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GEOLOGY OF BONA VISTA MAP-AREA,

NEWFOUNDLAND

(Summary Account)

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CONTENTS

	Page
Introduction	1
General	1
Previous geological work	1
Topography	5
Glaciation	5
General geology	9
Table of formations	9
Connecting Point group	10
Musgravetown group	12
Summary statement	12
Conglomerate	13
Volcanic rocks	13
Greywacke	15
General discussion of Connecting Point and Musgravetown groups	16
Comparison of Connecting Point and Musgravetown groups	16
Structure and relationships	17
'Random formation'	18
Discussion of the term 'Random terrano'	19
Lower Cambrian	22
Discussion of the term 'Brigus formation'	28
Middle Cambrian	28
Upper Cambrian	29
Elliott Cove formation	29
Lower Ordovician	30
Clarendville (Tremadoc) 'series'	30
Intrusive rocks	31
Granitic rocks	31
Dioritic rocks	34
Economic geology	34
Clay and shale	34
Slate	35
Iron	36
Lead	37
Copper	38
Manganese	39
Selected references	39

Illustration

Preliminary map -- Bonavista Newfoundland In envelope

GEOLOGY OF BONAVISTA MAP-AREA, NEWFOUNDLAND

INTRODUCTION

GENERAL

Bonavista map-area lies on the east coast of Newfoundland between latitudes 48° and 49° and longitudes 53° and 54° . Field work on which this report is based was done during the 1949 field season, and was confined to the coast, the roads, and the railways, with a few traverses across country.

In areas where passable roads exist, a light truck provided transportation for the party; in coastal areas inaccessible by road a 50-foot boat was used. Traverses, however, were done either by canoe or on foot.

I. M. Stevenson, G. D. Robinson, C. R. Mattinson, and J. D. Laite were members of the writer's field party, and rendered efficient service. Mr. George Marsh was skipper of the boat. The kindness and hospitality of many residents of the area are gratefully acknowledged.

PREVIOUS GEOLOGICAL WORK

The first geologist to visit the area was Jukes (1)¹ in 1839

¹ Numbers in parentheses are those of references listed at end of this report.

and 1840, who gave a most interesting account of his travels. He noted the similarity of the sedimentary formations of the area to those of the Avalon Peninsula, and separated what are now known as Cambrian and Ordovician strata from the underlying rocks. The granites and gneisses of the northwest corner of the area he considered as among the "aqueous or stratified rocks", and placed them at the bottom of the sequence.

In 1868, Murray and Howley (2) described the St. John's section, which must be regarded as the type section of Precambrian strata in eastern Newfoundland. This section has been reviewed by

Table I

Olenellus Zone of Lower Cambrian
(Unconformity)

Murray and Howley
formation letter

PRECAMBRIAN (PROTEROZOIC)		AVALON SERIES	
Cabot group	(Blackhead formation; approx. 5,500 + feet	(Red, green, and greenish grey sandstone, with thin intercalated beds of argillite and slate	
	(Signal Hill formation ¹ approx. 7,800 feet	(Red conglomerate	g
	(St. John's slate; approx. 2,000 feet	(Red sandstone	f
Conception group	((Green and greenish grey sandstone	e
	((Black to dark grey slate, with a bluish and greenish tinge in part, and a transitional zone of intercalated black slate and grey sandstone at the top	d
Harbour Main volcanic and sedimentary group	((Flinty green siltstone, green to grey-green slate, minor red slate, green sandstone and conglomerate	
	((Amegdaloidal andesite, basalt, rhyolite, and felsite, with volcanic breccias, agglomerate, tuff, and interbedded, flinty, green and red siltstone, slate, and coarse conglomerate.	a, b, and c
	(

¹ The three lithological divisions in the Signal Hill formation are in the order shown in the table and are roughly of equal thickness.

Walcott, Buddington, Hayes, Baker, Whay, and Rose. The most up-to-date and detailed information available on this section is that obtained by E. R. Rosc¹, and is summarized in Table I, in which the equivalent

¹

Roso, E. R.: Geol. Surv., Canada; personal communication.

divisions 'a' to 'g' of Murray and Howley are also shown.

In 1869, Murray visited Bonavista Bay (2, p. 194). After describing the 'Laurentian' gneiss of the northwest corner of the present map-area, he describes the rocks of Gooseberry Islands, Bloody Reach, and Bloody Bay as chiefly slate, with quartzites and diorites, and says: "The lithological resemblance these rocks bear to those of the intermediate system of Avalon is so striking as to leave little doubt of their identity --- The horizons of these rocks are supposed to be equivalent to the divisions b and c" of the St. John's section. Again, p. 196, on "reaching the southern shores of Clode Sound, --- there is a great development of red sandstones and conglomerates, representing the Signal Hill rocks, e, f, ---".

During the same year (1869) Howley examined the coast of Trinity Bay (2, p. 199) and says "between Cape Bonavista and British Harbour --; the rocks of the coast consist exclusively of the upper and middle members of the intermediate system; the slates and quartzites of divisions c and d of last year's section are surmounted by the sandstones and conglomerates of Signal Hill, e, f, g --"

It is apparent that Murray and Howley had little doubt that the strata mapped as Musgravetown and Connecting Point groups in the present report are equivalent to the rocks of the St. John's section b to g.

In 1899, Matthew (3) published a section of the Cambrian rocks in Smith Sound and described the fossils. He says in part: "the two Eopaleozoic basins in Smith Sound are separated by a wide area of strata of the Intermediate (Huronian) series, chiefly the slates of the 'd' division, and the sandstones or quartzites of the 'o' division ---".

In 1900, Walcott (4, 5) published two papers, which, when assembled, give sections of the Cambrian and underlying formations near Broad Cove on Smith Sound and near Hickmans Harbour on Random Sound. These sections are reproduced in the body of this report (p.22).

In 1914, van Ingon (6) published a table, which among other things subdivided the Clarendville formation (Lower Ordovician) into six zones marked by index fossils. Unfortunately, no description was published to accompany the table, so the boundaries of these subdivisions are not known, and three of the index fossils mentioned are new species that have not been described.

In 1919, Buddington (7) studied the petrology of the formations in the Avalon Peninsula, and included a few observations on the present area.

In 1938, Snelgrove (8) gave a brief description of the Workington iron deposit near Lower Island Cove and the Hatchet Cove lead prospect.

In 1945 and 1946, Hayes (9) mapped part of the present area and described an unconformity in the Precambrian formations. Those rocks above this unconformity he named the Musgravetown group, and those below it he termed the Connecting Point group. In his table of correlations he shows the Musgravetown group as equivalent to the Signal Hill formation of the St. John's area, and the Connecting Point group as equivalent to the Conception slates and Harbour Main volcanic rocks of the Avalon Peninsula.

During 1948, K. Widmer of the Geological Survey of Newfoundland extended the mapping of the Musgravetown and Connecting Point groups to the north and made a reconnaissance survey of ground to the west of the present area. A preliminary copy of his map was available during the field season and made possible more rapid coverage of certain areas.

TOPOGRAPHY

In general, the map-area is a plateau lying 100 to 400 feet above sea-level. Above this plateau, ridges or chains of hills composed mainly of volcanic rocks rise to maximum heights of 1,000 feet. Three examples of such hills are: (a) those extending northward through Clarendville; (b) a ridge trending east of north to the east of Southward Bay; and (c) a ridge east of the south end of Bloody Reach. A 600-foot hill composed of granite rises above the surrounding country southeast of Traytown; elsewhere, areas underlain by granite have a more moderate relief.

The surface of the plateau away from the coast is gently rolling, and is studded with lakes, ponds, and marshes that fill the slight hollows formed by ice erosion or by the irregular deposition of glacial drift. Many of the marshes or bogs are filled with moss or peat. The areas between ponds and marshes are underlain by ground moraine or outwash material, with only occasional outcrops of bedrock. Inland, if an exception be made of the volcanic ridges before mentioned, less than 5 per cent of the land surface is bedrock outcrop, and many traverses in the interior plateau encounter no outcrops.

In contrast with the plateau, the coast is commonly marked by cliffs between 20 and 300 feet high, which offer almost continuous rock exposures. The coastline is deeply indented by bays, some of which parallel the strike of the formations, as do Chandlers Reach and Bloody Reach, and others cut across the strike, as do Smith Sound and the North West and South West Arms of Random Sound. Smith and Random Sounds undoubtedly owe their configuration to faulting. All bays have been deepened by glacial erosion.

GLACIATION

An examination of the data on directions of ice movement, as plotted on the map, shows that the ice moved from west to east as far as the heads of the bays, thereafter tending to be channelled

into the bays on its way to the sea. These observations agree with previous findings on this coast. In general, glacial action does not appear to have been strong.

Some of the symbols on the map indicate the direction of glacial striae on rock outcrops. Others indicate the direction of furrows in overburden. These furrows are not easily observable on the ground, but are readily discernible in some air photographs. Roches moutonnées and glacial striations on the tops of hills west of Clarendville indicate a west to east movement of the glacial ice. Directions of furrows north and south of Clarendville and at the northwest end of Random Island agree with this observed direction. It has, therefore, been assumed that these and other similar prominent trends in the overburden, where unrelated to bedrock structure, are due to the overriding action of glacial ice.

Interesting relationships may be observed along the Cabot Highway from Shoal Harbour to Lethbridge. At Shoal Harbour, a terrace, roughly 55 feet above sea-level, is composed of stratified sand and clay overlain by 3 feet of gravel and soil. At the Pelley brickyard pit, $2\frac{1}{2}$ miles to the north, near Georges Brook, a vertical thickness of about 50 feet of interlayered sand and clay is exposed, the base of the section being 25 feet above high tide. The lower 35 feet of the section consists of interstratified sand and clay in layers about 1 inch thick, and is succeeded upward by sand. The bedding is horizontal. The interbedded sand and clay is used in the manufacture of brick.

From Georges Brook northward for $5\frac{1}{2}$ miles, shallow gravel pits expose unsorted sand, gravel, and boulders, and in places stratified outwash material. Six miles north of Georges Brook, the highway and railway cross a small stream. The road cut exposes an overburden about half of which is red shale fragments, and the remainder clay and sand. Blocks of shale are intact in the overburden,

but are much fractured and cannot be removed without breaking into small pieces. This material cannot have moved far. In the adjacent railway cut is an outcrop of red nodular limestone similar to that of the Smith Point section. From there northward about 60 per cent of the overburden exposed in shallow road cuts and gravel pits consists of shale fragments, which in some pits are red, in others green. This lack of intermixed red and green shale in the pits indicates a limited source and, therefore, short transportation. In a band 1,000 feet wide along the highway $2\frac{1}{4}$ miles south of the Lethbridge crossroads, many large angular blocks of red nodular limestone, similar to that of the distinctive Lower Cambrian limestone of Smith Point, have been revealed in road cutting. The number and angularity of these blocks and their abrupt termination to the north is evidence that they must have been transported only very short distances. On the surface, and apparently overlying the above-mentioned deposits of red and green shale detritus and blocks of limestone, are scattered, well-rounded erratics of porphyritic granite that could not have originated less than 18 miles to the westward. Farther north, at Lethbridge, the soil is underlain by blue and buff-coloured glacial clay.

These observations would indicate that the glacial ice in this area did not remove the overburden but rode over it, furrowing it and depositing on top the rounded erratics derived from distant sources. It is possible that the eroding power of the ice may have been exceptionally weak in this sector because it lies between the long bays, Clode Sound and Goose Bay to the north and Smith and Random Sounds to the south, into which the ice would tend to be channelled. The stratified clay, sand, and gravel deposits of Smith and Random Sounds and of Lethbridge originated in late or post-Glacial time. No residual soils were recognized elsewhere in the area.

Other parts of the area are covered with a thin mantle of glacial drift and outwash, and a few clay deposits. On the outer islands and exposed coast, superficial deposits have been removed by

wave action. The most extensive drift-covered district in the northern part of the area is that about Traytown, Sandringham, and Eastport. Much of the bay 3 miles south of Traytown is surrounded by low shores where, in places, 12 feet of bedded and crossbedded sand, with pebble bands, is exposed, and is evidently fluvial and of post-Glacial age. Sand and gravel together with small boulders underlie the farms of the community at Sandringham. At Sandy Cove, a flat-topped alluvial terrace 100 feet high rises directly from the water, and other terraces at similar heights are reported by Widmer at Eastport and Happy Adventure. Widmer reports "the head of Salvago Bay is formed by a terrace of fine sand and gravel 90-100 feet high -- the bedding is horizontal from the top to the bottom of the terrace. -- An intermediate terrace level at 52 to 58 feet occurs at Happy Adventure, the west end of Sandy Cove, and on the south side of Salvago Bay - . In some instances rock cut benches coincide with the level of these lower terrace deposits. Around Happy Adventure there are a few terrace deposits at an elevation of 12 feet".

GENERAL GEOLOGY

The following table indicates the probable geological succession of rocks in the map-area;

TABLE OF FORMATIONS

Era	Period or epoch	Formation or group	Lithology
Palaeozoic	Lower Ordovician	Clarendville formation (van Ingen)	Grey to brown shale; minor sandy limestone; sandstone
	Upper Cambrian	Elliott Cove formation (van Ingen)	Grey to black shales, with cone-in-cone concretions; thinly bedded sandstone
	Middle Cambrian		Grey shale
	Lower Cambrian		Red and green shale, in places containing limestone nodules; minor nodular limestone
Proterozoic or Palaeozoic	Lower Cambrian or earlier	Random formation	Quartzite, white, buff, and light green; minor shale beds
		Musgravetown group (Hayes)	(Red greywacke, green greywacke; minor shale) (Lava flows, rhyolite, felsite, andesite, and basalt, with minor intrusives) (Conglomerate)
Unconformity in some parts of area, apparent conformity in others			
Proterozoic		Connecting Point group (Hayes)	Grey to black shale, argillite, and slate; green greywacke; minor conglomerate

Intrusive Rocks¹

Granite (post-Musgravetown group)

Diorite and diorite porphyry (post-Connecting Point group)

¹

The intrusive rocks are not shown in their proper place in this table as only the earlier limits of their possible ages are known. They may well be the youngest consolidated rocks in the area.

CONNECTING POINT GROUP

The name 'Connecting Point' was introduced by Hayes (9) to designate those rocks in the Clarendville area that lie below an unconformity exposed on Connecting Point Peninsula. In 1948, Widmer used the term to designate similar rocks, which he traced to the north of Hayes' area.

The rocks of this group are the oldest in the area. They are commonly grey, green, or black, fine-grained sediments, principally shales, slates, argillites, and greywackes, with minor conglomerate bands. On weathered surfaces these rocks are commonly white, due to a thin film of kaolin.

Shales and argillites are the most abundant rocks of the group. Under the microscope they are seen to be composed of small grains of quartz and feldspar set in a fine-grained, siliceous or argillaceous matrix. A little chlorite commonly occurs in the matrix. The black shales contain minute grains of an opaque mineral, probably carbon. Locally, some of these fine-grained rocks have a pronounced slaty cleavage and are best termed slates.

The greywacke is most commonly green, and may display ripple-marks and crossbedding. The sand-size grains comprising the rock are subangular. Under the microscope, 60 per cent of the grains are of feldspar, principally plagioclase, with lesser potash feldspar, which is pink in some specimens and thereby conspicuous in the green rock. The plagioclase is mainly sodic, but more limy types are also represented. A few grains of microperthite were observed. A few of the feldspar grains are clear and fresh, but most of them are partly altered to sericite and a fine-grained unidentified material. Approximately 20 per cent of the grains in the rocks are of quartz; others are of rock fragments, including some, probably of volcanic origin, with small lath-shaped feldspars enclosed in a fine-grained matrix. One fragment of a spherulitic rhyolite, one of potash feldspar with graphic quartz intergrowths, one of strongly sheared lamellar quartz, and several of fine-grained

sedimentary rocks were observed. A few biotite flakes partly replaced by chlorite were noted. An almost isotropic chlorite fills the interstices between some grains and, in part, replaces the feldspars. In places chlorite veins the rock. Epidote occurs in small grains, and carbonate is common. In one thin section pyrite is abundant, occurring as irregular masses along crystal boundaries and in well-formed cubes. Other opaque minerals are rare.

Conglomerate bands are rare in these rocks. On the small point just south of Clarendville a narrow band of green conglomerate contains pebbles, $\frac{1}{2}$ to 1 inch in diameter, of rhyolite and basic volcanic rocks. The matrix is sandy and similar to that of the greywacke. Hayes also reports a conglomerate from Hillview on the southwest arm of Random Sound.

The above descriptions agree closely with that by Buddington for the "Conception Slate series", with which the Connecting Point group is correlated.

Buddington presented two chemical analyses of "Conception Slate series" rocks as follows:

	1	2
	Per cent	Per cent
SiO ₂	68.92	77.13
Al ₂ O ₃	17.67	14.01
Fe ₂ O ₃	1.43	2.25
FeO	3.48	Undet.
CaO	0.85	0.64
MgO	1.19	0.36
Na ₂ O	3.01	3.59
K ₂ O	1.46	1.01
Ign. loss	1.75	0.76
Total	99.76	99.75

1. Feldspathic slate, near Brigus, Conception Bay.
2. Feldspathic quartzite, Robinsons Bight, Random Sound, Trinity Bay (from the Connecting Point group of the present map-area).

Buddington remarks: "The feldspathic character of the typical slate and its normally fresh, undecomposed character are shown very well by the two chemical analyses - -. It will be noted that the soda is in excess of the potash, contrary to the usual rule for sediments derived from well-weathered materials, and that the analyses resemble those of certain rhyolites".

In summary, all the above-mentioned rocks appear to be derived directly, with a minimum of chemical decomposition, from volcanic or other fine-grained igneous rocks, with minor amounts from granitic and sedimentary rocks. The abundance of feldspar and its fresh condition are indicative of rapid erosion and redeposition. The sand-grain rocks may be termed greywackes; those of predominantly silt grain are also greywacke in detrital composition. Still finer grained rocks have been referred to by the earlier workers as slates, though a good slaty cleavage, in the present area at least, is the exception rather than the rule.

MUSGRAVETOWN GROUP

Summary Statement

The name 'Musgravetown group' was introduced by Hayes (9) to designate those rocks lying immediately above the unconformity on Connecting Point Peninsula and limited upward by the base of the 'Random terrane' of Walcott. Unfortunately the Musgravetown-Random contact is not everywhere sharply defined: in places there is no stratigraphic break, the red and green greywacke of the Musgravetown grading in a short distance into the purer quartzites or sandstones of the Random. Elsewhere the contact is more sharply defined, the white Random quartzite resting apparently conformably on conglomerate or lava of the underlying group.

The Musgravetown group is composed of conglomerate, red and green greywackes, and volcanic rocks. These lithological units have been separated on the map along traverse lines, but all units vary in

degree of development in different localities and even grade from one to the other along strike, so that few horizons can be traced with certainty from one traverse to the next. For this reason much of the Musgravetown group has not been subdivided.

Conglomerate

The Musgravetown conglomerate is widespread, and relatively constant in detrital composition. Most commonly it consists of pebbles about an inch in diameter in a sandy matrix; but rounded fragments may vary in size from 2 mm. to 1 foot.

About three-fourths of the pebbles are of volcanic rocks, those of red rhyolite, and red, mauve, or grey-green trachyte predominating, but others include dark green pebbles of andesite and basalt. Volcanic structures such as flow-bands, spherulites, and amygdules or vesicles may be seen in some of these pebbles. Associated with the volcanic pebbles are lesser numbers of quartz and a few of pink microcline granite of medium grain. Some of the granitic pebbles contain graphic intergrowths of quartz and microcline. Locally, on Connecting Point Peninsula, are considerable quantities of white-weathered pebbles of rocks similar to those of the underlying Connecting Point group.

The sandy matrix of the conglomerate consists principally of grains of sodic plagioclase, with others of microcline, microperthite, and quartz. The feldspar grains are no more altered than in an average granitic rock. The grains are cemented by a recrystallized, fine-grained matrix of sericite, epidote, and chlorite. Carbonate occurs in minor amounts in the matrix and replaces various minerals. Hematite stain may give the matrix a red colour.

Volcanic Rocks

The volcanic rocks of the Musgravetown group range in composition from rhyolite to basalt, with the more acidic types predominating. Red rhyolite and a red or brown felsite, termed the

'Bull Arm felsite' by Hayes, are the most abundant and conspicuous. Other, light grey, mauve, or roddish rhyolites and trachytes occur. The acidic members in places show flow-banding and are commonly amygdaloidal, the vesicles being filled with quartz, carbonate, chlorite, and prehnite. A spherulitic structure was noted, but is not common. Some outcrops are of volcanic breccias or pseudo-conglomerates. Basic lavas, andesite and basalt, are dark grey to green and dark green, but locally may be reddish, due to hematite stain. Amygdules are common and consist of carbonate, epidote, chlorite, and minor quartz.

The 'Bull Arm felsite', mentioned above, is a fine-grained rock carrying phenocrysts of white feldspar, commonly 2 to 6 mm. long. One thin section of a specimen from the southeast side of Bloody Reach indicated that the white phenocrysts are of microcline feldspar embedded in a fine-grained groundmass consisting of quartz, feldspar, and epidote. The groundmass also contains abundant very fine hematite grains, which give the rock its conspicuous red colour. Associated with the red felsite is a non-porphyrritic red rhyolite, which is undoubtedly a similar rock without the microcline phenocrysts.

Light grey acidic flows are common but are less abundant than the red volcanic rocks. The groundmass of the rhyolites commonly consists of a fine-grained aggregate of quartz and feldspar. Small areas of micropegmatite, however, can be observed in thin sections, and in these the constituent mineral grains are larger and freer from impurities than in the remainder of the groundmass. The feldspars and the groundmass in many of these rocks are largely altered to sericite. On the south side of Random Sound, opposite Hickmans Harbour, an amygdaloidal volcanic rock, trachytic to andesitic in composition, contains chlorite, epidote, and prehnite as vesicle fillings.

The andesites and basalts have a texture that varies from fine-grained to porphyritic. Under the microscope, the fine-grained rocks are seen to consist of small feldspar laths, composed of andesine or labradorite, in a groundmass containing small crystals of epidote and replacement areas of chlorite and minor carbonate. Amygdules in these rocks may consist of chlorite, carbonate, epidote, or quartz.

Greywacke

As the red and green greywackes have essentially the same composition except for the relative content of the ferric and ferrous iron oxides, they will be discussed together. These greywackes are similar to those of the Connecting Point group. The grains are predominantly of sand size, and consist roughly of 40 per cent feldspar (principally acidic plagioclase and potash feldspar), less than 30 per cent quartz, and 20 per cent rounded rock fragments mainly of acidic or intermediate volcanic rocks in which microlites of feldspar are visible under the microscope. Locally, there are fragments of sedimentary rocks. The red greywacke differs from the green in that a film of hematite coats the constituent grains and in places penetrates the cleavages of the feldspars. This description is very similar to that given by Buddington for the Signal Hill sandstone at St. John's, although the writer prefers to call rocks of this type greywacke rather than sandstone.

The following quotation is from Buddington (7):

"That the red color of the brown sandstones is due to hematite and to the oxidation of its iron content is evident from a comparison of the ferrous and ferric contents of the red and green sandstones. Although both have similar total contents of iron, 4.74 and 5.11 per cent respectively, --- the brown sandstone shows 4.75 per cent of ferric oxide and only 0.46 per cent of ferrous oxide, whereas the green sandstone shows 2.54 per cent of ferric oxide and 2.82 per cent of ferrous oxide.

"The red color of the sandstones depends in varying degrees upon the primary deposition of a hematitic mud in the interstices of the sand grains; upon hematite existing in the grains themselves as in the cleavage cracks of feldspar, or in oxidized basalt and rhyolite; and upon the hematite resulting from the oxidation of magnetite grains in situ".

Associated with the green greywacke is a green silt, silty shale, or shale. These rocks are well displayed in the vicinity of the Catalina dome and near New Melbourne on the Bay de Verde Peninsula, and are fine-grained, green rocks similar to corresponding rocks in the Connecting Point group. They have not been mapped separately from the associated coarser greywackes because of their limited occurrence, and because in places they are interbedded with the coarser grained rocks.

GENERAL DISCUSSION OF CONNECTING POINT AND MUSGRAVETOWN GROUPS

Comparison of Connecting Point and Musgravetown Groups

The Connecting Point group consists mainly of shales, siltstone, and slate, with rather abundant green greywacke and a few minor conglomerate bands with green matrices. The Musgravetown group consists mainly of conglomerate and greywacke, with minor siltstone and shale. The conglomerate is everywhere reddish, due to the contained pebbles of red rhyolite or red felsite, but the matrix may be either red or green. Although the Musgravetown greywacke is commonly red, much of it is green and cannot be distinguished from the greywacke of the Connecting Point group. Associated with the green greywacke near Catalina is green shale or siltstone. Similar relationships exist near New Melbourne. These rocks are indistinguishable from the shales and siltstones of the Connecting Point group. Another point of difference is the presence of volcanic rocks in the Musgravetown, whereas none has been recognized in the Connecting Point, except, perhaps, west of Clareville, where volcanic rocks mapped as Musgravetown may belong to the Connecting Point group.

The similarities between the two groups are obviously striking, inasmuch as their sediments were derived from similar rocks and were deposited with a minimum of decomposition.

Structure and Relationships

The unconformity between the Musgravetown and Connecting Point groups is well exposed on Connecting Point Peninsula and on the east side of the peninsula between Southward Bay and Cutler Head. In both localities the underlying beds are truncated by conglomerate beds of the upper group, and the exposures permit elimination of the possibility that the relationship is due to faulting.

Elsewhere, however, the relationship of the two groups is not as clear. Near Smith and Random Sounds, rocks of the Connecting Point group appear to grade conformably upwards into those of the Musgravetown group to the east. It is quite possible that the upper Connecting Point strata in this vicinity are equivalent to the green greywackes mapped as Musgravetown, which are exposed in the anticline west of the Palaeozoic syncline on Random Island. The western contact of the Connecting Point group with the Palaeozoic formations and with the Musgravetown group is not well exposed. However, adjacent Connecting Point and Cambrian outcrops at Forsters Point, on the southeast side of Random Island, are separated by only a few feet of drift, but strike and dip in very different directions. This may indicate either an unconformity or a fault contact.

In the vicinity of Bloody Reach, the Connecting Point-Musgravetown contact lies mainly beneath the sea; where exposed at the south end of Cottel Island, it appears to be faulted. Little was learned regarding the relations of the two groups in this region.

It has been suggested that those Musgravetown rocks above the unconformity on Connecting Point Peninsula may be much younger than the Signal Hill group of St. John's or the rocks mapped as Musgravetown on Random and Smith Sounds. The writer, however, believes

that the Musgravetown antedates the lowest fossiliferous Cambrian beds, partly because of the striking resemblance of its rocks to those of the Signal Hill group, which pre-date these beds, but more particularly because of the sequence examined in the Lockers Reach area. Here, Musgravetown rocks, traced northward from the area in which the unconformity is recognized, are overlain by beds resembling those of the Random and the Lower Cambrian. In this area, a syncline plunges northeasterly, the northwest flank being in contact with granite. On the south shore of the bay is a syncline composed of Signal Hill type conglomerate and red greywacke. Stratigraphically above these rocks, on Locker Flat Island, is a light green to white quartzite greatly resembling the Random quartzite. A similar light green quartzite lies immediately above the red greywacke on Deer Island. Above the quartzite band is a green slate, which contains concretions of limestone aligned parallel with the bedding planes. No red slate or shale was noted. The green slate is probably Cambrian and the quartzite is probably Random, but investigations are too incomplete to enable them to be so designated on the map.

In a small area on the north side of Alexander Bay, limy nodules rich in epidote were observed in a shaly metamorphosed rock. A search for fossils in this vicinity might be productive.

RANDOM FORMATION

The Random formation includes the relatively pure sandstones that overlie the Musgravetown group and underlie the fossiliferous Lower Cambrian nodular limestones and variegated shales. It is typically pure white quartzite, but includes grey, green, and pink quartzite and sandstone, which in places are shaly or slaty. Cross-bedding is common in the quartzites and mud-cracks in the argillaceous bands.

The Random is a thin formation, and in many places the thickness has been exaggerated to show on the map. The greater widths indicated at Hickmans Harbour Point and in the syncline near Burn Point are due to repetition of the beds by folding.

One of the better exposed sections of Random quartzite is the type section at Hickmans Harbour, of which the description below is quoted from Walcott. In this section the quartzite is crossbedded. In places in the section interbedded grey sandstone and shale show rhythmical deposition of beds about 1 inch in thickness, each bed varying from sandstone at the bottom to shale at the top. The shale top commonly shows mud-cracks. It is believed that these bands represent annual deposits in an enclosed basin that was flooded in the spring and dried up later in the year.

Discussion of the term 'Random Terrane'

In 1900, Walcott proposed the term 'Random Terrane' for the strata lying between the Signal Hill and Cambrian formations. In his paper (5) he includes three measured sections, but in only one, that near Hickmans Harbour, were both the top and the bottom exposed. The following is his account of this section:

"At Hickmans Harbour point [east of Hickmans Harbour] the Signal Hill conglomerate strikes north 40 degrees east; dip, 68 degrees southeast. At the summit of the Random terrane the strike is north 50 degrees east; dip, 70 degrees southeast. The section, as measured by Mr. Howley, is as follows, downward:

"Cambrian	
"Random	
	Feet
1. Reddish gray quartzitic sandstone	1½
2. Light greenish gray flaggy sandstones	3
3. Hard gray quartzitic sandstone	5½
4. Micaceous gray and greenish flaggy sandstone	68
(Several varieties of annelid trails present including a variety about 5 millimeters broad, a slender form ½ millimeter broad, and an annulated trail 2 to 3 millimeters in width.)	
5. Gray sandstone	16
6. Greenish and bluish gray slaty arenaceous beds, breaking up into fine shales in places	26
7. Pale pinkish quartzite in layers 1 to 3 feet;	25
8. Reddish brown hard sandstone	21
9. Massive bedded white quartzite	10
10. Massive and thin bedded hard gray sandstones and shales	90
11. Dark gray flaggy sandstones	55
12. Massive bedded white quartzite	63
13. Massive bedded reddish gray quartzitic sandstone	31

"There is a fold in the Random rocks of the section forming a sharp syncline and anticline, and I believe that a portion of the upper part of the Random terrane is faulted out of sight. On the opposite or eastern side of the synclinal basin holding the Cambrian rocks the Random terrane appears to be much thicker, although folded and repeated several times".

The present writer believes there is little ground for this correlation of the underlying conglomerate with the Signal Hill conglomerate of the St. John's area. The correlation was made purely on lithology, but similar conglomerates have been found at several horizons in the Musgravetown group and the writer would prefer to regard them as a Signal Hill type of conglomerate, and thereby to avoid the assumption that the conglomerate in the quoted section was formed at the same time as that near St. John's. Moreover, since Walcott wrote his report Hayes and Rose (See Table I) described the Blackhead formation, which comprises 5,500 feet of red, green, and greenish grey sandstone, with thin intercalated beds of argillite and slate (top not exposed), overlying the Signal Hill conglomerate in the St. John's area. Thus, that conglomerate is not at the top of the sequence in that area, or else the Blackhead is the equivalent of the Random, which the writer regards as improbable. No Cambrian is exposed there, so the distance from the top of the Signal Hill conglomerate to the base of the Cambrian is unknown but must exceed 5,500 feet. It is unlikely, therefore, that the conglomerate beneath the Random section (above) is to be correlated in time with the conglomerate at the top of the Signal Hill near St. John's.

Hayes (9) included this type section of Walcott's in his Lower Cambrian Brigus formation, and in the map-legend includes in the Brigus a "white quartzite, overlain by reddish brown shale, nodular limestone, grey and brown shale, slate and sandstone". This white quartzite is undoubtedly Walcott's Random. Hayes applied the name 'Random' to various beds, in most part underlying the above

section but in places including the white quartzite. In view of the confusion that has arisen in this matter it seems advisable to re-define the term 'Random' according to Walcott's original definition. Therefore, in this report and on the accompanying map the term Random will be applied to those beds described in Walcott's type section (including the conspicuous white quartzite) that lie beneath the Lower Cambrian green and red slates and limestone of the Olenellus zone, and in this section lie above a Signal Hill type conglomerate. Annelid trails were found by Walcott in the three sections of Random he gives at Hickmans Harbour, Smith Point, and Hearts Delight. In the type section, the base of the Lower Cambrian is defined by Walcott as a conglomerate, 6 inches thick, "with small pebbles of the subjacent Random rocks, and small quartz grains and pebbles, all cemented together by a fine calcareous sandy matrix". Fossils noted from this horizon are "slender tubes of Coleoloides and fragments suggesting Archaeocyathus". Overlying this conglomerate are 3 feet of purplish sandstone above which is more than 700 feet of red, green, and purple shales and slates with minor amounts of limestone. Hyolithes princeps and Coleoloides typicalis were obtained from this section by Walcott.

The upper boundary of the Random formation is well defined by Walcott, and where well exposed can be readily located in all parts of the present area. Whereas the Random is underlain by a Signal Hill type conglomerate in the type section, in other parts of the area it is underlain by other subdivisions of the Musgravetown group. At Keels, the contact appears to be gradational from red, sand-grain greywackes upward to the cleaner quartzites of the Random. Just west of Petley, the typical pure Random quartzite is underlain by 1 foot of conglomerate, which is of the Signal Hill type except that the matrix is green instead of red, and this in turn is underlain to the northwest, apparently conformably, by green greywackes, in places more siliceous than is usual, interbedded with a few pink greywacke bands. At the west side of the syncline on Random Sound opposite

Hickmans Harbour, white Random quartzite overlies amygdaloidal lavas interbedded with conglomerate, but the relations there may be confused by faulting.

It is, consequently, apparent that the Random quartzite may overlie any of the lithological subdivisions of the Musgravetown (Signal Hill) group. In places the contact is gradational, and the position of the contact cannot be determined with accuracy. The base of the Random quartzite is, therefore, defined as that horizon at which greywacke, conglomerate, or lava of the Musgravetown group is succeeded by relatively pure quartzites and sandstones.

LOWER CAMBRIAN

The Lower Cambrian strata in the area consist principally of red and green shale and slate, in places containing limestone nodules, and lesser amounts of nodular limestone. They lie between the Random quartzite and the Paradoxides-bearing beds of the Middle Cambrian. Some doubt exists as to the position of the contact between the Lower and Middle Cambrian strata in the Smith Point section.

Walcott (4) published the following detailed section of the Smith Point strata:

Middle Cambrian, downward.—	Feet
1a. Dark, argillaceous shales, with fragments of <u>Paradoxides</u> in the upper portion. At 45 feet down the <u>Paradoxides</u> are abundant; also <u>Acrothelo</u> , <u>Obolus</u> (L.) <u>ferrugineus</u> , <u>Ptychoparia</u> , etc. At 110 feet down a 4-inch band of pinkish limestone carrying fragments of trilobites occurs. A roll in the strata comes in at this point and continues for a considerable distance along the shore. It starts between the two east wharves at Broad Cove, and extends some distance east of the eastern point of Broad Cove	110
1b. Below the limestone greenish shale extends downward to a layer of reddish argillaceous shale 20 feet in thickness	80
No recognizable fossils were found in this bed.	
1c. Pinkish nodular limestone in several layers, interbedded in reddish shale	4
Fossils: <u>Paradoxides</u> (undet.), <u>Ptychoparia</u> .	

	Foot
1d. Reddish-purple argillaceous shales with interbedded greenish-colored bands	135

This band of shales corresponds stratigraphically to the Protolenus zone of the Hanford Brook section of New Brunswick. A basalt dike cuts through the shales a few feet above their base. On the weathered surface it has the appearance of a massive sandstone. It is 3 feet 4 inches in thickness, is vertical, and the dip of its cleavage planes is almost coincident with the dip of the shales.

- 1e. Nodular limestones. A pinkish layer 4 inches thick contains at base numerous fragments of trilobites and appears to be made up of a conglomerate formed of fragments of pinkish-colored limestone and purple shale, and dark iron- or manganese-stained nodules resembling a Stromatoporoid-like growth, and a few small quartz pebbles.

The entire stratum is as follows:

	Inches.	
Dark, nodular limestone	25	
Purplish-colored shale	2	
Pinkish limestone	2	
Brick-red shale	3	
Pinkish conglomerate ? limestone	4	3

At the point of exposure on the shore this band is faulted down 15 feet to the west. It is exposed near the top of the bank on the eastern side of the fault, where its dip is lower than on the western side.

The stratum 1e is taken as the base of the Middle Cambrian (Paradoxidian). It is the horizon indicated by Mr. Matthew in his diagrammatic section as the base of the Cambrian, and corresponds in stratigraphic position to the St. John quartzite of the New Brunswick Cambrian.

One observes no difference, in either strike or dip, between the shales beneath this band of nodular limestone and conglomerate and the shales above it until one passes to the east of the fault-line that cuts through and breaks the band a few feet above the water's edge.

Lower Cambrian (Etcheminian of Matthew).—

2a. Reddish-purple argillaceous shale with greenish shales in bands at irregular intervals and a massive band of greenish shale near the base	284
---	-----

Dip near base 20° to 23°W.

At 110 feet from the summit fragments of a large undetermined trilobite were noted. On the south side of Smith Sound, at Britannia Cove, Olenellus (H.) broggeri occurs at a horizon corresponding to 140 feet below the summit of the stratum.

Near the base of 2a the following fossils were found:

Obolella atlantica
Hyolithes sp.
Orthotheca sp.
Microdiscus sp. undet.
Olenellus (Holmia) broggeri
Solenopleura? bombifrons?

Inches

- 2b. Greenish-colored, arenaceous limestone, passing into an intraformational conglomerate formed of nodules of pinkish limestone mixed with fine sand and carrying numbers of fragments of trilobites 16
 Pinkish-colored nodular limestones 8

Fossils: Fragments of trilobites and a small brachiopod.

Feet

- 2c. Reddish-purple to brick-red argillaceous shale 56

The following fossils occur in the central and lower portions of this band:

Obolella atlantica
Microdiscus bellimarginatus, S. & F.
Microdiscus n. sp.
Olenellus (Holmia) broggeri
Zacanthoides sp. undet.
Agraulos sp.
Micmacca walcotti

- 2d. Brick-red and pinkish nodular limestone in layers varying from 3 feet to 6 inches in thickness 27

This is one of the most important horizons in the Lower Cambrian of Newfoundland (Smith Point limestone). It is very persistent about Trinity Bay, and it occurs, although much thinner, at various exposures in Conception, St. Marys and Placentia Bays. The upper 24 feet at Smith Point is practically solid limestone layers. The lower layer of limestone, 1 foot in thickness, is separated by 2 feet of reddish shale in which 3 inches of limestone occurs.

Fossils:

In the upper 6 inches of the top layer of limestone numerous fragments of Olenellus (H.) broggeri and Solenopleura? occur. About 3 feet below this, in the next bed of limestone, immense numbers of Hyolithes princeps are found in association with the fauna that marks this limestone band wherever it is found. The following species were collected in a few hours:

Iphidea Labradorica (Kutorgina granulata M.)
Fordilla troyensis
Scenella reticulata?
Randomia aurorae
Helenia bella
Orthotheca pugeo
Hyolithes princeps
Coleoloides typicalis
Hyolithellus micans?

	Feet
2e. Green argillaceous shale	23
2f. Massive stratum of nodular limestone, divided into 18 inches of a pinkish limestone, and 3 feet of purple to a pink, mixed with purple argillaceous shale	4 $\frac{1}{2}$
Fossils:	
<u>Coleoloides typicalis.</u>	
2g. Green argillaceous shale in massive bands, with numerous small pinkish limestone nodules scattered irregularly on the line of bedding. At 51 feet from the base the limestone nodules increase in number and size, and form the greater part of a layer 2 feet in thickness. Above this the reddish-purple and green shales occur in bands varying in thickness	62
Fossils:	
<u>Hyolithes rugosus</u> Matt.?	
<u>Coleoloides</u>	
<u>Urotheca pervetus</u> Matt.	
Crustacean, n.g., n. sp.	
2h. Reddish-purple, argillaceous shales, with irregularly distributed bands of nodular limestone of varying thickness. A layer of nodular limestone 42 feet from the summit has 12 inches of pinkish and reddish-purple limestone above, with 10 inches of greenish limestone below. In both layers numerous tubes of <u>Coleoloides</u> occur. At 66 feet below the summit a second band of nodular limestone 20 inches in thickness occurs. Thin layers of nodular limestone occur both above and below the two thicker bands mentioned	136
2i. Green argillaceous shale, with a few thin layers of purple shale, also scattered layers of pinkish-colored, nodular limestone	30 $\frac{1}{2}$
Fossils:	
Annelid trails are abundant in some portions of the greenish-colored shales.	
2j. Reddish-purple shale, with layers of greenish- and pinkish-colored limestone nodules scattered irregularly on the line of bedding. The nodular limestones are usually from 2 to 4 inches in thickness, but at 60 feet from the top a layer 12 inches thick occurs	185
The section is here cut off by the drift coming down to the water's edge.	

Again quoting Walcott (5) in what is undoubtedly a continuation of the same section, given as a part of his description of the 'Random terrane':

"East of the interval covered by soil occurs a section. 107 feet thick that evidently belongs to an older series, although it retains the same dip and strike as the roddish purple and green shales of the Lower Cambrian. The section exposed is as follows, downward:

	Thickness Feet
"a. Sandy shales, with some bands of arenaceous-argillaceous shales; a thin layer of intraformational conglomerate occurs 33 feet from the bottom, and at 17 feet from the bottom are some calcareous layers and nodules	51
"b. Light gray quartzitic sandstone in three principal layers, 22, 24, and 20 inches thick, respectively	5
"c. Arenaceous shales, with thin layers of dirty grey sandstone; well marked annelid trails occur on some of the beds of sandstone and shale	51

"Several hundred feet of the section along the shore are here concealed by drift, but to the eastward indurated gray sandstones and shales show in the cliffs where they are broken and distorted by dikes of basalt".

In 1912 and 1913, van Ingon (6) reviewed the Smith Point section, and presented the table of the Cambrian formations given in part (with simplifications) below:

Table II

Ago	Series	Formation	Lithology	Index fossils		
CAMBRIAN	UPPER	Elliott Cove	Elliott Cove	Grey and black shales, with conc-in-cone concretions and thin-bedded sandstones	<u>Olenus</u> <u>Orusia lenticularis</u> <u>Lingulella ferruginea</u>	
		Manuols	Manuols	Black, brown, and olive shales, thin sandstones, and kalkballen	<u>Paradoxides</u> <u>Conocoryphe</u> <u>Llostracus</u> <u>Agnostus</u> <u>Microdicus</u>	
	Phosphorite			Lower <u>Paradoxides</u>		
	<u>Disconformity</u>					
	LOWER	Hanfordian	Hanford	Green and red shale, with manganiferous lime-stones	<u>Protolenus</u> <u>Ellipsocephalus</u> <u>Avalonia</u>	
				Phosphorite	Radiolaria and sponges	
		<u>Disconformity</u>				
		Etcheminian	Smith Point	Red limestone, with red shale	<u>Hyolithes</u> , etc.	
			Brigus	Red shales, with nodular limestone	<u>Callavia broggeri</u> <u>Sternuella strenua</u>	
			Bonavista	Red and green shales, with limestone nodules	<u>Coleoloides</u> , etc.	

A study of this table in conjunction with Walcott's section, given above, and van Ingen's map and section as quoted by Dale, shows that van Ingen's conception of the Lower Cambrian is different from that of Walcott. Although both agree on the definition of Etcheminian, Walcott's Lower Cambrian is the Etcheminian only, whereas van Ingen includes the Hanfordian as well, which extends upward to the lowest horizon (10) in which Paradoxides was noted by Walcott. Van Ingen's definition of the Lower Cambrian-Middle Cambrian boundary has been followed in this report. It is a convenient boundary lithologically, as it places all the conspicuous red and green shales and slates and nodular limestones in the Lower Cambrian, with the exception of a 24-foot red and green band at the base of the Middle Cambrian. The prominent manganiferous limestone beds are also placed in the Lower Cambrian.

Discussion of the Term 'Brigus Formation'

Van Ingen first used the formational name 'Brigus' in the table reproduced on the preceding page, where it represents one of the three formations within the Lower Cambrian, Etcheminian series.

Hayes (9) used the term 'Brigus formation (van Ingen)' for strata of both Middle and Lower Cambrian ages and for "the underlying white quartzite which usually accompanies them". The white quartzite has been called Random in the present report. This extension of the term is not believed to be justified, and the writer suggests that van Ingen's original definition of Brigus be retained.

MIDDLE CAMBRIAN

In the Smith Sound section, given on preceding pages, the Middle Cambrian strata (Walcott's 1a to 1c, See Table I) are principally grey shales, green shales, minor reddish argillaceous shale, and a few thin limestone bands. Walcott reports Paradoxides, Acrothele, Obolus (L.) ferrugineus, and Ptychoparia from these beds.

The fossils collected by the writer from these beds, and identified by L. D. Burling of the Geological Survey of Canada, include Ctenocephelus?, Solenopleura?, and Bailliella?.

The base of the Middle Cambrian is considered to be the 4-foot limestone band carrying Paradoxides (Walcott's 1c). The top of the Middle Cambrian is concealed by drift at the head of Broad Cove, as Walcott reports Olenus, indicative of Upper Cambrian, to the west of the drift-covered area.

UPPER CAMBRIAN

Elliott Cove Formation

Van Ingen defined the Elliott Cove formation in his table as composed of grey and black shales with cone-in-cone concretions and thin-bedded sandstones. Index fossils are listed as Olenus, Orusia lenticularis, and Lingulella ferruginea. The only defined contact with the Middle Cambrian is, by Walcott, at the head of Broad Cove. It is presumed, however, that the formation occurs at Elliott Cove, from which it derives its name.

As van Ingen's description of these rocks is only a note on lithology in his table, the following more detailed description is submitted. The rocks comprising this formation are predominantly light grey shales, less commonly dark grey or reddish on the fresh surface. On weathered surfaces they may be dark grey, grey, or rusty. In places, thin beds of sandstone occur in the shale; in other places the formation includes thin beds of limestone. Disk-shaped limestone concretions are common throughout most of this formation, the concretions showing beautiful examples of cone-in-cone structure. Although the cone-in-cone concretions are a prominent feature of this formation, they will not serve to define the upper limit, as similar concretions occur in what must be Ordovician strata between Brown Mead and Bar Mead at the west end of Random Island.

LOWER ORDOVICIAN

Clareville (Tremadoc) 'Series'

The Clareville 'series' was named by van Ingen as a series to designate the Ordovician rocks of the basin near Clareville. His only description is in the following table:

Age	Series	Formation	Reference No.	Lithology	Index fossils
LOWER ORDOVICIAN	CLAREVILLE		F6	Shale	
		Riders Brook	F5	Grey sandy limestone	¹ <u>Bellerophon randomi</u> nov.
		Midment	F4	Shales	¹ <u>Niobe howelli</u> nov.
		Apsey	F3	Shales	¹ <u>Princeton</u> <u>terrannovica</u> nov. ² <u>Parabolina harrieta</u> nov.
			F2	Brown shales	<u>Shumardia</u>
		Brown Mead	F1	Grey shales	<u>Bryograptus</u>

¹ These fossils have not been described in the literature.

² E. S. Richardson (10) considers this fossil identical with a Tremadocian species from Argentina, Parabolina andina (Hoek).

Both above notes personal communications from Professor B. F. Howell, Princeton University.

Professor B. F. Howell was good enough to provide the following additional information:

"the Brown Mead Formation is exposed at Brown Mead, on Random Island, ---- and contains an unidentified species of graptolite referable to either Bryograptus or Dictyonema (we found only one imperfect specimen). The Apsey Formation is exposed along the western shore of Random Island north of Brown Mead, the Shumardia zone being, I think, exposed not far north of Brown Mead ---- and the Parabolina andina 'Princetonia Terranova' zone is exposed about half a sea mile north of Brown Mead. The Maidment Formation is exposed from a point a quarter of a mile to half a mile north of the best exposures of the Apsey Formation and thence on northward toward Bar Mead, ----. The Riders Brook Formation is exposed at Riders Brook, ----. The upper and lower limits of these formations have never been defined; and it would be difficult to set definite limits for them because of the folding in the beds involved and the discontinuous nature of the outcrops".

The Ordovician-Cambrian boundary is not properly defined, but lies somewhere between Elliott Cove and Brown Mead on the southwest shore of Random Island. Virtually no work was done on these formations in 1949. Lithologically, the Ordovician strata are difficult to distinguish from those of Upper Cambrian age, as both consist of grey to dark grey shales, with a few sandy and limy bands and cone-in-cone concretions.

INTRUSIVE ROCKS

Granitic Rocks

Granite forms several masses within the map-area, much the largest being that in the northwest corner. This mass is shown on Snelgrove's geological map of Newfoundland (8) along the coast for 50 miles past the northern boundary of the map-area. Within the map-area the rock is commonly a porphyritic grey granite in which large (average $\frac{3}{4}$ inch) phenocrysts of white potash feldspar are set in a finer grained groundmass of quartz, plagioclase feldspar, and biotite.

Under the microscope the large phenocrysts of potash feldspar are seen to be microcline; the plagioclase is albite, near An_{10} , and the biotite is pleochroic light green-brown to dark green-brown. Accessory minerals are chlorite, apatite, and iron oxides. Minute flakes of sericite occur as alteration products of the feldspars.

Away from its contact with intruded rocks, the granite is commonly massive, although a rude foliation is apparent in a few localities. In places, however, and particularly as its southern contact is approached, the granite loses its massive character and becomes more gneissic, due to the alinement of biotite flakes. Amphibole and biotite bands in the gneiss, undoubtedly representing altered inclusions, are common near the contact with the sedimentary rocks, and in many places the gneiss is a finely banded migmatite. The gneiss in this area is cut by finer grained granitic sills and dykes similar to the massive granite except that they have a finer grain and that white mica takes the place of biotite. No such dykes were noted in the massive porphyritic granite to the north.

The granite and gneiss complex has been mapped as 'Laurentian' by Jukes and Murray because of the banded and gneissic appearance of the border phase. The following observations, however, indicate that the granite is younger than the adjoining sedimentary rocks.

The contact between the granite and the strata of the Musgravetown group is well exposed on the south side of Content Reach $1\frac{1}{2}$ miles west of the border of the map-area. Here a pink, biotite granite, most commonly massive but in places showing a foliation, is in contact with a fine-grained green rock. The contact, a sharp vertical plane striking north 10 degrees east, is undoubtedly a fault. A thin section from a specimen of the sheared granite adjoining the fault showed quartz, albite, and well-twinned crystals of fractured microcline in a fine-grained, crushed groundmass composed of the same minerals. Many of the fractures have a subparallel arrangement and are filled with small flakes of sericite. The fine-grained green rock on the opposite side of the contact is composed

principally of epidote, chlorite, and quartz, with minor iron oxides and a little carbonate occurring as small grains or in replacement areas. Several bands composed of aggregates of small quartz crystals give the rock a bedded appearance. Numerous granite dykes from 3 inches to 10 feet in width cut the Musgravetown rocks near the contact. Although common near the contact, these dykes were not observed to occur more than a mile from the granite in this area.

On the peninsula between Content Reach and Lockers Bay, the granite-Musgravetown contact again appears to be a fault. Here the mixed sedimentary and volcanic rocks are cut in one place by a dyke of granite 100 feet wide.

Further indirect evidence bearing on the age of the granite is to be found in the pebbles of the Musgravetown group. Granite pebbles occur in the Musgravetown conglomerate and comprise between 0.1 and 10 per cent of the total. The granite pebbles, although relatively scarce, are widely distributed. Where observed they were of pink, moderately porphyritic granite. If the grey porphyritic granite of the northern area supplied any of these pebbles, the source would be readily recognized by the size of the phenocrysts. The absence of such pebbles from the Musgravetown conglomerates suggests again that the granite is younger than the sediments.

Near Traytown is a mass of granite that intrudes the sedimentary rocks. The granite is a massive, buff to grey rock of medium grain (maximum grain size 5 mm. to 1 cm.) composed of microcline and quartz. Dykes of granite cut the adjacent strata, and many dykes of various compositions cut the sediments near the granite contact north of the bay.

Near Clarendville, a medium-grained, pink to red granite is seen in thin section to consist of potash feldspar, albite, and quartz. The red or pink colour is due to hematite stain in the altered feldspar. Accessory minerals are a little biotite and iron ore. Hayes and Rose (9) mapped these masses as 'Northern Bight Granite', which in the Placentia Bay region was found to intrude formations of Cambrian age.

Dioritic Rocks

Diorite and diorite-porphyry occur in small masses in the vicinity of Gooseberry and Cottel Islands, where they intrude rocks of the Connecting Point group. The typical rock of Gooseberry Island is holocrystalline, with an average grain of about 4 mm., and is composed of andesine feldspar much altered to sericite (55 per cent) and hornblende (40 per cent). Intergrowths of quartz and potash feldspar occur between the larger feldspar grains. Chlorite is common and epidote scarce.

The diorite-porphyry contains crystals of andesine feldspar, commonly 4 mm. long, in a fine-grained green groundmass. No thin sections of this rock were examined.

ECONOMIC GEOLOGY

The only active mining in the area is at two pits, one at Georges Brook and the other at Snooks Harbour, Random Island, where clay is being produced for the manufacture of bricks. The slate quarries of Smith and Random Sounds are now inactive. The Workington iron prospect near Lower Island Cove was explored in 1898 and 1899, but has since been inactive. A lead prospect is known near Hatchet Cove, on the southwest arm of Random Sound, and another near Bloomfield. Several veins containing small amounts of copper minerals were noted, and manganese-bearing beds occur in the Lower Cambrian formations of Smith Sound.

CLAY AND SHALE

According to Snelgrove (8), the first attempt to manufacture brick in the area was made by a Mr. Cameron in the 1860s at what later became the Pitman pit on Smith Sound, 3 miles east of Riders Brook. This property was acquired by the Messrs. Pitman "who carried on the business on a small scale for many years, depending on local markets for the disposal of their product. In the nineties the output averaged about 60,000 bricks per annum". The property is now inactive. The clay occurs on an uplifted

terrace. The workings are no longer exposed, due to slumping of the walls and to grass cover. This deposit is described briefly by Hayes (9).

At Georges Brook, the Messrs. Pelley began making brick in 1888, and the pit and plant are still producing. The deposit is composed of interbedded sand and clay in roughly equal amounts, the layers being about 1 inch thick. Most of the bricks are sent to St. John's.

About the same time (1888) a brick-making plant was established at Elliott Cove. The clay was obtained from an elevated terrace, the top of which is 45 feet above Random Sound. Snelgrove (8) states: "In 1904, the Newfoundland Brick and Tile Co. abandoned their work at Elliott Cove and transferred their plant to St. John's".

The Smith Brothers' pit and plant at Smooks Harbour is now producing brick at the rate of several hundred thousand a year. According to Hayes (9), the clay-sand is obtained "by sinking through glacial gravel and raising the material by derrick". Hayes gives the results of tests run on samples of this material by the Bureau of Mines, Ottawa.

Hayes (9) also submitted a sample of shale, obtained from a cliff along tide-water half a mile west of the Smith Brothers' pit, to the Bureau of Mines for testing. The results show that the "shale can be used for the manufacture of face brick, common brick and building tile. The shale is accessible at tide-water both on Random Island and the northern shore of Smith Sound from cliffs 25 to 100 feet high. It forms the basis for a potentially large industry".

SLATE

Slate of possible commercial value occurs in the Lower Cambrian rocks at Keels, and in the Lower Cambrian belt that extends from near Burn Point on Smith Sound to the North West Arm of Random Sound east of Hickmans Harbour. The main quarries in the area are: the Newfoundland Slate Company's quarry near Burn Point; the Winter, Alison, and Bryant quarries near Hickmans Harbour on Random Island; and Grieves quarry on the adjacent mainland. The slates are green, red, purple, and brown,

and weather well, the durability having been tested over a period of 50 years in many local buildings. None of the quarries is operating at present, although large deposits of good quality slate are available at tide-water.

The commercial grade of slate appears to be restricted to the more easterly of the Lower Cambrian belts of the Random Island area because of the stronger folding that has occurred there, and consequent strong development of slaty cleavage. In the western basin, between Smith Point and Clarendville, the slaty cleavage is not well developed. Although the Lower Cambrian red and green slates extend south as far as the South West Arm of Random Sound, the slate at the latter locality is of no value for roofing because it is greatly fractured. In general, the fracturing is less intense farther north, and the best slate is found north of the North West Arm of Random Sound, and especially in the Smith Sound area.

Snelgrove (8) states, "between 1853 and 1909, -- 51,234 tons of roofing slates were produced from quarries in the eastern belt". This figure includes the production of a small quarry in Placentia Bay. "Only a small amount was used locally and the remainder went to English markets, especially London and Newcastle".

IRON

The Workington iron prospect is on the southern boundary of the map-area near Lower Island Cove on the Bay do Verde Peninsula. Snelgrove (8) describes this and similar deposits as an "iron formation of sedimentary origin ----- iron deposits are of frequent occurrence intermittently over a stretch of some 40 miles --. The most ambitious attempt at mining such ores was at Workington, -- in 1898. The Newfoundland Iron Ore Company Ltd. sank 7 prospect shafts ranging from 40 to 170 feet in depth on red hematite which had a higher iron content than the Wabana ore and was almost free of phosphorus and sulphur. The company dissipated its resources on a surface plant,

a 7-mile railway and a shipping pier but failed to develop sufficient ore to mine, and operations ceased in 1899. In 1904, the Nova Scotia Steel Co. examined the property. The deposit is reported to range from 5 feet to 7 feet in thickness, and to dip 31 degrees southeast. Because of cover, a diamond drilling programme would be necessary to reveal the extent of the deposit. Float ore in the vicinity is said to be traceable for many miles. An average analysis of dump ore yields 60.37 per cent iron, 0.17 per cent manganese, 0.028 per cent phosphorus, 0.02 per cent sulphur, and 6.72 per cent silica".

The workings are flooded and the surface exposures are poor. However, the evidence available appears for the following reasons to make the hypothesis of a sedimentary origin doubtful:

1. The sedimentary beds in the vicinity appeared to contain no abnormally iron-rich bands.
2. The beds in the vicinity strike northeast and dip about 45 degrees northwest, the attitude being rather uniform; Snelgrove reports the deposit to dip 31 degrees southeast. This reported divergence in attitude of ore and strata is difficult to reconcile with the hypothesis of a sedimentary origin.
3. The deposit occurs in a depression that strikes northeast parallel with the strike of the sediments, where it is cut by a cross-fracture or fault that strikes about north 60 degrees west, and is visible in air photographs. The occurrence of a metallic mineral deposit at or near the intersection of two lineaments visible on air photographs is a not uncommon feature of introduced metalliferous deposits.

LEAD

There are two lead prospects in the area, the better exposed of which is on the south side of a small pond 1 mile northwest of Hatchet Cove. A scarp here strikes south 80 degrees east and is visible as a lineament in air photographs for a mile on each side of the pond. This scarp is the surface expression of a fracture or fault. South of the

pond is a vein about 1 inch thick consisting of almost solid galena, with a little calcite. The vein strikes north, dips nearly vertically, and is well exposed for 50 feet in an adit driven southward into the cliff. The vein is continuous for this distance, and shows at the end of the drift. The wall-rock is a fine-grained massive flow or intrusion of andesitic composition. Seven hundred feet to the east along the scarp a 1-inch vein of almost pure galena is exposed in the cliff, and has the same strike and dip as the other vein. These narrow and fairly continuous veins appear to be in tension fractures related to the fault or fracture. A similar lineament striking south 80 degrees east occurs 4,000 feet to the north.

A vein containing galena and sphalerite occurs east of Bloomfield on the property of Mr. Samuel Howse. The following is quoted from Hayes (9): "The vein is within a quartz diorite dyke, and appears to have been deposited in a brecciated fault zone. The dyke is 55 feet thick, strikes northeast, and dips steeply northwestward. The vein is 15 feet from the west wall of the dyke. Pyrite, quartz, and calcite accompany the galena and sphalerite and form a vein in fault breccia varying from a fraction of an inch to 3 inches thick. A prospect pit sunk in the yard of Mr. Howse is now filled with water and debris. Mr. Howse stated that he had followed the vein some distance southwestward, and the writer saw the vein on the shore of Goose Bay to the northeast of the pit".

COPPER

Neither of the copper occurrences noted by the writer is considered to have economic value. One is in a joint plane in the most westerly band of Random quartzite on the south side of Random Sound opposite Hickmans Harbour. The joint plane is coated with small euhedral quartz crystals with which are associated minor amounts of chalcopyrite, bornite, and green copper stain. The other is on Pitt Sound Island, where the host rock, a basic flow or intrusion, is cut by a small shear zone striking north, dipping 80 degrees east, and

carrying on irregular quartz-calcite vein averaging 4 inches in width. Chalcopyrite and a little bornite occur in the vein and in the sheared wall-rock.

MANGANESE

Manganese-bearing strata are exposed in the Lower Cambrian rocks near Smith Point and at two localities on the south side of Random Sound between Petley and Britannia.

The Smith Point occurrence is Member 10 of Walcott's section given on page . Dale refers to this bed as a manganiferous, dolomitic, ferruginous shale, 38 inches thick. His analysis of an average sample of this bed shows 25.6 per cent MnO. Also in this section, 300 feet below the above band, is another, $2\frac{1}{2}$ feet wide, of "heavy green siliceous conglomeratic manganiferous limestone". It does not appear to contain as large a percentage of manganese as the first-mentioned band.

The occurrences on the south side of Smith Sound appear similar to the above, but no analyses are available.

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