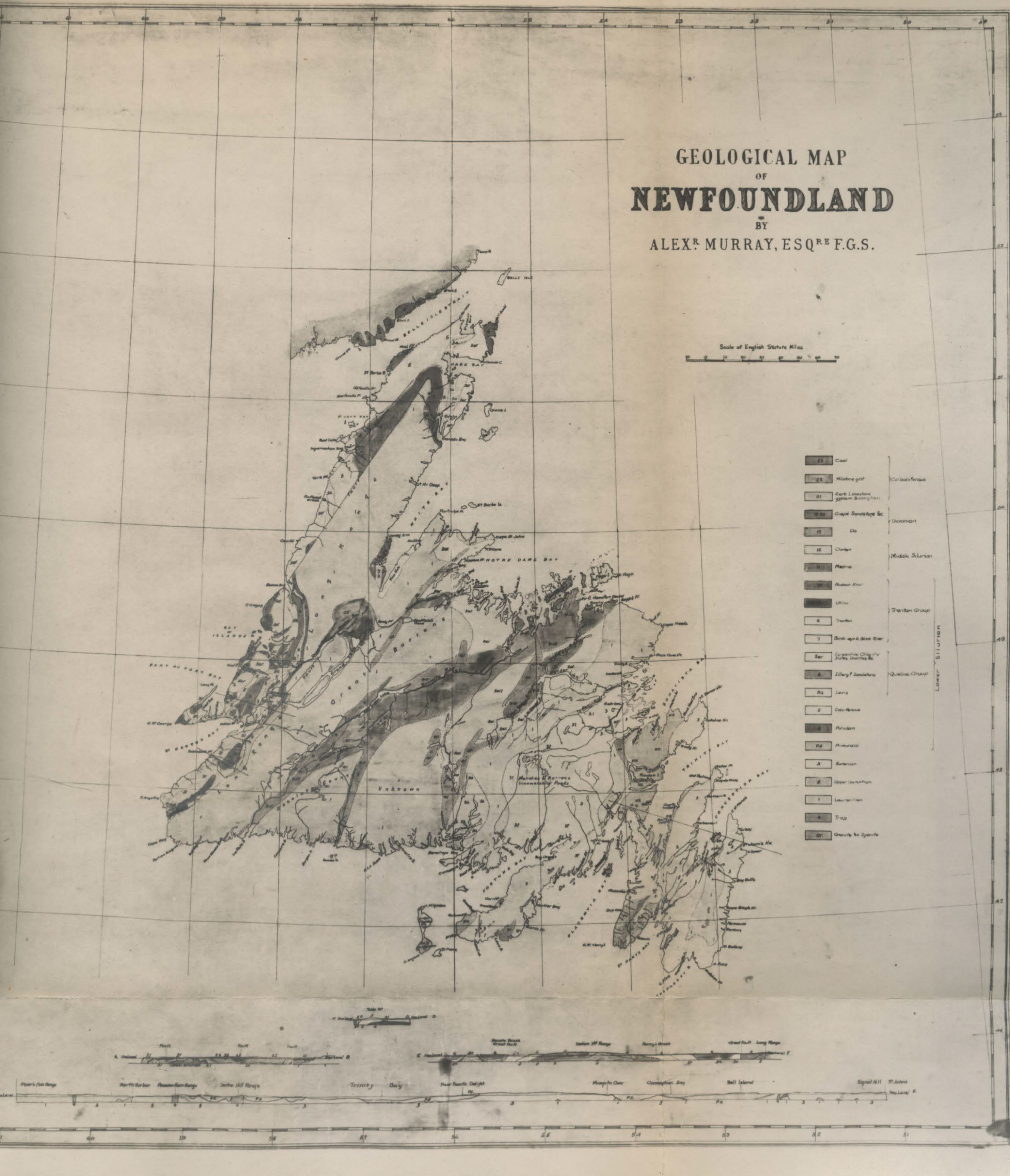
Two other smaller patches of Silurian are also depicted on Howley's map as occurring on the southern shore of Notre Dame Bay, at Badger Bay and Hall's Bay.

It is noteworthy that Perret (47), who in his Geographie de Terre Neuve has made a valuable contribution to our knowledge of the physical geography of Newfoundland, terms the above-mentioned embayment as 'Gothlandian,' in his geological map of the island.

(4) Carboniferous sediments are exposed within the Central Mineral Belt in the Sandy Lake and Grand Lake basins, where the existence of coal has been known from early times.

---

*In a traverse of part of this same railway section, during the past summer, it became evident to the present writer that at least some agglomerate and other volcanic rocks have been mapped by the Geological Survey as 'Silurian', in addition to the sedimentaries noted above.


GEOLOGICAL MAP
OF
NEWFOUNDLAND
BY
ALEXR. MURRAY, ESQRE F.G.S.
Scale of English Statute Miles
Coal
Carboniferous
Devonian
Do
Middle Silurian
Medina
Trenton Group
Trenton
Quebec Group
Lower Silurian
Levis
Primordial
Upper Laurentian
Laurentian
Trap
Granite &c Syenite
NOTRE DAME BAY
Trinity Bay

However, since coal is outside the scope of this work, the Carboniferous basin will not be adverted to further.

Of the "Igneous & Metamorphic Rocks,"

(A) "Granite, Syenite & Porphyry &c" occur chiefly in the form of elliptical bosses which are of wide distribution throughout the entire belt. The majority of these occurrences exhibit a definite northeast-southwest trend, not only in their alignment but also in the arrangement of the long axes of the exposures. Rocks of this description are shown as wholly surrounded by, and probably intrusive into, the 'Laurentian' in which they compose most of the ridges and 'tolts,' or isolated and rounded hills. One single boss occurs within the Silurian embayment, at a place immediately north of the railway and west of Grand Falls. In the Notre Dame Bay region, the granite is exposed on the peninsula between Green Bay and Baie Verte in the form of two batholiths, the greater of which is almost fifty miles in length and only a few miles wide, while the smaller is twelve by two miles in area. In both of these intrusions, the northeast trend of the granite bosses, as noted above, is accentuated; and both lie within the metamorphic rocks of division (C).

(B) Basic rocks of the "Trap, Greenstone &c" class are found mainly in the interior of the belt, where they constitute the high Annieopsquotch Mountains, as well as several other high peaks which stand out prominently above the surrounding Silurian sedimentaries. Flanking the eastern shore of

Grand Lake, they occur as a long intrusion between the Carboniferous and the 'Laurentian' terrains.

In the northern part of the belt, the trap is shown as composing several intrusions of lenticular or elliptical outline within the Silurian embayment; and in Notre Dame Bay, there are two small occurrences of this rock, one on Great Triton Island, and the other in the valley of Indian Brook, Hall's Bay. In both of the latter instances, the country rock is that of division (C).

(C) The greatest assemblage in Newfoundland of the series to which the name "Serpentines, Diorites, Dolerites, &c" is applied, is in the Notre Dame Bay area, at the northeast end of the Central Mineral Belt, where in addition to composing the majority of the islands of the Notre Dame Bay archipelago, it extends inland to the southwest for about fifty miles in a mass of bi-lobed outline.

In Murray's earlier map, the shores of this bay are represented as being underlain by serpentine, chloritic slates, diorites, &c., which he assigned to the Quebec Group of the Lower Silurian. It will be recollected that at the time Murray began his investigations in Newfoundland, the Geological Survey of Canada, under Logan was working out the sequence in eastern Canada. The influence upon Murray of the results obtained by the parent organization is apparent in his early reports. Subsequent examination of the Quebec Group in the type localities has led to radical changes in our conception of that geological hodgepodge. (Cf. in this connection, 8,9, 38,56,66.).

Unfortunately, however, no official geological field work has been carried out in the Newfoundland areas during the past thirty-five years; but the work of the Princeton University Expeditions in 1915, 1916 and 1919 is a welcome contribution towards a revision of this old classification as applied to Notre Dame Bay. (54). It is interesting to note that Murray in 1877 expressed the opinion that "the confusion and disturbance manifested in Notre Dame Bay is such that to obtain a structural section is almost impossible." (34, footnote).

The Work of Wadsworth (1880).

In 1880, Dr. M. E. Wadsworth, then assistant geologist of the Museum of Comparative Zoology, and later dean of the School of Mines, University of Pittsburgh, visited Notre Dame Bay, and in 1884 he published in the American Journal of Science (65) an article entitled "Notes on the Rocks and Ore Deposits in the vicinity of Notre Dame Bay, Newfoundland." This work, although "the object of the journey was a commercial one in behalf of parties interested in some ore deposits about the Notre Dame Bay," and "the observations and collections were naturally confined to the immediate vicinity of the mineral lands, and limited as to time," is a valuable addition to our knowledge of the petrography of that area.

To quote from his introduction "The key note is the belief that a large portion of the older rocks now designated by various names were once identical with their modern representatives and that the present differences of the former from the latter are due chiefly, if not entirely, to secondary changes since the time of eruption." Then follows a detailed description of the various rock types which he encountered in his examination of the district between Exploits Burnt Island and Betts Cove. These include: The Basalt Rocks:-Melaphyr lavas and dikes, Diabase, Diorite, Porodite; Andesite (?):-Minette, Porphyrite; Argillite and Jasper. Since references to the copper mines then being worked in Notre Dame Bay, are so rare in the literature, a few of his impressions of them may be repeated here.

(1) The Betts Cove Mine "is in mixed argillite, chlorite schist, and diabase. The ore band runs east and west, and is cut by north and south dikes, of which there were said to be ten in the mine. The dikes seen were all diabase. Over one-half of the adjacent country rock is eruptive, but all the ore of importance is found in the schistose portions formed from the altered argillite and diabase. The ore is of secondary deposition, being a segregation in the broken fissured altered portions of the rock, and, judging from the ore seen and the workings, must have occurred in immense irregular masses. The ore is chalcopyrite, mixed with pyrite, quartz, etc. The foot wall is formed by diabase."

(2)"The upper portion of Little Bay Mine is worked in chlorite schist impregnated with chalcopyrite. The whole is longitudinally cut by a dike parallel with which run three bands of chalcopyrite which lie near the dike. In depth these three bands pass into one, varying from six inches to four feet in thickness, and the mixed chlorite schist and ore of the upper portion of the mine is wanting. The character of the workings and the geological structure seen in this mine show that this deposit was an immense lenticular mass of schist impregnated with impure chalcopyrite, the widest portion being on the surface and gradually narrowing in depth. The ore from this locality is mixed chalcopyrite and pyrite with quartz, schist, etc."

(3) "The Roberts Arm Mine is worked on two veins from two to four feet wide in the eruptive diabase. The veins are composed of quartz carrying very compact chalcopyrite. While the veins widen in depth they do not appear to improve in quantity or quality of the ore. The sides of the veins are indistinct and firmly attached to the country rock, thus partaking more the character of a gash than a fissure vein."

A generalization which he makes as a result of his studies is:- "The mode of occurrence of the copper ores in northern Newfoundland, taken with the geological structure of the country, indicates the following as their origin. The argillaceous and schistose rocks have been cut through and through by dikes and irregular masses of eruptive basaltic rocks. During the time of this eruptive activity, after the chief portion of this basalt had been extravasated, the action of percolating thermal waters on the eruptive rock and its fissured and broken adjoining sedimentary rock, led to the concentration and deposition of the copper, iron, and quartz in the places in which they are found. The copper is here thought to have been brought up from below finely disseminated through the basaltic material and later concentrated by the percolating waters. The productive masses of ore seen were found in connection with these old basaltic masses. but generally deposited in the adjacent schist or in decomposed portions of the diabase, for the boundary lines of the eruptive masses afforded the conditions necessary for the precipitation of the copper sulphide. The eruptive masses are as a rule too massive and compact to afford suitable places for the deposition of the ores, thus the prospector is naturally to search for them in the schists adjacent to the large eruptive masses. The deposits thus occurring are irregular segregations or impregnations of varying bulk, but they do not promise in any one locality long continued mining. It is perhaps best to do as seems to have been done up to the time of my visit; work the mines in an irregular slovenly manner, stripping out the ore masses wherever found, as far as safety permits, with the idea of abandoning the mines as soon as the chief portion of the ore is extracted."

While Wadsworth's ideas as to the mode of origin of the ores are somewhat antiquated and largely untenable according to present beliefs, nevertheless his predictions concerning the life of the mines have, in general, been borne out by subsequent experience; although the long period of production in some of the larger deposits, such as Tilt Cove, together with the fact that all of the mines in the Notre Dame Bay area, even at this date, are practically confined to the shores, justify the expectation that more will yet be heard of this region as a copper producer.

In view of the importance attached at that time to the correlation of the serpentines of the Notre Dame Bay area with the middle division of the Quebec Group -- "the metalliferous zone of the Lower Silurian in North America," (36, p.50) -- it is interesting to note that Wadsworth states:- "No serpentine was seen by me at any of the points touched between Twillingate and Betts Cove, except one small bowlder at the latter place. ... The ores, so far as seen, occurred in diabase and schists; hence the statements, so industrially circulated in almost every article referring to the Newfoundland copper deposits, regarding the relation of the ores to serpentine, are entirely incorrect in the districts seen by me."

The Work of Sampson (1915,1916,1919).

The work of the Princeton University Expeditions to Newfoundland, of which Professor Sampson's paper on the Ferruginous Chert Formations of Notre Dame Bay is a partial record, has already been referred to (page 49) as practically the only investigations of a regional nature carried out on the general geology of the Notre Dame Bay region during the past thirty-five years.*

Professor Sampson describes in his article "Ferruginous cherts which for the most part are found as beds of very uniform thickness in sections composed largely of volcanic rocks." He considers the cherts to be chemically precipitated sediments, and further states that "The area in which the cherts occur on the coast is clearly limited, as they are confined to that portion within which the pillow lavas are found. The pillow lavas are thick conspicuous formations which in this part of the Newfoundland coast do not occur north of Cape St. John nor east of New World Island. Within Notre Dame Bay they are exposed at many places."

*The present writer hopes, under Professor Sampson's direction, to include some of the information collected on these expeditions in a more elaborate dissertation on this region, within the next few years.

The Work of the Natural Resource Dept., Reid Nfld Co., Ltd. 1918-1926.

For a description of the activities of this organization the reader is referred to a paper entitled Mineral Exploration in Newfoundland During the Decade 1917-1927, by the present writer (59, pp.12-19). See appendix A.

The Work of Miscellaneous Writers.

A list of various articles, of more or less importance, will be found in the bibliography at the end of this work. Of these, Garland's (11) and Marett's (31) are concerned principally with the Tilt Cove Mine. Garland refers to the occurrence of a nickel-bearing vein at this property, from which "411 tons were raised and shipped to Swansea," the ore being arsenide and sulphide of nickel. He also states that in another portion of the property magnetic iron ore was discovered. Both the nickel and iron ores at this property were, however, subordinate to the copper, for which the mines were worked.

Milne (34) in 1877 described in some detail the rocks of the 'Quebec Group' in Newfoundland, and his paper contains numerous interesting footnotes by Alexander Murray of the Newfoundland Geological Survey.

De Launay (7) gives a brief account of his observations in the Notre Dame Bay region; and another French scientist, Perret (47) in an admirable work on the geography of Newfoundland presents in his chapters entitled 'Le Sol' and 'L'exploitation de la Terre' a comprehensive and popular review of the history and results of geological investigations and mining in Newfoundland up to 1913.

CHAPTER 5

GEOLOGY OF HIND'S RIVER AND LAKE AND VICINITY, INTERIOR OF NEWFOUNDLAND.

Introduction.

This traverse gives a short cross-section of a comparatively unknown part of Newfoundland, in which the Geological Survey had early distinguished three formations, viz., a fringe of Carboniferous (Pennsylvanian) sediments on the eastern shore of Grand Lake, abutting against a long parallel strip of "Trap Greenstone, &c," which in turn is shown as in contact with the "Laurentian and Undetermined" composing the plateau between the Grand Lake and Red Indian Lake basins.

Because of its proximity to the Red Indian Lake mining district, the area described is at present one of economic as well as scientific interest; and, as will be shown later, these two regions, petrographically at least, have much in common.

The topographic work was done by means of an Army Sketching Case, and in part by Brunton compass, distances being measured by pacing.

A suite of eighty-four representative rock specimens was collected, from which forty-one thin sections have since been prepared and examined under the polarizing microscope. While it was not possible in the limited time to do more than cursory field work, the following description is felt to present a fairly accurate, although partial, picture of the geology of the area.

Topography.

Hind's River, particularly in the lower stretches of its eight-mile course from Hind's Lake to Grand Lake, is a torrential stream about one hundred feet wide, with numerous falls and rapids, having a total drop of over six hundred feet. In descending from the plateau level, it flows through a steep sided gorge, which in many places is impassable even on foot.

Near the mouth of the river, a well defined terrace occurs, as noted in Chapter 2, page 32. The valley is thickly wooded with spruce, fir, etc., but between the river and the foothills are numerous and almost continuous long, narrow marshes or 'leads' as they are called locally. On either side of the river the hills rise to over five hundred feet in flat or gently eastward-sloping plateaux.

Hind's Lake lies within a hill-surrounded basin, probably of glacial origin. The most northerly of its tributaries from the southwest, to which the name Chesapeake Brook is here applied, has its source in the uplands of the central plateau, near the Red Indian Lake watershed. The lower six miles of the course of the brook are marked by numerous rapids and several falls, but its upper stretches -- to the west of the area mapped see Fig. 11 -- are comparatively level. The hills of these uplands are in most cases barren, and at least some are of roche moutonne shape, and boulder-strewn.

Outcrops are plentiful in the beds of Hind's River and Chesapeake Brook; but on the shore of Hind's Lake the bedrock is concealed by a mantle of drift, as well as beach deposits and delta sands.

General Geology.

The valley of Hind's Brook and that portion of the environs of Hind's Lake which was examined in this reconnaissance is underlain by what is believed to be part of the eroded surface of an extensive granite batholith, elongated in a northeast-southwest direction, and intruded into lavas ranging from rhyolite through andesite to basalt in composition. In the gorge of Hind's Brook are exposed several preserved roof pendants of the basic members of these flows, in places agglomeratic, and locally intercalated with sediments; while in the hilly terrain of Hind's Lake the acidic members, typically microspherulitic and in part tuffaceous, are widespread.

Later igneous action is evidenced by diorite and quartz diorite intrusives, chiefly into the granite; and also by a series of dikes of which four types may be recognized.

The low foreland of Carboniferous sediments on the shores of Grand Lake is incised by the mouth of Hind's Brook, but unfortunately the contact with the lavas is obscured by glacial drift, and time did not permit of an exhaustive examination. Nevertheless, for various reasons, the Carboniferous appears to overlie the volcanics with a sharp unconformity.

Generally speaking, Grand Lake may be regarded as lying in a synclinal basin, which possibly is downfaulted. Its correspondence with the synclines of the Bay of Fundy and of

Prince Edward Island, Canada, has already been noted (page 31).

The broadly rectilineal course of Hind's River and part of the western shore of Hind's Lake appears to have no special structural significance, as revealed by a traverse of the western bank of the river, which is looked upon as a straight consequent stream. The relative age, and to some extent the structure of the various rocks may be represented schematically thus: See Fig 6

Without attempting any correlation, the interesting and possibly significant parallel provided by the northern Ontario and Manitoba districts, where Keewatin lavas and sediments are intruded by Laurentian and Algoman granites, should be pointed out at this stage.

DESCRIPTIVE GEOLOGY.

Hind's River: Beginning at the mouth of Hind's River on Grand Lake, and proceeding southwards towards Hind's Lake, the arkoses are first encountered, with an estimated thickness of over 1000 ft, and an average dip of 75° north. Next come the andesite-diabase flows, exposed over a width of 3000 ft, and intruded by diorite on the eastern bank at the first falls. The lavas near the Carboniferous contact are represented by brownish melaphyre and appear to be folded and shattered.

On the south, the basic lavas are in contact with granite, which is probably intrusive. The contact, as revealed

SCHEMATIC SECTION, NW-SE,

of

HIND'S RIVER AND LAKE DISTRICT,

Interior of Newfoundland.

(Not to scale; diagrammatic only)

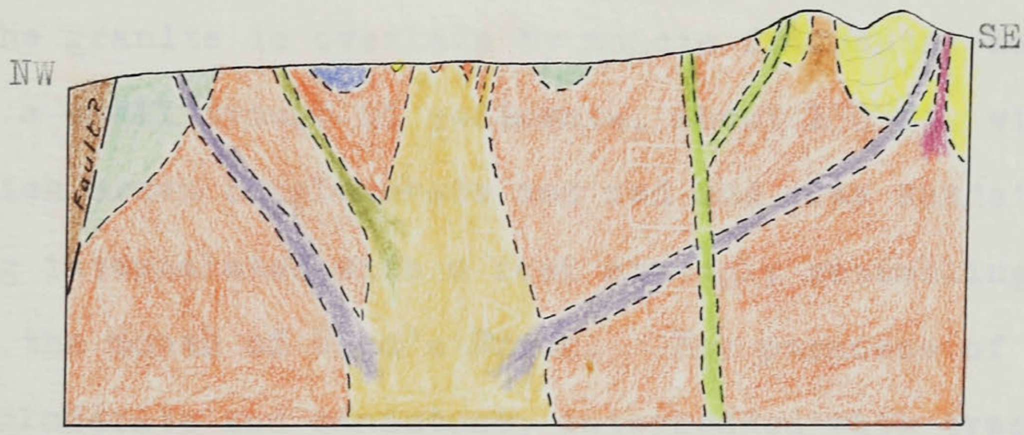


Fig. 6

- Arkose.............CARBONIFEROUS?

Unconformity?

PRE - CAMBRIAN ?

- Basalt Dikes
- Granite Porphyry, Granophyre & Granite Dikes
- Diorite & Diorite Porphyrite Dikes
- Hornblende Lamprophyre Dikes
- Diorite & Quartz Diorite
- Quartz Porphyry
- Granite & Porphyritic Granite
- Conglomerate & Sandstone, interbedded with Trachyte & Melaphyre, etc.
- Rhyolite, Spherulitic & Tuffaceous
- Andesite, Andesite Agglomerate & Diabase.

in the gorge of Hind's Brook, dips 75° toward the lava. A collection of seven specimens taken on either side of this contact revealed on close examination a strong alteration of the andesites and the development of porphyritic structure in the granite.

The granite is continuously exposed south of here for nearly two miles, when a change in the character of the rock is met with. An altered and finely porphyritic modification of the granite is overlain by acidic fragmental lava, together with a small trough of sediments, about 150 ft. wide, including reddish brown conglomerate and red and gray sandstone, the latter being intercalated with a rock strongly resembling the melaphyres near the mouth of Hind's Brook. For purposes of mapping the "Conglomerate and sandstone, interbedded with trachyte and melaphyre" are grouped together.

The granite outcrops again to the south of these sediments and volcanics, near which it is again porphyritic. About 500 ft further south, a rhyolite inclusion occurs in the granite. It is on this evidence, together with the fact that granitic dikes intrude the rhyolite at the extreme southwest end of the area mapped in this traverse, that the granite is considered to be of later age than the acidic lavas outcropping in the Chesapeake Brook region west of Hind's Lake.

About an eighth of a mile south along the river from the rhyolite inclusion, quartz diorite occurs. The diorite has a surface width of about 500 feet; its relations to the granite are complex, the intimate mixture of the two giving a somewhat gneissic appearance, and much more detailed study is necessary in order to ascertain definitely their relative age. Inclusions (or possibly irregular intrusions?) of granite are found within the diorite, and almost similar occurrences (or segregations?) of dioritic rock may be observed in the granite; whilst at one point the diorite appears to send off small offshoots into the granite. For the present the diorite is considered to be the younger rock, having both caught up some fragments of granite, and sent off irregular stringers into the walls of the invaded granite.

The granite which succeeds further south along the river is fine textured and contains relatively more ferromagnesian minerals, but both quartz and orthoclase are still present in sufficient amount to enter into the nomenclature.

At the falls which marks another contact, at the outlet of a long 'steady', about four miles up Hind's River, a well-jointed fine-grained dark reddish green rock outcrops. Two hundred feet south of the falls, along the 'steady' this rock assumes a definitely clastic appearance, with rounded pebbles averaging three inches long and some up to nine inches. On microscopic examination, this proved to be an agglomerate, with pebbles of andesitic composition in a matrix composed chiefly of volcanic glass. From this point, granite is exposed at intervals, both in the bed of the river and in rocky hummocks along the marshes near the river, up to Hind's Lake.

<u>Area West of Hind's Lake</u>: In ascending Chesapeake Brook on the west side of Hind's Lake, granite and granophyres are first met with, the exact relations of the two being unknown. About a quarter of a mile from the mouth of the brook, diorite dikes are encountered, being cut in turn by granite porphyry, by quartz veins and siliceous dikes, and finally by basaltic dikes. This is the only instance in the entire area in which granite porphyry is found in intrusive relation to the diorite dikes, and with the amount of information available it has not been considered wise to postulate any general acidic invasions other than that of the underlying granite batholith, which is at present supposed to precede the diorite and diorite dikes.

Further up the valley of Chesapeake Brook, well bedded and massive rhyolites outcrop, evidently folded into a steep syncline, and intruded by granitic, basaltic and diorite porphyrite dikes. On the northern limb of this syncline, quartz porphyry occurs, in what is presumed to be intrusive relations. In descending from these rhyolitic uplands by way of the southernmost tributary of Hind's Lake shown on the map, Fig. 11 isolated outcrops of andesite, andesite breccia, rhyolite tuff, and quartz diorite were noted.

PETROGRAPHY.

Following is a description of the megascopic and microscopic characters of the rocks collected, in the order of their relative ages, and as mapped on the accompanying geologic plan and section.

(1) Andesite, andesite agglomerate and diabase.

Andesite.

Megascopically, the andesites of this group are of fine grained texture, somewhat porphyritic structure, and of a typical green to an iron-stained brown colour. In hand specimen, the following varieties may be recognized: andesite, carbonatized andesite, chloritized andesite, silicified andesite, and brownish to green melaphyre.

In microscopic section, however, andesite porphyry, augite andesite, spilite, and amygdaloidal melaphyre in various stages of alteration can be distinguished.

Andesite Porphyry: This rock contains phenocrysts of plagioclase partly altered to calcite, and phenocrysts of chloritized amphibole in a ground mass composed of feldspar, a black iron mineral, and some undetermined ferromagnesian mineral.

Augite Andesite: Large phenocrysts of augite, roughly octagonal in shape, and largely altered to very pale green fibrous amphibole with some chlorite, occur in this type in a fine ground mass containing a black iron mineral, some lath-shaped plagioclase and calcite.

Spilite: This rock has a somewhat pilotaxitic structure, consisting of feldspar laths which show a fluxion parallelism in a devitrified matrix. Abundant small specks of a black iron mineral are present both in the ground mass which consists largely of feldspar, and in chlorite veinlets also containing calcite. The chlorite is pale green in ordinary light, but between crossed nicols some ultra browns are seen. See Fig. 7

Melaphyre: Under this caption it has been found convenient to include, in addition to the typical melaphyres, a few types which do not exhibit amygdaloidal structure, but which evidently were derived from an igneous rock of andesitic to basaltic composition. The following structures are shown: amygdaloidal, pilotaxitic and porphyritic. The characteristic phenocryst is plagioclase, either as small needles or felted laths. Augite is the commonest ferromagnesian mineral; and the secondary minerals include epidote in small quantity, calcite replacing feldspar and in veinlets, and some hematite. The amygdules are filled with an undetermined colourless isotropic mineral of low refractive index, possibly analcite. A black iron mineral, probably magnetite, is invariably present as finely disseminated specks, and in some cases as larger patches and in veinlets; its alteration product is hematite.

Altered Andesites: These are porphyritic rocks, made up of matted laths of feldspar in a matrix of chlorite and calcite. The chlorite appears to be replacing pyroxene. Accessory minerals include black iron oxide and a little quartz. Calcite is often abundant, both in the form of veinlets and disseminated throughout the matrix, in the latter case replacing feldspar. Other secondary minerals are amphibole, limonite and sericite.

Andesitic agglomerate.

Only one outcrop of this rock was observed, at a point about half way up Hind's River, where a reddish-brown clastic rock containing rounded pebbles averaging three inches long, with

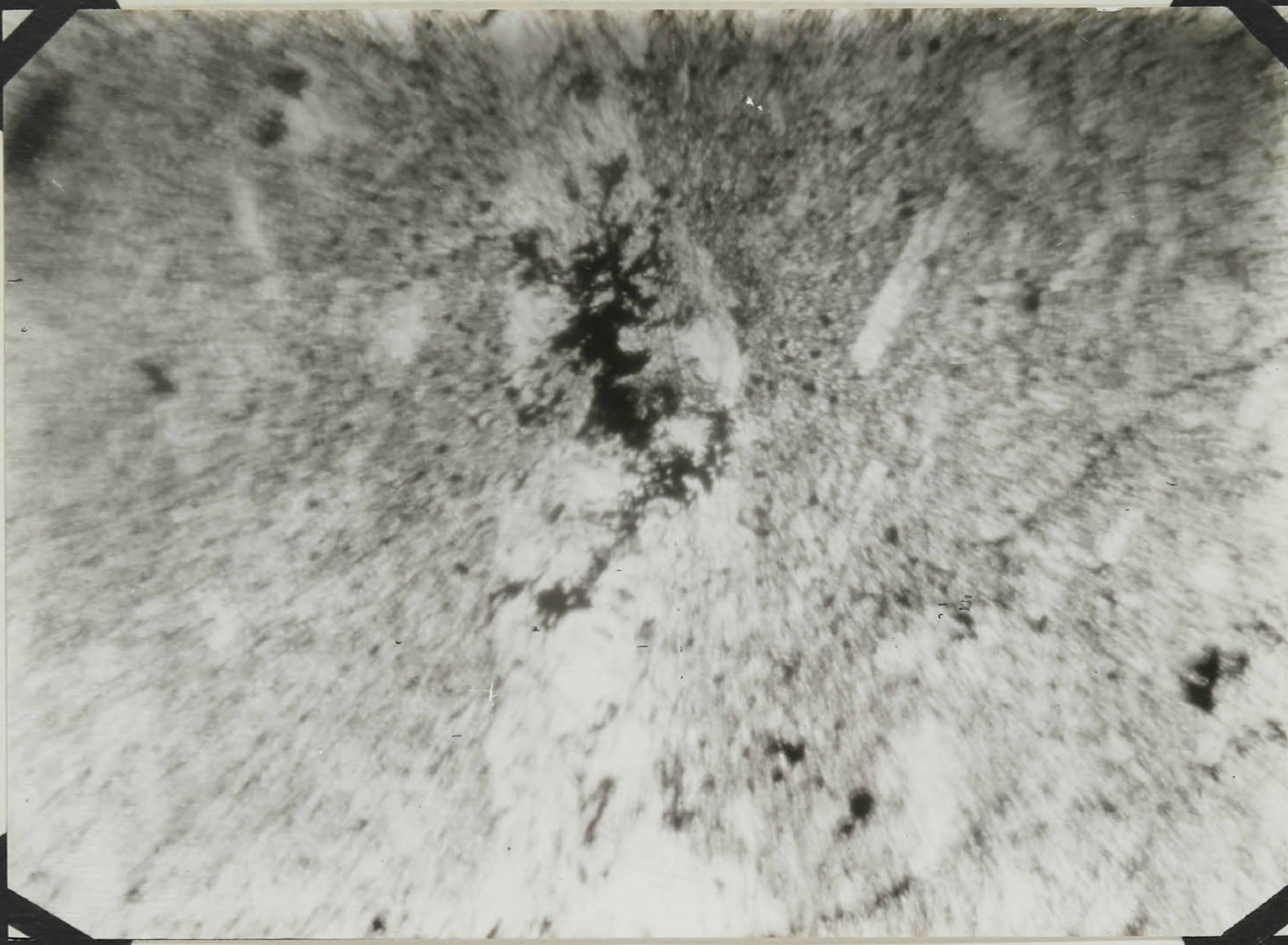


Fig. - 7

Photomicrograph of thin section No. A8a, SPILITE, from near mouth of Hind's Brook, Grand Lake.
The centre field is traversed from north to south by a veinlet of chlorite with magnetite (black), the latter partly altered to limonite. The rock approximates a spilite. Note the fluxional arrangement of the plagioclase laths in a devitrified groundmass containing also a few specks of magnetite and limonite.

Magnified 100 diameters; ordinary light.

some up to nine inches, is exposed for fifty feet with a dip of 55 degrees. A microscopic slide taken from a fine grained part of this material shows pebbles of andesitic composition in a matrix composed largely of volcanic glass. Some quartz and feldspar fragments are also present.

Diabases.

Typical ophitic structure, combined sometimes with amygdaloidal and porphyritic structure is exhibited by these fine grained green rocks. The phenocrysts are of feldspar and augite, sometimes hornblende. The feldspar, which is commonly in needles, is for the most part untwinned, but Carlsbad and lamellar albite twinning occur. Epidote and calcite are decomposition products of these plagioclases. Accessory minerals include ilmenite, with leucoxene alteration. Chlorite and hematite also are found; the former associated with a black iron mineral, and the latter surrounding some of the calcite. The hornblende present in some of the sections exhibits light to dark green pleochroism, a slight tendency to radiated structure, and an average extinction angle of sixteen degrees. Some of this amphibole is in all probability secondary, being composed of aggregates of small blades. The ground mass in some instances is a devitrified glass.

(2) Rhyolite, spherulitic and tuffaceous.

Spherulitic Rhyolite.

In hand specimen, the spherulitic rhyolites are pink in colour, and finely spherulitic in structure, the spherulites

Fig. - 8

Photomicrograph of thin section No. A77, MICROSPHERULITIC RHYOLITE, from Chesapeake Brook, West of Hind's Lake. Illustrates radial microspherulitic structure, (Note large black cross in upper centre field, and smaller one in lower left corner) and micrographic intergrowth of quartz (clear) and orthoclase (turbid) in upper left corner.

Magnified 100 diameters; crossed nicols.

consisting of a concentric arrangement of orthoclase and quartz, up to one-quarter inch in diameter. A few quartz-lined druses also were observed.

Under the microscope, the constituents are found to be quartz and feldspar, a black iron mineral, and much secondary limonite as stains and veinlets, together with some sericite. The quartz is not present as phenocrysts, but is found in the spherulites and as granulated aggregates in the ground mass.

Microspherulitic Rhyolites: These are fine to medium grained reddish-brown rocks, some of which have a very finely-banded flow structure. Microscopically, radially-microspherulitic, porphyritic, micrographic and fluxion structuresare seen in great perfection. The mineral constituents are essentially quartz and orthoclase, with an accessory black iron mineral largely altered to limonite. A little plagioclase is present in some of the sections, and one phenocryst of perthite was noted. Sericite is the commonest alteration product of the feldspar. See Fig. 8

Rhyolite tuff:

These acid pyroclastics are reddish-brown in colour, and contain sub-angular to angular fragments up to half an inch in size. In thin section, the fragments are found to be chiefly of rhyolite which shows flow structure; a few more basic ones, approximating andesite, being also found. There is also present interstitial quartz, much of which is secondary. The mineral constituents recognizable are quartz, feldspar and

Fig. - 9

Photomicrograph of thin section No. A72, RHYOLITE TUFF, from headwaters of Chesapeake Brook, West of Hind's Lake. Shows pyroclastic structure. Note subangular fragment of intermediate composition in a matrix of rhyolite fragments, some of which show flow structure. Quartz (clear) occurs as small patches in the interstices.

Magnified 100 diameters; ordinary light.

a black iron mineral (magnetite), together with secondary limonite and sericite. See Fig. 9

The rhyolite inclusion, mentioned on page is of a fine-grained dull brown variety, in which occasional small quartz phenocrysts may be observed.

(3) Conglomerate and sandstone interbedded with trachyte and melaphyre.

Conglomerate.

The conglomerate which occurs in this series is a very coarse one, with pebbles up to one foot long. The general colour of the rock is reddish-brown. The pebbles consist largely of acid porphyry, with some light coloured plutonic ones.

Sandstone.

This fine grained gray and reddish sandstone is found to contain the following allothigenous minerals: quartz, sub-angular in outline; with some sericite, in shreds, parallel to the bedding; chlorite, biotite, orthoclase, plagioclase, and a black iron mineral. The only authigenous mineral recognized was limonite. On the whole, the rock is comparatively unmetamorphosed.

Trachyte Tuff.

In hand specimen this rock, which is of very restricted distribution, is brown coloured, medium-grained, and evidently of clastic structure. Microscopically, it is found to be made up of orthoclase phenocrysts in a ground mass of fine feldspathic material, which also contains somewhat rounded volcanic fragments, as well as some resorbed crystals. A black iron mineral, altering to hematite, is the only other recognizable constituent. While possessing something in common with the rhyolite tuffs, this rock is here distinguished as a trachyte tuff.

(4) Granite and porphyritic granite.

Granite.

The typical granite of the batholith which underlies most of the area examined is a pink, medium to coarse grained rock, composed of quartz, orthoclase, hornblende, and sometimes biotite. Locally, the rock assumes a gray colour. In the coarser varieties, containing crystals up to two-thirds of an inch, biotite is more plentiful. Melanocratic modifications were observed at only a few places, and these are found chiefly in the vicinity of the roof pendants mentioned above. Other types which were mapped as granite, near the pendant of sediments and interbedded volcanics, appear to be felsitic and are speckled with chlorite grains.

Porphyritic granite.

In these rocks, large quartz and sometimes orthoclase crystals occur in a fine to medium-grained granitic matrix. They are almost invariably found contiguous to the roof pendants. Those near the contact of the andesite-diabase lavas with the granite, about four-fifths of a mile up Hind's River were studied in most detail, in order to ascertain what light they would throw on the mutual relations of these rocks. In hand specimen, the porphyritic granite is seen to be stained by a green alteration mineral. In thin section, the following minerals are observed:

quartz, as phenocrysts, some of which include material similar to that of the ground mass, and a few of the smaller ones being surrounded by an aureole which is probably a resorption phenomenon; orthoclase and plagioclase, the former showing Carlsbad twins and being somewhat altered; apatite in rare needles; a black iron mineral, probably magnetite; chlorite with calcite, entirely replacing some ferromagnesian mineral, the former giving to the rock its peculiar greenish colour. There is also present a little secondary limonite and muscovite (sericite).

(5) Quartz porphyry.

The type to which this name is applied includes fine grained pink, brownish-red and greenish rocks in which quartz phenocrysts, visible to the naked eye, are either rare or absent. Under the microscope, a fine porphyritic structure is shown by the quartz and some of the orthoclase, in a microcrystalline ground mass consisting essentially of a mozaic of quartz and feldspar. Accessory minerals are rare, but some pyrite, a little black iron mineral, plagioclase, and mica may be detected. In the darker phases, epidote occurs as large irregular grains. The quartz, both in the phenocrysts and as irregular patches is often granulated. Limonite gives to the lighter types their pink to reddish colour.

(6) Diorite and quartz diorite.

The rocks of this division are medium grained and of intermediate composition.

Diorite.

True diorite is found in quantities subordinate to that of the more acid quartz diorites. One of the basic injections (?) in the granite is a fine to medium grained massive rock containing essentially plagioclase and hornblende, with a little disseminated pyrite.

Quartz Diorite.

Megascopically, these are very similar to the diorites in appearance, but even in hand specimen numerous quartz crystals are quite evident. One specimen, collected by a colleague in the extreme south of the area mapped is said to show gneissic structure in the field.

In thin section, these rocks possess a granitic texture, and contain in order of abundance, the following minerals: quartz, hornblende, plagioclase, orthoclase, apatite, a black iron mineral, pyrite, and secondary chlorite (from hornblende), calcite, sericite, epidote and limonite.

(7) Hornblende lamprophyre dikes.

Only one dike of this nature was found, at a point nearly two miles up Hind's River, where it invades the granite in an irregular intrusion, 5 ft. wide at the water's edge, but pinching sinuously to one or two feet at the top of the river bank. The texture is fine and even grained, the centre of the dike being but slightly coarser than the edges. A thin section from the edge of the dike reveals a fine even grained, holocrystalline rock with much hornblende, some orthoclase, and subsidiary quartz and a black iron mineral.

(8) Diorite and diorite porphyrite dikes.

These rocks have much in common with the larger dicrite and quartz diorite intrusions of division 6, but it has been found expedient to distinguish between them for purposes of mapping and of description.

In structure, they vary from fine porphyritic to medium even grained and coarse grained dikes.

Diorite dikes.

Under this heading will be described the even-grained types, some of which in thin section exhibit ophitic structure. The essential mineral constituents are green hornblende and plagioclase. Quartz, a black iron mineral, brown biotite, and apatite are accessory; while as secondary minerals there are present epidote (from hornblende), saussurite (from feldspar) and some calcite.

The coarser grained variety, which is believed to intrude the andesite-diabase lavas near the mouth of Hind's River, but whose boundaries could not be delimited, is composed of plagioclase feldspar, mostly untwinned, but sometimes slightly zoned and altered to epidote, which in the altered phases gives to the rock a peculiar green colour in hand specimen, another alteration product being saussurite; hornblende, with an average extinction angle of 14 degrees, showing some simple twins, and being partly altered to fibrous serpentine; augite, almost entirely replaced by chlorite, with ultra-blue polarization colours; quartz, partly veined and disseminated in small quantity, and probably secondary to a large extent; sphene, which appears to be forming from ilmenite; and calcite as other alteration products of the feldspar. A little pyrrhotite is also present.

Diorite porphyrite.

One ten-foot-wide dike of this type was found intruding the rhyolites west of Hind's Lake. It is a dark porphyritic rock with phenocrysts up to an one-eighth inch of quartz, plagioclase and hornblende, in a fine dark ground mass containing a little pyrite.

Microscopically, the structure is porphyritic, less commonly micrographic and ophitic. Plagioclase, chlorite (after hornblende) some quartz, sphene, pyrite, limonite and saussurite are the mineral constituents. These are distributed through a ground mass composed of fine feldspar laths and a black iron mineral. The matrix is so finely crystalline as to appear nearly isotropic except under a very high power objective.

(9) Granite porphyry, granophyre and granite dikes.

Granite Porphyry.

This dike rock contains phenocrysts of orthoclase and some of quartz, in a fine grained ground mass that is evidently epidotized. Under the microscope, the structure is porphyritic, and the following minerals are recognized: orthoclase, quartz, hornblende (largely altered to epidote and chlorite); accessory plagioclase, a black iron mineral, apatite needles, and sphene; with much secondary epidote, pseudomorphous chlorite after hornblende, and some carbonate, probably calcite.

Granophyre.

Only two occurrences of this rock were noted. It is a pink porphyry with orthoclase phenocrysts up to one-third inch, and smaller quartz phenocrysts in a fine grained ground mass also of orthoclase and quartz.

In thin section the structure is porphyritic with a micrographic groundmass. Quartz and orthoclase are the phenocrysts; epidote is found in grains, and secondary limonite calcite, and probably secondary quartz are present. A small quantity of unidentified and highly altered ferromagnesian mineral was also noted. See Fig. 10

Granite dikes.

In these medium-grained, light to grayish pink rocks of slightly porphyritic structure, abundant quartz and orthoclase occur with accessory hornblende and muscovite.

(10) Basaltic dikes.

As a result of what is considered to be the last phase of igneous intrusion in this area, very fine-grained dark basic dikes with occasional small needles of plagioclase and blebs of

Fig. - 10

Photomicrograph of thin section No. A58, GRANOPHYRE, from near mouth of Chesapeake Brook, West of Hind's Lake. A porphyritic rock with quartz phenocrysts (upper left corner) in a groundmass of micrographic quartz (clear) and orthoclase (turbid). The dark constituent is an altered ferromagnesian mineral, now represented largely by limonite.

Magnified 100 diameters; ordinary light.

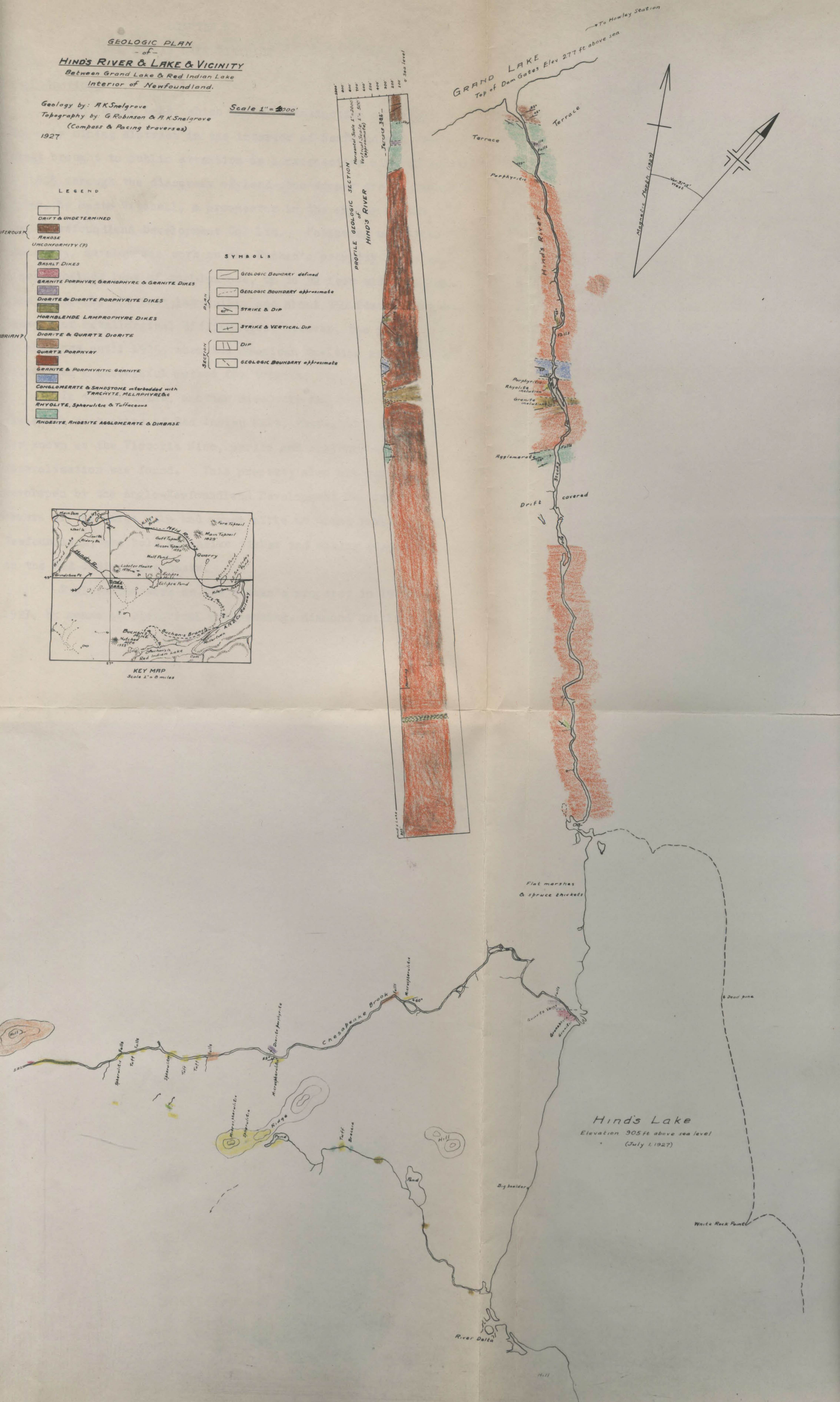
pyrite are found cutting the rhyolites, granite and the diorite dikes.

Under the microscope, a fine porphyritic structure is exhibited by the plagioclase, most of which is lath-shaped, with only a few stouter crystals. Decayed augite is invariably present. Accessory minerals include pyrite, a black iron mineral, and a little optically negative (high-iron) olivine. Calcite, chlorite and epidote are secondary products.

(11) <u>Arkose.</u>

This division no doubt forms part of the Carboniferous basin of Grand Lake, which near Howley only eight miles from here, contains coal.

The arkose is a fairly well compacted rock containing quartz and orthoclase in angular to sub-angular fragments averaging about one-tenth to an inch in size. The kaolinized orthoclase matrix and fragments give to the rock its characteristic pink colour.


GEOLOGIC PLAN
- of -
HIND'S RIVER & LAKE & VICINITY
Between Grand Lake & Red Indian Lake
Interior of Newfoundland.
Geology by: A.K. Snelgrove
Topography by: G. Robinson & A.K. Snelgrove
(Compass & Pacing traverses)
1927
Scale 1" = 4000'
LEGEND
DRIFT & UNDETERMINED
ARKOSE
UNCONFORMITY (?)
BASALT DIKES
GRANITE PORPHYRY, GRANOPHYRE & GRANITE DIKES
DIORITE & DIORITE PORPHYRITE DIKES
HORNBLENDE LAMPROPHYRE DIKES
DIORITE & QUARTZ DIORITE
QUARTZ PORPHYRY
GRANITE & PORPHYRITIC GRANITE
CONGLOMERATE & SANDSTONE interbedded with TRACHYTE, MELAPHYRE &c
RHYOLITE, Spherulitic & Tuffaceous
ANDESITE, ANDESITE AGGLOMERATE & DIABASE
SYMBOLS
PLAN
GEOLOGIC BOUNDARY defined
GEOLOGIC BOUNDARY approximate
STRIKE & DIP
STRIKE & VERTICAL DIP
SECTION
DIP
GEOLOGIC BOUNDARY approximate
KEY MAP
Scale 1" = 8 miles
Nfld Railway
Quarry
Eclipse Pond
Red Indian Lake
Buchans Branch
PROFILE GEOLOGIC SECTION of HIND'S RIVER
Horizontal Scale 1" = 2000'
Vertical Scale 1" = 500' (approximate)
0 Sea level
GRAND LAKE
Top of Dam Gates Elev 277 ft above sea
To Howley Station
Magnetic North (1927)
Terrace
Porphyritic
Hind's River
Falls
Porphyrite
Rhyolite inclusions
Granite inclusions
Agglomerate
Drift covered
Flat marshes & spruce thickets
Hind's Lake
Elevation 905 ft above sea level
(July 1, 1927)
Chesapeake Brook
Microspherulitic
Diorite porphyrite
Spherulitic
Tuff
Breccia
Ridge
Pond
Hill
Big boulder
White Rock Point
River Delta

CHAPTER 6.

RED INDIAN LAKE DISTRICT

Introduction.

Red Indian Lake, which has the distinction of being the only mining district in the interior of Newfoundland, was first brought to public attention as a prospective mineral region in 1905 through the discovery of lead-zinc-copper ore on Buchan's River, by Mattie Mitchell, a prospector in the employ of the Anglo-Newfoundland Development Co. Ltd. Following upon this discovery, development work on the Buchan's property revealed a well-defined lens of complex ore, up to 22 feet wide, and extending nearly 400 feet laterally, and about 350 feet on the dip. Because of metallurgical difficulties, however, the property was in abeyance until 1925, when the American Smelting and Refining Co.evolved a successful method for treating it.

In the meantime, another discovery had been made near the south east shore of Red Indian Lake, where, at a prospect now known as the Victoria Mine, pyrite and chalcopyrite mineralization was found. This property also was partly developed by the Anglo-Newfoundland Development Co. Ltd., the owners of the large pulp and paper mills at Grand Falls, Newfoundland, who hold extensive timber and mining concessions in the Red Indian Lake basin.

Exploration work on the Buchan's property in 1926 and 1927, by means of electrical prospecting, diamond drilling and underground development was successful in locating several new ore bodies, with the result that there has been much activity in speculation and prospecting in the whole Red Indian Lake District.

The Swedish-American Electrical Prospecting Co. is continuing its electrical surveys of the Buchan's Mining Company's property and of the adjoining claims to the north east which are held by The Porcupine Goldfields Development and Finance Company, Ltd.

The indications are that there will be a thorough combing of this entire region by prospectors during the summer of 1928 and succeeding years, and that these efforts will eventually spread north east towards the old mining districts of Notre Dame Bay.

The Red Indian Lake region therefore is one of much interest at this time. In this chapter will be reviewed the present knowledge of the geology of the area.

General Geology.

In his report for 1871, Alexander Murray (36, pp. 263-274) of the Newfoundland Geological Survey, said of the rocks of Exploits River and Red Indian Lake:-

"The geological formations which occupy the valley and lower features of the main (Exploits) river, below the Red Indian Pond (Lake) are of older date than the coal measures,' and more recent than the Quebec group (of the 'Lower Silurian.')

"Resting unconformably upon these strata (the Quebec Group, of magnesian strata, associated with quartzites, diorites, conglomerates and slates as exposed on the coasts and islands of Notre Dame Bay) more recent formations are spread over a large area in the Bay of Exploits, and for many miles up the Exploits Valley. ....These in many parts abound in fossils, often in a good state of preservation, most of which are typical of the lower part of the Upper, or upper part of the Middle Silurian system.

"Of still more recent date, there is a great display of igneous or eruptive rock of various mineral qualities, which has greatly disturbed and altered the sedimentary formations for the whole length of Exploits River and Red Indian Pond (Lake), and at many parts of Exploits Bay."

He divides the rocks of this section of the country into (1) the Lower Formation, and (2) the Upper Formation, which lies unconformably on (1).

(1) Lower Formation, (Quebec Group?)

This consists of magnesian strata associated with quartzite, conglomerate, slate, diorite, and serpentine; greatly disturbed.

These strata are intersected in places by "small veins of white quartz and halite, and the ores of copper and iron, especially the latter, in the form of pyrites, are of frequent occurrence."

(2) Upper Formations, Trap Dykes and Overflows.

"These formations appear to be distributed in the form of a rudely elliptical trough, with many irregular and deep indentations on either side, extending from the vicinity of Ragged Harbour, on Sir Charles Hamilton's Sound, on the north-east, to the Victoria Brook (River), on Red Indian Pond (Lake), to the south-west....... Nearly the whole valley of Exploits appears to be spread over by one part or another of these formations; but the breadth of the area on the northern side of the river is more limited than that on the south, as the final outcrop on the former side appears to run in a moderately straight line, from the northern arm to the confluence of the Badger Brook, and thence on to the north-eastern arm of the Red Indian Pond (Lake)........ The southernboundary has not yet been traced out; but the level character of the country on the south side of the Exploits River seems to favour the probability of the formation being extended over a great area in that direction. The evidences, so far, tend to show that while the formations butt up against the Quebec group on the northern and southern sides of the trough, they overlap the junction of the latter at the eastern and western extremes.

"The central part of this elongated trough has been greatly disturbed for the whole length of its course, from the head of the Red Indian Pond (Lake) to the Dildo Run (Notre Dame Bay) where vast dykes were seen to cut through the strata at very many parts, while great areas are spread over by overflows of traps, or breccious intercalations. These eruptive masses appear to run diagonally across the trough from Dildo Run to the north-east, bearing for the northern end of Change Islands....... It will be perceived that the course of this igneous action runs in a remarkably straight line northeast and southwest, and has, doubtless, given origin to the peculiar geographical features the region presents, and to the depression of the Exploits Valley. Moreover, the exact parallelism which obtains in this case, with the other main topographical features to the north and to the south, may be presumed to indicate that similar agencies were in active operation at the same time or a subsequent period along the lines of all these great valleys. In the valleys of the Grand and Deer Ponds (Lakes) the evidences appear to show that such movements were in operation at all events at as late a date as the Carboniferous period.

"The base of the Upper and unconformable formation consists of conglomerate and sandstone with slaty divisions. ......The lower conglomerates are of a reddish general colour, the matrix being constituted of fine reddish sand, sometimes slightly calcareous, which encloses well-rounded pebbles of quartz, red jasper, green jaspery slate, and fragments of magnesian rocks. The pebbles are not usually large, the largest being about the size of a hen's egg. The strata in ascending succession are still of conglomerate character, but the colour gradually passes into grey, and there are numerous pebbles of gneiss and syenite mingled with the other qualities, and they are frequently characterized by the presence of hard, blue or blackish cherty concretions, which weather a bright yellow, are sometimes concentric in structure, and of an elliptical shape. Total thickness..... about 2000 ft.

"The fossils recognized in the strata alluded to appear to be types of the Middle or Upper Silurian series, or about the horizon of the Llandovery group of the British Survey."....

At "Goldson's Sound, usually called Burnt Arm, ... the slates pass beneath a mass of limestone with black slate and trap breccia. At this part trap inclusions are met with, and the strata violently disturbed, and altered in some parts to such a degree as to assume somewhat the aspect of the inferior formation; but the occasional presence of fossils...... was supposed to indicate a horizon of later date than the Quebec group.

....."The graptolitic slates and associated strata, striking up the (Exploits) river, were recognized at several parts between the upper falls and Red Indian Pond (Lake); and finally, near the entrance to the Victoria Brook (River) where some strong bands of limestone constitute a part of the section, displayed in a series of acute corrugations; but at the lower part of the lake the rocks are of intrusive greenstone or trap breccia. A dyke of uncertain thickness runs into the lake at the upper end of the northeast arm bearing for and reappearing at the western end above Buchan's Island, where it assumes a columnar basaltic character, the columns almost pentagonal in shape, and inclined to a nearly horizontal position. Thence it runs near the margin of the lake in the direction of the Upper Valley, and at the foot of the Laurentian hills, immediately inland. Coarsely breccious rocks, which are often calcareous occupy the shores on each side of the dyke at the lower end of the lake, in which irregularly shaped masses of white, and sometimes pinkish coloured, carbonate of lime were found often to occupy the cells and cavities, while large angular fragments of quartzite and slate are bound together by a trappean paste. It was occasionally observed that a structure resembling a coral (Favosites?) occurred in the calcareous portions of the breccia."

Howley of the Newfoundland Geological Survey entered the Red Indian Lake area in 1888, from the south coast of the island, by way of Bay d'Est River and Noel Paul's Brook. In his report for that year he states:

"On approaching Noel Paul's Steady (south east of Red Indian Lake) no exposures of rock are met with till within about a mile of the river, when some finely laminated bluish grey silky slates are seen in a vertical attitude, striking up the valley. Similar slates, with frequent intrusions of a trap rock, crop out along the shores of the steady, and form a series of high ledges at the falls, where they cross the stream obliquely.

"On the west side of the steady, a peculiar pearly slate, passing into an impure slaty limestone, dipping south, angle 47°, crops out; and on the course of the river downwards at about a mile and a half below the steady, strong bands of bluish grey limestone strike across the river. This is succeeded at intervals by bluish grey slate,but at the lower falls, about two miles from the junction with the main Exploits River, the slates are interstratified with beds of diorite and here assume a hard flint nature approaching feldsites. These again are underlaid by fine conglomerates and sandstones in massive beds. .....These slates and associated limestones, sandstones, etc. are clearly of one geological horizon and correspond so closely in lithological character with those of the Exploits valley proper, that there is little doubt of their being identical. The absence of organic remains anywhere amongst the rocks seen this season renders it difficult to establish their exact age, but there are good grounds for assuming the above supposition to be correct.

"The few fossils found at the mouth of the Exploits on a former occasion, and the graptolites discovered in the black shales of Little Red Indian Fall on the Main River, (Graptolithus Namosus), were referred by Mr. Billings, late Paleontologist of the Canadian Geological Survey, to indicate a horizon equivalent to the Utica Slate and Hudson River divisions of the Trention series, at the top of the Lower Silurian formation, now known as the Cambro-Silurian."

The above quotations have been cited at length because they constitute the official knowledge of the geology of the Red Indian Lake area.

Descriptive Geology.

Whatever else is known of the area is due to visiting engineers and geologists. Of these, it may be noted that W.H.Weed (67, p.1611) some years ago classified the Buchan's rocks as sericitic schists formed of volcanic grits. This view, in the light of more recent work, is now discredited.

H.B.Hatch in describing the area southeast of Red Indian Lake, adjacent to the Victoria Mine stated "The areas are mainly underlain by sediments, which show intrusive metamorphism and structural deformations. Igneous intrusions are numerous and in their vicinity schisted areas occur."

A.V.Corlett, engineer of Porcupine Goldfields Development & Finance Company, after making a reconnaissance of that company's holdings north east of the Buchan's property, classified the formations as follows:

Post-Laurentian	(Intrusives:	Basic dikes
	(	(Tuffs and Breccias
	(Volcanics:	(Acid type
	(	(Basic type
	(Sediments:	Conglomerate, Quartzite and Arkose
Laurentian (?)		Granite

Furthermore, "the general strike in the area is roughly north sixty degrees east and the dip thirty degrees north."

Hans Lundberg in a paper entitled "Recent Results in Electrical Prospecting for Ore", (30) presented to the American Institute of Mining and Metallurgical Engineers February 1928, summarizes the geology of the Buchan's area thus:

"The bed-rock is covered with a rather thick mantle of glacial drift and rock outcrops are rare. The geological conditions are fairly simple, and it has been possible, with the aid of the electrical survey and the few outcrops, to form a general idea of the ore-bearing formation.

"The country rock is formed of bedded tuffs and porphyritic lava flows, probably to be classed as Archean. The tuff beds are composed of volcanic debris varying from fine powder of ash and tuff to arkose, grits, greywacke and even coarse conglomerate; thin beds of greenstone were found occasionally interbedded. Near the contact with the porphyrite the tuff beds are slightly altered. The beds composed of fine material here become dense and chert-like.

"The contacts with porphyrite are generally not well defined and often form agglomerates of varying aspects. This agglomerate, or pyroclastic breccia, is composed of rounded as well as angular fragments in a basic matrix which, farther from the contact, gradually turns into porphyrite. In some parts the fragments are fresh; in other parts they show heavy alteration.

"The tuff beds are sometimes folded and faulted, especially near the orebodies.

"The contact between the tuff beds and the porphyrites and sometimes large parts of the agglomerate are mineralized. The orebodies are found as lenses or irregular masses in the mineralization. The ore is composed of complex lead-zinc-copper sulfides in a baryte gangue.

"Two types of intrusive rocks are found in the area. A granite porphyry with large grains of quartz occurs in minor batholiths and resembles the acid granite found in this section of the island. It is suggested that this granite is connected with the formation of the ore-bodies. A younger and basic rock intrudes and cuts across both the granite and part of the mineralized area.

"The country has been glaciated during more than one period, which makes determination of the glacial transportation of boulders somewhat uncertain."

Dr. W.H.Newhouse, of Massachusetts Institute of Technology, geologist to the American Smelting & Refining Co., (Buchan's Mining Company) classifies the rocks of the Buchan's property thus:

Newer Series	Diabase Granite Quartz Porphyry	late Carboniferous ?
Older Series	Basalt, Basalt Agglomerate Andesite Tuffs Andesite, Andesite Agglomerate, Dacite, etc.	Pre-Cambrian ?

The present writer spent about a week in the Red Indian Lake area in the summer of 1927. Most of the time was occupied by an examination of the Buchan's property, of which a representative suite of rocks and ore specimens were taken, in addition he examined in a cursory manner the shore of Red Indian Lake between Buchan's and Millertown, at the north east of the lake.

The results of this work may be summarized thus:

(1) The Buchan's deposits of lead-zinc-copper ore occur

(a) in quartz porphyry.

(b) in the adjacent pyroclastics and lavas

and (c) at the contact of (a) and (b).

The quartz porphyry which is found in small masses aligned in a north east to south west direction is probably a differentiate of the granite which outcrops about three miles north west of the Buchan's Mine. The intruded lavas which are now more or less schistose, but much less so than those near Victoria Mine, on the southeast side of the lake, range from trachyte to andesite. They are interbedded with tuff, breccia and agglomerate and some grits, and strike northeast with a general dip of approximately forty degrees to the northwest.

Folding of the lavas, pyroclastics and sediments was observed along Buchan's Brook. Anticlinal structures occur near the quartz porphyry intrusives.

Minor faulting, accompanied probably by minor folding, occurs at right angles to the strike of the schistosity.

Later basalt dikes intrude the lavas and sediments, and possibly also cut the granite (30, p. 33).

A description of the rocks from this property will be found under Petrography, at the end of this chapter.

(2) Fine sediments (presumably Murray's Silurian, although no fossils were found) outcrop on the northwest shore of Red Indian Lake, on the property of the Porcupine Goldfields Development and Finance Co. At a place about three miles west of Miller's Point, on the lake shore, a section is exposed comprising coarse to fine greenish conglomerate and green and gray sandstone (total thickness about twenty feet) dipping forty-five degrees north and intruded by what appeared to be a diabase sill with the same dip, and striking north sixty degrees east (true).

A quarter of a mile further west, along the shore, the sandstones, with the same strike and somewhat flatter dips are conspicuously faulted. A fault of undetermined but presumably fairly large displacement, strikes north forty-five degrees east (true) and dips seventy degrees southeast. A parallel fault, with a throw of two feet, occurs a short distance to the west; while one hundred and fifty feet further west, the sediments are gently folded.

(3) The failure of some prospectors to locate the Silurian-Laurentian contact as roughly shown on the government geological map, is due to a lack of recognition of Murray's definition of the Silurian in this region. As shown above, Murray's upper division of the Silurian includes "overflows" or lavas, and in the writer's experience, these lavas actually abut against the granites approximately five miles north of the lake, although the age of the intrusives is probably later than 'Laurentian' as Murray mapped them.

(4) The 'Silurian' is intruded by hypabyssal rocks of intermediate composition at Exploits dam, at the outlet of Red Indian Lake. These intrusions were already noted by Perret on his geological map of Newfoundland (47) although the present writer was not aware of that fact until he returned from his field work.

Similar rocks also outcrop at Millertown, and between Exploits Dam and Millertown were found amygdaloidal lavas very similar to those exposed on Buchan's River.

Petrography.

The rocks of the Red Indian Lake district, so far as known at present, are divisible into two series: an older series of lavas, pyroclastics and sediments, intruded by a younger series composed of granite, quartz porphyry and basalt.

At the Buchan's property, the writer traversed Buchan's Brook which flows at right angles to the strike of the formations. The following descriptions apply particularly to the specimens collected in the course of that traverse, although for the sake of completeness some others will be included. In all fifty-two specimens were collected, from which thirty-five thin sections were prepared.

(1) Older Series (correlated tentatively with Murray's 'Upper Formation, Trap Dykes and Overflows' of Silurian or earlier Paleozoic age). It has been found possible to differentiate the following types in this group:

i) Lavas
  - a) Amygdaloidal Quartz Trachyte
  - b) Amygdaloidal Augite Trachyte
  - c) Andesite and Amygdaloidal Andesite

ii) Clastic Rocks
  - a) Pyroclastics
    - Tuff, Rhyolitic and Andesitic
    - Agglomerate
    - Breccia
  - b) Epiclastics (largely tuffaceous)
    - Tuffaceous Grits (-'Tuffite'
    - Feldspathic Grits)
    - Grits
    - Conglomerate

(2) Younger Series (correlated tentatively as post-lower Devonian)

i) Quartz Porphyry

ii) Orthoclase Porphyry

iii) Granite

iv) Basalt dikes

(1) The Older Series.

The LAVA members of this series were found, in thin section, to be much less basic than might be assumed from their appearance in hand specimen. As a rule, they are highly altered, the characteristic secondary minerals being chlorite, with lesser amounts of sericite, epidote and calcite.

The amygdaloidal facies are subordinate in amount to the normal lava types.

Amygdaloidal Quartz Trachyte.

In the field this lava appears to be of intermediate composition, with a light to dark green colour and fine texture. Small amygdules are fairly common. Under the microscope, numerous small amygdules are visible. These are largely filled with calcite, with a chlorite border. The ground mass of the rock is finely porphyritic. Sericitized orthoclase is the chief phenocryst; quartz is present in very small amount. Sphene occurs as numerous small irregular grains. The secondary products include much chlorite, and some sericite, epidote and calcite.

Amygdaloidal Augite Trachyte.

This rock in general appearance is very similar to the Quartz Trachyte, but pale brown augite is present as phenocrysts, together with orthoclase.

Andesites.

Matted plagioclase laths give a typical pilotaxitic structure to this rock, which is highly chloritized. Veinlets of serpentine traverse some of the sections. A little quartz and epidote were noted. In the amygdaloidal facies, calcite is invariably the filling.

The CLASTIC rocks are found in Buchan's district in large amounts.

Pyroclastics.

True Tuffs, composed entirely of volcanic material were rarely found. Several specimens, however, approximate this type. These are fine grained gray to light green in colour, and under the microscope show rude bedding. The fragments are of finely porphyritic rhyolite, lenticular or rounded in outline, with less common andesitic grains, cemented by quartz.

Agglomerate, with subangular and rounded pebbles of about walnut size are found in the old workings at Buchan's mine. Here the groundmass is replaced by galena, sphalerite and chalcopyrite. In places the rock is a volcanic breccia.

Epiclastics.

The classification of these rocks is somewhat problematical. In colour they are mottled reddish brown to grayish green, and in texture they vary from fine to coarse grain, the latter containing fragments up to one-third inch long. Field names such as arkose, greywacke and conglomerate have been employed by others in describing them, and their origin is explained by one worker as being due to mechanical deformation or crushing of quartz porphyry. While this explanation may hold in some cases, the present writer after examining numerous slides in which the heterogeneous character of the fragments became apparent, has no doubt that they are in large part cemented sediments. The name 'tuffite' ("A general term for composite clastic rocks, in which both volcanic - pyroclastic - and detrital - epiclastic - materials are present in considerable amount"), proposed by Mügge (19), probably describes these rocks most accurately, but it has been found expedient to employ the term'grit'in the following descriptions to connote their angular sedimentary character and texture intermediate between that of sandstone and conglomerate, with an adjective to emphasize the most prominent constituent.

Tuffaceous grit occurs in largest amount. The constituents are volcanic fragments of acid to intermediate composition, some of which show microspherulitic, fluxion and finely porphyritic structures; together with quartz, orthoclase, plagioclase and secondary sericite, calcite, hematite, limonite, chlorite and calcite. These grits are often veined and reticulated by secondary quartz.

The feldspathic grits are typically reddish brown to gray in colour, and in general appearance much like an arkose, but they are often highly decomposed, well compacted, and also contain more or less tuff fragments. The cement of these fragments was apparently argillaceous but is now largely sericitic. Further evidences of alteration are quartz and calcite veinlets cutting across fragments, and the subsequent crushing and comminution of these veinlets.

All gradations of these epiclastics are met with, from very fine grits to conglomerates.

(2) The Younger Series.

Of these rocks, quartz porphyry is the most important economically because of its probable connection with the origin of the ores.

Quartz Porphyry.

This rock is medium grained, light grayish green in colour, with quartz phenocrysts generally visible to the naked eye.

In thin section, quartz is found to be the commonest phenocryst, although crystals of orthoclase and sodic plagioclase sometimes occur. In rare instances the quartz is observed to be partly resorbed. Accessories, other than pyrite and a little apatite, are rare. A ferromagnesian mineral, probably hornblende, was noted in only one section, and it is almost entirely replaced by chlorite. The rock shows invariably an appreciable amount of alteration; the products are sericite, chlorite, calcite, limonite and epidote. The ground mass is commonly microcrystalline.

In the field, the quartz porphyry is found in varying degrees of schistosity and silicification.

Orthoclase Porphyry.

This acid hypabyssal rock is of restricted occurrence. It is light brown in colour. Orthoclase phenocrysts are visible in hand specimen, in a fine grained ground mass. Under the microscope, this ground mass is found to be made up of a fine mozaic of quartz and orthoclase. Only the latter mineral forms phenocrysts, and it is altered somewhat to sericite. Epidote occurs as small veinlets.

Granite.

Granite is found about three miles northwest of Buchan's Mine. The constituent minerals are orthoclase, quartz, mica, and a little plagioclase.

Basalt Dikes.

Two dikes of this composition were noted in Buchan's Brook. They are very fine grained dark green rocks with small feldspar phenocrysts visible in hand specimen. Under the microscope, the feldspar is found to be plagioclase, with an extinction angle indicating labradorite. Accessory minerals are magnetite, a little quartz and augite; and secondary products include calcite, epidote, limonite and chlorite.

CHAPTER 7.

THE SIGNIFICANT FEATURES OF THE ECONOMIC GEOLOGY OF THE CENTRAL MINERAL BELT.

The present knowledge of the geology of the Central Mineral Belt has been presented in some detail in the foregoing chapters. It now remains to extract from this mass of data certain generalizations which appear warrantable, and which while necessarily lacking finality may serve as a working hypothesis of the processes responsible for the deposition of the ores found in the belt.

The Origin and Age of the Ore Deposits.

The region is one of comparatively old rocks. This is evidenced by the nature and structure of the ore deposits and also by the absence of any proven geologic record, other than erosional and glacial, throughout the island generally, since late Paleozoic Times. However, it is now evident that much of the territory mapped by the Geological Survey (under Murray and Howley) as "Laurentian and Undetermined" is of more recent age than Pre-Cambrian, and in the present writer's experience the only areas in The Central Mineral Belt to which the old classification may be applied without much doubt are those underlain by ancient schists and gneisses on the south west coast (57), the granites and gneisses of the interior immediately east of the Central Mineral Belt near Red Indian Lake (20, p.113) and the granitic and basic gneisses near Kitty's Brook on the Newfoundland

Railway in the west central part of the belt.

Overlying the Pre-Cambrian are thick series of lava flows and sediments, most extensively developed in Notre Dame Bay and in the Exploits River - Red Indian Lake trough. These, with certain intrusive rocks, were in large part included by Murray in his "Quebec Group" in Notre Dame Bay, and in his "Silurian" in the trough which is now drained by the Exploits River.

But as a result of more recent work, Sampson (54) has been able to divide the Notre Dame Bay formations into

(1) Cambrian ? pillow lavas and pyroclastics,
(2) Ordovician volcanics, shales, sandstones, conglomerates and limestones.
and (3) Silurian sandstones and conglomerates, possibly with minor amounts of volcanics.

while in the Exploits trough, Murray's classification of "Upper Formation, Trap Dykes and Overflows" with basal conglomerate, sandstone and slate (the last-mentioned containing fauna of Llandovery age) unconformably overlying the "Quebec Group" of the "Lower Silurian" still prevails.

In both the Notre Dame Bay and Red Indian Lake districts the structure is complicated. Faulting in Notre Dame Bay is, according to Sampson, "highly developed, but folding is not conspicuous and is seldom observed, although dips are high, often vertical;" and Murray noted that "the central part of this (Exploits) elongated trough has been greatly disturbed for the whole length of its course from the head of Red Indian Lake to the Dildo Run".

Probably accompanying this faulting and folding, which inferentially was of post-Silurian age, was the intrusion of a granite batholith, or batholiths, now exposed in the western part of the Notre Dame Bay district, and at intervals throughout, and conceivably underlying a major portion of, the zone here designated as the Central Mineral Belt; together with smaller intrusions ranging from diorite to basalt in Notre Dame Bay, and quartz porphyry to diabase in Red Indian Lake.

It has been suggested in chapter 2 that the basic intrusions in Notre Dame Bay, where they are intimately associated with the ore bodies, are differentiates of the granite batholiths. Furthermore, in Red Indian Lake, the quartz porphyries, which are evidently genetically connected with the mineralization, are mineralogically similar to, and show textural gradation from, the granite.

On the whole, therefore, a general association of the deposits of the Central Mineral Belt with granitic batholiths and their possible differentiates is indicated.

As to the age of these igneous invasions, the writer has at present no direct evidence to offer. However, from the work of others, the approximate age of the orogeny may be placed with a fair degree of probability.

Murray (36, p.269), in 1871, stated that:

"The evidences appear to show that such movements (as were responsible for the disturbance of the Red Indian Lake trough) were in operation at all events at as late a date as the

Carboniferous period.... in the valleys of Grand and Deer Lakes."

Professor Sampson, in a personal communication (77) expressed his belief that the igneous rocks in Notre Dame Bay are later than any of the sedimentary formations.

Schuchert and Dunbar (55) found in their studies of western Newfoundland that:-

"The later Devonian was a second period of orogeny (the first being Ordovician) marked by folding and by both extrusions and extensive laccolithic intrusions of basic lavas. ....The third period of orogeny was that of the Appalachian revolution, which began here some time late in the Paleozoic."

Brunton (76) who also investigated the west coast of the island, believed:-

"The age of the igneous masses on the west coast of Newfoundland is in all probability Carboniferous or post-Carboniferous instead of Archean. ....The area including Gaspe, Nova Scotia, Cape Breton Island and Newfoundland is probably the same petrographical province."

Turning now to the mainland, it has been established (51) that:-

"The main period of folding is older than the Carboniferous, as is shown by the lie of the Coal Measures in New Brunswick, but folding movements did not go on after Permian times, for the Permian sandstones are in a horizontal position in Prince Edward's Island, and in the Bay of Fundy."

Referring to Devonian intrusive rocks, Reed states further:-

"Serpentine intrusives stretch the whole way from Newfoundland through Quebec to Georgia, and cut rocks of Upper Cambrian, Ordovician and Silurian age. They are supposed to be later than the earliest Devonian. ......At a somewhat later date in Devonian times.....along the main axis of Nova Scotia there occurred..... a great intrusion of granite, the main mass occupying the south-western part of the province, and extending as far east as Halifax, with a length of about one hundred and fifteen miles and a width of about thirty miles. The granite batholiths form the core of the Cobequid and South Mountains. Devonian granites also form the axes of the southern and northern mountains in New Brunswick. ......The above described igneous intrusions were a concomitant phenomenon.... of the Taconic Disturbances. Blackwelder has termed it the Brunswickian epoch, but it is generally called the Acadian Revolution."

The age of the orogeny in Newfoundland is, therefore, assigned to some time between the Devonian and the Pennsylvanian, most probably post lower-Devonian. It must, nevertheless, be kept in mind that only in the Notre Dame Bay and Red Indian Lake districts has the age of the intrusives been placed as post-Silurian; that the intrusions are not necessarily contemporaneous throughout the whole Central Mineral Belt, and that the suggestion advanced (p. 58) of possible pre-Cambrian age of the Hind's Lake batholith should still be taken into consideration until further investigation solves these problems.*

The Structure of the Central Mineral Belt.

The approximate coincidence of the Central Mineral Belt with the New Brunswick geanticline has already been referred to (p. 23). In support of this view the following facts may be cited:-

(1) The folded roof pendants in the Hind's Lake batholith (See section, Fig. 11).

(2) The bordering Carboniferous basin of Grand Lake on the western side of the belt, in which the structure indicated is that of a

*Much of the mountainous country south of Red Indian Lake was mapped by the Geological Survey as "Trap Greenstone &c" but in the absence of more definite information these traps are here regarded as of volcanic origin, rather than intrusive. In several other similarly mapped areas, such as that paralleling the east side of Grand Lake, this formation is believed to be composed of lavas; and in the better known parts of the belt basic intrusive rocks are of much more restricted development than those of more acid types.

downfaulted syncline.

and (3) The Silurian 'trough' underlying Exploits River and Red Indian Lake on the eastern side of the belt. Of the general structure of this 'trough' comparatively little is known. In the Red Indian Lake district, however, recent work has shown that the average dip of the sediments, and of the schistosity of the lavas and pyroclastics, is about forty-five degrees to the northwest, both on the east and west sides of the lake, with minor folds giving dips in the opposite direction. In a traverse across this sedimentary 'trough' from Grand to near Lake Bond, along the Newfoundland Railway, the present writer recorded eighteen dips, of which eleven averaged sixty-five degrees north west, two seventy-five degrees south east and five were vertical. No information is at present available as to the structure of the eastern part of the 'trough'.

Several other structural features of the belt deserve mention. Among these, the most conspicuous is the marked alignment of the Buchan's, Great Gull Lake and Robert's Arm deposits. A line joining these properties forms the central axis of the Central Mineral Belt as here defined. This 'line of weakness' has not, however, so well developed a topographic expression as that exhibited by the two structural valleys which cross the belt at a small angle to the central axis. The first of these is the Grand Lake to Indian Brook (Hall's Bay) depression, and the second, the Red Indian Lake - Exploits River depression has been referred to already.

The broad structural features appear to conform with the postulation made above, viz., that the belt is largely an uplift underlain by a granite batholith, or batholiths, intruded at the southwest, into older plutonic rocks, and at the northeast into lavas, pyroclastics and sediments dominantly of early to middle Paleozoic age, and now more or less highly disturbed.

Application of the Present Knowledge to Prospecting.

It follows from the conclusions arrived at in an earlier part of this chapter that the place to prospect for ore is near the contact of the intrusive batholiths and their apophyses or offshoots, with the surrounding sediments and lavas.

Since the three districts into which the Central Mineral Belt was divided in Chapter 2 have local features which only in their general relationships form a connected whole, it is well to consider them separately as fields for prospecting.

In the NOTRE DAME BAY DISTRICT as has been shown on page 20, the borders of the smaller granite batholiths are favorable loci for ore deposition. The Ming's Bight gold prospect illustrates this type of occurrence. The immediate periphery of the larger granite batholiths, however, is seldom mineralized, as was pointed out by Howley (36, p.414) in 1875:-

"It was further observed... that the same rocks (i.e., 'chlorite slate, diorites and dolomites, nearly related to or associated with serpentine') became barren of ore, or at all events it was more widely disseminated, when they came in contact or nearly approached tha granitoid intrusions; which latter appear to be destitute of metalliferous material, except iron pyrites, which mostly occur in intersecting quartz veins."

It is rather in the vicinity of smaller intrusive masses of intermediate composition, such as diorite, that the copper ores are to be found, and here the country rock most susceptible to replacement is almost invariably chloritic schist, which is often oxidized to a yellow gossan at the surface. The development of chlorite in the neighbourhood of these dikes and other intrusive masses is regarded as a phase of prophylitization. This alteration, in common with the orebodies themselves, was brought about by ascending thermal waters, with their igneous emanations derived from the postulated underlying batholith. The solutions travelled along channels provided by 'lines of weakness' probably developed during post-lower Devonian disturbances, and now in part occupied by dikes. In places the small intrusive masses are themselves ore-bearing, but oftener the deposits are found either at the contact or entirely within the adjacent chloritized country rock. It is considered likely that structure more than anything else was the determining factor in localizing the ores of this district. This relation has been used as one of the criteria for the existence of the Central Mineral Belt.

In the RED INDIAN LAKE DISTRICT the "ore bringer" as far as is at present known, was quartz porphyry, which occurs as small masses more or less aligned in belts, as far as eight miles horizontally away from any exposed granite, to which it is, nevertheless, in all probability connected at depth. Certain tuff beds appear to have been most easily replaced by the ore solutions and it is in these that the deposits are usually located, especially where schisting has been intense. Alteration processes in this district seem to be characterized by the development of secondary quartz, carbonate and some sericite and epidote. It is believed that here also structure will be found an important controlling factor in ore deposition. The presence of major northeast-southwest folding and possibly major faulting, with minor faults at right angles has already been referred to in Chapter 6.

On the SOUTHWEST COAST, the association of the ores with small granite batholiths indicates a genetic relationship between the deposits and these acid intrusives, and thus delimits in a general way the most likely ground for prospecting.

Throughout the entire belt erosion has been in progress uninterruptedly since the late Paleozoic, and in the Pleistocene the region was severely glaciated. Consequently a great part of the Paleozoic lavas and sediments has been stripped off, and the deep seated batholith exposed. Erosion is now at a stage where comparatively few large masses of the granite are revealed at the surface. Smaller stocks, which represent the top of the batholith, and dikes and other minor intrusions of possible differentiates are, however, common. One result of the present work is the elimination for purposes of prospecting of areas far removed from the effects of these smaller intrusions.

The ores now found at the surface were formed at intermediate to great depths. Any secondary enrichment has been almost entirely removed by glaciation. A blanket of glacial drift covers a large part of the area.

The discoveries of the future will be mainly of primary ores, in which secondary enrichment will be practically negligible.

The Central Mineral Belt as a Field for Exploration.

The Central Mineral Belt of Newfoundland combines, in a very compact manner, the three possibilities sought by the mining engineer, viz., new ore in old mines, new mines in old districts, and favourable prospecting ground in practically unexplored regions.

The conditions affecting exploration, such as location, accessibility, climate, water power, timber, labour, government attitude, and mining law, leave little to be desired.

The Notre Dame Bay copper mines were worked at a time when only high grade ores could be shipped. Lower grade deposits are now economically available, as a result of advances in ore dressing and metallurgy. The resumption of copper production from this bay is a problem which offers interesting possibilities, and one in which close co-operation of interests seems to be a prime necessity, in exploration as well as exploitation.

In the light of the present knowledge, much of the unexplored territory in the central, the southern, and the north-western parts of the belt, merits examination by the prospector, the geologist and the mining engineer.

Local conditions of glacial drift and moss-bogs tend to minimize the usefulness of ordinary prospecting methods in many places, and electrical prospecting and diamond drilling are bound to play an important part in the future development of both the proved and the as yet unexamined districts.

BIBLIOGRAPHY.

1. Allen, R., Copper Ores; Imperial Institute, London, 1923.

2. Bancroft, J.A., Report on the Copper Deposits of the Eastern Townships of the Province of Quebec; Quebec Mines Branch, 1915.

3. Bonnycastle, Sir R.H., Newfoundland in 1842; (Geology & geological relations, vol.1,pp.179-222), 2 vols. London, 1842.

4. Bowman, I., Forest Physiography;

5. Chappell, R.N., Voyage of H.M.Ship Rosamond to Newfoundland and the Southern Coast of Labrador; London, 1818.

6. Cormack, W.E., Account of a Journey across the Island of Newfoundland; Edinburgh Philosophical Journal, 10: pp. 156-162, (Map); Also in Howley, J.P., The Beothucks of Red Indians; Cambridge, 1915, pp. 130-168.

7. de Launay, L., Les richesses minérales de Terre-Neuve; Annales des Mines, 1894.

8. Dresser, J.A., Preliminary Report on the Serpentine and Associated Rocks of Southern Quebec; Memoir 22, Canadian Geological Survey.

9. Dresser, J.A., Copper in the Eastern Townships (Quebec); Trans. Canadian Inst. of Mining & Met., 1928.

10. Fay, A.H., Glossary of Mining and Mining Industry; Bull.95, United States Department of the Interior.

11. Garland, J., Copper Mining at Tilt Cove, Newfoundland; Royal Geological Society of Cornwall, Trans.11: pp. 95-105 (1888).

12. Geological Survey of Newfoundland, The, Annual Reports, 1864-1909, & geological map (reprinted 1925).

13. 'Geological Survey of Newfoundland;' Nature, XIV, 1876.

14. Gratacap, L.P., Newfoundland, its Geology and Mineral Resources; Mining World, 23: pp. 525-526 (1905).

15. Harker, A., Petrology for Students;

16. Harvey, Rev.M., Newfoundland in 1897; London, 1897.

17. Hatch, H.B., Private Reports to the Natural Resource Department, Reid Newfoundland Company, Ltd.

18. Hatton & Harvey, Newfoundland; (Geology, pp. 150-157), Boston, 1883.

19. Holmes, A., The Nomenclature of Petrology, London, 1920.

20. Howley, J.P., Annual Reports, Newfoundland Geological Survey, vol. 2, 1881-1909.

21. Howley, J.P., History of Mining in Newfoundland; Canadian Mining Review, Sept. 1901.

22. Howley, J.P., Geology and Mineral Resources of Newfoundland; Mining World, 31: 701-704, (map), 1909.

23. Iddings, J.P., Rock Minerals; New York, 1906.

24. Jukes, J.B., General Report of Geological Survey of Newfoundland during 1839-40; London, 1843.

25. Jukes, J.B., Excursions in and about Newfoundland during the years 1839-40; London, 1842.

26. Johannsen, A., Essentials for the Microscopical Determination of Rock-forming Minerals and Rocks in Thin Sections; Chicago, 1922.

27. Landell-Mills, T., The Carboniferous Rocks of the Deer Lake District of Newfoundland; Geol. Soc. of London, Abstr.proc.No. 1083, pp. 53-54, March 2,1922.

28. Lindgren, W., Mineral Deposits; New York, 1919.

29. Logan, Sir W.E., Geology of Canada; Montreal, 1863.

30. Lundberg, H., Recent Results in Electrical Prospecting for ore, Technical Publication No. 98, Amer. Inst.of Mining & Metallurgical Engineers; (Newfoundland, pp. 32-36).

31. Marett, E., On the Copper and Nickel Mines at Tilt Cove, Newfoundland; Nova Scotia Institute of Science, Pr.Tr. 3: pp. 27-31 (1872).

32. Marsh, O.C., Catalogue of Mineral Localities in New Brunswick, Nova Scotia and Newfoundland; Amer. Journal of Science (2) 35: pp. 210-218 (1863).

33. Milne, J., Notes on the Physical Features and Mineralogy of Newfoundland; Quarterly Journal, Geological Society of London, 1874.

34. Milne, J., On the Rocks of Newfoundland; Geological Magazine, (2) 4: 251-261 (1877).

35. Moreton, J., Some Account of the Physical Geography of Newfoundland; Journal, Royal Geographical Society, XXXIV, 1864.

36. Murray, A., Annual Reports, Newfoundland Geological Survey, vol. 1, 1864-1881.

37. Murray, A., Geography and Resources of Newfoundland; Jour. Geographical Society, XLVII, 1877.

38. Murray, A., Distribution of the Serpentine and Associated Rocks, with their metallic Ores in Newfoundland; (abst) Philosophical Magazine (5) 7: pp. 216-(1879).

39. Murray, A., Mining in Newfoundland; Engineering Mining Journal, 31: p. 430, 1881.

40. Murray, A., Orographical Map of Newfoundland.

41. Murray, A., Resources of the Interior of Newfoundland; St. John's, 1874.

42. Outerbridge, A.E., jr., Mineral Wealth of the Islands of Newfoundland and Jamaica; Journal, Franklin Institute, vol. 168: pp. 457-469, 1909.

43. Outerbridge, A.E., jr., The Undeveloped Mineral Wealth of Newfoundland; Journal, Franklin Institute, vol. 144: pp. 163-170, 1897.

44. O'Neill, J.J., St. Hilaire (Beloeil) and Rougemont Mountains (Physiography, pp. 18-19), Memoir 43, Canadian Geological Survey, 1914.

45. Perley, M.H., Observations on the Geology and Physical Characteristics of Newfoundland; Canadian Naturalist and Geologist, 7: pp. 321-334, 1862.

46. Perley, M.H., On Subsidence of the Shore of Newfoundland; Boston Society of Natural History, Pr. 3: pp. 374-375, 1850.

47. Perret, R., La Geographie de Terre Neuve; Libraire Orientale et Americaine, Paris, 1913.

48. Perret, R., La Cartographie et la Morphology de Terre Neuve; Commission de Topographie du Club Alpin Francaise Procès-verbal de la séance du 24 mai, 1912.

49. Phillips, J.A., A Treatise on Ore Deposits; (Ref.to Little Bay and Bett's Cove properties), London, 1884.

50. Pirsson & Schuchert, Textbook of Geology.

51. Reed, F.R.C., Geology of the British Empire; London,1921.

52. Robinson, G., Report of a journey across the island of Newfoundland, undertaken at the instance of His Excellency Sir J.H.Glover, from Southern Arm, Green Bay, to Southeast Arm of Bonne Bay; Jour. Royal Geographical Society, XLVII, 1877.

53. Rogers, J.D., Newfoundland; in Oxford Survey of the British Empire; Oxford, 1914.

54. Sampson, E., The Ferruginous Chert Formations of Notre Dame Bay, Newfoundland; Journal of Geology, vol. 31, No.7, pp. 571-598, 4 figs. Oct-Nov. 1923.

55. Schuchert & Dunbar, Stratigraphy and Diastrophism of Western Newfoundland; (abst) Geol. Society of America, Bull. 32, No. 1, pp. 38-39, March 31, 1921.

56. Selwyn, A.R.C., The Quebec Group; Science, vol.IX, 1887.

57. Sexton, Dr. F.H., Personal communication to the author.

58. Smith, H.G., Minerals and the Microscope; London, 1919.

59. Snelgrove, A.K., Mineral Exploration in Newfoundland during the Decade 1917-1927; Proc. 2nd Triennial Empire Mining Congress, 1928.

60. Spurr, J.E., The Ore Magmas, 2 vols.; New York, 1923.

61. Symons, B., Mineral Resources of Newfoundland; Mining Journal, London, 67: pp. 167-169 (1909).

62. Symons, B., Mineral Resources of Newfoundland; Engineering Mining Journal, 90: pp. 360-363 (1910).

63. Toque, Rev. P., Newfoundland as it was and as it is in 1877; Toronto, 1878.

64. Twenhofel, W.H., Physiography of Newfoundland; American Journal of Science (4) 331, pp. 1-24, (1912).

65. Wadsworth, M.E., Notes on the Rocks and Ore Deposits in the Vicinity of Notre Dame Bay, Newfoundland; Amer. Jour. Science, (3) 28: pp. 94-104 (1884).

66. Walcott, C.D., Notes on the Quebec Group; American Journal of Science, 1890.

67. Weed, W.H., The Mines Handbook; New York, 1918.

68. Weston, T.C., Notes on the Geology of Newfoundland; Nova Scotia Inst. Science, Pr.Tr. 9 or (2), 2: pp. 150-157, (1896).

69. Willis, B., Mechanics of Appalachian Structure; 13th Annual Report, United States Geological Survey, 1894, pp. 211-261.

70. Willson, B., The Tenth Island; An Account of Newfoundland; London, 1897.

71. Wilson, A.W.G., The Laurentian Peneplain; Journal of Geology, vol. 11, Oct-Nov. 1903, pp. 615-669.

72. Wingfield-Bonyn, Agricultural and Mineral Lands of Newfoundland; St. John's, 1890.

73. World Atlas of Commercial Geology; United States Geological Survey, Washington, 1921.

74. Coleman, A.P., The Pleistocene of Newfoundland; Journal of Geology, 3, April-May, 1926.

75. Reudemann, R., New York State Museum Bull. 240.

76. Brunton, Sir S., The West Coast of Newfoundland; Mining Magazine, vol.27, no.5, pp. 265-273, Nov. 1922.

77. Sampson, Prof. S., Princeton University, Personal communication to the author.

Appendix A

Mineral Exploration in Newfoundland During the Decade 1917-1927

BY

A. K. Snelgrove

The Congress as a body is not responsible for the Statements or Opinions expressed in any of its Publications.

Subject to revision.] [*This paper was presented at the St. John's, Newfoundland, meeting of the Second (Triennial) Empire Mining and Metallurgical Congress, September 14th, 1927. Contributed discussion should be addressed to the Editor of the Congress at No. 604 Drummond Building, Montreal, Que., Canada.*

MINERAL EXPLORATION IN NEWFOUNDLAND DURING THE DECADE 1917-1927

BY A. K. SNELGROVE (*Stud. Mem. C. Inst. M. & M.*)*

HISTORICAL SUMMARY

The history of prospecting and field-work in economic geology in Newfoundland during the past decade resolves itself, in large measure, into an account of the activities of the Natural Resource Department of Mines & Forests (Newfoundland), Limited, a subsidiary of the Reid Newfoundland Company, Ltd., the late operators of the railway and steamship systems. Nor is this surprising when one learns that the Reid interests either own or control an area of over 2,650,000 acres of mineral lands in this country, to the development of which the Natural Resource Department has devoted its efforts since its inception in 1918.

While paramount, Mines & Forests (Nfld), Ltd., have not, however, been alone in the field of mineral exploration, and in the sequel an attempt will be made to present a résumé of all exploratory work of any consequence during the past ten years, as well as to indicate the results achieved.

CONDITIONS AFFECTING EXPLORATION IN NEWFOUNDLAND

As a preamble to our main topic, it is fitting that we should, at this point, review the conditions which confront the prospector, the geologist, and the mining company wishing to engage in exploration in Newfoundland. These conditions we may classify as (1) Physical, and (2) Governmental.

---

*LeRoy Fellow in Geology, McGill University, Montreal.

Physical Conditions

Location and Accessibility:

Newfoundland is an island about 42,000 square miles in area, and approximating an equilateral triangle in shape, situated off the east coast of North America, at the mouth of the gulf of St. Lawrence.

Its dependency, Newfoundland Labrador, on the eastern watershed of the Labrador peninsula, on the mainland, has an area, under recently defined boundaries, of over 110,000 square miles.

The geographic position of the Island is such that both American and European markets for mineral products are in almost equal and comparatively close proximity. Both passenger and cargo boats ply regularly between St. John's, the capital city, and the great ocean ports of the Atlantic, especially Liverpool, New York, Boston, and Halifax. At North Sydney, Nova Scotia, connection is made with the Island by way of a one-hundred mile trip across Cabot strait, on steamers owned by the Newfoundland Railway, which operates 4,134 miles of railway and steamship lines within and around Newfoundland. This transportation system gives access to all the settled parts of the Island, from which communication with the interior is readily established.

Climate:

Newfoundland enjoys a cool temperate climate, with no extremes either of heat or cold. Actual geological field-work can be carried on during the season between the middle of May and the end of November. In mild years, an extra fortnight's work, both before and after this period, is sometimes possible. The annual precipitation is in the neighbourhood of 55 inches, of which about one-quarter is in the form of snow. Between the 15th of January and the 1st of May, the northern part of the Island is frozen-in, but on the south coast good, all-year ports are numerous.

Geology:

Newfoundland is built up about a nucleus of pre-Cambrian rock, which, although composing over three-quarters of the Island, have as yet been but little differentiated petrographically. Surrounding, and in part encroaching upon, this protaxis, are extensive sedimentary formations, none of which is later than the Pennsylvanian (Carboniferous).

Along the entire west coast of the Island, Palæozoic sediments form a low foreland to the Long Range mountains, with a stratigraphic sequence, according to Schuchert and Dunbar ([1]), beginning with a well-developed Lower Cambrian, resting on Laurentian granite and metamorphics, and closing with the Pennsylvanian. Petrographically, and in their fauna, the lower Cambrian quartzites, shales, and limestones here show limited relations with the Lower Cambrian of eastern Newfoundland, whereas all the succeeding fauna indicate complete isolation of these two regions.

Penetrating into the centre of the country, and stretching almost across its entire length, are long, narrow embayments of Silurian sediments, comprising limestones, slates, and sandstones, in many places highly metamorphosed.

The southeastern section, including the Avalon peninsula, is composed largely of pre-Cambrian sediments, plutonics, and volcanics. These have been correlated tentatively by Dr. H. A. Baker ([2]), Newfoundland Government Geologist, with the Keewatin, Laurentian, Lower and Middle Huronian, Animikie, and Keweenawan of Canada. In this region, good sections of Cambrian are also exposed, overlain in places by patches of Ordovician, of restricted distribution.

The west coast exhibits evidence ([3]) of having shared in at least three periods of orogeny, *viz.*: (1) At the close of the Ordovician, when the western fault-scarps of the Long Range mountains were formed; (2) In the later Devonian, which was marked by folding and by both extrusions and extensive laccolithic intrusions of very basic lavas; and (3) The Appalachian revolution, which began here some time late in the Palæozoic. The close of Cretaceous time is thought to have witnessed the uplift of the highlands of the west coast to an amount equal to about 800 feet, according to Twenhofel ([4]),

---

(1) Schuchert, C., & Dunbar, C. O., Stratigraphy and Diastrophism of Western Newfoundland (abstract); Bull. Geol. Soc. Am., Vol. 32, No. 1, pp. 38-39, March 31st, 1921.

(2) Geol. Survey of Nfld., Report of Progress for 1926, pp. 5-12.

(3) Schuchert, C. & Dunbar, C. O., *loc. cit.*

(4) Twenhofel, W. H., Physiography of Newfoundland; Am. Jour. Sci., Vol. 33, pp. 1-24, 1912.

in whose opinion the slope of the Cretaceous peneplain, traceable across the entire Island, is probably due to tilting that has occurred with uplift, which, however, does not appear to have been a simple warping uplift, but to have been due to different blocks acting as units, of which the Long Range is perhaps the most conspicuous.

In the interior of the Island, as well as in the areas already studied in more or less detail, the rocks have also been involved in major faulting and folding, which laid an early foundation for the present physiography. Igneous intrusion and extrusion have been widespread. That at least some of this activity is of Silurian or post-Silurian age is instanced by the numerous elliptical stocks intrusive into Silurian sediments. Brunton has expressed the opinion (1) that many of the igneous masses of the west coast are in all probability of Carboniferous or post-Carboniferous age.

Figure 2.—Glacial boulders, Western Plateau Region.

Newfoundland has been shown by Professor A. P. Coleman (2) to have suffered at least two advances of Pleistocene glaciation. Following the depression of the land surface caused by these ice sheets, the Island experienced resilient uplift, whereby isostatic equilibrium was restored. The zero

(1) Brunton, Sir Stopford, The West Coast of Newfoundland; Min. Mag., Vol. 27, No. 5, pp. 265-273, Nov., 1922.

(2) Coleman, A. P., The Pleistocene of Newfoundland; Jour. Geol., 3, April-May, 1926.

isobase for post-glacial emergence, Daly [1] finds to cross the Island from a point on the west coast, about 40 miles north of Port aux Basques, to a point on the east coast between cape Bonavista and Fogo island. North of this line, the amount of emergence increases, measuring about 400 feet at the northern tip of Newfoundland.

Economic Geology:

The economic mineral deposits of Newfoundland, as at present known, are as follows, in their order of importance:

(*1*) *Metallic ores.*—Iron, copper, silver-lead-zinc, sulphur (pyrite), chromium, molybdenum; and

(*2*) *Non-metallics.*—Coal, limestone, slate, gypsum, oil-shale, cement rock, marble, building stone.

The broad problems presented by most of the mineral areas of Newfoundland have as yet received scant attention. Very little effort has been made to determine the genetic relationships of the metallic ores in various parts of the different fields, to collate the experience gained at the mines, or to employ such knowledge in the intelligent direction of prospecting.

Copper mineralization in Newfoundland is for the most part closely associated with an extensive series of basic igneous rocks which were mapped by Murray and Howley of the Geological Survey as "Serpentines, Diorites, Dolerites, etc.", but which actually embrace a much wider petrographical range, including altered diabases, chloritic schists, amygdaloidal basalts, and many magnesian rocks, intruded in places by more acidic types. These were correlated tentatively at the time with the Lauzon division of the Quebec group of the Lower Silurian [2]. The greatest assemblage of these rocks in Newfoundland is to be found extending inland from Notre Dame bay on the northeast coast. The origin of the remarkably widespread copper ores, chiefly in the chloritic schists of this region, is as yet unknown, but the presence of 'granite', or possibly grano-diorite, batholiths, is at least suggestive.

---

(1) Daly, R. A., Post-glacial warping of Newfoundland & Nova Scotia; Am. Jour. Sci., 5th Ser., Vol. 1, pp. 381-391, May, 1921.

(2) Newfoundland Geological Survey, Report for 1864, Appendix.

The lead deposits of the Island are chiefly found in the Huronian and later pre-Cambrian sediments on the east coast, and in Carboniferous limestones on the west coast. Very little definite information is available as to the geological relationships of the lead ores in the new and important Red Indian Lake district, in the interior.

The famous Wabana iron ores at Bell island, Conception bay, on the southeast coast, are of the hematite-chamosite-siderite type, and occur in the upper 1,000 feet of flat dipping Ordovician sandstone and shale. This deposit, in refreshing contrast with the other mineral areas of the Island, has been studied in great detail by Hayes and others ([1]).

As in Canada, any secondary enrichment of metallic deposits in Newfoundland has been removed by glaciation, and is rarely, if ever, of any consequence.

Topography:

The Island of Newfoundland presents an excellent example of rias-coast-line topography; that is, one developed across the geological structure, which here predominantly strikes N.28°E. (true), or, in other words, parallels the Appalachian Mountain system of North America, to which the Island is closely related. The coastline is a succession of long, narrow peninsulas and deep bays, with abundant safe harbours.

The interior is a dissected peneplain, rising from about 700 feet at the east to nearly 2,600 feet on the west coast. This peneplain still preserves, to some extent, a plateau-like character, but is carved into extensive, broad valleys trending northeast-southwest. The boundaries of these depressions are defined by long, parallel monadnock ridges, sometimes marked by prominent isolated hills, or 'tolts' as they are called locally.

([1]) Hayes, A. O., The Wabana iron ore of Newfoundland; Mem. 78, Geol. Survey of Canada, 1915.

Gilliatt, J. B., Folding and faulting of the Wabana ore deposits; Trans. Can. Inst. Min. & Met., Vol. 27, pp. 616-634, 1925.

Gilliatt, N. B., Method of Mining at Wabana; Proc. Second (Triennial) Empire Min. & Met. Congress, 1928.

The most westerly series of these uplands, the Long range, constitutes the backbone of the Island, and assumes the proportions of a mountain range, with a maximum elevation of 2,540 feet.

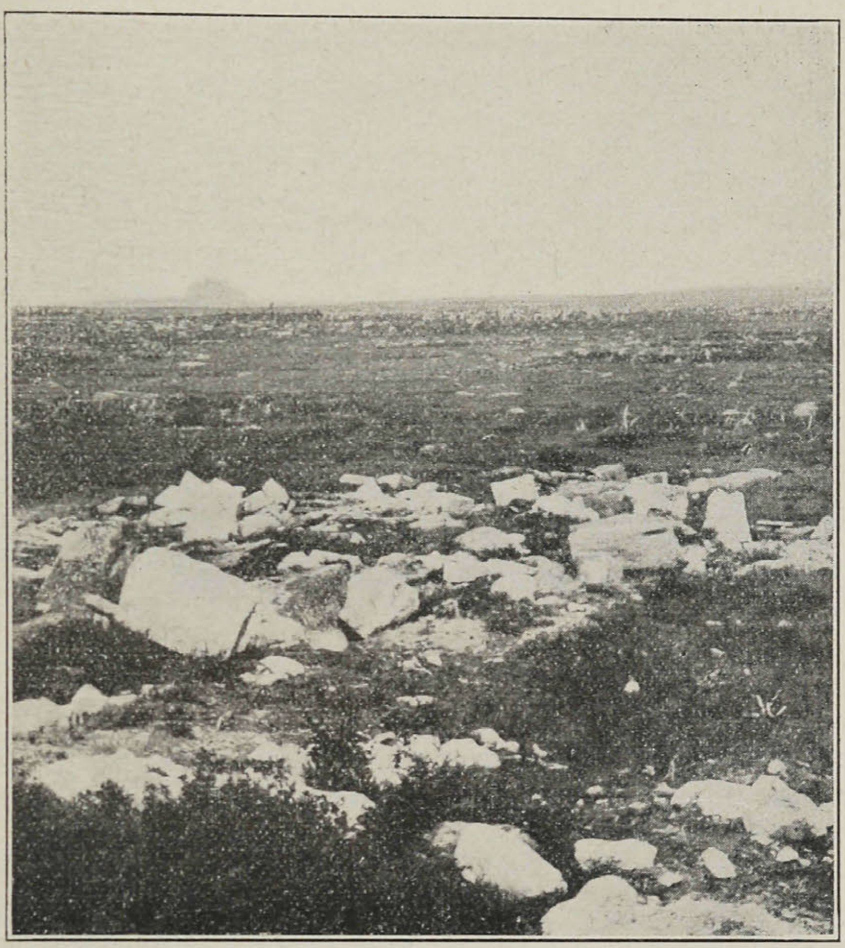


Figure 3.—Bleak granite uplands of the central plateau. A 'tolt', Main Topsail, in the left background.

The course of the larger rivers is thus determined by the trend-lines of the geological features, and the drainage between the main ridges finds its way to the sea either at the northeast or southwest coasts, by way of river valleys which, in many instances, follow post-glacial channels, with many rapids and falls.

The largest river system in the Island is the Exploits, the headwaters of which extend inland about 150 miles from Notre Dame bay, on the northeast coast, where it empties into the ocean. The Gander and Terra Nova waters also

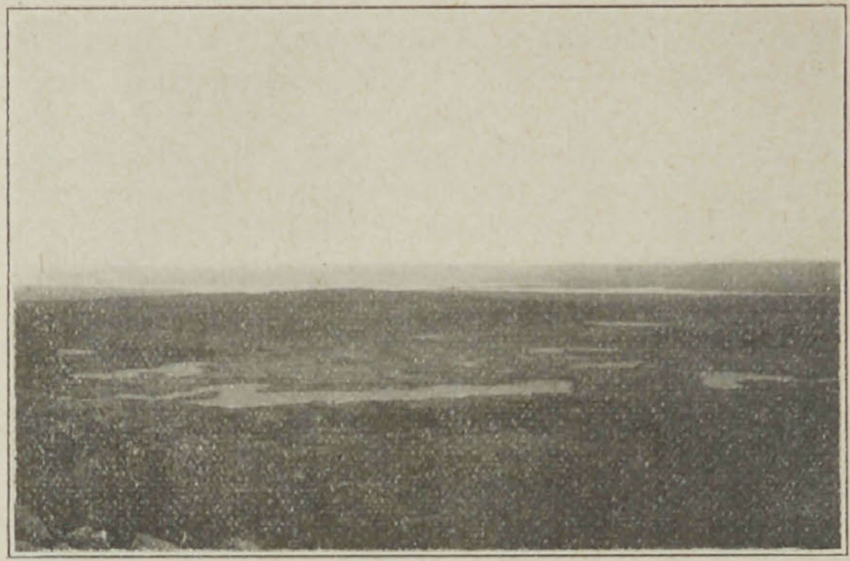


Figure 4.—Peneplain surface, Gander Lake Basin, from Mount Peyton.

flow northeast to the coast; while at the south of the Island, the Bay d'Espoir system drains in the opposite direction.

In striking contrast to this general direction of drainage is the Humber river on the west coast, which cuts its way across the mountain range and has a westerly flow, in common with the smaller St. George's river, lying forty miles to the south.

Generally speaking, only a few of the larger rivers lend themselves to canoe work, and the prospector is obliged to travel on foot and to 'pack' his supplies in exploring much of the interior. Nevertheless, the extensive lakes and the smaller rivers provide splendid means of access to a large portion of the country, and a small canoe can in many places be used advantageously.

The forest growth is thickest in the river valleys and along the lake shores, while most of the higher hills are barren. Between these extremes, there are often to be found long 'leads' through open marsh or muskeg (locally known as 'mash' or 'mesh').

Figure 5.—Packing along the 'leads'.

As a result of Pleistocene glaciation, the interior is largely covered with a mantle of till and bowlder clay, in the form of drumlins, moraines, eskers, etc. Consequently, rock exposures are best developed along the sea coast and in the river courses and lake shores. The comparative difficulty of access and the paucity of outcrops in the hinterland have militated against inland exploration to such an extent that, even at this date, there is but one mine situated in the interior of the Island.

Water Power:

Water power is to be had in practically every part of the country. The larger river systems, together with the smaller torrential streams from the central plateau, can be readily harnessed, and there is already developed in the Island over 150,000 h.p.

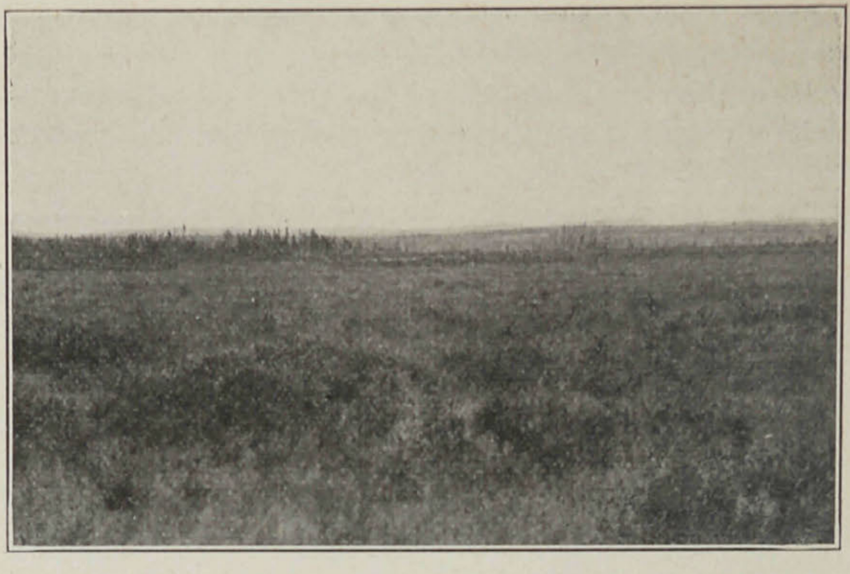


Figure 6.—The barrens, near Red Indian Lake, central plateau of Newfoundland.

Timber:

Timber for all mining purposes is readily available. The general run is of pulpwood size, and this is extensively exploited by the several important paper-making plants. On a smaller scale, lumbering is also a thriving industry.

Labour:

Labour is abundant, very adaptable, and comparatively inexpensive. A considerable body of experienced miners is to be found in Notre Dame bay, where Newfoundland in the past experienced her greatest copper-mining boom.

Governmental Conditions

Government and Government Attitude:

Newfoundland is an autonomous unit of the British Empire. The seat of government is at St. John's, in which city, also, is the residence of His Majesty's representative, the Governor. The Cabinet of the Legislative Assembly includes a portfolio of Agriculture and Mines, and the minister of that department has control of the geological and topographical surveys, and also of the government assay office.

The attitude of the government toward mineral exploitation is entirely favourable, and new mining operations are usually encouraged by the exemption of the necessary machinery, etc., from the comparatively high import duties, which are the chief form of taxation.

Mining Law:

The *Crown Lands Act* of Newfoundland, insofar as mining is concerned, is an antiquated law which requires of the prospector no license, and demands only a discovery stake, without actual delimitation of claim boundaries by the staker. Under its provisions, the prospector is entitled to a mining claim of 320 acres on payment of a fee of $11.00 per claim, with the option of securing nine adjoining claims without further staking, and at a similar rate. The claims are renewable yearly on payment of $11.00 per claim, without the exaction of any bona fide exploration or assessment work. The lessee is entitled to a grant in fee simple should he expend, during the first five years of his lease, the sum of six thousand dollars in surface and subterranean mining, per claim.

Geological and Topographical Surveys:

A geological map of Newfoundland, embodying the results of surveys carried out under the direction of Murray and Howley between 1863 and 1909, is published by the government. This map represents a great amount of painstaking and arduous work on the part of these pioneers in Newfoundland geology, to whose memory I should like to pay tribute. In its broad outlines, this map is tolerably accurate, and for general purposes it is still invaluable alike to the prospector and to the geologist. Supplementing it, much information is also to be found in the annual reports of the Survey. No geological maps of a more detailed nature for any particular region are, as a rule, available.

It is a matter for gratification to those interested in mineral development in Newfoundland, that the government last year engaged the services of Dr. H. A. Baker, late Government Geologist of the Falkland Islands. Dr. Baker's work in the Island has already been productive of results, and it is to be hoped that his efforts on behalf of the mining industry of the Island will be eminently successful.

Topographic maps, lacking profiles and at various scales, may be obtained of the Agriculture and Mines Department for most of the better-known sections of the country; but as a rule the geologist is obliged to make his own maps before beginning any work requiring even a moderate amount of detail. For work near the coastline, the charts issued by the British Admiralty are quite valuable.

Government Analyst:

The government maintains an up-to-date assay office in the Court House Building, St. John's, under the able direction of Mr. D. James Davies, Government Analyst. Mineral samples are analysed and reported upon free of charge, and a splendid service is extended to the mining industry generally.

THE NATURAL RESOURCE DEPARTMENT, MINES & FORESTS (NFLD) LIMITED

The Natural Resource Department of the above company was organized in 1918, when the parent company, the Reid Newfoundland Company, Limited, was still operating the Newfoundland railway and steamship services. Mr. J. M. Forbes, a Newfoundlander, who was then associated with the mining industry in Quebec, was appointed director, with

Figure 7.—Prospectors towing outfit on raft, on small lake, central Newfoundland.

Mr. Hamlin B. Hatch as chief geologist. Mr. Hatch assumed charge of the department in 1922 and retained that position until 1926. To his initiative we are indebted for much of our present knowledge of the mineral resources of Newfoundland, and his reports are the chief source of most of the following information.

The primary object of the department was the geological examination of the numerous Reid land lots, and this was, from the start, the routine work of the various field parties which were sent into the field. As occasion demanded, however, special investigations were undertaken, and these we shall review cursorily. Simultaneously, a systematic examination was made of most of the known mineral localities of the Island.

Coal Investigation

During the early post-war period, when shipping was at a premium, the Natural Resource Department began an intensive examination of the Carboniferous areas of the west coast, in which the Geological Survey, under Howley and Murray, had already proved the existence of coal seams in three districts, *viz.*, South Branch, St. George's Bay, and Grand Lake. As Dr. Baker will present, at this meeting, a detailed description ([1]) of the St. George's Bay area, which is the main coalfield on the Island, it will not be necessary here to advert to it further.

Figure 8.—Peneplain surface, Grand Lake Basin.

([1]) Baker, Dr. H. A., The St. George's Coalfield; Proc. Second (Triennial) Empire Min. & Met. Congress, 1928.

In the South Branch and Grand Lake areas, however, the Natural Resource Department, acting in conjunction with the Newfoundland Government, started operations and succeeded in supplying the railway with fuel for some time; but work was abandoned after a short period, as in the Grand Lake area diamond drilling indicated that the existence of economic coal seams was doubtful, while at South Branch the measures were found to be folded and faulted to such an extent that mining was not considered practicable.

Copper

The Department then began a study of the copper situation in Newfoundland. Thenceforward, one of its major interests was the resuscitation of the copper industry, in which the Island, some forty years ago, ranked sixth among the copper producing countries of the world.

The chief copper region of Newfoundland is Notre Dame Bay, where chalcopyrite, 'cupriferous pyrite', and lesser amounts of bornite and chalcocite, occur in chloritic schists and basic lavas. Here, intensive exploration of new copper-bearing ground, as well as a thorough examination of old properties, was commenced. Among the properties of this district which made history for Newfoundland during the 'eighties' are Tilt Cove, Little Bay, Betts Cove, Baie Verte, Sunday Cove Island, Roberts Arm, and numerous others of lesser importance. During the life of these old mines, only high-grade ores could be shipped, and material containing less than 10 per cent copper had to be discarded, with the result that the mines died a natural death on the depletion of the rich ores.

Little Bay:

Of the worked properties, Little Bay was considered by the Department as one of the most interesting, and accordingly an investigation of the holdings of the Little Bay Drilling Syndicate, Ltd., was undertaken during the years 1921-22. The main ore-body of this property is lenticular in shape, and occurs as stringers and disseminations of chalcopyrite, associated with pyrite and chloritic schist. Seven diamond-drill holes, with a total footage of 8,751 feet, served to prove an extension eastward of the known ore-body, which had already been worked over a length of 600 feet and to a depth of 1,400 feet. Owing to various reasons, including the adverse condition of the copper market since the war, further work has not since been attempted on this property, although the results of diamond drilling, which also showed that a considerable tonnage of ore can be won from the old workings, together with the presence of extensive old dumps, make this mine one with a future.

Gregory River:

In the summer of 1921, a field party of the Natural Resource Department made an important copper discovery on the west coast at Gregory river, between bay of Islands and Bonne bay. Bordering the contact of trap, intrusive into gabbro, a shear zone was located, in which numerous rich copper lodes, containing primary chalcopyrite and pyrite, with a little secondary chalcocite and covellite, were found. Very little work has been done in this area to date, but the results obtained are sufficient to indicate a field possessing potential value.

Great Gull Lake Copper Property:

During the years 1922-23, the Natural Resource Department extensively diamond-drilled the property of the Great Gull Lake Copper Company, situated 14 miles inland from Hall's bay, Notre Dame bay. This campaign indicated a pitching lens about 1,500 ft. long, 400 ft. deep, and 57 ft. wide, in a shear zone in diabase. The metallic mineralization consists of pyrrhotite and magnetite, with lesser amounts of pyrite and chalcopyrite; the average copper content being between 2.75 per cent and 3.0 per cent. Various reasons, chief among which were the necessity of building a railway, and the inability to come to terms with the owners, led to the option on this property not being exercised.

Tilt Cove:

This famous old property, on the north shore of Notre Dame bay, was worked continuously between 1864 and 1918. It consists of two mines: (1) The West mine, in olivine basalt impregnated with chalcopyrite, pyrite, and magnetite along

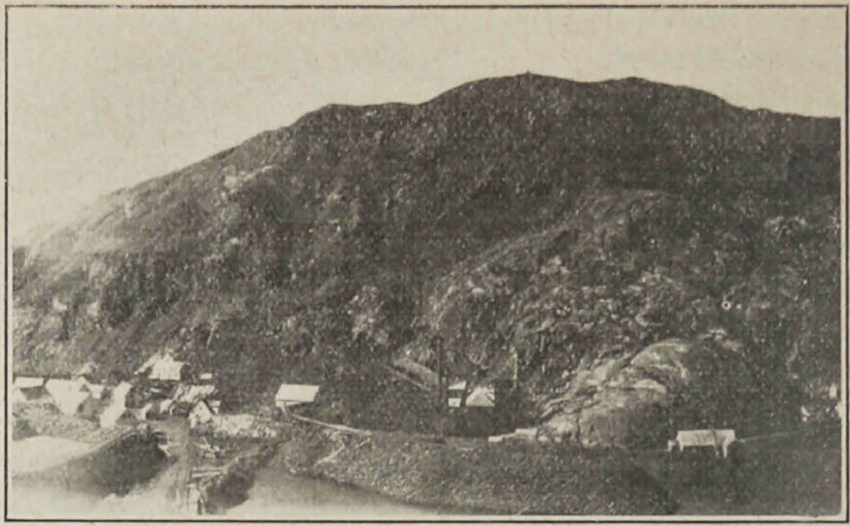


Figure 9.—West Mine, Tilt Cove.

oint and cleavage planes, and extending over a length of 1,200 ft., a thickness of 250 ft., and a depth of 480 ft., with copper values still strong at the bottom; and (2) the East mine, in massive lenses of 'cupriferous pyrite', also in olivine basalt. An option was taken on this property by the Natural Resource Department, and the old workings and dumps were thoroughly examined. The findings obtained in a subsequent examination by a third party, however, failed to check with those of the Department, and the property has since reverted to the original owners.

Roberts Arm:

An investigation of the Roberts Arm property, two miles from tidewater at Notre Dame bay, was undertaken in 1924. This mine shipped about 2,000 tons of ore averaging over 12 per cent copper during the two years of operation in the late 'eighties'. The old workings were pumped out and sampled, and later a shaft was sunk to cut the lodes of the property at lower levels. The results of this work proved discouraging, and consequently the option was dropped.

Hall's Bay-Green Bay Area:

Exploration parties from the Natural Resource Department have spent several summers in mapping the 150 claims which the Company holds in this area, under yearly lease.

Much favourable ground, on which recur the geological conditions present in the nearby mines, was delimited. The area is pre-eminently one for the application of electrical prospecting methods.

Copper on Reid Lots:

The geological examination of the Reid fee simple lots disclosed the presence of copper on at least six blocks, but these have not as yet been prospected in a detailed manner.

Chromium

One of the earliest activities of the Department was an examination of the chrome area between Port au Port bay and bay of Islands, on the west coast. Here, lenticular masses, disseminations, and narrow lodes of chromite occur in dunite. A small quantity of ore was shipped at the time, but no further work has since been attempted in this promising field.

Oil Shale

In the Lower Carboniferous strata of the Grand Lake-Deer Lake region, in the interior, field parties of the Department discovered a 1,500-foot thick section of oil-shale beds, intercalated with sandstones. The areal extent underlain by this

Figure 10.—Bituminous-shale beds, Big Bend, Upper Humber River.

series is approximately 250 square miles. As much as 16 Imperial gallons per ton have been obtained from some of the rock in this area, which is at present dormant.

Slate

The Department controls the main slate deposits occurring on the two slate belts of Newfoundland. The easterly belt extends from Placentia bay to Trinity bay and strikes north 55 degrees east, magnetic. In the past, this belt was worked mainly in the vicinity of Random island, Trinity bay. The westerly belt lies between bay of Islands and Bonne bay, on the west coast, and parallels the easterly belt in strike. Quarries on this belt have been worked in Humber arm, bay of Islands. These slate properties contain tremendous reserves which are readily accessible. They are at tidewater near deep harbours, and are not encumbered with royalties, leasehold restrictions, or shipping dues. The overburden is slight, excellent tippage ground is present, and all the deposits can be worked by open cut.

Gypsum

Gypsum has been discovered on eight Reid lots, and, in addition, the Reid company also control over 4,000 acres of other gypsum ground. During 1926 some underground work

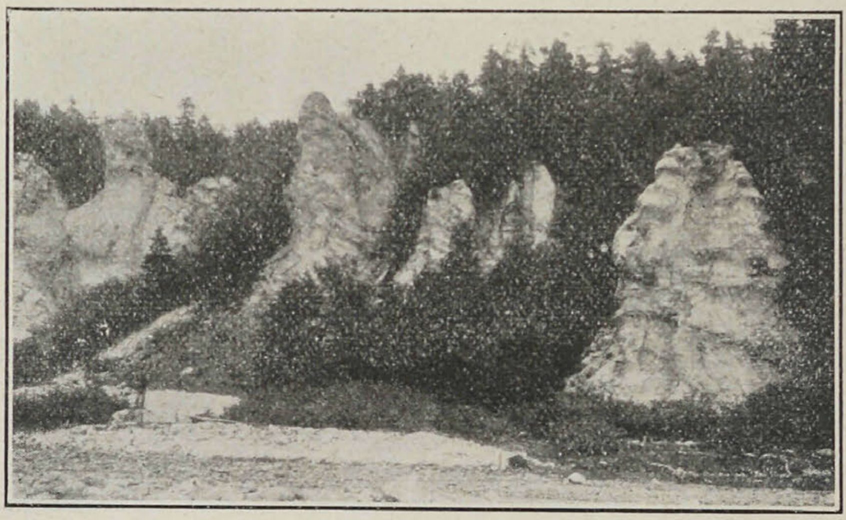


Figure 11.—Gypsum deposit, west coast, Bay St. George.

was done on the Romaines property, in bay St. George, on the west coast, and a quantity of gypsum was mined and shipped. Large tonnages of good quality gypsum await exploitation in the Carboniferous of the west coast of the Island.

Other Minerals

Other deposits, either owned or controlled by the Department and already investigated to some extent, include ores of molybdenum, lead, manganese, and iron; as well as mica, feldspar, oil, alum shale, limestone, marble, peat, and building stone. Further information as to occurrences of these may be obtained from the Natural Resource Department.

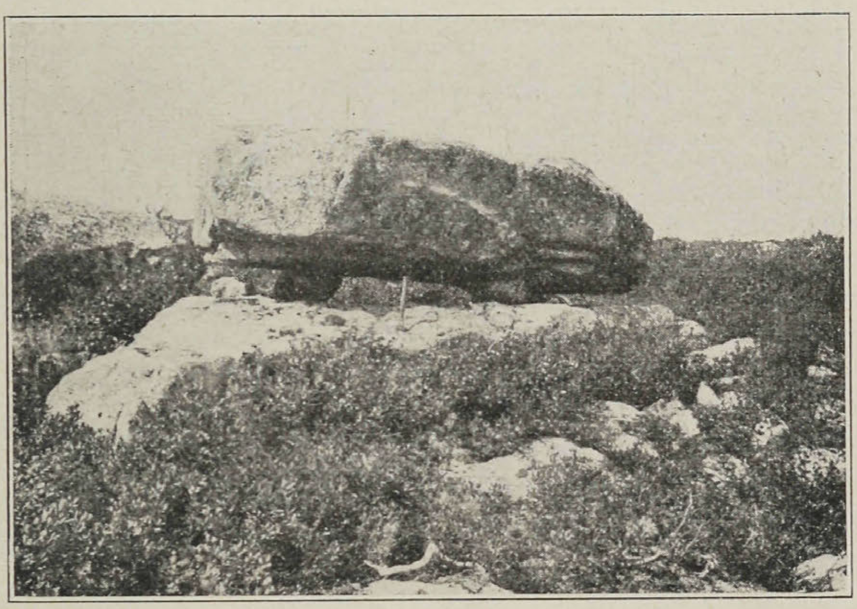


Figure 12.—Perched granite block near the Topsails, interior of Newfoundland. Note geological pick, centre of picture.

EXPLORATION BY INTERESTS OTHER THAN MINES & FORESTS (NFLD) LTD.

Silver-lead-zinc

Silver Cliff Mine:

This property, financed by local capital, began operations in 1922, on the site of an old lead location, which had in the past been partly developed by Cornish miners, at Argentia, Placentia bay. The area is traversed by two series of lodes, on some of which a considerable amount of work was performed by the present company, who also erected a crushing and concentrating plant. About two thousand tons of good lead-ore were mined, and several hundred tons of concentrates were shipped. At the present time the mine is idle, but a recent report by the government geologist is very encouraging, and in the near future an attempt to finance the property for further development may be looked for.

Placentia:

The Galleon's Point Mining Company, Ltd., during 1925-26 carried on underground exploration of their property at Placentia; as did also the Castle Hill Mining Company on a nearby property. The lead ore revealed by this work is of good quality, and further development is proposed.

LaManche Lead Mine:

This mine is also located in Placentia bay, and is now being explored by a local syndicate. The original prospect was discovered some seventy years ago, and a total of 2,375 long tons of ore were produced before the mine closed in 1873, owing to the low price of lead. The ore consists of galena in a gangue of calcite, and the vein has a proved extension of 6,000 ft., with an average thickness of 4 ft., and assays between 10 per cent and 15 per cent lead. A 100-ton gravity flotation concentrator is about to be erected by the present company, who have indicated important extensions of the ore-body at depth.

Buchan's River Mine:

The outstanding event in the mining industry of Newfoundland in recent years is the development of the Buchan's River property, situated five miles north of Red Indian lake, in the interior. The ore, which is a complex lead-zinc-copper sulphide, was discovered by an Indian prospector in the employ of the Anglo-Newfoundland Development Co., Ltd., in 1905; but it was not until 1925 that a successful metallurgical process for its treatment was worked out. In 1926, the Anglo-Newfoundland Development Co., Ltd., in conjunction with the American Smelting and Refining Company, began an intensive exploration by means of electrical prospecting, diamond drilling, and underground development of the property, which had already been proved to contain a well-defined lens of complex ore, up to 22 ft. wide, and extending nearly 400 ft. laterally and about 350 ft. on the dip.

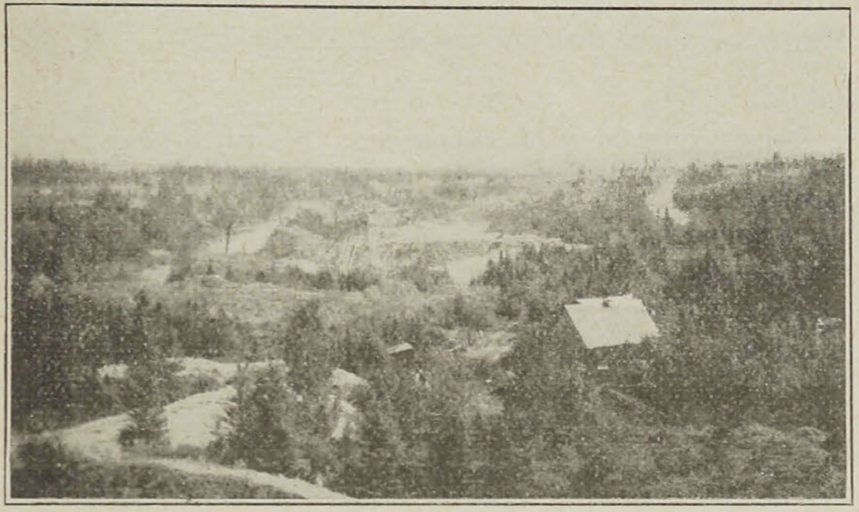


Figure 13.—Buchan's Mine, Red Indian Lake, showing old workings.

This programme was successful in locating several new ore-bodies, of a somewhat similar character, and of an extent sufficient to warrant the construction of a 22-mile railway, now nearing completion; the development of a 2,000 h.p. hydro-electric plant; and the erection of a 500-ton mill and other mine buildings and dwellings.

Electrical prospecting is still being carried on by the Swedish-American Prospecting Corporation, whose method has proved a distinct success in this field.

The activities of the Buchan's camp have attracted wide attention, not only to Red Indian lake, but also to the mineral resources of the Island generally.

A local syndicate controls extensive mining sections surrounding the Buchan's location, and already some of their claims have been optioned to such firms as Porcupine Goldfields Development & Finance Company, Ltd., of Ontario; and the Consolidated Mining & Smelting Company of Canada, Ltd. These interests are at present engaged in geological examination of their options.

Hatchet Cove:

This property, situated at Hatchet Cove, Trinity bay, was worked on a small scale a few years ago, when one of several narrow veins of galena was drifted upon, but without much success. The veins trend approximately at right angles to a prominent strike fault, and whether this main fault plane is also mineralized has not yet been established.

Catalina:

Some occurrences of galena near this town have recently been receiving attention, and it is understood that the results obtained from surface work are encouraging.

Copper

Hodder Copper Property, Fleur de Lys:

Since 1924, a copper property located at Fleur de Lys, on the northeast coast, has been developed somewhat by a local concern. In a country rock of calcareous gneiss, invaded by both acid and basic intrusives, several lodes of copper ore, containing chalcopyrite, with a little bornite and malachite, have been located. The property is at present awaiting further development.

Goose Cove Property:

This prospect is situated at Hare bay, on the northeast coast. In the first decade of the present century, several shafts were sunk. These were de-watered and examined several years ago by a local company, but no further action has resulted.

Sulphur (Pyrite)

Pilley's Island Mine:

This property is located on the southern end of Pilley's island, in Notre Dame bay. The ore consists of pyrite, in places cupriferous, and occurs as replacement bedded deposits in metamorphosed sediments. Over half a million tons have been shipped since the mine was first opened in 1889. In 1919, the Blast Furnace Products Corporation of New York diamond-drilled the property and were successful in locating the lost or faulted end of the old mine lens. When pyrite again comes into demand as a source of sulphur, the large reserves in this mine ensure for it another considerable period of activity.

Gold

Stag Bay, Labrador:

In the summer of 1923, Newfoundland attracted much attention of a very undesirable nature by reason of a mild gold rush, resulting from the reported discovery of placer gold at Stag Bay, Labrador. This incident, besides serving to make the way of the honest prospector one of increased difficulty, also demonstrated the pernicious effects of a mining law which permits armchair prospecting.

Non-metallics

As a matter of record, mention may be made of the fact that limestone has for some years been quarried on the Humber river, in connection with the pulp and paper industry; and also at Aguathuna, also on the west coast, by the British Empire Steel Corporation, for use as flux in their steel mills at Sydney, Nova Scotia.

At Parsons Pond, the only working oil-well in the Island, small quantities of oil are being obtained by pumping.

CONCLUSIONS AND RECOMMENDATIONS

Labrador

A review of the more outstanding developments in the field of mineral exploration in Newfoundland during the past ten years would be incomplete were attention not directed to the possibilities opened up by the recent award to this country, by His Majesty's Privy Council, of an area of over 110,000 square miles of territory on the eastern watershed of the Labrador peninsula. This acquisition comprises more than one-eighteenth of the area of the 'pre-Cambrian shield' of North America, and the probabilities are that the geological conditions responsible for the gold, silver, and copper deposits of northern Ontario and Quebec, the harvest of which is today adding so materially to the prosperity of Canada, should be found, upon close examination, to obtain also in Newfoundland Labrador. The Newfoundland Government would, I feel sure, be well advised in investigating the mineral possibilities of this important dependency.

Mining Law

The baneful effects of the present mining law are so obvious that it is unnecessary to enumerate them. The present exigency, on the eve of throwing open a further vast field for prospecting, must surely recommend itself as opportune for the amendment of this law, to conform broadly with such an excellent mining act as that of the Province of Ontario.

Geological Survey

In respect to geological surveys, also, Canada furnishes much worthy of emulation. The results derived, in Ontario for instance, from preceding, or at least actively co-operating with, the prospector in his work in the field, by intelligently directing his efforts to the most promising ground, and by imparting valuable information gained by regional surveys, need no further commendation.

The Copper Situation

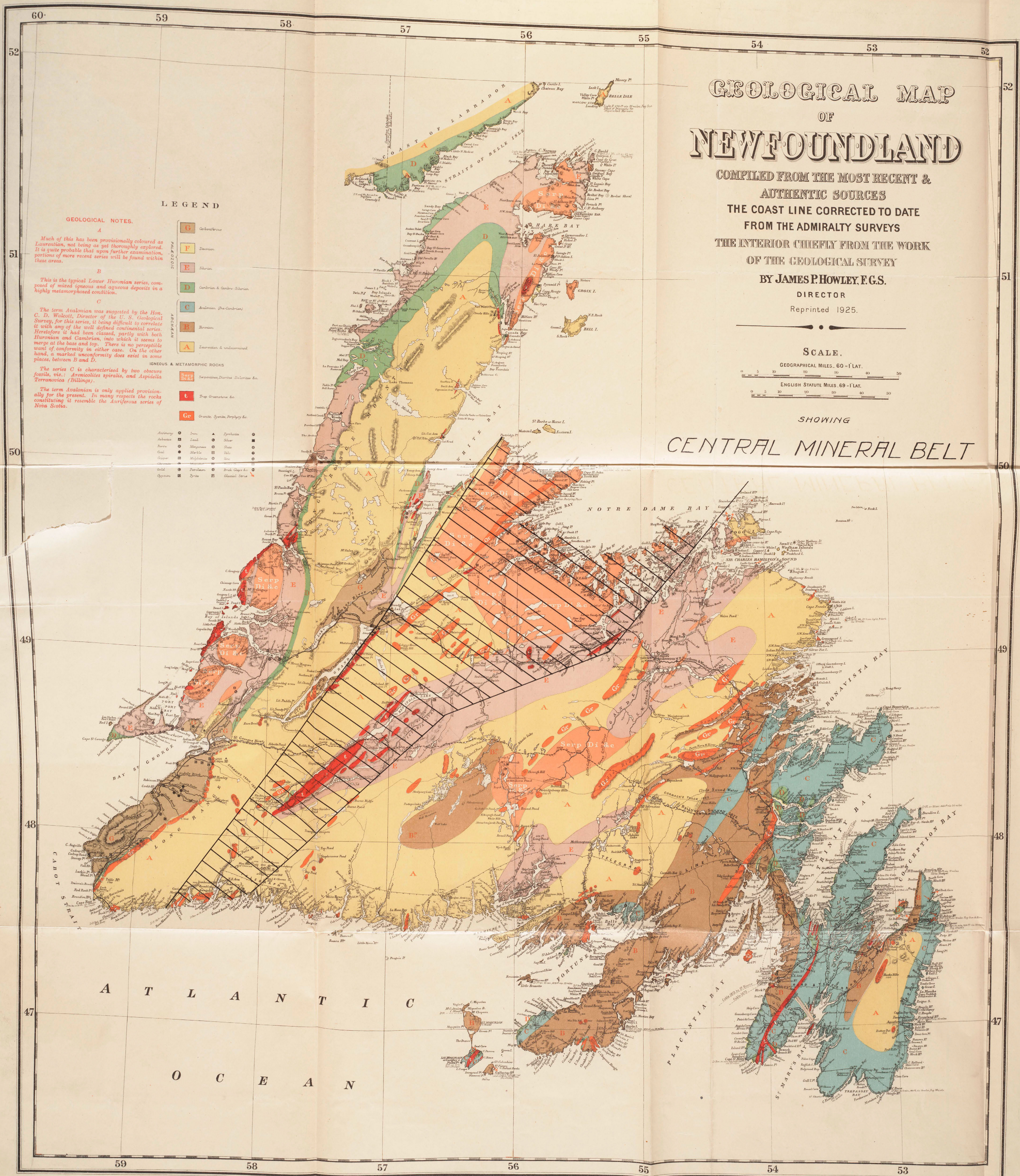
A prominent delegate to this Congress, Sir John Redmayne, at a recent technical session in Canada, has said that the Empire is looking to Canada and to Newfoundland for its future copper supply. The impetus which the copper situation in Newfoundland should derive from this condition, warrants, in my estimation, an enquiry on the part of the government into the copper resources of the Island, as well as into the possibility of organization and co-operation of the numerous mines, and an investigation of such problems as centres for concentration and also possibly for fabrication.

The Past, Present, and Future

The history of mining in Newfoundland has been one both of success and failure; but failure has, more often than not, been due to injudicious judgment, to adverse markets, to inadequate financing, and to lack of organization and of concentration facilities, rather than to lack of mineral wealth.

The present is a period of reawakened interest, of critical examination, and of intensive searching, such as Newfoundland never before experienced.

The future of mineral exploitation in this country, with the assistance of electrical prospecting methods, modern flotation concentration, better organization, and the stimulus that comes from successful operation, bids fair for the increasing importance of the mining industry, not only to Newfoundland, but to the Empire at large.



Appendix B

Whitehead Morris Limited, Printers, Westminster.