GEOLOGICAL SURVEY OF CANADA
G. M. DAWSON, C. M. G., L.L.D., F. R. S., DIRECTOR

REPORT

ON THE

SURFACE GEOLOGY

OF

EASTERN NEW BRUNSWICK, NORTH-WESTERN NOVA SCOTIA

AND A PORTION OF

PRINCE EDWARD ISLAND

TO ACCOMPANY ¼ SHEET MAPS, NO. 2 S.E., NO. 5 S.W. AND NO. 4. N.W.

BY

ROBERT CHALMERS, F.G.S.A.

OTTAWA
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EXCELLENT MAJESTY
1895

To Dr. G. M. DAWSON, C.M.G., F.R.S., Etc.,

Director of the Geological Survey of Canada,

Ottawa.

SIR,—Herewith I beg to present you my report on the Surface Geology of eastern New Brunswick, north-western Nova Scotia, and a portion of Prince Edward Island, accompanied by the three quarter-sheet maps No. 2 S.E., No. 5 S.W. and No. 4 N.W. illustrative thereof. The report embraces the results of the field-work carried on during the four seasons of 1890, 1891, 1892 and 1893.

Permit me to express my sincere thanks to the gentlemen named below for assistance and various acts of kindness:—To P. S. Archibald, Chief Engineer of the Intercolonial railway, and his assistant, W. B. Mackenzie, C.E., for maps, plans and profiles, and for valuable information at all times cordially given; to J. R. Cowan, Manager of the Cumberland Railway and Coal Company, for permission to copy the profiles of the Springhill and Parrsboro' railway; to H. G. C. Ketchum, C.E., for important information respecting the Chignecto Marine Transport railway, and for the results of observations on the tides of Cumberland Basin, at the head of the Bay of Fundy, and of Baie Verte in Northumberland Strait. To Dr. Thomas Harrison, President of the University of New Brunswick, J. F. Connors, Chatham, and Arthur Newbury, Charlottetown, P.E.I., I am indebted for barometric readings taken at the respective meteorological stations under their charge. W. C. Milner, Collector of Customs, Sackville, and B. E. Paterson, of the Amherst *Press*, formerly of the Chignecto *Post*, have placed me under obligations for data relating to the salt marshes at the head of Cumberland Basin; and W. H. Crosskill, of the Legislative Library, Charlottetown, kindly presented me with reports and papers treating of the geology and natural resources of Prince Edward Island. To the many other friends who have, year after year, aided me in the prosecution of my work, but whom it would be impossible to name here, I desire to offer my grateful acknowledgments.

I have the honour to be, sir,

Your obedient servant,

ROBERT CHALMERS.

OTTAWA, January, 1895.

NOTE.—The bearings given in this report are all referred to the true meridian, and the elevations to mean tide level, unless otherwise stated.

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INTRODUCTION.

The following report embodies the results of the surveys and explorations carried on by me in Northumberland, Kent, Westmoreland and Albert counties, New Brunswick; Cumberland county, Nova Scotia; and the central part of Prince Edward Island, during the seasons of 1890-91-92-93. These areas embrace one of the most interesting and important fields of investigation to be found in eastern Canada, both as regards their surface geology and their agricultural resources, and present to the student a great variety of questions for correlation and study. The detailed work described in these pages has resulted in the discovery of a large number of facts, many of them new, especially those showing the relative effects of land ice and floating ice in the Pleistocene period, which are better exemplified in this region, perhaps, than elsewhere on the coasts of North America. The eastern and south-eastern limits of the land ice which covered that portion of Canadian territory lying south of the valley of the St. Lawrence River, between

Area covered

Results of investigations.

Gaspé and the Bay of Fundy, were traced out approximately and defined. The conclusion that the ice-limits in this direction were unaccompanied by terminal moraines will be presented and facts adduced showing the probable cause of such conditions. An attempt will also be made to define the dimensions of the several local glaciers which occupied the country in the ice age, as far as the data at hand enable me to do so ; and their connection and relation to the larger ice-sheets which had their sources in the Appalachian Range to the north-west will be pointed out. Data demonstrating beyond question the existence and action of floating ice in the Pleistocene were obtained, and will receive adequate treatment in this report. Changes of level during the later Tertiary and Post-Tertiary periods, which within the last decade have been much discussed, were carefully investigated; shore-lines were levelled in a great number of places and a body of facts obtained which will elucidate this question with more accuracy of detail than has yet been attempted. The region offered special advantages for a study of this kind and the results, it is hoped, are of value. The physical features and remarkable tides of the Bay of Fundy were considered worthy of special study and some space will be devoted to a discussion and explanation of their origin. The wide dispersion of boulders from the higher to the lower grounds, and occasionally in a contrary direction, is a subject which also received careful inquiry. The distribution of crystalline boulders from the central highlands of New Brunswick over the whole Carboniferous plain to the east, and upon the western part of Prince Edward Island came under observation and will be discussed in the sequel. The occurrence of sandstone boulders on the summit of the Cobequid Mountains, apparently derived from the Carboniferous plain on the north, from 200 to 400 feet lower, was a problem to which we also endeavoured to find a solution. Horse-backs, osar, or kames, of which there are some good examples in the maritime provinces, were studied in their relation to the Pleistocene drift, to the drainage of the respective districts in which they occur, and to post-glacial denudation, river-terraces, etc.

A considerable amount of field investigation has been bestowed upon the pre-glacial sands, gravels, angular boulders, etc., usually called residuary, which have been found in different parts of the region, and their relation to the glacial and post-glacial deposits traced as far as it was possible to do so. These materials are much more common than has hitherto been supposed. The dunes of sand which skirt the coast of the Carboniferous area on the mainland and the north-east side of Prince Edward Island, and are especially well developed around the

Magdalen Islands, have received special attention. One of the most important of the superficial deposits of the district around the head of the Bay of Fundy is the marine alluvium, known as salt marsh, the mode of formation and economic aspects of which were carefully investigated. Everywhere within the region under examination the character of the soil and its suitability to agriculture were noted, and close attention was also given to the forest growth, the area still covered by the original forest being mapped as accurately as possible.

Portions of country explored.

In the examination of the surface geology of the areas under review, all accessible parts of the country were explored, every road travelled over, the hills and mountains ascended and their altitudes measured with aneroid or otherwise, rivers and lakes examined with canoe or on foot, and as careful and accurate an investigation of the superficial phenomena made as the means at my disposal and other circumstances would permit.

Glacial striæ shore lines, etc., photographs of.

Photographs of glacial striæ, shore-lines, sections of the superficial deposits, etc., were taken during the seasons of 1892 and 1893, some of which exhibit the difference between striation produced by land ice and that produced by floating ice. Several remarkable sets from the Isthmus of Chignectó, the Cape Tormentine peninsula, and the Baie des Chaleurs district, show the diverse movements of the striating agent, and cannot have been produced by other than the latter agency.

Assistants.

In the field-work of the four seasons embraced in this report I was assisted by the gentlemen named below:—In 1890 by John H. McDonald, of Brockville, Ont., and for part of the season by Wm. J. Wilson; in 1891 by Mr. Wilson and W. D. Matthew, of St. John, N.B., but only for a few months; in 1892 Mr. Wilson was with me the whole season, and K. C. Cochrane, of Brockville, Ont., from the 20th of May till the 10th of September. In 1893 Mr. Wilson alone was my field assistant.

Maps.

The preparation of the maps for the engraver, quarter-sheets Nos. 2 S.E., 5 S.W. and 4 N.W., has been largely accomplished by W. J. Wilson.

The surface geology of those portions of New Brunswick and Nova Scotia included in this report were cursorily referred to by the writer and Dr. Ells in the reports of 1885, where partial lists of the striæ were published.*

Previous work in region

The surface geology of Prince Edward Island is described in Dawson and Harrington's report.†

*Annual Report, Geol. Surv. Can., Vol. I. (N.S.), 1885. Parts E and GG.

†Report on the Geological Structure and Mineral Resources of P.E. Island, by Sir J. W. Dawson and Dr. B. J. Harrington, 1871.

Topographical and Physical Features.

Topographical features.

The topographical features of large portions of the mainland in the area under discussion are those of a flat and uninteresting plain. Where this area is occupied by Middle Carboniferous rocks, the surface has, in a general way, a slight descent toward Northumberland Strait, varied to some extent by low, wide undulations, the axes of which trend nearly east and west. In the isthmus of Chignecto and in those parts of Cumberland county, Nova Scotia, lying north of the Cobequid Mountains, the Upper Carboniferous rocks have a considerable development, and the east-and-west anticlinals and synclinals are narrower and more conspicuous, rendering the features of the country more pronounced. In some instances these irregularities have affected the drainage, but as a rule the larger rivers have taken courses independent of them. It is evident, however, that the Carboniferous rocks in the latter district (that is, those in proximity to the crystalline ridges of southern New Brunswick and the Cobequids in Nova Scotia,) have suffered more disturbance than they have in the central part of the great triangular basin. In Albert county, New Brunswick, the north-east prolongation of the crystalline ridge or plateau referred to, which stretches along the north-west side of the Bay of Fundy, rises in broken ridges and mountains to an altitude of 1,300 or 1,400 feet, Shepody Mountain, which was a station in the Admiralty Survey, being 1,050 feet high. The general slope of this elevated country is towards Shepody Bay; but the north-east extremity inclines towards the east, north-east and north-west. These highlands are, however, much denuded and trenched wherever the crystalline series are overlapped by Lower Carboniferous rocks. They have had an important influence on ice-movements in the Pleistocene period.

Albert county, N.B.

To the north of the Petitcodiac River, about six miles distant from Moncton, ridges or hills known as Lutz or Indian Mountain rise from the level Carboniferous plain to the height of 500 or 600 feet above the sea. At the head of the Bay of Fundy, between the estuary of the Petitcodiac and La Planche River, hills and ridges extending nearly east and west lie between the tongues of salt marsh running up the valleys of the Petitcodiac, Memramcook, Tantramar, Missaquash and La Planche rivers, which carry the drainage waters of the Isthmus of Chignecto into the head of the Bay of Fundy. None of these ridges exceed 400 or 500 feet in height. The strata are broken and faulted, evidencing disturbance and pressure from both sides, but principally from the side of the New Brunswick crystalline range above mentioned.

Head of Bay of Fundy.

In the part of Nova Scotia included in sheet No. 4, N.W. the Cobequid Range is the most prominent topographical feature. It extends in a nearly east-and-west direction along the north side of Minas Basin, with a width of nine or ten miles, and a height of 900 or 1,000 feet, some of the culminating peaks reaching probably 1,100 feet. Passes exist in some places, notably one at Halfway River, which is traversed by the Springhill and Parrsboro' railway, and others at Westchester and at Folly Lake, the latter the route of the Intercolonial railway. The bottom of the pass at Halfway River is only eighty-five feet above mean tide level; that at Folly Lake is 600 feet. Cobequid Mountains.

On the slope between the Cobequid Mountains and Northumberland Strait, a number of hills occur, besides the ridges or anticlinals referred to on page 8 M. Springhill, the summit of which is 610 feet above mean tide, is the highest; Claremont Hill to the east of Springhill is 565 feet high. These two lie near the northern base of the Cobequids, where the undulations or disturbances due to the uplift of the mountain range have been greatest and where ridges parallel thereto, such as Windham Hill, rise to altitudes of more than 600 feet. Further to the north rise the Maccan Mountains, the heights along the Leicester Road and Mount Pleasant, which attain altitudes of from 350 to 600 feet above the sea. These hills appear to have been local ice-sheds during the Pleistocene period. North slope of Cobequids.

Crossing Northumberland Strait to Prince Edward Island we find that it presents a more or less close repetition of the topographic features of the adjacent mainland. A large portion of the island is low, from two-thirds to three-fourths of it not exceeding 150 feet in altitude, but in the centre, between Cape Traverse or Sable River and New London, ridges and hills rise from 400 to 500 feet above sea-level. The surface is undulating or rolling with a number of valleys extending more or less transversely or diagonally across the island, though several, especially on the higher grounds, have nearly an east-and-west course, corresponding to that of the anticlinals on the mainland. During the post-glacial subsidence, when Prince Edward Island stood from seventy-five to eighty feet below the present level, there were four or five islands instead of one. Great denudation of the soft rocks of the island formations has taken place, the hills being due rather to this cause than to orogenic movements. The denudation has, however, been largely pre-glacial. The higher portions of the island have suffered less than the slopes and coast districts, and are covered with a thick sheet of residuary material. Prince Edward Island.

The Magdalen Islands exhibit some curious topographic features, as might be expected from their non-glaciated condition. Each island Magdalen Islands.

seems to have one or more masses of eruptive rocks (dolerite or diabase, porphyritic and amygdaloidal traps, etc.) which stand up in conical hills and have disturbed or broken through the Lower Carboniferous sediments. The general direction of these hills or ridges, where any linear arrangement is apparent, is approximately north-east and south-west, corresponding with that of the crystalline ridges in Nova Scotia and New Brunswick.

Rivers and Lakes.

Rivers flowing into Northumberland Strait.

The most important rivers in that part of New Brunswick embraced in this report are the Southwest Miramichi, the Richibucto and the Petitcodiac. The Southwest Miramichi is one of the large rivers of the province, being one hundred and twenty-five miles in length above its confluence with the Northwest Miramichi River. Several of its tributaries are rivers of no mean size, such for example, as the Renous, Dungarvon, Cains, Taxus, etc. A curious feature of this river is the proximity of its chief catchment basin to the valley of the St. John River, robbing the latter, as it were, of a portion of its waters. The Southwest Miramichi, like all the large rivers of New Brunswick, existed in pre-glacial times, its valley having been so deeply eroded then as to enable it to affect the movement of the Pleistocene ice, especially in the latter part of the glacial period. Glacial striæ parallel to its course are found along its sides. The north-easterly trend of its lower part and of its principal affluents, the Renous, Dungarvon, Cains, etc., indicates that the watershed separating its waters from those of the St. John River, was higher, relatively to the adjacent district to the north, in pre-glacial and glacial times, than at present.

The rivers flowing into Northumberland Strait, between the Miramichi and Pictou, Nova Scotia, are unimportant. Their silted up estuaries denote that the coast region is in a partially submerged condition compared with what it was in the Pliocene or late Tertiary age, when the valleys, now buried in sediments, underwent their final touches of erosion.

Petitcodiac River.

Of the rivers flowing into the head of the Bay of Fundy, the Petitcodiac and the Maccan are the largest and most important, and exhibit some remarkable features deserving of more than a passing remark. The first-mentioned of these has a singularly curving course, and in the estuarine part shows unique physical peculiarities. The non-tidal part, or that between Petitcodiac and Boundary Creek stations, Intercolonial railway, to which the name "Petitcodiac

Photo by H. Marshman.

PLATE I.—THE BORE, PETITCODIAC RIVER, MONCTON, N.B.
As seen on the 22nd of August, 1892; height, 5 feet 4 inches.

River" properly applies, is only thirteen miles in length. Above Petitcodiac station it is called North River. The latter rises in the higher grounds of Lutz or Indian Mountain, eight miles and a half north of Moncton, and flows south-westward for twenty-two or twenty-three miles, *i.e.*, in a reverse direction to that of the Petitcodiac River, properly so called, till it joins the latter. The Petitcodiac has, however, several tributaries of considerable length besides North River, and a very peculiar drainage system. Pollett River, one of these tributaries, flows northward from a source 1,200 to 1,400 feet high in the plateau bordering the Bay of Fundy; and Coverdale is another affluent rising in the same region. It is not improbable that the two latter, Pollett and Coverdale rivers, were, in pre-glacial times, the chief head-waters of the Petitcodiac, and that North River, if it had a pre-glacial existence at all, flowed south-westwardly along the valley of the Anagance River into the Kennebeckasis without joining the Petitcodiac. This theory as to the original drainage-basin of the Petitcodiac River presupposes somewhat different relative levels of the region, that on the north of the river being probably higher, or that to the south rather lower, than at the present day; or a slight differential uplift of the divide between the Petitcodiac and Kennebeckasis waters in the Pleistocene would produce the same result. If, however, North River is post-glacial this supposition is unnecessary.

"The bore" of the Petitcodiac River.

But it is in the tidal or estuarine part of the Petitcodiac River that the most interesting features occur, and that the singular phenomenon, called "the bore" is seen. The estuary extends from Folly Point, at the entrance to Shepody Bay, north-westward to "The Bend" at Moncton, where it takes a sharp curve to the south-westward, thence continuing to Salisbury on the Intercolonial railway, its whole length being thirty-two or thirty-three miles. At "The Bend," where the river's course is somewhat narrow, the tidal wave or "bore" can be seen to best advantage. Here it may be observed rushing in as a foaming breaker (see Platé I.) five or six feet high, with a velocity of six or seven miles an hour. After it passes, the waters flow in like a river, slackening off, however, before the full height of flood-tide is reached. The difference between low and high tide at Moncton is, at spring tides, forty-five feet, at neap thirty-eight feet.

The ebb-tide sets out, at first, slowly, but after an hour or two rushes along like a mill-race, the water sinking rapidly until the bare muddy channel is exposed and finally the river becomes a small meandering stream in the bottom. This continues for two hours or more, when again the rushing waters of the "bore" are heard and soon sweep past at their usual velocity.

Maccan River, "bore" of.

In the Maccan River, which discharges into Cumberland Basin, a similar "bore" occurs though not as high as that of the Petitcodiac.

At spring tides these tidal phenomena are of course seen to full advantage. The winds have also at times the effect of producing a perceptible difference in the height. A south-west wind may prevent the recession of the tides to their lowest possible level, and of course the incoming wave which follows will not be so high.

Other noteworthy peculiarities of the tidal phenomena of the Bay of Fundy will be referred to later on.

Tantramar River.

The Tantramar, which is chiefly a tidal river, also exhibits certain phenomena of a remarkable kind along its course. The sediment composing the Bay of Fundy salt marshes is known to be a finely divided material, and is carried in by flood tides and deposited along estuaries and on overflowed marshes. This operation of nature is, perhaps, better exemplified along the river referred to than elsewhere, in proof of which it is noticeable that the marsh surfaces are higher immediately on both sides of the river than at some distance from it, and that the material there is oxidized. Certain portions of the salt marshes are now undergoing artificial reclamation from the blue coloured, mossy, "corky" marsh, by draining and by allowing the spring tides to overflow them and deposit this red oxidized sediment. A considerable acreage of excellent marsh land near Sackville has thus been brought into a condition to produce abundant crops of hay.

Hebert and Maccan rivers.

Hebert and Maccan rivers, both of which flow into Cumberland Basin, likewise exhibit some singular features in their drainage systems. These rivers rise in the northern slopes of the Cobequid Mountains, but the Maccan has branches joining it from the north and east as well, *i.e.*, from the high grounds of Springhill and Leicester, and has, therefore, a pretty large catchment basin. The catchment basin of River Hebert is, on the contrary, small, the main source of the river being in a valley or pass in the Cobequid Mountains, through which the Springhill and Parrsboro' railway runs. The origin of this pass is one of the difficult problems appertaining to the surface geology of the region. It does not seem to be due to a fault or dislocation, but mainly to erosion. It is certainly pre-glacial but post-Carboniferous. Connected with this pass are two valleys, one through which River Hebert flows, the other extending from Halfway Lake to Southampton, thence along Maccan River to Athol and Maccan stations, Intercolonial railway. These valleys afford evidence of having been occupied by the sea during the post-glacial subsidence of the land, gravel- and sand-terraces and water-worn deposits being abundant in them. A remarkable gravel ridge called the "Boar's Back," which will be described in the sequel, stretches along the valley of River Hebert.

Pre-glacial outlet of Maccan and Hebert rivers.

Viewing the drainage-basin of Maccan and Hebert rivers as a whole, especially in its relation to the pass in the Cobequid Mountains through which the Springhill and Parrsboro' railway runs, it appears to be not improbable that in pre-glacial ages the waters of these rivers found outlet southward through the pass referred to into the Basin of Minas, and may have been the agent of erosion to which it owes its origin. This erosion must date from a very early geological period, having commenced when the relative levels of the country were different, and previous to the elevation of the Cobequids, subsequent erosion and uplift going on concurrently until the advent of the ice age. The pass is now largely drift-filled, especially in the central part, the drift material there being due to glacial and post-glacial deposition. The differential uplift of the Cobequid Range since that date relatively to the Carboniferous area lying to the north, has caused this drainage to become partially reversed and to seek escape by the existing channels. This question will be discussed in further detail on a following page.

None of the rivers of Cumberland county flowing into Northumberland Strait exhibit any noteworthy features, except, perhaps, Wallace River, which affords proofs of once having been the outlet of Folly Lake. A slight rise of that lake would still allow it to overflow in the direction of this river. The change in the drainage here has doubtless been caused by the same orogenic uplift of the Cobequid Mountains that caused the northward flow of the Maccan and Hebert rivers, viz., the late upheaval or upheavals of that range relatively to the country to the north.

LAKES.

Lakes.

The lakes of the region are small and but few of them seemed to require special investigation. Several of the lakes on sheet No. 2 S.E. are bordered by mounds or gravel ridges produced by the shove of the ice which covers their surfaces every winter. One of these at the head of the south branch of Muzroll's Brook, a branch of Cain's River, has a kame on one side, and another small lake about the head of the millstream along the Kent Northern railway, called Lake Elsie, has a gravel ridge around its border. In early post-glacial times small shallow lakes must have been numerous in the Carboniferous area, but most of them have since been filled with peat.

Lakes on Isthmus of Chignecto.

On the Isthmus of Chignecto, there are a number of small shallow lakes, around the borders of the salt marshes of the Bay of Fundy. They have been formed by the stoppage of the drainage which flows down from the slopes upon the inner border of these marshes. A fringe of shrubbery grows around them on the surface of the marsh. Peaty material likewise accumulates in these places. Portions of these marshes are now being reclaimed and brought under cultivation by flooding them with the tidal water.

Lakes of the Cobequid Mountains.

The most remarkable lakes of the region are those of the Cobequid Mountains, including Halfway Lake lying at their northern base. This lake is merely the remnant of a much larger one which existed here in post-glacial times. Folly Lake affords evidence on the slopes of the hills surrounding it, that it stood at one time in post-glacial history forty feet above its present level, and overflowed into Wallace River, the gorge in the Cobequids here, to the north of Folly Lake, having in this way been eroded. A rise of from fifteen to twenty feet in the level of the lake would still enable it to flow in this direction. Mounds and ridges of gravel and sand, the material being well rounded, occur at both ends of the lake. There is no evidence of glacial action in the basin of Folly Lake, or in the gorge to the north of it; but a few small water-worn pieces of Carboniferous sandstone were observed among the local boulders.

Folly Lake.

Origin of Folly Lake basin.

The origin of the depression in which Folly Lake lies has not been determined. That the gorge or pass has been eroded by the action of running water there seems no doubt. But originally there must have been a catchment basin here in which to store up this water-power, and the question is, how was this formed? The only solution of the problem seems to be that it was orogenic, the existing topography, indeed, supporting this view. A circle of hills surrounds the depression forming the lake basin, and it is probable that previous to the formation of the gorges extending northward and southward from Folly Lake, it held in the larger body of water, the old shore-lines of which were observed at a height of forty feet above the present lake-surface. That this high-level, ancient, post-glacial lake is rock-rimmed seems pretty certain.

Several of the small lakes on the summit of the Cobequids contain infusorial earth which will be referred to on a subsequent page.

Bay of Fundy.

Bay of Fundy; origin of the name.

The name of this bay is said to have been given to it by the early Portuguese explorers. It was called by them Baya Fonda or Funda, or

Deep Bay, "expressing not the depth of its waters, but the depth to which it penetrated the continent." * During the French occupation of the country it was called "La Baie Française, or La Grande Baie de la Française," but this like other French names of places in this region was, when the French gave up possession of the country, replaced by what appears to have been the original name anglicized.

Some of the physical features of this remarkable bay were briefly described in a previous report. †

Tides of.

Its phenomenal tides, which are best exhibited in the eastern and north-eastern extremities, rise from fifty to fifty-five feet above low-tide level. The entire length of the Bay of Fundy to its inner extremities, supposing its mouth to be at Grand Manan Island, is about one hundred and forty-five miles, its width at the mouth forty-eight miles; between Digby Gut and the mouth of the St. John River, forty miles, and from the entrance to Minas Basin to Salisbury Bay, thirty-five miles. The bottom of the bay has a gradual ascent from the mouth to the north-east extremities, the depth below mean tide level at the former place ranging from seventy to one hundred and ten fathoms. Taking an average gradient of the bottom of the bay from its mouth to the head of Shepody Bay, we find that it is not less than four feet per mile. Of course it has many inequalities, and rises abruptly towards the shore in some places, but on the whole is remarkably uniform for a bay the waters of which are affected by such powerful currents.

Rise and fall of the tides of the Bay of Fundy.

In reference to the tides of the Bay of Fundy, it can be seen from an examination of the charts of the British Admiralty Survey, and of the United States Coast Survey, that immediately outside of the mouth of the bay they rise higher than in the open ocean, the sea apparently being heaped up against the coast of the mainland. For example, south of Pubnico harbour, Nova Scotia, and just east of Seal Island, the spring tides rise twelve feet and three-quarters, and neap tides ten feet and a quarter, while near the coast of Maine and west of Machias Seal Island, spring tides rise eighteen feet, and neap, fourteen feet and three quarters.

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* The Portuguese on the North-east coast of America, and the first European attempt at colonization there. By the Rev. George Patterson, D.D. Trans. Royal Society of Canada, 1890, vol. VIII. A history of the Discovery of Maine, U.S., by J. G. Kohl, vol. I., edited by Wm. Willis, Portland, Me., Bailey and Noyes, 1869.

† Annual Report, Geol. Surv. Can., vol. IV,. N.S., 1888-89, p. 16N.

Inside of the mouth of the Bay of Fundy, however, the rise in the tides increases more perceptibly as we advance from the mouth towards the north-east extremity, as shown by the following table :—

Places.	Spring Tides.	Neap Tides.
	Feet.	Feet.
Digby Neck, N.S	22	18
L'Etang Harbour, N.B	23½	20
Point Lepreau	24½	21
Digby Gut, N.S	27½	23
St. John, N.B	27	23
Quaco, N.B	30	25
Spicer Cove, N.S.	37	30½
Advocate, N.S	39	33
Cape Enragé, N.B	41	32
Petitcodiac River, N.B.	46	36
Apple River, N.S.	39	29
Cumberland Basin	44	35
At west dock, Chignecto marine railway	44	35
Noel River, in Cobequid Bay	53	31

This last is the greatest tidal oscillation in any part of the Bay of Fundy.

Explanation of their rise and fall.

The greater rise of the tides in the upper parts of this bay is attributed to its narrowing funnel form, and its shallowing bottom cooping up the tidal wave as it advances up the bay. But it would seem that the waters really acquire a movement of translation as they enter the narrow bays and inlets and become as it were heaped up, the upper parts rolling over the lower in the way that waves break upon the shore. The "bores" exemplify this. The ebb tides are not so easily understood. That the inward rush of the tidal wave should raise the waters from twenty to twenty-five feet above the mean level of the ocean in these narrow bays with ascending bottoms can be readily explained, but why these waters should recede to a depth of twenty feet or more below the same datum, leaving the bays empty, or nearly so, for hours, is a phenomenon, the cause of which is not so apparent. That it is the result of gravitation—of an effort of the waters to reach an equilibrium—is unquestionable. The bottom of the Bay of Fundy, as already shown, is really in the form of an inclined plane, the average slope being, as stated, about four feet per mile, while the average slope of the surface of its waters at flood tides within the bay is one hundred and fourteen thousandths (·114) feet per mile ; in other words, the waters are then sixteen feet higher, in round numbers, at the inner extremities of the bay than they are at the mouth. At every flood tide therefore, there is a great body of water in the upper end of the bay, carried to a position above the normal level of the ocean. Gravitation seeks to restore an equilibrium. The receding waters of the ebb tides, descending an inclined plane, as it were, rush down with such force and rapidity that, like the receding waves on a shore, they fall below the mean level of the sea about as far as they had risen above it at the flood. Then follows another abnormal condition of things; the surface of the waters of the bay again loses its horizontality, but this time the slope is in the reverse direction to that of the flood tide, viz., from the inner or eastern extremities of the bay outwards and upwards towards the mouth. Another effort is therefore made to restore the equilibrium, and the great tidal wave rushes in once more. This oscillating or rythmic flow and ebb of the Bay of Fundy waters thus goes on throughout the ages, and not until the contours of the bay are changed from erosion or subsidence, and the tidal wave is allowed to pass over the Isthmus of Chignecto into Northumberland Strait, will it cease.

It has been assumed that the slopes of the surface of the Bay of Fundy at flood and ebb tides were regular or comparatively so; but the conformation of the sides and bottom seriously affects, and in some places, obstructs the tidal flow. The slopes are, therefore, only approximately regular.

Mean tide level in Bay of Fundy and Northumberland Strait.

It may be asked how do we know that the ebb tide falls as far below the mean tide level of the ocean, or mean sea-level, in the bays and inlets of the Bay of Fundy as the flood tide rises above it? In answer to this we will state that it has been ascertained by careful levellings above a common datum in the surveys of the Baie Verte canal and of the Chignecto Marine Transport railway that mean tide-level, *i.e.*, the level of half tides, closely corresponds on both sides of the Isthmus of Chignecto. For example, the levels of the Chignecto marine railway have their datum one hundred feet below the high-water mark of the Saxby tide, a remarkable tide which occurred on the 5th of October, 1869. From this datum, the heights of the tides at both ends of the marine railway, viz., at the Tidnish dock and at the Fort Lawrence dock, have been measured, during at least one whole season, with the following results :—

Datum of Chignecto marine railway.

At Tidnish dock, Baie Verte—

	Feet.
High water, spring tide	79·
" ordinary tides	74·
Low water	68·40

At Fort Lawrence dock, Cumberland Basin—

	Feet.
High water, spring tides	96·
" ordinary tides	89·
Low water	52·59

Correspondence of mean tide level at both ends of the Chignecto marine railway.

The levellings were started from the Tidnish dock. H. G. C. Ketchum, C.E., of the Chignecto marine railway states that "the extreme range of the tides in Baie Verte was observed to be 10 feet 8 inches; the ordinary range being only 5 feet 7 inches. Thus while the fluctuations above and below the mean sea-level were only 2 feet 9 inches at Baie Verte, they were at the same time 19 feet above and below mean sea-level in the Bay of Fundy at neap tides and 24 feet at spring tides."*

From the data at hand it has been shown, however, that the level of half tides, usually called mean sea-level, does not strictly correspond on both sides of the Isthmus of Chignecto, there being a difference of a few inches (5 to 10 inches). But this difference is so small that it may well be due to slight errors in the observations or in the levellings.†

The statement that the tides of the Bay of Fundy rise from forty to sixty feet high, signifies that they rise that number of feet above low-water mark. Their rise above the normal mean tide-level of the ocean is approximately only half of these figures. As a matter of fact, the highest tidal flow in any part of the Bay of Fundy, which, as already shown, is at Noel Head, in Cobequid Bay, is only fifty-three feet above low-water mark, according to the Admiralty survey.

Tides of the Bay of Fundy in the Pleistocene

In studying the tides of the Bay of Fundy the question arises, what was their maximum rise and fall during the Pleistocene period, more especially during that stage when the Isthmus of Chignecto was submerged and Nova Scotia formed an island? From the levels taken in the surveys of the Baie Verte canal and of the Chignecto marine railway, it appears the axis of the isthmus in its lowest part is not at present more than eighteen or twenty feet above the high tide level of Cumberland Basin, in the Bay of Fundy. No drift-filled channel crossing the isthmus has been found; on the contrary, the rock *in situ* appears, even in the lowest places, to be covered with boulder-clay, residuary material, etc., and has evidently not suffered greater erosion on the lower levels, in post-glacial times, than other parts of the country. But there is evidence which will be adduced in this report showing that in the Leda-clay and Saxicava-sand period the isthmus was submerged to the depth of at least one hundred and twenty feet. How would the Bay of Fundy tides act during this subsidence? An inquiry into their height and dynamic power in the wider parts of the bay, as it exists at the present day, will, perhaps,

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*The Chignecto Ship railway, a paper read before the Canadian Society of Engineers at Montreal, Dec. 29th, 1891, by H. G. C. Ketchum, M. Inst. C. E.

†The Tides of the Bay of Fundy. By M. Murphy, Provincial Engineer, N.S. Proc. Inst. of Nat. Science, Halifax, Nova Scotia, vol. VII., page 48.

be our best guide in elucidating this question, those parts of the bay being no wider or deeper than the strait across what is now the Isthmus of Chignecto would be at the time of the subsidence referred to. Would the tides during the post-glacial submergence of the isthmus be as high in the north-east extremities of Chignecto Bay as at present?

Effect of changes of level upon the tides

The remarkable tidal phenomena of the Bay of Fundy being due to the convergence of its sides and the shoaling of its water towards the north-east, it follows that if the barrier there were removed and the tidal wave allowed to flow without obstruction into Northumberland Strait, the conditions favourable for high tides would be diminished if not entirely eliminated. The tidal wave which now moves up the bay with such velocity (six to seven miles an hour in some places) instead of being stopped and thrown back, would then sweep across the isthmus into the open sea beyond. It is not probable, therefore, that the tides would rise any higher than they do now in the mouth of the bay or in the Gulf of Maine; indeed, all things considered, there seems no reason to suppose that the highest tides during the maximum stage of the submergence referred to would exceed from ten to fifteen feet.

Erosion from Bay of Fundy tides.

But although the tides during this stage of the Pleistocene submergence were not as high as at present, their dynamic effect in the erosion of the shallow parts of the strait and coast border, which then existed on both sides of what now forms the Isthmus of Chignecto, was very great. It was then that the low-lying portions of the isthmus received their present contours, that the Kennebeckasis Valley in New Brunswick and the Annapolis Valley in Nova Scotia were eroded, if not wholly, yet received their latest sculpturing, and that the precipitous sides of the lower Petitcodiac Valley, the Memramcook Valley and Cumberland Basin, etc., were carved out and fashioned nearly as we now see them. It must be remembered, however, that all the valleys, now partially filled or occupied with salt marsh, would then be comparatively empty, and denuding agents would have much greater scope.

The chief erosion of the isthmus from marine action appears to have been during the upward movement of the land in the later stage of Leda-clay and Saxicava-sand period. In the earlier stage of the Pleistocene subsidence the isthmus would, of course, be covered wholly or partially by ice, either land, or floating ice, or both, and consequently erosion from the sea would then be less active. Tidal erosion must therefore have been active chiefly after the retirement of the ice and before the tidal wave was shut off from Northumberland

Strait and confined to the Bay of Fundy, by the elevation of the axis of the isthmus above sea-level.

Action in depositing sediments.

As soon as the rising of the land in the Leda clay and Saxicava-sand period had brought the present geographical barrier between the Bay of Fundy and Northumberland Strait into existence, the tidal wave, thrown back on itself, would begin to deposit its burden of sand, mud, etc., in the estuaries and bays. This process has been in active operation since, and it is in this way that the sediments of the extensive salt marshes have accumulated. The action of the tidal wave in the north-eastern extremities of the Bay of Fundy is therefore accumulative and not destructive, that is, it deposits material where it is thrown back on itself, but further down the bay, where it receives no check to its onward progress, its erosive power, especially on the shores, is very great.

Flow and ebb in later Pleistocene.

During the maximum subsidence of the land in the Pleistocene period the tidal wave or current may have passed over the submerged Isthmus of Chignecto in both directions,—at the flood running north-eastwardly through what then formed a strait between New Brunswick and Nova Scotia, and at the ebb in the reverse direction from Northumberland Strait or the Gulf of St. Lawrence, into what is now the Bay of Fundy and Atlantic Ocean. Erosion would then, no doubt, be powerful, but not as powerful as at the present day, as the tidal oscillations would be similar to what they are now in the open and wider parts of the bay.

It was probably during the early stage of the subsidence mentioned that the isthmus received its final glaciation from the floating-ice jammed in between Prince Edward Island on the one hand, and on the other, the higher grounds of New Brunswick and Nova Scotia on both sides of the isthmus. This ice moved chiefly from Northumberland Strait south-westward into the open waters of the sea now forming the Bay of Fundy, but also partially in the reverse direction. The evidence bearing on this question will be brought forward on a later page.

Origin of the Bay of Fundy depression.

The origin of the great depression in which the Bay of Fundy lies is a question the adequate discussion of which would lead us far back in geological history. Prof. H. Y. Hind speaks of it as a valley of erosion,* and this is doubtless partially correct; but originally it must have been formed by crustal movements, though at what geological period is not evident. The Carboniferous rocks bordering Northumberland Strait are but slightly disturbed, but when we cross the Isth-

*A Preliminary Report on the Geology of New Brunswick, 1865.

mus of Chignecto to the head of the Bay of Fundy a marked difference in their position and in the structure of the beds is found. The Lower Carboniferous there is generally folded and thrown into highly tilted attitudes, while the Middle Carboniferous (Millstone grit), though in many places occupying a horizontal attitude has, on the west side of the Petitcodiac River, in Cape Maringouin peninsula, at Westmoreland ridge, and at South Joggins and Springhill likewise suffered great dislocation and faulting. The promontories, projecting into Chignecto Bay and even Cape Chignecto itself appear to have also undergone differential uplift relative to the coast border of Northumberland Strait, and doubtless were affected by the same orogenic influences as the Cobequid Mountains themselves. The sequence of these movements seems to have been, an upheaval after the Lower Carboniferous rocks were formed and previous to the deposition of the Middle Carboniferous beds; then another disturbance and fracturing of the strata subsequent to the formation of the coal series. Since Carboniferous times the region appears to have undergone repeated oscillations, the latest being the subsidence in the recent period. This question will, however, be referred to in detail, when I come to treat of the changes of level which took place here in the Tertiary and Post-Tertiary periods.

The crustal oscillations to which the Bay of Fundy valley is due seem, therefore, to have been to a large extent local, at least they were much more intense immediately around it than in the region of Northumberland Strait. Evidently the origin of this depression has been dependent upon and closely related to the crystalline ranges on both sides of the bay, the proximity of which doubtless led to so much local disturbance of the Carboniferous and other rocks, as referred to. Upheaval and denudation have been proceeding in some instances correlatively and *pari passu*, and have brought about important changes in the surface features. The excavation of the valleys now occupied by the estuaries of the Petitcodiac, Memramcook, Tantramar and La Planche rivers, which have in Post-Tertiary times been partially filled with boulder-clay, salt marsh deposits, etc., indicates intense and prolonged erosion.

Due probably to crustal movements.

The physical features and dynamic action of this remarkable bay have been thus dwelt upon, because it occupies a valley where intense forces have been and are still in operation, and where the formation of salt marshes in the Recent Period is exhibited on a scale unparalleled elsewhere in Canada. Nor have we on any other part of the North American coast evidence of such a trustworthy character respecting the subsidence of the coast in the latest epoch of its geological history.

Tertiary and Post-Tertiary Changes of Level.

Changes of level in later Tertiary and Post-Tertiary.

Considerable attention has been devoted of late years to the changes of level of the earth's crust, especially in the Post-Tertiary period. That great oscillations have occurred is undeniable, but the evidence as to the extent of the vertical movements is, for the most part, extremely fragmentary, and no very satisfactory conclusions have been deduced from it. Nevertheless, along the coasts a large body of facts awaits investigation and co-ordination, which would elucidate this question. Shore-lines, marine terraces and benches of different kinds lie exposed in every estuary and along every coast, the heights of which, if properly measured and classified, would form an important contribution to our knowledge as regards these oscillatory movements. The amount of deformation by differential upheavals and subsidences could also by this means be shown, and the efficiency of certain theories to account for the phenomena properly tested.

Data, where obtainable.

Where collected.

For a number of years the writer has been collecting all the information available respecting the oscillations of level on the Atlantic coast of Canada, especially in the region lying between the mouth of St. Lawrence River and the International boundary. The following table embodies the results of this investigation:

Table of elevations and subsidences.

No.	Localities.	Elevation in later Tertiary above mean tide-level, in feet.	Elevation of highest Pleistocene or post-glacial shore line above mean tide-level, in feet.	Subsidence in the Recent Period below mean tide-level, in feet.
	EASTERN QUEBEC.			
1	Along Temiscouata Ry., near Rivière du Loup station, I.C.R.	Not known, but 840 or upwards in mouth of Saguenay River opposite Rivière du Loup	418 (bar.)........	Not known.
2	Between Rivière du Loup and Ste. Flavie..........	" ..	345 to 375 (bar.).	"
3	Gaspé Basin..............	This basin 180 ft. deep between Capes Brulé and Haldimand	225 to 230 "	"
4	Port Daniel, on north side of mouth of Baie des Chaleurs..................	Not known......	225 to 250 "	"
5	Between Carleton and Maria in Baie des Chaleurs.....	"	200+ "	"
6	West of Nouvelle River and between that and Scaumenac	"	215 to 220 "	"

No.	Localities.	Elevation in later Tertiary above mean tide-level, in feet.	Elevation of highest Pleistocene or post-glacial shore line above mean tide-level, in feet.	Subsidence in the Recent Period below mean tide-level, in feet.
	NEW BRUNSWICK.			
7	Near Dalhousie Junction, I.C.R., on south side of Restigouche River	73 at least, at mouth of Metapedia River; 90 at mouth of Restigouche River.	223 at end of trap ridge; probably higher than normal (spirit level)	5 at least, according to peat bed at Charlo.
8	Near Bathurst, on road to Dunlop settlement	Not known	188 "	5 to 10.
9	Near Caraquette, south of harbour	40 to 50 or more.	138 (bar.)	5 to 10 between St. Simon Inlet and Pokemouche, also on Miscou Island.
10	North side of Miramichi River, between Newcastle and Bartibogue River	115 at least	125 to 135 (bar.).	10 to 15.
11	On Cape Tormentine peninsula, along Emigrant Road	See page 27 M.	125 (?) (bar.)	Not known.
12	Near Berry's Mills station, I.C.R.	Not known	251·95 (sp. level).	"
13	Indian Mountain, north of Moncton	See page 27 M.	248·91 "	"
14	In another place further east, along south base of Indian or Lutz Mountain	" "	251·95 "	"
15	At Hillsboro', Albert county	" "	222·44 "	15·32 (sp. level).
16	At St. John, east of harbour	200+	225·91 "	10 to 15.
17	At Pennfield station, Shore Line Ry., on Pennfield terrace	Not known	228 (Ry. levels).	Not known.
18	Five miles east of St. George on highest part of Pennfield terrace	90, or more at mouth of L'Etang Inlet	243 "	"
19	On marine terrace, at Dyer's crossing, in valley of Digdeguash River	Not known	231 "	"
	NOVA SCOTIA.			
20	Half a mile north of Nappan station, I.C.R.	See page 27 M.	143·72 (sp. level).	10·75 at Fort Lawrence; 79 at Aulac.
21	On north side of Amherst Head	" "	138 to 140 (bar.).	Not known.
22	On east side of Mount Pleasant, in River Philip valley	Not known	133 (bar.)	"
23	Between Wallace harbour and Pugwash	"	133 "	"

No.	Localities.	Elevation in later Tertiary above mean tide-level, in feet.	Elevation of highest Pleistocene or post-glacial shore line above mean tide-level, in feet.	Subsidence in the Recent Period below mean tide-level, in feet.
	NOVA SCOTIA—*Continued.*			
24	On peninsula north of Wallace Harbour, in several places, distinct.	Not known.....	133 (bar.) Other shore lines at 120, 110, and 55 to 60......	Not known.
25	East of Wallace, on road running south from Plaster Cove............... .	"	138 (bar.)......	"
26	On Wallace Ridge, east of road going south from Plaster Cove, in several places..................	"	133 "	"
27	In Deware River Valley.	"	138 "	"
28	South-west of Athol Station, I.C.R..................	"	138 "	"
29	On north side of Claremont Hill..................	"	135 to 140 (bar.).	"
30	At Thomson Station, I.C.R.	"	138 (bar)........	"
31	On east side of Halfway River, at northern base of Cobequid Mountains....	See page 28 M...	170·84 (sp. level)	"
32	Halfway between the last and Lakelands, a bench on east side of pass.........	Not known.....	186 (bar.).....	"
33	At Lakelands, on both sides of valley or pass.........	"	223 "	"
34	Further south, at head of Parrsboro' River, on east side of valley or pass.....	"	160 " ...	"
35	Still further south, on east side of valley, at south base of Cobequids.	"	130 "	"
36	On south side of Cobequids and west of Parrsboro'—a wide terrace............	"	110 to 115 (bar.)..	"
37	At Port Greville...........	"	112 (bar.).......	"
38	At Spencer's Island........	"	128 "	"
39	At Advocate Harbour.....	"	130+ "	"
40	Near Granville, at foot of North Mountain (terraces)	"	110 "	"
41	At mouth of L. Quille Brook, south of Annapolis	"	110 to 115 (bar.).	"
42	Near head of St. Mary's Bay, at base of North Mountain....................	"	110 (bar.)......	"
	PRINCE EDWARD ISLAND.			
43	West of Alberton..........	"	75 "	5 to 10.
44	At west end of O'Leary Road, near Cape Wolf...	"	75+ "	Not known.
45	At Coleman Station, P. E. Island R..............	"	75 "	"
46	At Ellerslie Station, P. E. Island R..............	"	75 "	5 to 10.

No.	Localities.	Elevation in later Tertiary above mean tide-level in feet.	Elevation of highest Pleistocene or post-glacial shore line above mean tide-level, in feet.	Subsidence in the Recent Period below mean tide-level, in feet.
	PRINCE ED. ISLAND—*Con.*			
47	North of Kensington, near P. E. Island R.........	Not known.....	75 (bar)..	Not known.
48	At Wilmott's Creek, near P. E. Island R.	"	75 "	"
49	At Tryon River...........	"	75 to 95 (bar.)...	"
50	At North River Bridge, P. E. Island R...... ...	"	75 (bar.)........	"
51	In Oswell Bay............	"	75 to 80 (bar.)...	"
52	At Souris................	"	75 (bar.)........	"
	MAGDALEN ISLANDS.			
53	On Amherst, Entry, Grindstone and Alright Islands.	"	110 to 115 (bar.).	"

The data respecting the height of the region in the later Tertiary are necessarily imperfect, and only at the mouths of the Restigouche, Miramichi and St. John rivers have we measurements which may be relied upon as correct. They are minimum figures, however, and the elevation must have been considerably greater than that they represent. At the two first-mentioned rivers, borings were made for foundations to the Intercolonial railway bridges spanning them, through gravel, sand and clay to the depths below tide-level here given, showing that at a period anterior to the Post-Tertiary the land stood at such an elevation as permitted the rivers to flow along their rocky floors and erode them to that level. That this erosion continued to the later Tertiary, is inferred from the fact that no deposits of that age have yet been discovered in the bottoms of these river-valleys. At St. John, the figures are taken from the Admiralty Survey charts, the depths being those of the St. John River above Indiantown and of the Kennebeckasis near its confluence with the latter. To enable the two last-mentioned rivers to erode the valleys in their lower reaches down to the rocky floor, the land must have stood two hundred feet or more above its present level. It is probable, however, as stated above, that the heights for the Tertiary border of the land in the northern and southern parts of New Brunswick do not represent the maximum elevation. There are reasons for believing that some parts at least were much higher. For, the mouths of the rivers referred to, must be largely silted up; and, moreover, the buried channels where the borings were

Tertiary elevation of the coast border.

made are so far up the river-valleys that they may have been beyond the then existing estuaries.

On the whole, the evidence thus far obtained points to a difference in elevation in the later Tertiary period of certainly not less than from two hundred to three hundred feet above existing levels. The difference was not, however, equal throughout the whole coast region from the mouth of the St. Lawrence to the St. Croix River or International boundary. Certain facts now to be adduced show, on the contrary, that the Tertiary oscillations, like those of other geological periods, before and since, have been differential, and the upheavals and subsidences to some extent, at least, complementary. The facts upon which this conclusion is based were observed chiefly in the Isthmus of Chignecto and in the region around the head of Chignecto Bay. It seems necessary to give them in some detail.

Evidence as to changes of level at the head of the Bay of Fundy.

The district around the head of the Bay of Fundy is remarkable for the great changes of level which have taken place there throughout its geological history. The evidences of these are first recorded in the Carboniferous rocks as exhibited in the celebrated South Joggins section described by Logan and Dawson.* At the close of the Carboniferous period, the land here rose and appears to have continued above sea-level until the glacial epoch, no rocks of the intervening geological periods having been met with on the Isthmus of Chignecto or around the head of Shepody Bay and Cumberland Basin. On the contrary, the rock-surface of the country seems during these ages to have undergone a great amount of subaerial denudation, as evidenced by the quantities of residuary material still found upon it. During the geological interval referred to, there appears to have been a ridging up of the Isthmus of Chignecto, which continued till after the beginning of the Pleistocence, and till the surface of the region became covered with a sheet of ice. Striæ are found on hills and ridges, from five hundred to six hundred feet high or more near Shepody Mountain in Albert county; at Dorchester Cape, three hundred feet high; at Westcock, there hundred feet high, and along the Cumberland shore to the south of South Joggins as far as Apple River, three hundred and eighty feet high, all trending from south to south-west with the stoss side clearly to the north-east, showing the movement of a heavy mass of land ice in the direction indicated. On the north-east side of the isthmus, along Northumberland Strait, the land is low, seldom rising more than from one hundred to one hundred and fifty feet in height, the greater portion not exceeding from sixty-five to seventy-five feet. Where, then, had the glacier which produced the striæ just referred to its

Height of Isthmus of Chignecto at present.

*Acadian Geology, 2nd ed., p. 133. Supplementary Note to 4th ed., p. 18.

source or collecting ground? Careful and repeated examinations of the coast district of Northumberland Strait and of the higher grounds of Prince Edward Island to the north-east showed, that no ice capable of producing these striæ came from that quarter, rather we have the evidence of land ice moving in an easterly direction in the strait and on Prince Edward Island at the time the Chignecto glacier was in existence. The striæ referred to have clearly been produced by land ice during the early stage of the glacial period, the action of floating ice within the same region evidently belonging to a later stage of the Pleistocene. How then were these striæ produced, or rather what caused the ice producing them to move from what is now a lower district south-westward over ridges and along slopes from five hundred to seven hundred feet in altitude? Only one answer can, in my judgment, be given to this question, viz., that the axis of the Isthmus of Chignecto and the valley occupied by the waters of Northumberland Strait as far to the north-east as Prince Edward Island, were higher relatively to the basins occupied by Shepody Bay and Cumberland Basin than at present. This differential elevation, existing in the Tertiary, continued into the early Pleistocene, as will be shown on a subsequent page. This explanation does not imply that the axis of the isthmus was elevated five hundred or six hundred feet above the present bed of Chignecto Bay, but that the difference in the relative levels amounted to that. The land to the north-east must have been higher, while that to the south-west was lower; the attitude of the district being such that the general slope was south-westward, to enable the ice to flow in that direction. On no other hypothesis can the facts be explained.

Height of Isthmus of Chignecto in the Tertiary period.

If this conclusion be correct, the height of the Isthmus of Chignecto during the Tertiary period was, therefore, different from that which now obtains, and further, the bottom of the depression now occupied by Chignecto Bay and the smaller bays and estuaries connected therewith must have oscillated very considerably since. We may now inquire whether there are any data showing that other portions of the region under review occupied different relative levels during the Tertiary period.

Pass in the Cobequid Mountains at Halfway River.

On page 12 M reference is made to the existence of a pass in Cobequid Mountains at Halfway Lake, through which the Springhill and Parrsboro' railway runs. This pass is about six hundred feet deep below the summit of the mountains, and quite narrow, with steep sides, and the drift-encumbered bottom is, in the central or highest part, now only eighty-five feet above mean tide-level. The character of the rocks on either side is the same, there being no evidence that the pass was due to an original transverse fracture or dislocation of the mountain range. It is simply a valley of erosion, which can scarcely be explained by marine currents. No Carboniferous rocks are found in it. How then was it eroded? Evidently by the slow, long-continued agency of running water. Two small streams head near the centre of the pass, their sources being in two small lakes only a short distance apart and separated by a gravel bank. Halfway River, one of these (the lower part of which is called River Hebert), flows northward in a low valley, with bordering slopes two hundred to three hundred feet above sea-level, and empties into the north-eastern end of Cumberland Basin. The other, called Parrsboro' River, flows southward into the Basin of Minas. But these rivers are evidently insufficient to erode the pass. It cannot have been formed otherwise than by a river flowing through in one direction or the other. In which direction did this river flow and where was its catchment basin? From the How formed. physiographic features of the region, it is obvious that only on the north side of the mountains could there have been such a catchment basin, viz., in the district drained by the Maccan River; and it seems highly probable, therefore, that in pre-glacial ages this river flowed southward through the pass just described. Its upper branches, indeed, trend in this direction still, and between Southampton and Halfway Lake there is a low valley, now unoccupied by any stream, which doubtless was the ancient valley of the Maccan River when it had a southward course, but was abandoned when the river became diverted northward. But were the waters of the Maccan River alone sufficient to erode the pass in the Cobequids? This seems doubtful, unless the precipitation was much greater than at present. But it is not only the Maccan which may have flowed southward, River Hebert, or rather a river then flowing along its valley may also have had a reverse course with a catchment basin in the depression in which River Hebert and Maccan River now unite. To render this possible two postulates have to be assumed; first, that the land to the north of the Cobequids was higher and the Cobequids lower, that is, the mountains were then in their incipient stage,—in short, that the watershed of the area lying west of River Philip and Economy was not the Cobequid Range as at present, but extended across by Springhill and Maccan Mountain, and along the axis of the Isthmus of Chignecto westward, and, secondly, that the basin in which the Maccan and Hebert Rivers meet was closed to the west. It may have been that even the La Planche and Missaquash Rivers also drained into it. Be this as it may, it seems to have been in this way that the erosion of the pass through the Cobequid Mountains was effected. This erosion must, however, have commenced long before the Tertiary period and have kept pace with the uplift of the mountain range as it proceeded.

The theory outlined regarding the origin of the Cobequid Pass, takes us back to the incipient stage of the history of the western part of the Cobequid Mountains. At what geological period did they first rise above the surrounding strata? No rocks older than the Carboniferous are exposed in this district to the north of these mountains; and the rivers which are supposed to have been instrumental in eroding the pass have their courses superimposed on these strata. It is therefore a reasonable inference that erosion of the pass did not commence until after the Middle and, perhaps, the Upper Carboniferous rocks were laid down. Other facts lend support to this theory. For example, sandstone and conglomerate boulders belonging to Carboniferous rocks are sparingly scattered on the northern brow and summits of the Cobequids. The presence of these in the position referred to is attributed to the overlapping or transgression of these Carboniferous rocks upon the Cobequid series in past ages, there being no system of glaciation known to me which could have transported them thither with existing levels. Since then the denudation subsequent to the Cobequid uplift has removed the greater part of the sandstones and conglomerates from the summit of the mountains, leaving isolated patches and boulders merely as remnants.

Period when the erosion of the Cobequid Pass referred to took place.

The work of eroding the Cobequid Pass referred to, seems to have gone on *pari passu* with the uplift of the range and continued as late as the Tertiary and early Pleistocene, the river keeping it at base-level; but during the glacial period it received a check and the movement of upheaval gained the ascendency on the erosive forces as shown by the fact that the pass, especially in the central part, is now occupied by heavy beds of drift. On the retirement of the Pleistocene ice the present drainage systems seem to have been inaugurated. The upward movement in the western Cobequids did not, however, cease, but continued into the later Pleistocene and may, indeed, still be in progress.

Its erosion coincident with the rising of the Cobequids.

The phenomena therefore when co-ordinated, indicate a higher level for the Carboniferous series along Northumberland Strait and the region north of the Cobequids during the later Tertiary, probably corresponding to the level of that of the Miramichi basin in the same period. This altitude of the coast border was maintained until after the advent of the ice age.

Reference has already been made to the initial stage of the local upheaval which resulted in the formation of the Cobequids. The up-

Date of upheaval of Cobequids.

heaval seems to have commenced after the deposition of the coal measures, as the Upper Carboniferous rocks in some places contain débris derived from the crystalline rocks of the Cobequid series; but a general post-Carboniferous rise of the whole region also took place. That the Cobequid uplift has been going on since the glacial period is unquestionable, as post-glacial terraces and deltas, evidently of marine origin, found near Halfway River, in the northern part of the pass referred to, have a height above mean tide level of about 171 feet (see table) and near Lakelands, on both sides of the pass, of 223 feet; while well-marked shore-lines north of the mouth of Maccan River and along Northumberland Strait, occur at elevations of only 130 to 140 feet, showing a differential uplift of the Cobequid Range of, at least, eighty-three feet or more within post-glacial times.

Post-glacial invasion of the Cobequid Pass by the sea.

During the post-glacial subsidence of the region, the sea extended through the Cobequid Pass from the Basin of Minas along the valleys of Halfway River, River Hebert and Maccan River to the head of Cumberland Basin. At present the highest point, of what was then the bottom of a strait by the River Hebert valley and through the Cobequid Pass, lies in the central part of the Cobequids, and as stated above, is, eighty-five feet above mean tide level.

It may be remarked that the foregoing statement in reference to the initial uplift of the Cobequid Mountains is supposed to apply only to the western part; the eastern part may be, and doubtless is, older.

Relation between the changes of level in the Cobequids and in the Isthmus of Chignecto.

These differential changes of level in the Cobequid Mountains and in the region lying to the north, and indeed to the south of them as well, during the Tertiary and Post-Tertiary periods (see table) are, therefore, in harmony with those supposed to have taken place in the Isthmus of Chignecto during the same geological age.

Changes of level in the crystalline range of southern New Brunswick.

The crystalline range of southern New Brunswick, extending along the Bay of Fundy coast from Shepody Bay to the International boundary, exhibits some features which lead me to infer that, besides the general oscillations of Post-Tertiary date, a slow, secular, upward movement relative to the Carboniferous area to the north has also been in progress. The zigzag courses of the St. John River in the lower part of its course, the occurrence of waterfalls at the mouths of this and a large number of other rivers traversing this crystalline belt and emptying into the Bay of Fundy, and several facts respecting the glaciation of the region, lead to this inference; these being conditions which would not be likely to prevail had there been no displacement of the river, beds or differential movements.

Attitude of the Region, and Changes of Level in the Glacial Period.

Changes of level in the glacial period.

A number of facts have been obtained in the region under discussion which show the attitude of the coast border with respect to sea-level, approximately at least, during two stages of the glacial period. From the data at hand it appears that the greater elevation of the later Tertiary period continued into the Pleistocene, and, perhaps, was one cause of the ice accumulation. No evidence of a subsidence in the early stage of the ice age has been found in this region. The residuary material such as rotted rock, consisting of sand, gravel, boulders, etc., found in many places, evinces no action of water; and the hardened peat bed met with at River Inhabitants in Cape Breton by Sir J. W. Dawson* testifies to the fact that the land there must have been above the sea just previous to the deposition of the boulder-clay which overlies it.

Coast border probably higher in the early part of the glacial period.

In the earlier part of the glacial period, the ice in several places extended beyond the present coast border, and its movements were apparently affected by the peculiar local topographic features of the bays and estuaries. Striæ are met with in many localities running down beneath the sea, and as the facts prove that the ice (except perhaps, in southern New Brunswick, near the International boundary), cannot have been thick or heavy, it follows that the land must have been as high, if not higher than at present, in order that the valleys and estuaries could influence the ice movements in the manner supposed. If the coast border were lower, the ice moving outwards and discharging into these bays and depressions would have been broken up and floated off as icebergs, before it scored the rocks on the low levels to which it reached, and could not possibly have been guided in its movements by the conformation of these valleys as it appears to have been.

Evidence as to the altitude of the land, relative to sea-level, at this stage.

Commencing at Gaspé Basin, where there is evidence of a local glacier discharging from the valleys of the York and Dartmouth rivers into it, described on page 89 M, although no facts were observed indicating the exact height of the land here at this stage, yet from the position of the striæ on both sides of Gaspé Basin, and of the ice margin, it is inferred that the glacier was small, and that the land was as high as at present and probably higher.

At Baie des Chaleurs.

The western end of the Baie des Chaleurs depression was occupied by a glacier in the early Pleistocene, which seems to have extended as far eastward as Belledune Point and Bonaventure River. This

*Acadian Geology, 2nd ed. p. 68.

glacier followed the trend and sinuosities of the Restigouche estuary and the valley of the bay, and this fact leads me to infer that the land was rather higher than at present when the glacier reached its maximum thickness and extent, withdrawing to the slopes to the north, west and south coincidently with the subsidence which followed.

In Northumberland Strait.

The evidence respecting the attitude of the area covered by the Northumberland glacier, so-called (page 29 M) in the later Tertiary, shows that it was at least one hundred and nine feet above its present level. The eastern part of this area, and indeed the whole of the Carboniferous basin, was probably higher; at all events, it seems certain that Prince Edward Island was, in the early glacial period, a part of the mainland. A large portion of Northumberland Strait is now from sixty to one hundred feet deep only, so that an uplift of one hundred feet alone would lay bare nearly the whole intervening passage from Richibucto Head and Cape Wolf to Pictou Island. Subsidence may have been inaugurated at the time the Northumberland glacier reached its maximum thickness and extent, or soon afterwards, but of this there is no evidence. Certain facts point to the still greater elevation of the south-eastern part of Northumberland Strait, or rather of the area lying between Prince Edward Island and the axis of the isthmus of Chignecto than that indicated above as referred to on page 27 M.

On north side of the Bay of Fundy.

The north-west coast of the Bay of Fundy seems also to have been higher in some places than at present, in the early part of the glacial period. At St. John harbour and westward to Grand Manan Island, the evidence shows that the Pleistocene land ice extended beyond the existing coast-line into the depression of the Bay of Fundy. Partridge Island in St. John harbour, distant a mile from the mainland, is glaciated by land ice, and Campobello and Grand Manan islands have also been similarly overridden by it. As the passage between the mainland and Grand Manan is 45 to 50 fathoms deep and the island about four hundred feet high, it follows that either the ice which moved out toward it has been quite thick, or the coast border stood higher relatively to sea-level than the present. The latter view is in accordance with the facts obtained along the coast of other parts of New Brunswick. But that the ice covering of the earlier Pleistocene period west of St. John harbour consisted of one confluent massive sheet, is a theory not sustained by the evidence. For example, Passamaquoddy Bay, which is 20 to 30 fathoms deep, was filled by an ice-mass at this period which overflowed Deer and Campbello islands, from 200 to 250 feet high, and also Letite Peninsula, in radiating lines.* This does not betoken a

*Ann. Report Geol. Surv. Can., vol. IV. (N.S.), 1888-89, page 48 N.

confluent ice-sheet moving into the Bay of Fundy. While, however, the ice may have been sufficiently massive to cross the passage between the mainland and Grand Manan with existing or higher levels of the land, there are reasons for believing that this island itself was not as high in the later Tertiary and early Pleistocene, as at present relatively to the mainland. Like the Cobequid Range and other ridges of intrusive rocks, it is not improbable that it has been undergoing a slow differential uplift before and since the glacial epoch. The diverse courses of striæ along the coast of the Bay of Fundy and on the West Isles, lend countenance to the view that the ice cannot have been so heavy and massive as to move out into the Bay of Fundy and override Grand Manan with the present levels, and, therefore, either the mainland has been higher with respect to sea-level, or the ice much more massive than other facts would warrant us in believing.

Probable height of the land at mouth of St. John River at this stage.

It has been shown on page 25 M that the land at the mouth of the St. John River was 200 feet and upwards higher in the later Tertiary than at present. During the period of maximum extension of the ice, it was probably not very far different from this. There is no evidence here or elsewhere in Eastern Canada of any changes of level having occurred between the later Tertiary and the period of maximum ice accumulation; and unless it be that the subsidence, which culminated in the Leda clay period, had then commenced, we know of no other changes of level which could have taken place. It was not till the last stage of the ice age in this region that any facts become available showing the attitude of the land with respect to sea-level.

Height of the Region at the Departure of the Pleistocene Ice.

Attitude of the region, relative to sea-level, at the close of the glacial period.

Soon after the glaciers of the eastern provinces of Canada reached their maximum extension, it would seem that a subsidence of the coast border—or, more correctly speaking local subsidences of the coast border—set in, accompanied by an amelioration of climate, while the glaciers began to diminish. This changed attitude of the land surface and the thinning and breaking up of the ice into still more local sheets, caused it, in many places, to move in different directions from those pursued in the earlier stage of its existence. Concomitantly with the movements of these local glaciers, masses of floating, or sea-borne ice, were carried in different directions by marine currents. In some bays and straits the floating ice formed packs, or ice-jams which seem to have been capable of striating the rocks on which they grounded in a manner scarcely distinguishable from the markings produced by land ice. These ice-jams appear to have been similar to those described by arctic voyagers as occurring in Smith's Sound and other straits on the west coast of Greenland.

The height of the coast border with respect to sea-level at this stage of the Pleistocene can, in some places, be fixed with tolerable exactness from the position of striæ supposed to have been produced by floating ice on the rock surfaces. Even at this stage the land would seem to have been still subsiding, at least along certain portions of the coast, for marine terraces of Leda clay and Saxicava sand are found at greater elevations than the striæ or markings produced by floating ice, and are undisturbed by ice-movements though subsequently formed. Indeed, it is tolerably certain that not till some time after the final disappearance of the ice from the coast districts, and perhaps also from the interior, did subsidence cease and the post-glacial rise of the coast borders set in.

Brief descriptions of the striation produced by floating ice, in connection with the facts indicating the attitude of the land with respect to sea-level will now be given.

At Trois Pistoles, Quebec.

At Trois Pistoles station, Intercolonial railway, fine scratches parallel to the course of the St. Lawrence Valley here, and also cross stri , the latter broken and irregular, were observed on rock surfaces about 100 feet above sea-level. These are attributed to the action of floating, sea-borne ice, showing that the land was, at least, 100 feet lower at that stage of the glacial period than at present.

The ledges on which these striæ occur have a thin sheet of boulder-clay resting on them which was covered with Leda clay and Saxicava sand subsequently. A deep trench has since been cut in these deposits by a stream flowing over the ledges. On both sides of the excavation the marine deposits, which here form an extensive terrace, lie undisturbed by glacial action, and show no boulder-clay or other glacial products interstratified or overlying them. The striæ have evidently been formed first and the ice which produced them has probably retired before the marine deposits were laid down. The fossiliferous Leda clay and Saxicava sands of this part of the St. Lawrence Valley seem, therefore, to be later than the ice period.

At Cape Gaspé.

Along the south-west side of that narrow peninsula terminating in Cape Gaspé, irregular striæ, formed apparently by some jumping body, occur. The striæ or markings were observed at the following places: The west end of the road leading to Griffin Cove, N. 67° E.; at Little Gaspé, one mile north of Grand Grève, 75 feet high, N. 13° E., N. 23° E. and N. 28° E., and at Grand Grève, 75 to 100 feet high, N. 23° E. These striæ occur on ledges sloping westward towards Gaspé Bay. In places they are one-fourth of an inch deep or more, and have a gouged out appearance, but do not exceed from two to three feet in length, the majority being from three to nine inches. They are both fine and coarse and have evidently been formed by drift-ice jammed into Gaspé Basin when the coast stood from 75 to 125 or 150 feet lower than at present.

At Baie des Chaleurs.

On the south-west side of the Baie des Chaleurs, along the Intercolonial railway, from Jacquet River to Elmtree River, two or more principal sets of striæ occur. The earliest are heavy, showing an eastward movement. Crossing these nearly at right angles, and also at right angles to the coast line, are numerous fine striæ evidently formed by ice which was pushed against the land. On examining these striæ in detail, it is found that the stoss side is invariably towards the bay. Where they cross ledges with deeply cut east-and-west grooves, the ridge of rock between each groove is found to be stossed on the shoreward side. The greater number of the courses vary from S. 20° E. to S. 20° W.; but as we approach Elmtree River, where the coast-line curves round to the south, the courses of these fine striæ are found trending from S. 36° W. to S. 40° W. On exploring the district as to the extent of rock-surface covered by these fine striæ, it becomes evident that they are confined to a certain zone which is from 60 to 140 or 150 feet in height above sea-level. Below the 60-foot contour line, none of these fine striæ were found, although exposures showing the west-to-east striation are abundant; nor could any be discovered above the 150-foot contour-line. Rock surfaces examined in some of the back settlements, where striated ledges from 150 feet up to 500 feet high occur, were found to be without any of the fine striæ referred to upon them. But it was only at wide intervals that exposures of striæ were noted in these higher grounds.

The conclusion to be deduced from these facts, therefore, is that the fine striæ were made by heavy ice-jams impinging against the coast border while it stood from 75 to 150 feet or more lower than at the present day.

The marine terraces along the south side of the Baie des Chaleurs, indicate that they have been formed subsequent to the stage of the glacial period when these fine striæ were produced, as the deposits in certain places rest on the glaciated surface undisturbed. These marine beds (Leda clay and Saxicava sand) occur at all elevations from sea-level up to 200 feet, in the Baie des Chaleurs basin. It seems probable, therefore, that at the period of the formation of these fine striæ the coast border had not quite reached the lowest stage of the post-glacial subsidence.

In southern part of Gulf of St. Lawrence.

A considerable number of facts from eastern New Brunswick, north-western Nova Scotia and Prince Edward Island have been obtained, the details of which are given on pages 79-83 M, all tending to show that floating ice, or rather heavy ice-jams ground over portions of the Isthmus of Chignecto and the coast districts of Prince Edward Island during the closing episode of the ice age. In order that floating ice might perform this work, it is necessary to suppose that the coast of the mainland was from 125 to 150 feet, and Prince Edward Island 75 to 80 feet lower than at present. This subsidence was probably unequal in different parts of the Carboniferous area during the glacial as well as the post-glacial period. Differential oscillations in the Isthmus of Chignecto have been referred to on page 27 M, and similar movements are evidenced by the striæ of the closing stage of the glacial period in the central part of the New Brunswick Carboniferous area, where there has been an apparent swerving from the easterly course of the earlier stage to a northerly course in the closing stage, coincidently with the progress of the subsidence, as recorded on page 102 M.

At St. John, New Brunswick.

At St. John harbour, unequivocal proofs have been found of the lower attitude of the coast border during this stage of the ice age. On the west side, a bank of boulder-clay from forty to sixty feet in height extends along the beach from Negrotown Point to Duck Cove, a distance of a mile and a half or more. This boulder-clay has been deposited by land ice which came from the north, the materials belonging to rocks lying in that direction. It is partially stratified, or rather contains intercalated seams of stratified clay, which are fossiliferous in some places. A section of the bank, about a quarter of a mile west of the Negrotown Point breakwater, gives the following series in descending order:

Section of boulder-clay containing fossils, at Negrotown Point.

1. Commencing at the summit—typical boulder-clay, unstratified, containing boulders two or three feet in diameter, most of them glaciated. Thickness eleven feet.

2. An irregular, wavy, lenticular seam of stratified boulder-clay, not in horizontal position, varying in thickness from a few inches to a foot or more.

3. Boulder-clay, the same as No. 1, and containing similar boulders, but apparently bedded, or rudely stratified, in some places. In this division of the series the following species of marine shells were found:—*Yoldia (Leda) arctica*, abundant and well preserved, often with the epidermis on, *Balanus crenatus* (fragments), *Saxicava rugosa*, *Mya arenaria* (a single valve), *Macoma calcarea*, *Nucula tenuis* (much broken), *Buccinum* sp.? probably *undatum* (a fragment), etc. All the species except *Yoldia* are quite rare. The fossils appear to be

indiscriminately scattered through the mass. Thickness of this part of the boulder-clay six to ten feet.

4. Stratified, dark red, tough clay, distinctly laminated, with a few boulders of the same kinds of rocks as those met with in the unstratified portions. The whole bed irregular and wavy, not in a horizontal attitude, and somewhat lenticular, or rather not maintaining the same thickness for any distance. Layers of this division of the series are sometimes seen to run up obliquely into and terminate in the unstratified boulder-clay immediately above, and in other places apparently to graduate into it. Scattered throughout are shells of *Yoldia (Leda) arctica*, well preserved, often, in the bottom, with the valves closed, and the epidermis on ; *Nucula tenuis* (broken), *Balanus crenatus* (fragments), *Saxicava rugosa*, *Macoma calcarea*, *Buccinum* and *Mya* (fragments), and one or two undetermined species. Thickness, four feet.

5. The height of the whole bank here is about forty-five feet above the beach, so that there is still nineteen or twenty feet of it below division No. 4. But this portion is concealed from view by land-slides. From the appearance of the bank, however, it would seem that a thick bed of unstratified boulder-clay underlies the stratified seam No. 4, whether containing other stratified layers and fossils it is at present impossible to say.

At the Fern Ledges, the boulder-clay bank is upwards of sixty feet in thickness, and also contains stratified seams of clay, though none have yet proved fossiliferous.*

The inferences deducible from the foregoing facts in reference to the fossiliferous boulder-clay at Negrotown Point are, that in the later stages of the glacial period the land was subsiding, and that the subsidence had reached one hundred feet or more below the present level.

The western part of the boulder-clay bank is overlain by fossiliferous Leda clay and Saxicava sand forming a consecutive series. As the latter deposits are nowhere in this region overlain or interstratified with boulder-clay, it is evident that the ice had retired, at least from the coastal and submerged districts, at the time of the deposition of the Leda clay and Saxicava sands. These deposits occur as terraces up to a height of from two hundred and twenty to two hundred and thirty feet above mean tide level, and it would appear, therefore, that the land along the Bay of Fundy coast continued to subside after the fossiliferous portions of the boulder-clay described above were laid down.

General statement regarding the

The data relating to the attitude of the coast border in the later or closing stage of the glacial period, therefore, indicate that subsidence

*Ann. Rep. Geol. Surv. Can., Vol. IV., (N.S.) 1888-89, Part N. ; Bull. Geol. Soc. of America, Vol. IV., pp. 361-370.

altitude of the region at close of glacial period.

had so far advanced that the land stood from one hundred to one hundred and fifty feet lower than at present on the mainland of New Brunswick, with perhaps a somewhat less amount in Prince Edward Island, the movement being apparently differential. This subsidence seems to have continued after the close of the glacial period, and did not reach the point of greatest depression till the deposition of the Leda clay. How long it remained at the lowest level it is impossible to say, but if deposition of sediments and subsidence are concurrent phenomena, as is usually held, the marine border must have continued at the stage of maximum depression for some time.

Be this as it may, the subsidence was followed by an upward movement of the land. This movement progressed, as is evidenced by the nature of the deposits around the coast borders and the character of the fossils entombed therein, until the land reached an elevation with respect to sea-level somewhat higher than it is at present. This may be regarded as closing the Pleistocene, or first, division of the Post-Tertiary.

Pleistocene or Post-Glacial Upheaval of the Coast Borders.

Altitude of the coast border at commencement of post-glacial rise of the land.

The attitude of the land at this stage with reference to the present sea-level may be approximately obtained by the addition of the figures in the second and third columns of the table on pages 22-25 M. Those in the second column representing the existing height of the Pleistocene shore-lines or the amount of the post-glacial upheaval less the subsidence of the recent period, are accurate within a small limit of error ; but those in the third are meagre and indefinite. In measuring the heights of shore-lines we used a Y level and rod, two or three aneroids and a hand level. The barometric work represents the mean of a number of observations taken at each locality, and the railway levels are from the profiles of the Intercolonial, Prince Edward Island, Shore Line and Springhill and Parrsboro' railways, the difference between datum and mean tide level being worked out as carefully as possible.

The methods adopted in this investigation were :—first, to trace out a wave-cut terrace, or one formed of sedimentary material, for some distance along a coast or estuary until we were certain it really represented a shore-line. Having ascertained this, measurements were then carried out in the manner most practicable.

This upheaval probably differential.

A comparison of the facts relating to the upheaval of the region embraced in the south-western embayment of the Gulf of St. Lawrence during the Pleistocene period, leads to the conclusion that it was unequal or differential throughout. At first it would seem as if there must have been two systems of upheaval independent of each other,—

one a general movement of the entire region, though somewhat unequal in different localities; and a second which was local and confined to hill and mountain ranges, to which the term orôgenic might properly be applied. The latter is exemplified in the uplift of the Cobequid Range and the crystalline belt of southern New Brunswick bordering the Bay of Fundy, described on a previous page. In both of these ranges there appears to have been a slow secular upheaval which had its beginning far back in geological time independent of the oscillations of the Pleistocene period. Was this a separate and distinct movement from the latter, or were they both a part of the general crustal oscillations which characterize the eastern border of the continent?

An examination of the height of the shore-lines in the second column of the table, in connection with the geological map of the older rocks shows that these are highest in the regions of old crystalline or altered and disturbed strata and lowest in the Carboniferous basin where the rocks lie nearly horizontally and where little or no disturbance has occurred. Prince Edward Island and the Magdalen Islands lie nearest the centre of this Carboniferous basin and, accordingly, we find the Pleistocene uplift to be less there than on the mainland. It is possible there may be a centre of least oscillation or zero point to the north of Prince Edward Island, from which the oscillations increased towards the pre-Carboniferous rocks on either side. Low undulations, or anticlinals and synclinals traverse the Carboniferous strata, and the dips become higher as we approach their limits, indicating greater disturbances or oscillations of the older rocks beneath.

Uplif greater in the regions of crystalline rocks than in flat Carboniferous area.

From the table it will also be observed that the post-glacial shore lines are highest at Gaspé, Dalhousie, Indian or Lutz Mountain, Hillsboro', St. John, etc., and on the Magdalen Islands they were also found to be higher than on Prince Edward Island. In all these places a local or orogenic uplift would seem to have taken place as well as the general Pleistocene uplift, thus raising them above the normal gradient similarly to the shore-lines in the Cobequid Pass referred to on page 30 M. Investigation show these ridges and hills to have a central mass of intrusive rocks (dolerite or diabase, felsite, etc.), to the presence of which in all probability the differential movement may be due.

Where highest.

This fact may be taken as indicating that shore-lines on the slopes of isolated crystalline ridges or hills are unsafe guides as to the general post-glacial uplift of the region.

It will be observed, further, that the general Pleistocene oscillations not only involved the larger portion, if not the whole, of the Carboniferous area, but also the rising crystalline ridges and mountains

Local or general oscillations.

locally. For example, the marine shore-lines found throughout the region prove that a general upheaval, though unequal, took place in the Pleistocene, simultaneously, or nearly so; but the local or orogenic uplift of the Cobequids and other local ridges proceeded concurrently, and apparently continued after the general upheaval ceased. But if the supposed local and general upheavals were due to separate and distinct causes, should we not expect to find the latter more uniform throughout this region, especially in that portion occupied by Carboniferous rocks, instead of diminishing towards a central or pivotal point north of Prince Edward Island, as it appears to have done? The fact that this upheaval was greater in the vicinity of the crystalline hills and ridges and gradually lessened as we recede from these, certainly indicates that the orogenic movement affected the Carboniferous basin also. For these reasons it is assumed that the two really belonged to the same system of oscillations, and are effects of the same cause or causes, the apparent difference being due primarily to the fact that the forces producing the upheavals did not at all times exert the same amount of pressure; that is to say, there would be periods of almost paroxysmal intensity when they would affect the crust over large areas and a general upheaval would take place such as that of Pleistocene times. These would be followed by periods of comparative repose, during which slow subsidence would go on, this being the general tendency of the crust from its own weight. While this secular subsidence was proceeding, whatever lateral strain there was imposed on the crust would find relief in linear upthrusts such as those of the Cobequid Range, the crystalline belt of southern New Brunswick and other minor ridges, these local orogenic uplifts being merely correlative movements of the gradually subsiding wider areas of the Atlantic coast border as it sought a position of static equilibrium. This relation is well exemplified in that existing between the secular subsidence of the recent period, as shown by the drowned peat bogs, etc., along our coasts and the slow, progressive uplift of the crystalline ranges bordering the Bay of Fundy and other parts of the Atlantic coast referred to.

Probably only one system of oscillations.

Granting this theory to be correct, it serves to explain the supposed local and general oscillations of level which occurred in this region in the Post-Tertiary period, and probably, with some modification, in preceding geological ages. The apparent decreasing oscillation of the Carboniferous area from the circumference towards the centre, makes it appear as if the tangential force had partially spent itself in that direction upon these undisturbed, unaltered rocks; though why this area should have occupied a more stable attitude than the belts of older rocks surrounding it is not evident. The breadth and horizontal position of the strata may have been one cause. In this last respect they differ from the older strata bordering them, which are often upturned at high angles. The Cambrian slates of St. John, N.B., which are nearly vertical, exhibit slips and displacements that have occurred since their surfaces were striated by Pleistocene ice, the uplifts being mostly, so far as observations have extended, on the seaward side. None of these displacements were seen to exceed from two to five inches, nevertheless, slips of even this small extent, if numerous, as they appear to be in these slates, when added together give a total of many feet. This is doubtless one way in which local upheavals take place.

Dislocations in Cambrian slates at St. John.

SUBSIDENCE IN THE RECENT PERIOD.

Subsidence in the recent period.

The Recent Period was inaugurated with a land surface along the Atlantic coast border somewhat higher, in many places, than at the present day. A differential subsidence of a small amount has taken place since, and may still be in progress, but with a diminishing tendency. The facts on which this inference is based are the sunken peat bogs and forest beds, originally formed in shallow basins around the coasts, the margins of which are now being eroded by the sea.

At head of Bay of Fundy.

The extent of this subsidence as given in the third column of the table is more or less problematical, except in the region at the head of the Bay of Fundy. Here we have good evidence that there was, at the west end of the marine ship railway, a subsidence of 10·80 feet ;* at Aulac Station, Intercolonial railway, 79 feet, and at Edgetts Landing, in the mouth of the Petitcodiac River, 15·32 feet, below mean tide level. The figures for Aulac station are from borings for a well sank there under the direction of P. S. Archibald, Chief Engineer of the Intercolonial railway, (see diagram, p. 129 M). This boring discloses, in descending order, 80 feet of marsh mud, 20 feet of peat, etc. The great subsidence at this place is due to a fault along the north-west side of Westmoreland Ridge, which lies a few hundred yards to the south-east of Aulac station. This ridge trends north-east and south-west, is 140 feet high, and consists of Middle Carboniferous or Millstone grit rocks dipping S.E. $<$ 30°. The downthrow or displacement is 364 feet, that is, assuming the present surface of the ridge has not suffered any appreciable denudation, if it has, the amount must be added to the above figures. How much of this displacement occurred before the glacial period and how much since, it is difficult to tell ; but in the recent period, *i. e.* since the

Displacement of beds at Aulac.

*Acadian Geology. Supplement, 3rd ed., page 13.

peat beds began to grow, it has been 79 feet below mean tide level. Has this downthrow or subsidence been accompanied by a correlative upward movement in the adjacent district? It seems possible to give an affirmative answer to this question.

Head of Bay Fundy, a great oscillating area.

It was stated on a previous page that the region around the head of the Bay of Fundy has been remarkable for great changes of level. The subsidence or downthrow at Aulac is doubtless related to the uplift of the Westmoreland Ridge and of the parallel ridges lying between it and Petitcodiac River. These all bear evidence of differential upheaval of a greater or less amount since the glacial period. Striæ are found on the summits of these ridges 300 or 400 feet high, evidently produced by the land ice referred to on page 27 M. To enable this ice to flow off the axis of the Isthmus of Chignecto in a south-westerly direction into the Bay of Fundy and produce these striæ in its passage, the land around the head of Chignecto Bay must have been lower relatively, for no elevation exists to the north or north-east sufficient to give it impetus to override these ridges with the levels of the present day. Hence it is inferred that they have sustained a post-glacial, differential uplift which is doubtless complementary to the subsidence shown to be going on in other portions of the same region.

Subsidence as evidenced by sinking peat bogs.

The slow subsidence in progress in several places around the south-western embayment of the Gulf of St. Lawrence in the recent period, as evidenced by the sinking of the peat bogs, is probably not general, although its occurrence along the coast borders of the Carboniferous area and on the north-east side of Prince Edward Island in localities where there is much less oscillation than around the head of the Bay of Fundy, would indicate that it may be. Indeed, it would appear to have altogether ceased locally on some parts of the coast, but continues in other places, though at a very slow and apparently diminished rate, showing, however, that the coast border has not yet reached a position of equilibrium.

Remarks on hypothesis of ice-load causing subsidence.

In reference to the hypothesis of ice-load weighing down the crust at the time of the Pleistocene subsidence; while this is not inconsistent with the facts and inferences brought forward in preceding pages, it does not seem to be required for the explanation of the phenomena in this region. The great difficulty appears to be not so much to account for subsidence, which is the natural tendency of the crust, as for the upheaval of the larger areas. It has been shown on a preceding page, that during the epoch of ice accumulation, at least, the coast region stood higher than at present, and that the period of melting and retirement of the Pleistocene ice was also the period of subsidence. If this ice, by its weight, had been capable of causing a sinking of the earth's crust, it might naturally be supposed that such a movement would have coincided with the ice accumulation, and an upward movement should have occurred during the melting period as the crust became relieved of its weight. On the contrary, however, the coast border seems to have remained at a low level long after the retirement of the ice, that is to say, during the time the Leda clay and Saxicava sands were being deposited. All the evidence available tends to show that in this region the Pleistocene ice was not of sufficient thickness and weight to sensibly affect the crust of the earth, even if the hypothesis regarding its sensitiveness to load be tenable. It may be added, that the depression of the recent period just described, which has been going on at a time when, as the evidence hows, no ice-covering existed in the region to affect the crust by its weight, materially weakens the force of any arguments that may be advanced in favour of the hypothesis.

CLASSIFICATION.

In this report the general term Post-Tertiary or Quaternary will be used, and it is intended that it shall comprise the whole series of superficial deposits from the close of the Tertiary or Pliocene up to the present. The Post-Tertiary, according to the best authorities,* is divided into the Pleistocene and the Recent or Pre-historic periods. The former is made to embrace all the deposits from the base of the boulder-clay to the summit of the Saxicava sands; the Recent includes the formations lying above the latter. Classification

The Pleistocene of the region under review may, perhaps, be subdivided stratigraphically, if not palæontologically, into two periods or stages,—one characterized by extreme glacial conditions, when glaciers occupied the land and floating ice the adjacent seas, and when life, except that of an arctic character, was very scanty. The deposits of this period are boulder-clay, moraines, osar, glaciated boulders, etc. This might be called the glacial period proper. Fossils occur in these glacial deposits on the Bay of Fundy coast at Saint John, New Brunswick, and in the Saint Lawrence valley at Rivière du Loup, Isle Verte, etc. The shells denote a highly arctic climate, or rather a temperature of the adjoining sea as low as that now prevailing on the coast of Greenland. Subdivisions of the Pleistocene First division of the Pleistocene.

The second division of the Pleistocene may be made to include all those stratified sands, gravels and clays overlying the deposits of the Second division of Pleistocene.

*Sir A. Geikie, Text Book of Geology, 3rd ed., 1893.
Dr. James Geikie, The Great Ice Age, 3rd ed., 1894.
Prof. J. D. Dana, Manual of Geology, 4th ed., 1895.

above designated glacial period and underlying the formations of the recent period, and consist of (1) the marine deposits, Leda clay and Saxicava sands, which are a coast and estuarine series lying below the uppermost shore-line of the post-glacial submergence; and (2) the fresh water deposits occurring on the higher levels. These are probably of contemporaneous origin. The Leda clay and Saxicava sand a
ally fossiliferous, especially the first-mentioned, and contain, in certain localities, an abundant marine fauna, the principal species of which exist in the off-shore or deeper coast waters of eastern Canada and Labrador at the present day. A small part, probably about ten or twelve per cent, of the whole assemblage, is not found on these coasts now, and occurs only in arctic and sub-arctic seas. Taken as a whole, the marine fauna of the Leda clay and Saxicava sand, while denoting a more rigorous climate, or rather a somewhat lower temperature of the coast waters than prevails in the region at present, nevertheless, evinces considerable amelioration from the glacial conditions which preceded it.

Marine deposits.

The marine deposits referred to are usually well defined at the base and summit, and distinct from the boulder-clay beneath and from the formations of the recent period above them. They contain no material which can properly be called glacial, *i. e.*, no boulder-clay or morainic matter interstratified therewith, or overlying them, the sand, gravel, boulders, etc., comprising the series, even the boulder-clay itself beneath, being almost wholly derived from the rock-formations of the district in which they lie. At or near the mouths of rivers, the deposits are always of greater thickness than elsewhere and contain a larger assemblage of fossil shells. That the Pleistocene ice had not wholly retired from the higher grounds of the region when the lower portion of the Leda-clay was deposited seems possible, though no evidences of the action of land or floating ice are shown in the structure of the beds, nor are any disturbances apparent, such as we would expect to find had land ice moved down the slopes subsequent to their deposition, or floating ice ground over the areas occupied by them. In their character and mode of deposition, these are similar to marine beds now being formed on the north side of the Gulf of St. Lawrence and on the coast of Newfoundland. Occurring, as they do, at Bathurst, New Brunswick, and other localities in the maritime provinces, with a vertical range or thickness of one hundred and seventy-five to two hundred feet, without any intercalated or overlying glacial deposits, it is evident they must have been laid down when the extreme glacial conditions of the region had very nearly, if not wholly, passed away.

Fresh-water deposits.

In regard to the fresh-water deposits, so-called, of the second division of the Pleistocene, which consist of stratified sand, gravel and clay occupying those portions of the region above the highest marks of the submergence of the Post-Tertiary period, no fossil remains have yet been found in them in the maritime provinces of Canada.* They are distinctly above the boulder-clay and morainic material and underlie the peat and marl beds; but are often thin and sporadic upon the higher grounds. Along river-valleys and in lake-basins, also in localities outside of these, they blend insensibly into the sands, gravel and clay of the recent period, so that it is impossible to tell where the one ends and the other begins. The bottom portions of some of these have doubtless been deposited by waters from the melting ice of the glacial period; but no boulder-clay or morainic material has been found intercalated with or overlying them. While, therefore, in the region in question, it seems difficult, if not impossible, to differentiate the stratified deposits due to melting ice from those formed by alluvial and subaerial action, there appears to be no doubt that the latter, viz., rivers, streams, lakes, and atmospheric denudation of the land surface generally, were the principal agents to which these deposits owe their origin.

Except when occuring along with osar and moraines, there is usually a tolerably well defined line of demarkation at the base of these stratified, fresh-water deposits, their contact with the true boulder-clay having been observed in many places. Their upper limit, too, is often traceable, especially when they are overlain, as they are in many places in this region, by peat-bogs, shell-marl, etc., of the recent period; but in general their limits are poorly defined and uncertain. It is believed, however, that they have been deposited contemporaneously with the Leda clay and Saxicava sands, and constitute the fresh water equivalents of these marine beds.

Classification of formations of the recent period.

As regards the classification of the formations of the recent period, there are here few facts indicating succession in these, as in the Pleistocene, the deposits and their contained fauna and flora betokening conditions of climate throughout the whole period not far different from those now prevailing. In the early stage, however, the land in some portions of the maritime districts at least, stood from ten to twenty-five feet or more above the present level, and the climate,

*In the summer of 1894 the remains of a fish about eighteen inches in length were found at Ryan's brick yard, Fredericton, N.B. It is reported to have been imbedded in stratified clay at a depth of twenty-seven feet beneath the surface of the ground. The skeleton is now in the museum of the University of New Brunswick. The deposits in which the fossil fish was found lie in the valley of the St. John River, and are probably of fluviatile origin, and of post-glacial age.

or rather the temperature of the adjacent waters was warmer. It was at this stage that the marine mollusca, whose habitat is now in the coast waters south-east of Cape Cod, are supposed to have spread northward and settled in certain localities around the coast of Nova Scotia, and especially in the southern embayment of the Gulf of St. Lawrence. In the latter place they still continue to exist.

Two main divisions, marine and fresh-water.

The deposits of the recent period may also be classified into two divisions, marine and fresh-water, supposed to be of contemporaneous origin. Usually they are arranged into two groups, viz.: (1) alluvial, that is formed by the sea, by rivers, lakes, etc., and (2) indigenous, *i. e.* formed by the growth of vegetable or animal matter, as peat-bogs shell-marl, infusorial earth, vegetable mould or humus, etc. Peat has been observed in a great number of places resting on sand, sometimes blown sand (sand beaches) also on shell-marl, while it underlies the salt marshes around the head of the Bay of Fundy. If we regard any of these as of successive formation to others, it would seem that shell-marl, infusorial earth, etc., were first formed or deposited, afterwards beds of peat grew upon these, then the deposition of the marsh mud of the Bay of Fundy tides followed. It is probable, however, that the growth of all the peat bogs in their earlier stages was not strictly coeval, but commenced at irregular intervals, continuing till the present. In general, therefore, it may be stated that in the region in question the whole of the recent deposits, marine and fresh-water, are still in process of growth and accumulation, and the forms of life, animal and vegetable, buried therein are those existing around us at the present day.

General classification of the Post-Tertiary.

The whole series of deposits in the Post-Tertiary of the region under review may, therefore, be classified as follows :—

Post-Tertiary.	Recent or Prehistoric......	1. Indigenous (peat bogs, etc.) 2. Lacustrine. 3. Alluvial, fresh-water and marine.
	Pleistocene....	1. Stratified sands, gravels and clay, fresh-water and marine. 2. Glacial (boulder-clay, moraines, osar, drumlins, glaciated boulders, etc.)

Tabular statement of deposits in the region.

The general character and succession of the Post-Teritary deposits is shown, so far as it is possible to classify them, by the following table :—

M 3.

DEPOSITS OR FORMATIONS OF THE RECENT PERIOD.

Fresh-water. (a)	*Marine.* (b)
Peat bogs.	1. Dunes, or sand beaches.
. Lacustrine—shell-marl, infusorial earth, etc.	2. Estuarine flats, mussel or oyster beds natural dykes, etc.
3. River-flats, intervales (alluvium).	3. Salt marshes (alluvium).

M 2.

DEPOSITS OR FORMATIONS OF THE LATER PLEISTOCENE.

(a)	(b)
1. River and lake terraces and their accompanying kames, etc. 2. Stratified inland gravel, sand and clay, and kames associated therewith.	1. Saxicava sand and Leda clay and kames formed by marine agency.

M 1.

DEPOSITS OF THE EARLY PLEISTOCENE OR GLACIAL PERIOD PROPER.

Boulder-clay or till, moraines, boulders, erratics, etc.

PRE-GLACIAL OR TERTIARY.

Rotted rock *in situ*, angular boulders, gravel, sand, etc.

TERTIARY OR PRE-GLACIAL GRAVELS, SANDS, ETC.

Pre-glacial materials.

Unstratified materials of pre-glacial origin exist in sporadic masses and detached sheets in many parts of New Brunswick, Nova Scotia and Prince Edward Island, especially in districts occupied by Carboniferous rocks. The glaciation of these flat areas has been of a less vigorous and sweeping character than in the more elevated parts of the country, the ice apparently having been sluggish in movement, passing over the loose deposits and rock surfaces without eroding them deeply. Only from certain low ridges, or from the brows of hills exposed to the full force of the grinding ice did it remove the whole of the residuary material and score the solid rocks beneath. In New Brunswick, the thickest beds of this material met with are near the coast of Northumberland Strait, where in a few instances it was found overlain by boulder-clay, which in turn was mantled by stratified deposits of post-glacial age. Upon the higher grounds of the interior of the province, non-glaciated areas of greater or less extent occur, occupied with irregular sheets of the decomposed material belonging to the subjacent rocks. On the sloping surfaces and declivities, these have suffered more or less transport from glacial and atmospheric denudation and they are, therefore, more uneven and irregular than upon the flat Carboniferous tracts referred to.

In New Brunswick.

In Nova Scotia.

The northern flanks of the Cobequid Mountains in Nova Scotia and the slope between these and Northumberland Strait, are also masked with lenticular, detached sheets of residuary material of greater or less extent. This can be observed east of Halfway Lake, at Rodney, River Philip, Williamsdale, Westchester, Wentworth station, etc., and in numerous places between the mountains and the coast of the strait. In the latter area great quantities of such deposits have been kneaded and moved greater or less distances and changed into a kind of boulder-clay by the Pleistocene ice.

In Prince Edward Island.

In Prince Edward Island, large portions of the loose deposits covering the solid rocks consist of residuary material, and sheets five, ten, and even twenty feet in thickness are not uncommon. Much of this resembles boulder-clay in texture, though without scratched or polished pebbles or boulders, and has evidently been compacted by the weight of the snow and ice of the glacial period, and modified by atmospheric action since. The great bulk of it is, however, in an oxidized condition, showing that it is not a true boulder-clay. Further, it contains no travelled boulders or drift, being wholly local, and the materials are unworn. Beds of it may be seen in several places along the Prince Edward Island railway between Summerside and Charlottetown, in cuttings and gravel pits resting on non-glaciated rock surfaces. It occurs along the coast also in numerous localities, especially at Alberton, Campbellton, Wood Islands, etc., often in banks ten to twenty feet thick. Upon the uplands not infrequently it comes to the surface and forms the soil, having apparently undergone considerable denudation. Transported boulders are occasionally found on the surface.

The occurrence of such extensive sheets of decomposed rocks *in situ* points to the fact of light glaciation in PrinceEdward Island, and indeed everywhere upon the Carboniferous area on both sides of Northumberland Strait. If the ice which overrode the island from west to east had been heavy and of much erosive power, it is evident the higher portions would have been greatly denuded and the rock surfaces ice-worn, exposed as it would be to the full onset of the mainland glacier. Instead of this being the case, however, the heaviest beds of residuary material occur on the higher ridges of the central part of Prince Edward Island while the thickest deposits of boulder-clay are found along the coast where they seem to have been produced by the heavy impingement of coast or floating ice against the land.

In Magdalen Islands.

The Magdalen Islands exhibit the most remarkable non-glaciated condition of any part of the eastern provinces of Canada. Each island has a nucleus or central mass of intrusive rocks, apparently thrust up into the Lower Carboniferous, gypsiferous strata, breaking through and throwing these into various attitudes. Around the margins of the islands overlying the Lower Carboniferous rocks, occurs a later series of soft, bright-red sandstones, with false bedding, which for the most part occupies a horizontal position. The crystalline series consist of dolerites or diabases, porphyritic and amygdaloidal felsites or traps, etc., forming conical-shaped hills which rise to altitudes of from 400 to 600 feet. In some places the dykes of these rocks penetrate the overlying gypsiferous series in such a manner as to reduce the whole to a confused mass apparently without order or arrangement. Upon the surface of the whole lie thick beds of rotted rock *in situ* without any boulder-clay or glaciated material. On the north-east sides of Amherst and Grindstone islands, a few pebbles and boulders were observed which may be foreign to them, but even these were not glaciated. The residuary materials were modified on the surface below the 110- to 115-foot contour line by the action of the sea during submergence, while above that level no trace of marine or glacial action could be observed. Indeed, the whole examination of the surface of the four largest islands, viz., Amherst, Entry, Grindstone and Alright failed to show any evidence of glaciation whatever.* Rotted rock alone, with stratified marine beds up to the highest marks of the Pleistocene submergence, are everywhere, the prevailing superficial deposits; above the shore-line referred to some stratified lenticular sheets, due to atmospheric action, occupy the surface and overlie the residuary material; but the pebbles and debris are mostly angular and unworn.

It is possible, however, that more detailed investigation might result in showing some evidences of, at least the impingement of floating ice against the slopes or coast borders of these islands.

The origin of these residuary products is a question which takes us beyond the limits of Post-Tertiary geology. Their occurrence here indicates that in pre-glacial ages the land surface was, for a great length of time, above the sea. The peat beds found by Sir J. W. Dawson underlying boulder-clay at River Inhabitants, attest to the same fact. Whether the decomposed material formed as thick sheets here before it was eroded by Pleistocene ice, as it does now to the south of the glaciated zone, is not evident. In regions swathed in snow and ice, with the ground frozen to a greater or less depth for five or six months of the year, as the eastern part of Canada must have been previous to, as well as during the Pleistocene and since, there would be a conservative effect, checking and, indeed, practically arresting atmospheric disintegration of the rocks every winter. It is true that the melting period each spring is, owing to the loosening of the beds from the unlocking of the previous winter's frost, one of greater denudation than is usual in non-glaciated or tropical regions, but these conditions last only a short time. On the whole, however, the question of extensive and deep-seated pre-glacial rock decay in these latitudes, may be said to require further investigation before it can be correlated with that of non-glaciated tropical countries.

Origin of these residuary materials.

*Mr. James Richardson says "nowhere could deposits of clay or gravel be distinguished such as are usually attributed to the drift period." (Report of Progress, Geol. Survey of Canada, 1879–80, page 8 G.)

(M 1.) Deposits of the Early Pleistocene, or Glacial Period.

Boulder-clay and Boulders.

Boulder-clay and boulders.

The boulder-clay and boulders of the region are so intimately related and their distribution has been affected to such an extent by the same agencies that it seems best to describe them together. And first it may be stated that no boulder-clay, boulders, or other glacial products have been found upon the higher grounds of the region under discussion, except such as belong to rocks on the south side of the watershed of the north-east Appalachians or Notre Dame mountains, so far as my observations have extended. Upon the coast districts, which were submerged during the post-glacial subsidence, scattered boulders occur which do not seem related to the rocks of the region. These have doubtless drifted from the Labrador coast, from the Magdalen Islands, from Cape Breton, and perhaps from Newfoundland.

Dispersion of boulders, where best shown.

The districts which best illustrate the dispersion of boulders are the Carboniferous area of New Brunswick and Prince Edward Island. Upon these large quantities of boulders of granite, diorite or diabase, felsite, Lower Carboniferous conglomerate, etc., are strewn and embedded in the sheets of boulder-clay of greater or less thickness, a considerable portion of them having undergone transportation long distances across the New Brunswick plain.

Table showing dispersion of boulders in the region.

To show the distribution of boulders in the area referred to, certain localities were selected and the boulders upon a given space in each counted. The following table will illustrate the method adopted. But first a list of boulders from two localities on the pre-Carboniferous belts to the north-west of the Carboniferous plain will be given, to show the relation of the boulders on the two areas. All boulders above a minimum size of three inches in diameter were counted.

At Pleasant Ridge, Northumberland county, on an area fifty feet square the following boulders occur.

Granite	88
Diorite	80
Slate	40
Gneiss	16
Felsite	12
Quartz	4

Near Hayes' Brook, South-west Miramichi River.

Diorite	85
Granite	15
Gneiss	2
Slate	2
Quartz	2

Each locality in the following table represents a measured area of fifty feet square.

No.	Localities.	Gray or red sandstone.	Diorite or diabase.	Conglomerate or grit.	Granite.	Gneiss.	Felsite.	Syenite.	Schists, (mica, hornblende, &c).	Quartz and quartzite.	Slate or argillite.	Epidote.	Trap.	
	New Brunswick.													
1	At Ludlow	94			2		1				1			In New Brunswick
2	One mile above Boiestown	176	6		14	2	2							
3	At Cross Creek	78			1				1					
4	At Muzroll's Brook	96	3		1									
5	East of St. John River, opposite Fredericton	33	32	21	9		1			3	1			
6	Near Davis's Landing Brook, 5 miles north of mouth of Big Hole Brook	200												
7	Doaktown, east side of river	137	7		3	1				2	1			
8	" west "	300			2	1								
9	" " ½ mile below last	40	91	1	78		15			9	16			
10	" " in another place	7	34		66	6	10			5	5			
11	Between Doakton and Dunphy's	640	20		17	5	9		3		1			
12	Near Blackville	71	5	1	1									
13	Junction of Renous and Dungarvon rivers	36	9		49	3			3					
14	Below mouth of Dungarvon	18	8		54	14	6							
15	Between Renous and Dungarvon rivers		85		11				3			1		
16	Near Rogersville, I. C. R.	45	8		30	4	6				7			
17	East of Harcourt station, I. C. R.	132												
18	Salmon River, near Castaway River	151			1									
19	" " Gaspereau P. O.	69	14		9		3		3	2				
20	" " Meadow brook	99			1									
21	Garry Settlement, Sunbury county	89	3		6					1	1			
22	Enniskillen, Sunbury county	56	18	7	5		5				9			
23	Rushiagonis "	76	6	3	7	1				1	6			
	Nova Scotia.													
24	On northern slope of Cobequids	7	150			1	36	16	2	2			6	In Nova Scotia.
25	Summit of Cobequids on road to Five Islands	7	39		28		36	59	9		2			
26	On highest ground, South Joggins	56												
27	Margin of Minudie marsh	78					2			1				
28	Near Maccan	221	16							1				
29	At Athol	501	1	34			2	1						
30	Near Springhill, east side	173	9	10	3		3	23	3	2				
31	Maccan River, near foot of Cobequids	96	4					8	1					
32	At Halfway River	35					68			2				
33	Mouth of Sand River	93		3					1					
34	At River Philip	83	6		5				3	6				
35	Four miles north of Oxford	34		2										
36	Near Black River	63								1				
37	North of Thompson station, I. C. R.	43	6				2	18	4	1		1		
38	Near Westchester	45	10	2			28	13	2					
39	On DeBert River road	4	48		1		15	27	6					
40	Near Pugwash	147	5		2									
41	West side of Pugwash River, two miles from mouth	116						1						
42	Two miles west of Conn's Mills	128			1				2				3	
43	Wallace River	181	1		1		2							
44	Near Wallace village	91	1				4	2	1		1			
45	" another place	95		2				2				1		
46	" "	208						2						

In P. E. Island.

No.	Localities.	Gray or red sandstone.	Diorite or diabase.	Conglomerate or grit.	Granite.	Gneiss.	Felsite.	Syenite.	Schists, (mica, hornblende, &c.)	Quartz and quartzite.	Slate or argillite.	Epidote.	Trap.
	PRINCE EDWARD ISLAND.												
47	North Cape....	*	*	....	*	*	..	..	....	*	..	..	..
48	Mills' Point, north-east shore........	*	45	....	75	39	12	..	....	....	5	..	..
49	At Alberton..................	*	*	*	*	..	*	..	....	*	*	..	..
50	At Campbellton.....................	*	*	....	*	..	*	..	....	....	*	..	..
51	At Ellerslie station, P. E. I. R........	*	*	*	*	..	*	..	....	....	*	..	..
52	At Port Hill....	*	*	*	*	..	..	..	....	....	..	..	..
53	At Coleman station, P. E. I. R. ...	*	*	....	*	..	*	..	....	*	..	..	..
54	At Portage " "	*	....	*	*	..	*	..	....	....	..	..	..
55	At Wellington " "	*	*	....	*	*	*	..	....	*	*	*	..
56	At north-east coast, near Margate	*	*	....	*	*	..	..	....	....	..	..	..

In Prince Edward Island, the boulders were not counted, the different kinds only being noted. The relative proportion of transported crystalline boulders to those of local origin is, however, much less there than on the mainland of New Brunswick.

Crystalline boulders the same on the Carboniferous areas of New Brunswick and Prince Edward Island.

From a study of the foregoing table, it is apparent that the transported or crystalline boulders upon the Carboniferous area of New Brunswick and Prince Edward Island, are identical with those upon the surface of the pre-Carboniferous rocks to the west. Upon the latter area no sandstone or grit boulders were met with, and this fact, taken along with others, goes to show the direction of the drift movement, viz., that it was from west to east. Notwithstanding the immense quantities of material transported in this direction, however, everywhere upon the surface of the Carboniferous plain the great preponderance of boulders derived from the underlying sandstones, is especially noticeable. Only in a very few localities near the western margin of the area do the boulders of the older crystalline rocks from the west predominate. Beyond a distance of twenty or twenty-five miles from the margin of the crystalline rocks, the sandstone boulders outnumber all others put together.

In New Brunswick and Prince Edward Island, the most abundant of the crystalline boulders are granite and diorite, which again largely preponderate over all others. Slate and felsite come next, then gneiss, etc. This relative proportion as regards the number of these boulders upon the Carboniferous plain is not far different from that prevailing on the surface of the crystalline rocks themselves, so far as observations have extended.

Boulders in Nova Scotia.

Turning to Nova Scotia, we find the distribution of boulders in the district occupied by Carboniferous rocks north of the Cobequid Mountains to be somewhat different from that just described. Sandstone and grit largely predominate, and among the crystallines, diorites still occupy a prominent place; but boulders and debris derived from the Cobequid Mountains are elements which have to be taken into account here. Hence the great abundance of syenite and felsite boulders upon this slope, as compared to the portions of New Brunswick and Prince Edward Island to which these observations have reference. Upon the northern brow and summit of these mountains, a few sandstone and grit boulders occur intermixed with those belonging to the underlying crystalline rocks, and an interesting problem has arisen in regard to them. Sir J. W. Dawson explains their presence there by the action of floating ice, and it is possible he may be right. But I have been unable to find any system of glaciation either by land or floating ice which will account for the phenomena without raising other difficulties, some of them insuperable, and have therefore been compelled to adopt another hypothesis (page 29 M this report). The sandstones dip away from the mountains wherever they are seen resting on their northern base, and in some places are found *in situ* well up on the slopes, *e.g.*, at Williamsdale, where they occur six hundred to seven hundred feet high, and west of Wentworth station four hundred and sixty-five feet high. No stossing from ice action was found along the northern slope of the Cobequids, and the inference, therefore, is that neither land nor floating ice has impinged against their summits from the north. On the contrary, wherever glaciation is found, the proofs are not wanting that it is due to ice which moved down-hill northwardly. The Cobequids have been uplifted largely, some parts perhaps wholly, since the Middle Carboniferous age, and certain portions of the sandstone strata have been raised with them. Extensive and deep-seated denudation has removed these strata, except very small patches on the flanks, and scattered boulders of sandstone among the local debris on the summit, which still exist there. Wherever the debris showed ice action, it was found that the sandstone boulders were glaciated similarly to those belonging to the crystalline series underneath, this glaciation, I take it, being all due to local land-ice.

On Cobequid Mountains.

Boulder-clay occurs in low, rolling, or lenticular-shaped mounds near the coast of Northumberland Strait in Cumberland county, Nova Scotia, and Westmoreland county, New Brunswick. These often have a thickness of ten to twenty feet or more. Back from the coast here the boulder-clay, as a rule, becomes thinner and more sporadic in its distribution. Along the northern slope and base of the Cobequids, it is only here and there that it is to be seen, long stretches of the slope being covered with residuary material. On the summit, however, it

Boulder-clay, mode of occurrence.

occurs in sheets of limited extent, local glaciers having apparently had gathering grounds there.

Boulder-clay on Carboniferous area of New Brunswick.

Heavy beds of boulder-clay occur upon the Carboniferous area of New Brunswick which appear to be thickest in the valley of the Northwest and Southwest Miramichi rivers. These valleys, which are pre-glacial, were in the glacial period pretty nearly filled with boulder-clay, containing a large proportion of transported materials, often including boulders from five to ten feet in diameter derived from the pre-Carboniferous rocks to the west. The valleys have since been deeply eroded by the rivers, and the great numbers of boulders lying in them are such as have been exposed in this way. In general there are a greater number of boulders in the lower portions of the valleys than along their upper reaches, which is mainly due to the fact that erosion has been greater there. The beds of these rivers may be compared to an inclined plane, the upper parts being nearly as high as the general level of the country, or of the boulder-clay filling each valley, while the lower portions have been cut down more deeply into it. For example, along the upper parts of the Little Southwest, Renous, Dungarvon, Main Southwest Miramichi rivers, etc., flowing through the Carboniferous plain, the terraces and banks inclosing them become lower and lower with respect to the rivers' bed as we ascend, and it is evident that the rivers flowed at higher levels in early post-glacial times, probably upon surfaces very nearly as high as the general level on both sides of their present valleys. Indeed it would appear that in some places their waters must, at that stage, have diverged from the valleys and inundated certain tracts on either side, remodelling the boulder-clay and transporting boulders. The upper portion of the Renous River then flowed into the Little Southwest by a wide valley along the western margin of the Middle Carboniferous. May not the wider distribution of gravels and clay and the scattering of boulders over the surface of the Carboniferous area have been at least partially accomplished in this way? It would seem that in early post-glacial times, as these rivers debouched from the mountains or higher grounds of the pre-Carboniferous region to the west upon the plain, they spread their waters over the level country by many devious routes, until after a time they became confined to one particular valley. At the present day, they flow along their lower reaches in deep trenches of greater or less width cut into banks of boulder-clay which, in early post-glacial times, filled their valleys to the brim. This feature is especially noticeable along the Miramichi rivers referred to.

Towards the coast of Northumberland Strait, near Miramichi River, the boulder-clay, unlike that of Cumberland county, becomes thinner and more sporadic and in many places is underlain by rotten rock *in situ*.

The western part of Prince Edward Island is covered pretty extensively with boulder-clay in which pebbles and boulders from the crystalline rocks of central New Brunswick and a few from the Middle Carboniferous are embedded. The debris of Millstone grit also occurs in some localities intermixed with the boulder-clay. On the higher grounds of the central part of the island, the superficial beds consist largely of residuary material often from ten to twenty feet in thickness.

Where heaviest beds of boulder-clay occur in P. E. Island.

The heaviest beds of true boulder-clay in Prince Edward Island occur on the coast. Banks of it from ten to twenty feet thick may be seen near Cavendish and Cape Turner, also on the south-west coast near Cape Traverse. Overlying these and strewn over the coast districts, especially on the north-east side of the island, occur a number of boulders, in addition to those transported from New Brunswick, which do not seem related to any of the rocks of the region under examination. How these reached there is a problem. At present it is supposed they have been borne thither by floating ice.

Very interesting deposits of boulder-clay were met with along the north-west coast of the Bay of Fundy, some of which have been described in previous reports.*

Magdalen Islands without boulder-clay.

On the Magdalen Island, a few small crystalline boulders were observed on the north-west sides of Amberst and Grindstone islands; but whether transported, or derived from the central crystalline hills of each could not be determined in the limited time at my disposal. It is not improbable they were borne thither by floating ice when these islands stood at a lower level, though none were found in the sand beaches of the recent period. As stated already, no boulder-clay was found on the four largest islands of the group, viz.: Amherst, Grindstone, Entry and Alright.

Intercalated beds in boulder-clay.

In the study of the boulder-clay of the region, particular inquiry was made in respect to the occurrence of intercalated beds of clay, sand or gravel, or whether there were any other facts tending to show a division of the glacial deposits. Except at Saint John, New Brunswick, however, none were found. The origin of the deposits there has been explained as simply due to local oscillations of the ice-front in a subsiding area, with the margin, for part of the time at

*Annual Report Geol. Surv. Can., Vol. IV., (N.S.) 1888-89. Part N. Bulletin Geol. Soc. of America, Vol. IV., pp. 361-370.

least, *i.e.*, during the local advances, extending some distance beyond the then existing coast line.

In a number of localities where the boulder-clay exceeds a thickness of eight to ten feet, the upper and lower parts exhibit the differences due to oxidation and non-oxidation. A deposit of this kind occurs at Alma, Albert county, New Brunswick,* and similar examples were noted at other localities, showing the upper portion of the boulder-clay to be oxidized, while the lower portion consisted of bluish-gray, compact till. No intercalated beds were observed, however, along the line of demarkation between the oxidized and non-oxidized portions, and the inference is, therefore, that the whole mass is really one bed, the chemical change in the upper portion having taken place since its deposition.

Glacial Striæ.

Glacial striæ.

The following list of striæ, embraces all that have been discovered in the district referred to in this report. An attempt is here made to differentiate those produced by the ice at the period of its maximum extension from the striæ formed when it was diminishing and retireing, the movements at the latter stage having been apparently more local and affected to a greater extent by the minor inequalities of the surface. There are, however, a considerable number of striæ which it is difficult, if not impossible, to correlate in this way, or to assign to any particular stage of the glacial period.

Striæ produced by floating ice, or ice-packs, have been found in a number of places along the coast. These will be placed in a separate group.

The bearings of the striæ are in every case referred to the true meridian, and the elevations to mean tide-level.

Striæ produced at maximum extension of the ice.

Striæ Supposed to have been Produced at the Maximum Stage of Glaciation.

Albert County, N.B.

In Albert Co., N.B.

1. In Dawson settlement, S. 44° E. and S. 57° E. Stoss side to the N.W. Height, 430 feet.

2. On upper cross-road leading from Weldon Creek to Turtle Creek, part of it west of sheet No. 4 N.W., S. 52° E. Stoss side N.W. Height, 225 feet.

3. South of Mary's Point quarry, S., S. 8° W., and S. 16° W.

*Annual Report Geol. Surv. Can., Vol. IV., (N.S.) 1888-89, pp. 24-25 N.

4. A short distance south of road running out to Mary's Point, S. 8° E., S. 10° W., S. 23° W., S. 28° W. and S. 33° W. Distinct and well defined. Slope to N. Height, 110 feet.

5. Still further south, on same road, S. 25° W.

6. Half a mile north of Little Ridge cross-roads, on shore road, S. 7° E., S. 23° W. and S. 28° W.

7. On road to Cape Enragé, about one mile from Cape, S. 23° W. Steep slope to E. Height, 150 feet.

8. Half a mile east of Albert (Hopewell Corner) on Crooked Creek, S. 23° W. Height, 340 feet.

9. Going south from Albert (Hopewell Corner), on cross-road leading towards New Ireland, S. 28° W. Obscure.

10. On road going up from Riverside, through Caledonia settlement (at bend of road), S. 23° W. Height, 770 feet.

11. On road from Riverside, going through Caledonia settlement before reaching cross-road leading towards Albert Mines, S. 2° E., S. 8° E. and S. 12° E.; a short distance beyond, S. 4° E. and S. 12° E. On other exposures near by, S. 2° E., S. 7° E. and S. 3° W. Distinct grooves. Height, 1,120 feet.

12. Further north, at extreme height on this road, a small exposure exhibits, S. 6° E. Height, 1,230 feet.

13. South of Woodworth settlement, one mile above cross-roads, S. 18° W. and S. 23° W. Slope, S. Height, 500 feet.

14. At the top of the hill further up, on same road, S. 18° W., S. 28° W. and S. 30° W. Exposure here shows southward ice-movement very clearly. Height, 590 feet.

15. In Sawmill Creek valley, 2½ miles south of Hopewell Hill, S. 8° W. Height, 500 feet.

16. At upper cross-road, on west side of same valley, S. 7° E. Slope E. Height, 950 feet.

WESTMORELAND COUNTY, N.B.

17. About half a mile north of Catamount siding, I.C.R., in a gravel cutting (perhaps on a boulder),* N. 79° E. Very few signs of glaciation on watershed here. n Westmore and Co., N.B

18. At Boudreau quarry, S. S. 8° E., S. 9° E., S. 13° E., S. 12° E., S. 22° E., S. 24° E., S. 1° W., S. 8° W., S. 11° W., S. 28° W., and S. 38° W. Height, 420 feet. Great ledges striated. Courses persistent.

*The striated boulders noted in this list are such as the ice has apparently ground over while they were held in the boulder-clay, *i.e.*, embedded in it, the striæ being in the same direction as those upon the rock surfaces in the neighbourhood. Such occurrences are common in the Carboniferous areas of New Brunswick, Nova Scotia and Prince Edward Island.

19. On slope facing Petitcodiac River, S. 7° E., S. 12° E., S. 22° E. and S. 38° W. Height, 100 feet.

20. On opposite slope, facing Memramcook valley, S. 2° E., S. 12° E., S. 32° E. The S. 2° E. and S. 12° E. striæ are well defined and abundant. Height, 250 feet.

21. On hill near Dorchester Cape, on road leading from Dorchester to Grand Anse, S. 2° E., S. 8° W. The S. 2° E. set deepest. Stoss side to the N. Height, 300 feet.

22. Along Intercolonial railway, east of Dorchester, five or six miles, S. 2° E., S. 5° E., S. 9° E., S. 14° E., S. 3° W., S. 5° W., S. 8° W., S. 12° W., S. 14° W., S. 20° W., S. 28° W. and S. 42° W. The S. 8° W. striæ are the most abundant, covering the whole surface in parallel lines. Stoss side, N. Height, 100 feet.

23. At Second Westcock, half a mile south of forks on road, S. 2° E. and S. 8° W. Stoss side, N. Height, 320 feet.

24. On westernmost road leading from Second Westcock to Petitcodiac River, about two miles from forks, S. 2° E. Height, 250 feet.

The S. 2° E. course is seen to be remarkably persistent on the ridges at the head of Chignecto Bay.

25. Below Peck's Cove, S. 16° W. and S. 28° W.

26. West of Westcock, on road running south-west in centre of Maringouin peninsula, S. 33° W. Height, 150 feet.

27. Two miles west of Four Corners, on Beech Hill road, S. 2° E. Height, 250 feet.

28. Going out from Sackville by road leading towards Colonial Copper Mine, after passing third brook, S. 8° W. and S. 10° W. Height, 70 feet.

29. South of Colonial Copper Mine, on road coming from Sackville, S. 8° E. and S. 12° E. Height, 353 feet. Further west beyond road crossing, S. 1° W. and S. 18° W. Height, 320 feet.

30. On road leading from Memramcook Valley to Beech Hill road S. 2° E. and S. 8° W. The S. 2° E. set heaviest. Height, 300 feet.

31. On summit of ridge behind Memramcook, S. 18° E. Height, 320 feet.

32. On first east-and-west road north of Rockland station, I. C. Ry., about two miles from Memramcook River, S. 7° E. and S. 12° E., further east, additional sets, S. 17° E. and S. 19° E., and in a third locality near by, S. 4° E. Height, 280 feet. Slope to north. Ice movement apparently southward.

33. At a railway cutting a mile and a half east of Midgic station, New Brunswick, and Prince Edward Island railway, S. 54° E., N.

78° E., and N. 88° E. The N. 78° E. set most numerous and distinct. Height, 160 feet.

34. Near the north end of the Tantramar marsh, on the south-east side of the last mentioned railway, S. 28° W., S. 34° W., and S. 38° W. Slope south-west towards marsh. Ice doubtless moved in that direction. Height only a few feet above the marsh surface.

35. At Westcock, S. 8° W., and at Wood Point quarry, S. 18° W., S. 33° W., S. 43° W. and S. 48° W. Stoss side N. Height, 90 feet.

Northumberland County, N.B.

36. At east branch of Barnaby River, along I.C.Ry. track, N. 86° E. Stoss side W. Height, 207 feet. In Northumberland Co., N.B.

In another place, at first brook south of east branch, Barnaby River, N. 88° E., N. 78° E., N. 76° E., and N. 68° E. Stoss side distinctly W. Height, 250 feet.

37. About one-fourth of a mile north of Rogersville station, I.C.Ry., near end of road going eastward, S. 73° E., N. 86° E. and N. 82° E. Stoss side west. Height, 230 feet.

On this cross-road, near head of Bay du Vin River, S. 82° E., S. 87° E. and N. 88° E. Slope S. W. Height, 280 feet.

38. Half a mile south of east branch of Barnaby River, along I. C. Ry., N. 78° E. and N. 88° E., and in another place, S. 77° E., E. and N. 83° E. Latter heavy. Stoss side W.

39. Two or three miles west of Rogersville station, I.C.Ry., S. 84° E., and S. 78° E. Height, 322 feet.

40. In gravel and rock cutting just north of Rogersville station, I.C. Ry., S. 86° E. Stoss side W. Height, 298 feet.

41. One mile north of Acadieville station, I.C.Ry., N. 59° E. Stoss side W. Height, 290 feet. Boulder clay three to five feet deep on ledge.

42. About a quarter of a mile north of Kouchibouguac River along the I.C.Ry., N. 84° E. and N. 89° E. Stoss side W. Height, 278 feet.

43. Half a mile east of Indiantown, Southwest Miramichi River, on west side of Canada Eastern railway, S. 82° E. and S. 88° E. Near tide level.

44. At Indiantown brook bridge, S. 88° E., S. 86° E., S. 83° E, and S. 78° E. The S. 88° E. set is the most numerous and heaviest.

45. On north bank of Southwest Miramichi River, 135 paces above the mouth of the Renous River N. 87° E. (deep ruts), N. 89° E., N. 68° E., N. 80° E., N. 74° E., N. 73° E., N. 72° E., N. 70° E., and N.

62° E. These striæ have the stoss side distinctly to the W. Height, 10 to 15 feet.

46. Two miles above Derby on the south side of the river, N. 70° E., N. 58° E. These striæ, also later ones produced here, show the influence of the valley of the S. W. Miramichi upon the ice-movement.

47. Along the Canada Eastern railway, at first highway crossing east of Blackville, N. 88° E., S. 82° E. and S. 74° E. Slope to N. E. Height, 50 feet.

48. One to two miles above mouth of Renous River on south-east side of S. W. Miramichi River, S. 74° E., S. 67° E., S. 62° E. and S. 52° E. The S. 74° E. set heaviest. Slope N. W. towards river. Height, 70 feet.

49. One mile east of last place of observation, at bend to south in river, N. 88° E., S. 84° E. and S. 74° E. Height, 40 feet.

50. Five miles and a half below Blackville, on the south-east side of the Southwest Miramichi River, N. 88° E., S. 84° E. and S. 74° E. Land slopes to S.W. Height 55 feet.

51. On Cain's River, on N. side of first big bend above Six-Mile brook, due E., S. 82° E. and S. 72° E., Striæ light. Stoss side W. Height, 128 feet.

52. A short distance below the branch of Dungarvon River coming in from Dungarvon L., in rivers' bank, N. 70° E., Stoss side W.

53. On N. side of S. W. Miramichi R. one mile below Boiestown, N. 68° E. Height, 260 feet.

Queen's County, N. B.

In Queen's Co., N.B.

54. Half a mile E. of Castaway brook, on Salmon River road, N. 78° E. and S. 72° E.

55. Along Gaspereaux River, 7 miles from its mouth, S. 54° E.

56. On west side of Gaspereaux River and half a mile above third brook from its mouth, fine distinct striæ, S. 56° E., S. 58° E., S. 62° E., S. 66° E., S. 67° E. and S. 72° E. Slope S. W. Height, 160 feet.

Kent County, N. B.

In Albert Co., N.B.

57. Between St. Anthony's station and Little Buctouche River, along, Moncton and Buctouche Ry.,' N. 59° E. Height 195 feet. Several other sets here veering towards the N. indicate swerving ice movement during melting period.

58. In Macdougall settlement, one mile from railway station, N. 63° E. and N. 50° E.

59. East of Pelerin settlement, on Little Buctouche River, N. 59° E. Height, 214 feet.

60. On N. side of Shediac Bay, S. 81° E.

61. On N. Side of Shediac River, just west of Richibucto road, S. 81° E.

62. Less than half a mile south of Harcourt station, I.C.Ry., one set, S. 71° E. Others swerving to the north.

62½. In a rock cutting along I.C.Ry., about 4 miles south of Harcourt station, N. 84° E.

CUMBERLAND COUNTY, N. S.

63. On Amherst and Fenwick road, a short distance west of junction with road to Nappan station, I.C.Ry., S. 38° W. In Cumberland Co., N.S.

64. On road leading from Salem to Fenwick, half a mile or so from former place, and just north of first bridge, S. 16° W., Stoss side N.; ledge broken off abruptly on S. side. Height, 450 feet.

65. On road from Fenwick to Baird's brook and thence to Maccan station, I. C. R., on bank of brook, S. 2° E. Stoss side N. Height, 350 feet.

66. A quarter of a mile from Salem, near Leicester cross-roads, S. 18° W. Slope S. Height, 385 feet. Five rods further west, S. 7° E.; still further west, S. 18° W.

67. A mile and a half along Leicester road north of junction with Economy road, S. 62° E., S. 8° W. and S. 26° W.

The last five sets have been produced by ice coming from the watershed on the north, *i.e.* from the Leicester and Maccan heights.

68. On Leicester road, two miles from Economy road, N. 18° E., N. 23° E., N. 26° E. and N. 30° E.

These striæ occur on ledges near the summit of the Leicester heights, but on a northern slope. Land to the south, in immediate vicinity, 50 to 100 feet higher. It seems probable, therefore, that the ice producing these moved northwards mainly by the valley of Shinimicas River. Height, 510 feet.

69. One mile east of last striæ along Leicester road, N. 22° E., N. 23° E., N. 26° E. and N. 28° E. Height, 550 feet.

A few rods to the west of these a good exposure exhibits deep grooves one inch or more in width, N. 8° E., N. 13° E. and N. 22° E. Height, 570 feet.

70. Two and a half to two and three-quarter miles from junction of Little River and Leicester roads, N. 12° W., N. 14° W., N. 18° E., N. 22° E., N. 23° E., N. 26° E., N. 38° E. Height, 380 to 400 feet.

71. On same road at head of Shinimicas River, N. 28° E. Height of ledge, 440 feet.

The ice producing these striæ has also flowed down the valley of Shinimicas River. The stoss side is nowhere well exposed.

72. On going from Leicester road to Oxford by Little River road, on bank of Black River, N. 20° E. or the reverse. Stoss side apparently N. Height, 150 feet.

73. On short cross-road to north-west, three miles south of Mount Pleasant, course N. 18° E., N. 21° E. and N. 23° E, or the reverse.

74. On first cross-road to west on road leading from Oxford to Mount Pleasant (may be on a boulder) N. 8° W. or the reverse. Stoss side apparently north. Height, 270 feet.

The last three sets are on a southward slope, Mount Pleasant being to the north.

75. Along semi-circular road on west side of Mount Pleasant, S. 8° W. and S. 24° W. and a few paces further north, S. 12° W. and S. 32° W., or the reverse. Stoss side apparently to the north. Height, 380 feet.

These striæ are on the south side of the summit of Mount Pleasant, and it seems probable the ice may have moved in the direction indicated into Little River and River Philip valleys.

76. On the north side of the summit of Mount Pleasant along the straight road going towards Leicester road, N. 8° E., N. 7° E., N. 10° E., N. 12° E., N. 3° E., N. 13° E., N. 20° E., N. 2° W., N. 8° W. and N. 12° W., or the reverse.

These striæ are all on the slope of Mount Pleasant facing Northumberland Strait. The finely glaciated surfaces exhibited along the roads mentioned, do not enable us to decide the question of the stossing ; on a few of the ledges the stoss side seems to be to the north, and on others to the south. The glaciated surfaces slope northwards from 400 to 280 feet, and the uppermost ledges show, generally speaking, the southern faces stossed, (one is clearly rounded, and the northern face abruptly broken off) while the lower are mostly doubtful. Curving striæ are a common feature on these ledges. The two main courses are the N. 8° E. and the N. 8° W. ones, the latter being those in which the principal curved striæ occur. The N. 8° W. set is the older and deeper.

77. On the east side of Mount Pleasant on the cross-road going direct to River Philip, N. 14° E. and N. 24° E., or the reverse. Height, 360 feet. Slope, northward.

78. On a cross-road one mile south of Mount Pleasant (not on map) which runs westward from the Oxford and Mount Pleasant road, S.

12° W. and S. 18° W., or the reverse. Stoss side, apparently north. Height, 360 feet.

Glaciation of Mount Pleasant.

Viewing the glaciation of Mount Pleasant, as a whole, it seems possible to explain it by supposing the summit to have been a local glacial centre; indeed, the evidence rather points in that direction. The course of the ice northward would take it to the nearest and lowest part of the coast, just west of Pugwash harbour. These striæ, however, run diagonally across the northern slope of Mount Pleasant, and the ice which produced them must, therefore, have been influenced, to some extent, by the valley near its northern base which trends in the direction of the striæ. Were it not for the difficulty of explaining a southward ice-movement here, I would be inclined to say that the whole mountain had been glaciated by ice which came from the north. Whether the ice which produced the easterly-trending striæ in the coast district east of Mount Pleasant, described below, received an impetus from the higher grounds of Leicester road and this mountain, is a question that may be answered in the affirmative. And the evidence seems, further, to indicate southward movement off the Mount Pleasant slopes locally.

79. On the south-east side of River Philip, just below the cross-road leading to Conn's Mills, S. 85° E. Stoss side to the W. Height, 190 feet.

80. About 200 yards west of Pugwash Junction, Oxford and Pictou Branch railway, S. 73° E. and S. 75° E. Stoss side, W.

81. On another rock cutting near Pugwash Junction S. 68° E., S. 76° E., S. 77° E. and S. 82° E. Height, 60 feet.

82. On the east side of Pugwash harbour, on boulders and ledges, due E. and S. 68° E.

83. A mile west of cross-roads, which are two miles north of Thomson station, Intercolonial railway, (perhaps on boulder), N. 73° E. Height, 275.

84. At Mackenzie Point, north of Wallace harbour, S. 62° E., S. 67° E., S. 72° E., S. 74° E., S. 77° E., S. 82° E. and S. 84° E.

These striæ extend along ledges on the shore a distance of 400 to 500 feet, and are well marked.

85. Half a mile south of Wallace village, S. 77° E. Height, 165 feet.

This set is noteworthy as exhibiting older and deeper striæ, then later striæ trending nearly N.

86. On east side of Wallace River, a quarter of a mile north of six mile road (on boulder ?) N. 72° E. Height, 80 feet.

87. At Wallace quarry, S. 83° E., very distinct and numerous, also S. 72° E. The overlying boulder-clay is from five to ten feet deep and contains none but local boulders.

88. On road from Wallace quarry leading straight southward to Deware River, near brook, due E. and S. 72° E.

89. On east-and-west road, north of Scott's Lake, S. 87° E. Slope S. Height, 90 feet.

90. Half a mile north of cross-roads, at Hornsey, S. 82° E. and due E. Slope, S. Height, 150 feet.

91. About two and a half miles east of Wallace station, Oxford and Pictou railway, at a rock cutting, S. 84° E. and S. 86° E. Stoss side, W. Height, 175 feet.

92. About three miles east of Wallace station, O. and P. Br. railway, E., S. 86° E, and S. 88° E. Height, 150 feet.

93. About two miles west of Wallace station, N. 78° E.

94. On east bank of Wallace River, just above railway bridge, S. 72° E., S. 82° E. and S. 83° E. Stoss side distinctly W.

95. On Economy road, west of Westchester, on N. slope of Cobequids (on boulder ?) N. 2° W., or the reverse. Height, 689 feet.

96. On short east-and-west road, a mile, or a mile and a half, south of Purdy's Inn, Westchester, S. 2° E., or the reverse. Stoss side apparently N. Height, 967 feet.

97. On Castlereagh road, half a mile from north end, S. 2° E.

98. Three miles south of Sutherland's Lake, on south-easternmost road, S. 2° E. Stoss side, N.

99. On Economy road near fourth brook crossed west of Thomson station, Intercolonial railway, and Williamsdale road, N. 73° E. Height, 300 feet.

100. On road south of Folly Lake, near border of sheet (No.4 N.W.), S. 2° E., S. 22° E., and S. 27° E. Stoss side, N. These striæ are on the southern flank of the Cobequids. Height, 650 feet.

101. A few rods further north on the same road, S. 4° W.

102. On a hill on same road further north and near water-parting, S. 22° E. Course of ice here nearly in direction of valley. Height, 725 feet.

On a hill between this and Folly Lake, and slightly higher there are no signs of glaciation.

103. At first cross-road north of Westchester (Purdy's Inn), N. 2° W., or the reverse. Probably on boulder.

104. On Economy road just north-east of Claremont Hill, S. 62° E., S. 78° E. and S. 82° E. Height, 120 feet.

105. On road from Springhill to Salt Springs on eastern slope of hill, N. 2° W. or the reverse. Stoss side apparently to the N., but all things considered it seems probable that the ice moved northward. Height, 310 feet.

106. On cross-roads south-west of River Philip P. O., N. 6° E. Stoss side S.

107. On summit of Springhill, highest point, S. 28° W., or the reverse. Height 610 feet.

108. At Springhill near Coal Mines Creek, on east side of railway track, S. 11° W. A short distance further east, S. 13° W. and S. 26° W.

109. Two miles south of Springhill Mines on road going directly southward ending at branch of Upper Maccan River, and at last cross-road before reaching river, S. 11° W. Height, 300 feet.

110. On road near Intercolonial railway west of Athol station, S. 28° W., S. 38° W and S. 40° W. Stoss side distinctly to N.E. and ledge broken off abruptly to S.W. Height, 150 feet.

111. Going along Upper Maccan River towards Southampton about two miles from end of Mapleton road, S. 68° W., S. 48° W., S. 36° W., and S. 33° W. The S. 68° W. striæ are the oldest and are nearly obliterated. Stoss side not distinct, but appears to be to N.E.

112. On southernmost cross-road in West Brook settlement, light and irregular striæ S. 28° W. Stoss side N.E. Height 350 feet.

A short distance further west on the same road, S. 8° W. to S. 38° W. Stoss side N.E.

Glaciation of northern slope of Cobequids.

These striæ have been produced by a very small local glacier, or a tongue of the larger one which followed a small valley opening into the larger valley of West Brook. The ice producing them does not appear to have ascended the Cobequid Mountains, for, at greater elevations on their northern slope no sign of glaciation was observed, the material being angular, the rock surfaces wherever exposed, jagged and broken, indicating subærial weathering only, while boulder-clay and other evidences of glacier action are absent.

113. Along West Brook between two cross-roads and about two miles from the Springhill and Parrsboro' railway (on a boulder *in situ*) S. 58° W.

The three last sets of striæ show that ice from the Springhill district impinged against the northern base of the Cobequids here, but does not seem to have been higher than the 400-foot contour line above sea-level. From this district the ice flowed south-westward filling the inequalities of surface along the northern base of the mountains reaching up the Parrsboro' gap some distance, but does not seem to have gone through. How far westward along the foot of the mountains the ice extended is not known, as the surface is heavily covered with superficial deposits and no glaciated surfaces were noted.

114. On road from Halfway Lake to Southampton, half a mile out on cross-road on N. W. side, S. 46° W. Height, 180 feet.

115. In Parrsboro' Pass, through which the Springhill and Parrsboro' railway runs, just south of border of sheet (No. 4 N. W.) faint striation S. 12° E. Stoss side apparently to the N.

The latter striæ have been produced by the extreme southern end of the ice lobe which flowed south-westward and southward along and towards the northern base of the Cobequid Mountains here, from the Springhill district and other higher grounds to the north-east, as referred to above.

115½. On road along N. side of Minas Channel, near Spencer's Island, S. 67° W. and S. 70° W.; well defined. Stoss side apparently to the E., ice having doubtless moved westward into the Bay of Fundy.

116. On the road leading from Maccan station, Intercolonial railway, to River Hebert, near Patrick Mine, S. 23° W. and S. 40° W. May be local. Height, 175 feet.

117. On southerly road going from Lower Cove or Boss Point, north of the South Joggins towards River Hebert, two miles out from quarry, and on the east side of the watershed, S. 18° W., S. 26° W. and S. 38° W. Stoss side doubtful. Height, 210 feet.

118. Eighty rods further east on same road, S. 23° W. and S. 33° W. Height, 180 feet.

119. On road going from River Hebert to South Joggins, half a mile from river, S. 62° W. and S. 63° W. Height, 150 feet.

Ice producing these clearly moved south-westward.

120. On the coast of the Bay of Fundy, just south of Two Rivers, S. 33° W., S. 38° W., S. 43° W. and S. 48° W. Height, about 100 feet.

121. Two miles further south, before crossing a brook, S. 36° W., S. 38° W., S. 42° W., S. 53° W. and S. 58° W. Height, 200 feet.

122. Half a mile south of last brook referred to, which is about half way between Two Rivers and Flat Brook, S. 40° W. Height, 100 feet.

123. A quarter of a mile further to the south-west, distinct striæ, S. 38° W. and S. 41° W. Height, 50 feet.

124. Five rods further to the south-west, S. 48° W.

125. Half a mile beyond Flat Brook, S. 43° W. and ten rods further to the south-west, S. 48° W. and S. 51° W. Height, 60 feet.

Eighty rods further to the south-west, S. 40° W.

126. One and a half miles north-east of Shoulee River, S. 43° W. and S. 48° W. Stoss side on N.E. Height, 100 feet.

127. On slope towards Sand River and about one mile from it, S. 33° W. and S. 38° W. Height, 210 feet.

128. Two miles south of Sand River road, S. 30° W., S. 27° W. and S. 33° W. Height, 350 feet.

In another place a quarter of a mile further south, S. 28° W.

Ten rods further to the south-west, a splendid exposure, S. 30° W. and 33° W. Height, 350 feet.

129. Half a mile or more further south, S. 33° W. and S. 35° W. and still further to the south-west, S. 33° W., S. 28° W., etc., numerous. Stoss side to N.E. Height, 380 feet. Small projections on glaciated surfaces of the sandstones with crag-and-tail form, show southward ice-movement. A perceptible vëering to more southerly courses is apparent as we ascend the slope of the Cobequids, which is remarkable, and can only be explained on the hypothesis that Chignecto Bay was filled with a local glacier moving south-westerly, whose south-eastern border overlapped the district in which these striæ occur.

Prince Edward Island.

130. At Linkletter's shore, on flat surface, under boulder-clay, distinct striæ, N. 67° E., N. 74° E. and N. 76° E. Stoss side to W. In P. E. Island.

131. Along Prince Edward Island railway track, south-east of Kensington station, N. 71° E. Stoss side W. Height, 116 feet.

132. Along Cape Traverse railway, about one mile from Emerald Junction, N. 75° E. and on another ledge near by, N. 67° E. Stoss side W. Height, 130 feet.

133. One to one and a quarter miles north of Kinkora station, N. 85° E. Stoss side W. Height, 100 feet. From two to five feet of boulder-clay overlies the rock surface, and contains numerous glaciated boulders, all local.

134. Half a mile north of Albany station, S. 78° E. and N. 82° E. Height, 125 feet.

135. South of Albany station, on boulder *in situ* in a gravel pit, which fits into position in a ledge, S. 79° E. and N. 83° E. Height, 80 feet.

136. At Breadalbane station, Prince Edward Island railway, 131 feet high, N. 69° E.

137. Two miles west of Hunter River station, N. 89° E., N. 73° E. and N. 72° E.

138. Where a road crosses railway track about half-way between Hunter River and North Wiltshire stations, S. 87° E., N. 89 E°., N. 85° E., N. 83° E. and N. 79° E. The N. 89° E. striations numerous. Height, 210 feet.

The ice producing these striæ has followed valleys along which the railway runs. The glaciation of the higher grounds in this part of the island has been light, as great masses of rotted rock occur in places.

139. A quarter of a mile east of cross-roads, South Wiltshire, on a small exposure, sloping eastward, N. 82° E. Height, 280 feet.

140. At the end of road between Platt River and Bentick Cove, N. 67° E., N. 85° E., etc.

141. Three quarters of a mile to east of County Line on New Bedeque road, N. 69° E. Height, 200 feet.

142. West of intersection of County Line and New Bedeque roads, N. 77° E. Height, 210 feet.

143. At intersection of above roads, N. 77° E., N. 88° E. and N. 62° E. Height, 250 feet. Slope N.W.

144. North-east of Middleton where road crosses branch of Dunk River, N. 71° E., N. 67° E. and N. 77° E. Height, 55 feet.

145. On Southwest road, one mile and a half south of New Bedeque road, S. 88° E. Height, 150 feet. Slope S.

146. Ninety or one hundred rods east of junction of Southwest and New Bedeque roads, N. 87° E. Height, 170 feet. Slope W.

147. Fifty rods west of County Line on cross-road, one mile N. of Tryon, N. 69° E. Height, 100 feet. Slope, W.

148. Near end of road, N. of Bentick Cove, N. 77° E. Tide level. A few rods further W., N. 67° E.

149. A quarter of a mile east of ferry over Ellis River, N. 67° E.

150. On west side of Sable River bridge, N. 73° E., N. 63° E. and N. 77° E.

151. On east side of Sable River on road to Bonshaw, N. 77° E. Height, 170 feet. Slope W.

152. A quarter of a mile east of Cape Traverse, S. 73° E and S. 71° E.

153. At Point, Cape Traverse, S. 73° E.

154. West of Cape Traverse, S. 71° E.

155. A few yards further west, S. 63° E. and S. 68° E. Still further west, S. 68° E., N. 77° E. and S. 81° E.

156. West of Cumberland Point, S. 75° E. and S. 81° E. On another exposure a short distance to the west, N. 72° E. and S. 67° E. Still urther west, S. 71° E., S. 73° E. and S. 79° E.

157. East of Cumberland Point, N. 73° E. and S. 67° E.

Half a mile further west, S. 73° E.

158. Near small brook one mile and a half north of Tryon Head, S. 85° E. Height, 20 feet.

159. At end of short road west of Paul's Bluff, N. 87° E.

160. At junction of Bedeque road with east branch of Tryon River, S. 85° E., N. 89° E. Height, 20 feet.

161. On west side of Augustine Cove, a quarter of a mile west of small brook, S. 73° E., S. 68° E., S. 81° E. and S. 85° E., distinct.

162. On road east of Albany, ten rods north of Tryon River, N. 87° E. Slope, S.E. Height, 75 feet.

163. At point west of Gordon Cove, S. 63° E., S. 68° E. and S. 55° E.

164. At Boquet Point, S. 81° E , S. 73° E. and S. 63° E.

On another exposure, S. 68° E., S. 76° E., S. 63° E. and S. 79° E. There are two main courses, S. 68° E. and S. 79° E. A little further east, S. 63° E. and S. 73° E.; and still further east, S. 83° E. and S. 63° E. The latter are a quarter of a mile east of Boquet Point.

165. On ledges below high tide level, one mile west of railway wharf, Cape Traverse, S. 81° E., S. 78° E. and S. 55° E.

166. North of Gordon Cove, S. 71° E., S. 68° E. and N. 87° E.

167. At Sea Cow Head, S. 68° E. and S. 81° E. Height, 5 feet.

168. East of Indian Point, N. 87° E.

169. At Simpson's Point, north of Hope River, S. 82° E., S. 86° E., S. 78° E. and S. 89° E. Peculier grooves indicate eastward movement. Height from three feet below high tide level to four feet above it. An excellent exposure.

170. Near head of Trout River, S. 88° E. and N. 80° E. Stoss side, W. Height, 105 feet.

171. Where Millvale road bends northward down Trout River, S. 83° E. Height, 110 feet.

172. New London Bay, one mile north of Stanley Bridge, S. 78° E., S. 68° E., S. 85° E., S. 83° E., S. 73° E. and S. 88° E. Height, from tide level to four feet above it.

173. Old Prince Town road, forty rods north of Margate, N. 65° E. Height, 60 feet.

174. A quarter of a mile north of road end, Mill's Point, N. 67° E.

174. At Mills Point at end of road, N. 65° E.

175. In Malpeque Bay, near end of road west of Mill Creek, N. 75° E., N. 71° E., N. 67° E., N. 79° E., N. 81° E., N. 77° E., N. 69° E., N. 57° E. and N. 59° E. Near high tide level. Striæ numerous and extending across 46 paces of rock surface.

176. Seven hundred and seventy paces west of last mentioned road end, N. 83° E., N. 51° E., N. 40° E., N. 67° E., N. 41° E., N. 65° E., and N. 87° E.

177. North of St. Peter's Bay, near railway station, N. 87° E.

178. On S.W. side of St. Peter's Bay, west of railway station, N. 84° E. Boulder-clay plentiful.

Striæ at St. Peter's Bay.

Three sets of striæ occur at St. Peter's Bay, viz., (1) an easterly set which is the oldest, (2) a northward set made by local glaciers flowing northward from the higher grounds of the island towards the Gulf, and (3) a set parallel to the depression occupied by St. Peter's Bay, and approximately parallel to the N.E. coast of the island, produced apparently by floating ice. None of these sets are, however, very well defined.

179. Near Light House at Souris, N. 87° E., and in a railway cutting east of Souris village, N. 79° E.

On another exposure east of village, N. 87° E. and S. 83° E.

New Brunswick ice on P. E. Island.

No transported boulders occur in the boulder-clay here, the whole of the material being local. The inference may be drawn that the glaciation is also local, but this is, perhaps, incorrect. The non-occurrence of foreign material in the eastern part of the island rather indicates that the ice was of local (Prince Edward Island) origin, forming an outlier of the mainland sheet and moved by the impingement of the latter, thus producing the glacial phenomena noted. If the New Brunswick ice itself had passed over the whole island, instead of only over the western half, where we find boulders and other glacial products from the mainland intermixed with the boulder-clay, we should expect to meet with crystaline boulders embedded and intermixed with the deposits here also. Their absence, except on the immediate coast, where they have been left by floating ice, is otherwise not easily explained.

Striæ produced by local glaciers during closing stage of glacial period.

Striœ supposed to have been produced by Local Glaciers, etc., during the later or closing stage of the Ice Age.

ALBERT COUNTY, N.B.

In Albert Co., N.B.

180. At Hopewell Cape, S. 86° E., S. 82° E. in two places, S. 80° E. due E. and N. 88° E., also further N., S. 22° E.

181. A mile N. of Hopewell Cape, N. 82° E.

182. At Mary's Point quarry, several striated exposures, S. 2° E., S. 3° W., S. 22° E., S. 32° E., S. 37° E. and S. 46° E. Heaviest striæ or grooves, S. 22° E.

183. At point where Cape Enragé road branches off to the east, S. 52° E., S. 62° E., S. 77° E., S. 82° E., due E., N. 78° E. and N. 80° E. Height, 190 feet.

184. Near mouth of Demoiselle Creek, S. 2° E. Stoss side N. Slope, E. Height, 170 feet.

185. At Jasper Creek, on cross-road from Demoiselle Creek to Sawmill Creek, S. 2° E. and S. 1° W. Slope towards E. Height, 580 feet.

On same road further up hill, at height of 610 feet, where slope is towards the N, S. 4° W.

186. On road going west from Curryville, S. 12° E., S. 20° E. Slope, E. Height, 400 feet.

On another good exposure here, S. 19° E. and S. 22° E.

On the same road a little further eastward down the slope, S 20° E., S. 12° E., S. 2° E., S. 8° W., S. 18° W. and S. 28° W.

Twenty feet from this exposure another exhibits, S. 32° E., distinct. Slope, E. Height, 300 feet.

Westmoreland County, N.B.

187. In Weissner settlement, on bank of Bateman's brook, N. 49° E. Flat exposure. Height, 90 feet. In Westmoreland Co., N.B.

188. Along I.C.Ry. track between Painsec Junction and Dorchester road-crossing, just N. of Meadow brook, N. 55° E. May be on boulder.

189. At southern base of Lutz Mt. at cross-road, 3 miles east of Berry's Mills station, I.C.Ry., N. 48° E. Height, 300 feet.

190. Near Chapman, on slope towards Northumberland Strait, N. 42° W. Height, 80 feet. May be on a boulder.

Northumberland County, N.B.

191. At the Tickle, junction of N.W. and S.W. Miramichi rivers, just opposite Beaubair's Island, S. 17° E. and S. 20° E. Striæ light. In Northumberland, Co., N.B.

192. On N. bank of S.W. Miramichi River, just above mouth of Renous River, N. 2° E., N. 10° E., N. 22° E. and N. 32° E. Stoss side S.

193. Two miles above Derby on the south side of the S.W. Miramichi River, S. 37° E., N. 28° E., N. 46° E. and N. 43° E.; on another exposure two hundred feet further west, N. 34° E., N. 36° E., N. 40° E., N. 43° E. and N. 46° E. Tide level. The N.E. course seems to have been produced by local ice following the valley of the S.W. Miramichi River here.

194. One to two miles above the mouth of Renous River on the S.E. side of the S.W. Miramichi River, due N. Whole surface of exposure with parallel grooves in this direction. Height, 70 feet.

The two main sets of striæ are well exposed here, one indicating eastward ice-movement, as recorded in No. 45, and the second a later and independent flow northward.

195. Eight miles and a half below Doaktown, along Canada Eastern Ry. track. N. 38° E.

196. Eight miles below Doaktown, along same railway (at 72nd mile post), N. 24° E., N. 30° E., N. 26° E., N. 32° E. and N. 38° E.

197. Five miles below Doaktown, along C.E.Ry., N. 13° E. and N. 28° E.

198. Three and a half miles below same place, along railway, N. 16° E., N. 20″ E., N. 23″ E. and N. 28° E.

The N. 28° E. set most numerous. Height 320 feet.

A few yards further to N.E., N. 18° E., N. 23° E. and N. 33° E.

199. A quarter of a mile above the cross-road at Dunphy's, on the north side of the Miramichi River, N. 24° E and N. 28° E.

200. One to two miles above Blackville bridge in the S.W. Miramichi Valley, in river's bank, N. 12° W. and N. 22° W. These courses are closely parallel to the river-valley here, and may have been produced by river ice.

201. At mouth of Bett's brook, above Doaktown, fine distinct striæ, N. 42° W. (heavy), N. 6° W. and N. 23° E.

202. At Ludlow one mile and a half south of Boiestown, where road and river diverge, on south side of river, N. 42° W., or the reverse.

203. In railway cutting at covered bridge just west of Boiestown, N. 18° E. and N. 28° E. Stoss side, S.W.

204. Along S.W. Miramichi River, on N.W. side of Hayes' brook, N. 28° E., N. 33° E., N. 38° E. and 46° E. Stoss side distinctly S.W. Height, 520 feet. (This is in York county).

Queen's County, N.B.

In Queen's Co., N.B.

205. Along Gaspereaux River, seven miles from its mouth, S. 54° E. Half a mile above the third brook from the mouth of Gaspereaux River, several deep grooves have a bearing of S. 32° E. in addition to more easterly courses. Slope, S.W. Stoss side, N.W. Height 160 feet.

Kent County, N.B.

In Kent Co., N.B.

206. About one mile east of Macdougall station, Moncton and Buctouche railway, on road to Cocagne, N. 18° E., N. 38° E.; and on another surface near by, N. 38° E. Slope, N.W. Height, 130 feet.

PLATE II.—STRIÆ NEAR HARCOURT STATION I.C.R.
(No. 216, List of striæ;) Course N. 9° E. View from south-west side.

207. One mile south of St. Anthony station, M. & B. Ry., a good exposure, N. 52° E.

208. Just west of Cocagne village, on shore, N. 38° E., N. 43° E.

209. Just north of St. Anthony station, Moncton and Buctouche railway, N. 44° E., N. 49° E. and N. 54° E.

210. Between St. Anthony station and Little Buctouche River, along railway track, N. 39° E., N. 49° E., N. 54° E. and N. 59° E. In another place N. 44° E. Height, 195 feet.

211. Just N. of Little Buctouche River, along M. & B. Ry, N. 19° E. and N. 39° E.

212. At border of sheet (No. 5 S.W.) one mile south of Buctouche River, S. 31° E. Height, 90 feet.

213. About two miles from St. Anthony station, M. & B. Ry. going towards Cocagne River, in Ohio settlement, N. 49° E. Numerous and well defined. Stoss side, S.W. Height, 150 feet.

214. On the north side of Shediac Bay, N. 29° E., N. 39° E., etc.

215. 770 yards south of Harcourt station along the I. C.Ry., on one exposure, fine, curving striæ, the general trend being N. 22° W.

216. 990 yards from Harcourt station and just south of last point of observation, great flat exposures occur in gravel pits on both sides of the I. C.Ry. track, with well marked striæ, N. 27° E., N. 17° E., N. 16° E., N. 13° E., N. 11° E., N. 9° E., N. 7° E., N. 6° E., N. 4° E., N. 3° E., N. 1° E., N. 1° W., N. 2° W. and N. 16° W. These striæ have evidently been produced by ice moving northward, but there is no distinct stossing. Height, about 190 feet.

217. About two miles south of Harcourt station, in a rock cutting, N. 3° E., N. 4° E., N. 5° E., N. 9° E., N. 11° E. (heavy), N. 12° E., N. 19° E,, N. 24° N. 29° E., N. 1° W. (numerous), N. 6° W. and N. 21° W. The stoss side is also doubtful here; but several circumstances favour the conclusion that the ice moved northward.

218. A mile and a quarter north of Adamsville station, I. C. Ry, in a rock cutting, N. 1° E., N. 2° E., N. 3° E., N. 4° E., N, 5° E., N. 6° E., N. 7° E., N. 8° E., N. 9° E., N. 11° E., N. 12° E., N. 13° E., N. 14° E., N. 17° E., N. 19° E., N. 31° E., N. 1° W., N. 3° W., N. 6° W., N. 8° W., N. 16° W. N. 33° W. Stoss side not evident; but some facts were observed on the south side of the exposure which show that the ice movement must have been northward.

219. On the south branch of Coal Branch, just east of Intercolonial railway track, in an old quarry, N. 9° E., N. 19° E., N. 29 E., N. 32° E., N. 34° E., N, 39° E., N. 42° E. and N. 49° E. Stoss side distinctly to the S.W. Height, 203 feet.

Remarks on swerving and irregular ice movements.

It will be observed that the courses along the S.W. Miramichi, and the Intercolonial railway at Harcourt, Adamsville, Coal Branch, as well as near the coast between Buctouche and Shediac rivers show similar ice-movements. These striæ, it seems to me, have been produced by the ice during the period of melting or retirement, though a few may belong to the earlier or increasing stage previous to its maximum extension. The finer striæ, however, clearly indicate the later movements, when the ice was breaking up into detached sheets and became diverted more and more from its eastward course as it diminished, the movements becoming more conformable to the slopes, and to the trend of the river-valleys. This swerving is a characteristic and noteworthy feature of the glaciation on the Carboniferous plain north-east of the divide between the drainage basin of the St. John River, and of those rivers flowing into Northumberland Strait.

Cumberland County, N.S.

In Cumberland Co., N.S.

220. North-east of Amherst Head, on a boulder, apparently *in situ*, N. 3° W., or the reverse Stoss side, S. Height, 130 feet.

221. Just west of Fenwick, on an exposure, apparently a boulder, on road side, S. 78° W. and S. 73° W. Stoss side, E. Height, 135 or 140 feet.

222. Near a quarry about a mile east of Amherst, N. 12° W. and N. 22° W. Height about 150 feet.

These striæ have apparently been produced by ice which flowed down upon the low grounds of the Isthmus of Chignecto, or into the Pleistocene sea occupying it as a strait, during the retiring stage of the glacial period.

223. One mile south of Pugwash, on the main highway to Wallace, N. 23° E. Slope to S. Height, 80 feet.

224. On the west side of Pugwash harbour, on boulders and ledges, N. 22° E. and N. 45° E.

225. At cross-roads at Victoria, N. 2° E., N. 10° E. and N. 18° E. Stoss side distinctly to the S. Exposure on N. slope. Boulder-clay abundant. Height, 275 feet.

226. On north-and-south road to south-east of Victoria and between two branches of Wallace River, N. 8° E. Stoss side also distinctly S.

227. In Hansford settlement, two miles along road from River Philip, N. 20° E. and N. 23° E. Height, 250 feet.

228. Near cross-roads, half-way between Coun's Mills and Doherty Creek, N. 48° E. and N. 53° E. Height, 25 feet.

229. On east-and-west road at Howard's Mill and a quarter of a mile from the west end or the junction with the north-and-south road, N. 10° E. and N. 40° E. Height, 150 feet.

230. Half a mile south of Wallace, N. 3° E. and N. 2° W. Height, 165 feet. East-and-west courses on same exposure prove that the S.-to-N. set is the latest.

231. On the N.E. and S.W. road along the upper part of Deware River, N. 8° E. Height, 200 feet.

232. On the second road east of Wallace Lake and north of Deware River, N. 7° W. and N. 12° W. Height, 150 feet.

233. At Wallace quarry, N. 2° W., N. 10° W., also N. 3° E., N. 32° W. and N. 54° W. or the reverse.

234. A quarter of a mile south of Wallace station, Oxford and Pictou Branch railway, N. 3° E. and N. 18° E. Slope N. Height, 90 feet.

235. On the road along DeBert River, near the border of the map, and at the height of 620 feet, S. 2° E. and S. 12° E. These striæ are on the S. slope of the Cobequid watershed.

236. North of the cross-roads to the north of the railway track near Wallace station, Oxford and Pictou Branch railway, due N. Height, 220 feet.

237. Just east of Wallace, on shore, striated ledges occur, N. 8° E.

238. On road going from Plaster Cove east of Wallace, to north side of Scott's Lake, at third cross-road, N. 30° E. Slope E. Height, 170 feet.

239. On the easternmost cross-road from Scott's Lake to the Strait of Northumberland, near shore, (perhaps on boulder), N. 36° E.

240. Near by on same road, another set, N. 12° E. Height, 170 feet.

241. On cross-roads at Hornsey, due N. Slope S. Height 45 feet.

242. South of Head of Tatamagouche, perhaps on boulder, N. 2° W.

243. On Lake road, just about south of Head of Tatamagouche, on boulder, *in situ*, N. 12° E. Height, 270 feet.

244. On road running up south side of Mill Brook, N. 3° E.

245. On road east of Wentworth along Higgins's brook, N. 18° E. and N. 7° W.

246. About two miles west of Wallace station, Oxford and Pictou Branch railway, N. 2° E.

247. On east bank of Wallace River, just above railway bridge, N. 28° E. and N. 38° E. Height, 25 feet.

248. Near border of sheet (No. 4 N.W.), and south of Sutherland's Lake, S. 32° E. Stoss side N. Height, 600 feet.

249. Still further south S. 14° E. and S. 12° E., and a lighter set S. 3° W.

250. A mile and a half to the northwest of Sutherland's Lake, along the road, due S. Slope N. Height, 650 feet.

251. On road going from Westchester station, I.C.Ry. to Acadia Mines and near border of map (sheet No. 4 N.W.), S. 14° E.

252. On Economy road near fourth brook crossed west of Thomson station, I.C.Ry., on Williamsdale road, N. 10° W. Height, 300 feet.

253. On road going west from Westchester station, I.C.Ry., on west side of brook, N. 6° E. Stoss side clearly S. Height, 310 feet.

254. North of Claremont Hill and between it and the I.C.Ry., fine striæ were observed on the roadside, N. 68° E. Stoss side W.

The ice producing these moved down the N.E. slope of Claremont Hill into the River Philip valley.

255. Two miles east of Oxford Junction on N. side of I.C.Ry. track, N. 12° W. Height, 125 feet.

256. North of Rodney, on northward slope, fine but distinct striæ, N. 12° W. and N. 3° E. Stoss side clearly S.

257. On Williamsdale road, half a mile from West Branch, N. 20° E., slope to N. Height, 225 feet.

258. Near Upper Maccan River on Five Islands road, S. 8° W. and S. 12° E., or the reverse. Height, 175 to 200 feet.

259. On road going south from Springhill and Parrsboro' Ry. along Harrison's brook S. 20° W. A mile from the railway, another exposure, S. 27° E. Height, 400.

260. On road which leaves Upper Maccan River road a mile and a quarter west of Mapleton bridge leading southward to a back settlement (South Brook settlement) about two miles up from river, N. 10° W. and N. 32° W. (may be on boulder). Stoss side distinctly to S. Height, 400 feet.

On another boulder near by N. 12° W.

261. On same road and just south of branch of South brook, on gray sandstone *in situ*, N. 6° W. and N. 8° E. Stoss side clearly S.

262. In West Brook settlement on second cross-road three miles south of Springhill and Parrsboro' Ry., S. 12° E., S. 22° E., and S. 18° W., or the reverse. Stoss side N. Height, 350 feet.

263. On cross-road leading north-westward from main road between Halfway Lake and Southampton, S. 12° E. (may be on boulder). Height, 120 feet.

264. On west side of River Hebert, about two miles above bridge, doubtful, S. 7° E. or N. 7° W. Stoss side apparently S.

Prince Edward Island.

265. A mile and a half south of North Cape, on the western coast, N. 52° E., N. 27° E. Height, 20 feet. In Prince Edward Island.

Four rods further south N. 57° E. and N. 47° E. Stoss side distinctly S.W. Height, 20 feet.

266. A quarter of a mile east of Lighthouse, North Cape, N. 53° E., N. 22° E. and N. 27° E. Height, 15 feet. The N. 53° E. set is the heaviest.

267. At Cape Kildare, on several exposures along the shore, S. 11° E., S. 13° E., S. 29° E., S. 23° E. and S. 18° E. Height, 10 feet.

268. On shore at Fifteen Point, S. 10° W. Height, 5 feet.

On road at Fifteen Point, S. 45° E. Height, 20 feet.

269. A quarter of a mile east of ferry over Ellis River, N. 69° E. and N. 50° E. Height, 4 feet.

271. At Linkletter's Point, in two places, under boulder-clay, S. 55° E. Stoss side apparently N.W.

272. At Clifton, east of cross-roads, N. 42° E. Height, 10 feet. On another exposure, N. 52° E., height, 110 feet; and a quarter of a mile west of Clifton, on ledge, N. 51° E. and N. 58° E. Height, 100 feet.

273. East of road on west side of Mill Creek, N. 22° E., N. 47° E., N. 45° E., N. 57° E, N. 54° E. and N. 65° E.

274. Just west of the end of the same road, N. 61° E., N. 47° E., N. 52° E. and N. 57° E. On a fresh surface near by N. 65° E. and N. 54° E.

275. At end of road at Mills Point, N. 52° E.

276. A quarter of a mile north of road end, at Mills Point, N. 52° E. and N. 37° E.; and a short distance farther north, N. 55° E., N. 51° E., N. 42 E. and N. 39° E.; and again on another exposure a few paces further north, N. 55° E., N. 49° E. and N. 51° E.

277. On old Prince Town road, north of Margate, N. 37° E. Height, 60 feet.

278. At New London Bay, one mile N. of Stanley bridge, N. 37° E.

279. At end of road N. of Beach Point, N. 37° E.

280. At breakwater, Prince Town, N. 11° E. and N. 22 E.

281. On old Prince Town road, one mile north of Punch Bowl, N. 42° E.; (doubtful). Height, 165 feet.

282. One mile west of railway wharf, Cape Traverse, S. 58° E. and S. 53° E.

283. North of Gordon Cove, S. 58° E.

284. Half a mile west of Cumberland Point, on a small exposure, N. 57° E. and N. 62° E. Just west of these, striæ, N. 57° E.

285. Immediately west of Cumberland Point, N. 53° E. and N. 63° E.

286. East of Carleton Point, S. 32° W., S. 27° W., S. 22° W. and S. 13° W. Height, 10 feet. And on other exposures near by, S. 22° W., S. 17° W. and S. 15° W.

It is probable these striæ have been produced by small local glaciers sliding down off the island into the depression now occupied by Northumberland Strait.

287. West of Cape Traverse, S. 53° E. Height, from 3 to 5 feet.

A few rods further west, S. 33° E., S. 38° E. and S. 48° E.

288. East of Westmoreland harbour, on south side of peninsula, S. 58° E. and S. 33° E.

Further east, at point, N. 57° E. or the reverse.

289. On east side of Sable River on road to Bonshaw (half a mile from river), N. 49° E., N. 57° E. Height, 170 feet. Slope W.

290. At cross-roads, Sable River, N. 57° E.

291. On New Bedeque road, three miles west of Hartsville, N. 47° E. Height, 300 feet.

292. Eighty rods east of junction of south-west road with New Bedeque road, N. 37° E. Slope W. Height, 160 feet.

293. West of intersection of County Line and New Bedeque road, N. 53° E. Slope W. Height, 200 feet.

293½. At intersection of above roads, an excellent exposure, N. 47, E., N. 52° E. Slope N.W. Height, 250 feet.

294. Half a mile west of the south end of Lot 30 road, N. 36° E. Slope S.E. Height, 190 feet.

295. On old Tryon road three miles south-west of North Wiltshire railway station, N. 27° E., or the reverse. Slope W. Height, 150 feet.

296. Fifty rods west of County Line, on cross-road, one mile north of Tryon, N. 57° E. Slope W. Height, 100 feet.

297. At end of road between Platt River and Bentick Cove, N. 47° E. and N. 57° E.

298. Near end of road north of Bentick Cove, N. 47° E.

Twenty rods further west, on several exposures, N. 27° E., N. 47° E., N. 52° E., N. 57° E.

299. A quarter of a mile east of ferry over Ellis River N. 50° E., N. 69° E.

300. On road at Fifteen Point, S. 45° E. Height, 20 feet.

And on shore at Fifteen Point, S 10° W.

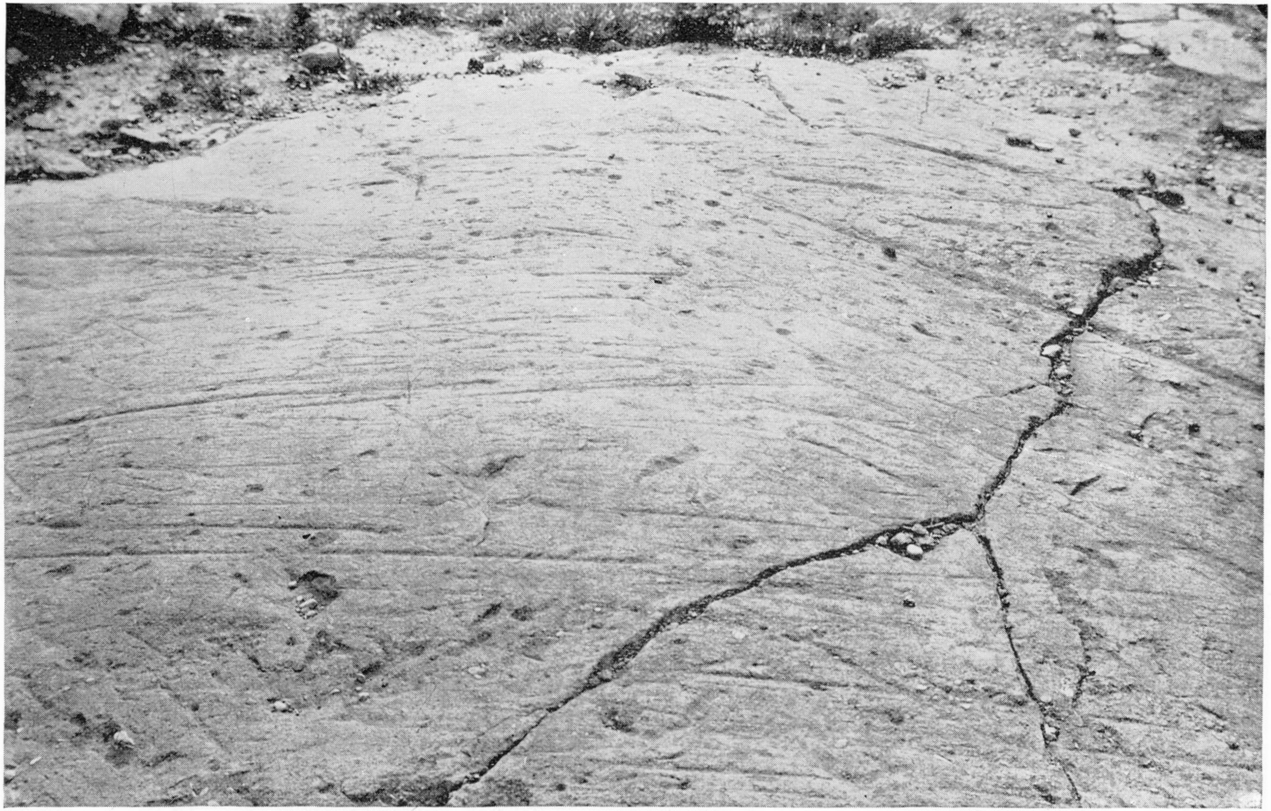

PLATE III.—STRIÆ NEAR CAPE TORMENTINE, N.B.
(No. 9, List of striæ produced by floating ice.) View from east side.

301. At Cape Kildare, on several exposures along the shore, S. 11° E., S. 13° E., S. 18° E., S. 23° E. and S. 29° E.

303. On south-west side of St. Peter's Bay about three-quarters of a mile north-west of the railway station, N. 59° E.

304. Just west of first brook about two miles to west of St. Peter's railway station, N. 6° E. Stoss side, S.

Boulder-clay abundant on south side of St. Peter's Bay.

305. East of Souris on bank of first brook on shore, S. 14° E. Light and local.

Striæ supposed to have been produced by heavy floating ice.

Striæ produced by floating ice.

The floating ice which scored the rocks in many places along the coasts of the eastern provinces, as shown on page 104 M consisted mainly of heavy packs, or floes, and the striæ are due to their impinging force as they were driven against the land-border by winds, currents, tides, etc. The ice composing these packs does not seem to have been wholly such as may have been derived from the land ice of the region. Large portions have doubtless, come from the land ice of Newfoundland, Labrador and Greenland, borne hither by the arctic currents and the easterly winds which prevail in these latitudes. In the later stages of the glacial period, the southern part of the Gulf of St. Lawrence must have been largely choked up with these heavy ice-packs a great portion of the year. Coincident with this condition of the coast waters, the ice on the adjacent land-surface was melting and retiring, while a slow subsidence was going on. The rock scoring by local glaciers and that by floating ice may, therefore, have been to a large extent contemporaneous.

At Gaspé.

Commencing at Gaspé Basin, in the province of Quebec, we shall note the striæ produced by floating ice around the south-western embayment of the Gulf of St. Lawrence.

1. At Little Gaspé, N. 13° E., N. 23° E. and N. 28° E. Height, 75 feet.

2. South of Grand Grevé, N. 23° E.

These striæ have been produced by an irregularly-moving, jumping body, impinging heavily against the sloping coast-border. The marks vary in length from three or four inches to two or three feet, and are both fine and coarse, often a quarter of an inch deep, and apparently gouged out. They occur only on the east side of the widest part of Gaspé Basin, and have evidently been produced by packs of ice driven in from the Gulf of St. Lawrence by heavy winds, tides, etc., forcing ice-jams here.

At Baie des Chaleurs.

3. On the south-west side of the Baie des Chaleurs fine striæ, to all appearance produced by floating ice, occur. The best examples were observed near Belledune station, I.C.R. Half a mile north of the station at a height of about 100 feet, the following courses were seen: S. 39° W., S. 21° W., S. 19° W., S. 9° W., S. 5° W., S. 7° W., S. 2° W., S. 1° E., S. 3° E., S. 5° E., S. 8° E., S. 12° E., S. 13° E., S. 15° E., S. 16° E., S. 18° E., S. 19° E., S. 20° E., S. 21° E. and S. 23° E.

4. About half a mile south of the same station, S. 1° W., S. 5° E., S. 9° E., S. 10° E., S. 11° E., S. 15° E., S. 17° E., S. 21° E., S. 23° E., S. 27° E., S. 31° E., S. 29° E., S. 35° E., S. 38° E.

5. Going southward along I.C.Ry., one mile south of Fournier's brook, S. 5° W., S. 11° W., and on another ledge near, S. 18° E., S. 43° E. and S. 45° E.

6. Halfway between Fournier's brook and Elmtree River, on north side of a diorite boss, S. 9° W., S. 5° W., S. 3° E., S. 9° E., S. 11° E., and S. 13° E.

7. Still nearer Elmtree River another boss shows S. 27° W., S. 29° W., and S. 37° W., with a great number of fine criss-cross striæ.

8. Just north of Elmtree River, on bosses of diorite or diabase, S. 45° W., S. 37° W., S. 29° W., S. 25° W., S. 21° W., S. 17° W., S. 7° W. and S. 1° W.

The elevation of the rock surfaces where No. 3, 4, 5, 6, 7 and 8 sets occur, ranges from 100 feet down to 75 feet. The stoss side is everywhere distinctly to the N. The sides of the deep E. and W. grooves formed by the earlier land-ice are always stossed on the N.

The surface of the country on the south-west side of the Baie des Chaleurs, rises from the coast border with a gentle ascent, reaching an elevation of 500 or 600 feet at the sources of the rivers which drain the district. Against this sloping surface, floating ice, or ice-jams, seem to have impinged heavily in a direction at about right angles to the curved coast-line, along a zone of variable width, from 75 to 175 feet above the present sea-level. This part of the coast, being directly opposite the mouth of the bay, has received the full force and impact of the floating ice driven in from the Gulf of St. Lawrence by easterly storms. Hence the formation of these striæ along the zone mentioned.

At Cape Tormentine.

9. At Lane's quarry, near Cape Tormentine, striæ evidently produced by floating ice or ice-jams, also occur. One set seems to have been caused by ice shoved against, or over the Cape Tormentine peninsula, from Baie Verte, and shows the following courses:—N. 56° W., N. 44° W., N. 42° W., N. 38° W., N. 36° W., N. 32° W., N. 31° W., N. 30° W., N. 24° W., N. 18° W., N. 16° W., N. 12° W., and N. 2° W. The other set has apparently been formed by floating ice which came from

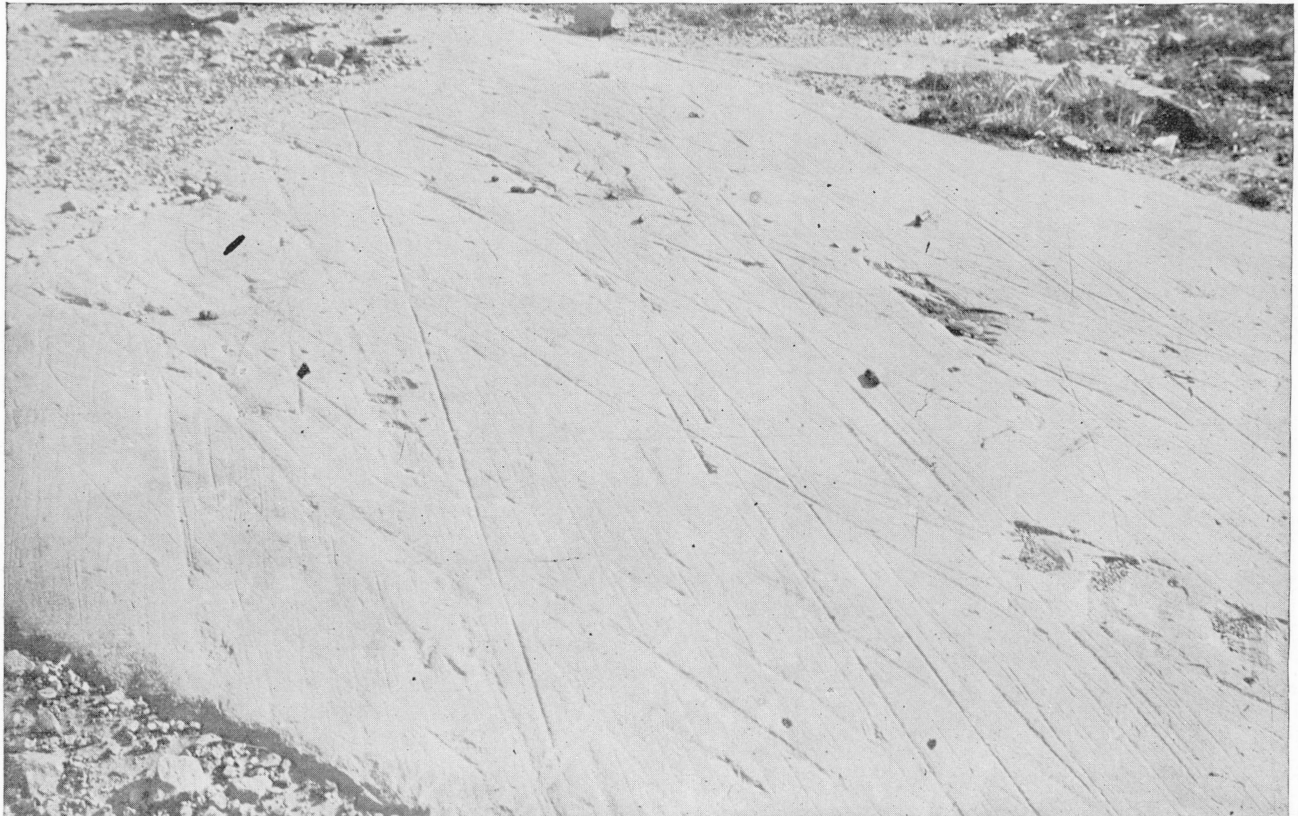

PLATE IV.—STRIÆ NEAR BAIE VERTE VILLAGE, N.B.
(No. 16, List of striæ produced by floating ice.) View from south-west side.

the north and north-west, and exhibits the following striæ:—S. 18° W. S. 13° W., S. 11° W., S. 10° W., S. 6° W., S. 4° W. and S. 3° W.

The N. 34° W. and S. 11° W. striæ or grooves are the heaviest. The scorings cover an exposed rock surface of 75 by 130 paces. The direction of the ice-movement in regard to both sets was determined by certain small crag-and-tail prominences on the nearly flat sandstone ledges. Height, 100 feet.

10. On the New Brunswick and Prince Edward Island railway, six miles and a quarter west of Cape Tormentine the two sets recorded under No. 9 again occur, viz. :—S. 5° W. and N. 37° W., and N. 32° W. Slope, S.E. Height, 135 feet.

These occur on a surface eight by four feet in extent. The western half is striated with the S. 5° W. course, some of the grooves being an inch deep; the eastern slope is covered with the N. 37° W. and N. 32° W., courses, which are light but well defined.

Thirty feet further east on an exposure ten by six feet, N. 37° W. and N. 32° W.; and on two other exposures near by the N. 15° W. course was seen.

11. On the Emigrant road about a mile and a half from Cape Tormentine, N. 32° W. and N. 42° W. Height, 50 feet.

In another place further west, N. 32° W.

12. At Bayfield, N. 2° W. and N. 12° W., or the reverse. Height, 15 feet.

Nearer Cape Jourimain Lighthouse, N. 12° W., or the reverse. Tide level.

13. On Emigrant road three miles east of Port Elgin, N. 27° W., N. 22° W., N. 16° W., N. 12° W. (deep), N. 7° W. and N. 2° W.; also S. 13° W. and S. 8° W. (both heavy). Striæ distinct. Height, 45 feet.

14. On Emigrant road, at third brook east of Port Elgin, S. 13° W. Height, 125 feet.

At Baie Verte.

15. At Coburg quarry about one mile west of Baie Verte village, S. 38° W., S. 32° W., S. 28° W., S. 21° W., S. 18° W., S. 13° W., S. 10° W. Besides these are two courses, S. 8° E. and S. 4° E. or the reverse, and a third N. 68° E., or the reverse. Many broken, irregular, curved striæ occur and several curious markings. From the abundant crag-and-tail prominences, it appears the ice came from the north. Height, 55 feet.

16. About two miles from Baie Verte village, in an old quarry on the south-east side of the New Brunswick and P. E. Island railway, and about fifty rods distant from it, S. 43° W., S. 40° W., S. 38° W., S. 28° W., S. 23° W., S. 20° W., S. 18° W., S. 15° W., S. 13° W., S. 11° W., S. 3° W., and S. 12° E., S. 10° E., S. 4° E., S. 2° E. and S. In

addition to these N. 78° E., N. 68° E. and due E. sets occur, belonging doubtless to the older striation of the maximum extension of the ice. The other courses have apparently been caused by ice which came from the N.E., probably floating ice (ice-jams). The principal sets in these are the S. 43° W. and S. 18° W. striæ. The crag-and-tail projections are here also conspicuous. Height, 55 feet.

17. At east end of Chignecto marine railway, S. 2° E., S. 3° W., S. 13° W., S. 18° W., S. 23° W. and S. 28° W. These show stossing on the north side, but not clearly. The rock surface is covered with from 10 to 15 feet of boulder-clay, and the striæ have apparently been produced by ice impinging against it from the north, probably floating ice. Height, 40 feet or more.

18. On another ledge in the heavy cutting along the east end of the railway mentioned, and from half to three-quarters of a mile from the Tidnish dock, S. 3° W., and S. 18° W., with numerous minor and irregular courses.

Still further west in the same cutting S. 48° W., and S. 50° W.

These all appear to be the work of floating ice-jams.

At the latter exposure a set of striæ was observed with a course of S. 60° E., or the reverse, doubtless produced by land-ice.

19. At Cook's cutting, on the Chignecto marine railway, which is about the axis of the isthmus, and nearly equidistant from both ends of the line, S. 8° W., S. 18° W., S. 22° W., S. 23° W., S. 32° W., S. 38° W. and S. 46° W. The predominent sets are the S. 22° W., S. 28° W. and S. 32° W. ones. The striating agent evidently came from Northumberland Strait.

20. Half a mile further east on the south side of the railway track, S. 10° W., S. 18° W., S. 24° W., S. 30° W., S. 36° W. and S. 46° W. These appear to have been produced in a similar manner to the last.

The height of these ledges above mean tide level is 43 feet.

The manner in which the floating ice scored the rock surfaces on the Isthmus of Chignecto and the Cape Tormentine peninsula is referred to on pages 104-105 M.

In Shepody Bay.

21. In the vicinity of Germantown Lake, Albert county, in a valley trending parallel to the coast of Shepody Bay, a number of striæ occur which seem to have been produced by floating ice.

On the west side of Germantown Lake, south of Beaver Brook, S. 38° W. and S. 43° W. Height, 20 feet.

About 150 yards farther back on the same road, S. 6 °E., S. 18° W., S. 31° W., S. 38° W., S. 41° W. and S. 43° W. Height, 100 feet.

In another place near by on the same road, S. 28° W. and S. 38° W. Height, 125 feet.

Still further up the slope of the hill to the north-westward a large exposure exhibits, S. 3° W., S. 38° W., S. 40° W., S. 43° W. and S. 46° W. The S. 38° W. striæ are the best defined and most numerous. Several grooves can be traced from five to ten feet across the rock surface in straight parallel lines.

In another place near Beaver Brook, S. 43° W. Are all these floating ice striæ?

22. On the south side of Cocagne harbour, on a bank, half a mile below Cocagne village, S. 1° E., S. 6° E., S. 11° E., S. 12° E. and S. 9° W.

These may be due to floating ice, as they correspond with courses on P. E. Island and on the Isthmus of Chignecto. If produced otherwise it must have been by small local glaciers moving northward.

At P. E. Island.

23. On Prince Edward Island striæ, evidently produced by floating ice jammed against the coast border, were found north of Cape Wolf, on the bank, at the shore, S. 9° E. Height, 5 feet.

24. At Cavendish, on the bank along the shore, S. 66° E. Height, 15 feet. Overlying the glaciated surface is a mass of boulder-clay upwards of ten feet thick without any intermixture of transported boulders, though they occur on the surface of the land near by.

25. A quarter of a mile south of Orby Head, S. 59° E. and S. 62° E.

26. One mile west of Cape Turner, S. 62° E.

27. On the south-west side of St. Peter's Bay, west of the railway station, S. 74° E.

None of these striæ occur on ledges more than from ten to twenty feet in height.

In St. Lawrence estuary.

In the St. Lawrence valley, between Metis and Pointe Lévis, striæ, apparently produced by floating ice-masses moving up river, and in a few cases in the reverse direction, were noted.

At Bic, S. 54° W. Height, 125 feet.

At Trois Pistoles, north of Intercolonial railway station, S. 74° W.; west of station, S. 64° W. Height, 100 feet.

Just west of St. François station, I. C. Ry., bosses glaciated on both the east and west ends were observed.

Between St. Charles, I. C. Ry., and Pointe Lévis, striæ were found running S. 64° W. Stoss side to the east. Height, 145 feet.

Osar and Kames.

Osar and kames.

No moraines or drumlins.

No moraines or drumlins are known to occur in the region specially referred to in this report, and it is doubtful whether there are even any of the structural boulder-clay deposits to which the name osar or eskers may properly be applied. Gravel ridges are met with along River Hebert, and Pugwash River, to the south of Thomson station, in

Nova Scotia, and a ridge or series of ridges occurs east of Pictou. In New Brunswick short gravel ridges have been observed at the mouth of Renous River, or along the Southwest Miramichi above it, on the south of the Little Southwest Miramichi, opposite John Dennis's, twelve or thirteen miles from its mouth, also another about five miles west of Doaktown, stretching from the confluence of Big Hole and Meadow brooks to Bartholomew River, and a fourth at the source of Muzroll's Brook. Smaller sand and gravel ridges were observed elsewhere, and a number of the shallow lakelets of the Carboniferous area are bordered with kame-like ridges which have probably been formed by the expansion of the ice that covers them every winter.

Gravel ridges.

The Boar's Back.

The Boar's Back.

The most remarkable gravel ridge of the region is the one stretching along River Hebert, above referred to, called the 'Boar's Back.' It was long ago described by Sir J. W. Dawson,* and as measured by us is six miles and a half long, 130 to 135 feet in height above sea-level at the point of greatest altitude, and from ten feet in some places to twenty-five or thirty feet in others above the general level of the valley in which it lies. Although hitherto classified as a single ridge, it really consists of a series of ridges of greater or less length, arranged for the most part parallel, or approximately so, to the course of River Hebert, but a number are divergent and curving, and obviously without regular alignment. Some of the shorter ridges seem joined to, or rather have their ends abutting against, each other, or more frequently against a main dominant ridge, or series, along the summit of which the road runs, for there is really no main ridge. Sometimes it is one ridge that is the highest and widest, and again it is another abutting against the last and continuing for a greater or less distance. Not infrequently, however, there is a gap or hiatus between each ridge and the end of the next succeeding one, and lateral valleys on one or both sides intervening between it and the parallel ridge on one side or the other. In this way is the Boar's Back bunched up, so to speak, into a series of ridges in two or three places, within its whole extent, while between these bunched ridges, narrower and more linear ridges extend. At the lower or northern end of the Boar's Back, a certain stretch of it forms only one simple ridge. This part is low, narrow, and the material composing it is compact and resembles boulder-clay, or that of a moraine. For the next mile or two south of this, however, the ridge is irregular and in places entirely wanting. Occasionally short

Not a simple ridge.

*Acadian Geology, 2nd ed., page 82.

ridges run off from the main ridge nearly at right angles thereto, and sometimes they curve and inclose peat bogs.

Taking a general view of the ridges composing the Boar's Back, it is observed that those farthest away from River Hebert on the west side, are the highest, as if the summits of all those in a cross-section of the valley corresponded, roughly of course, to the former surface of a low valley before it became cut into ridges. But there are wide gaps and valleys between the ridges, and at intervals along the sides. Indeed, between the ends of several, we come across what is apparently a portion of the original land surface, flat and undisturbed, the material being sand and gravel belonging to the underlying sandstone. Nearly all the ridges are rounded or stossed at the south end, from which it is evident that the denuding agent moved against that end, *i. e.*, in the direction in which River Hebert flows at present.

The materials composing the series of ridges of which the Boar's Back consists are altogether local, belonging to the underlying Carboniferous rocks, only one or two small boulders apparently derived from the Cobequid series having been met with throughout the whole formation. They seem to be finer, perhaps, at the north end, but only in places, for there are also coarse deposits. In the southern part of the Boar's Back coarse beds seem to predominate. No rock outcrops were observed in the River Hebert valley.

How the Boar's Back was formed.

Viewing the facts broadly, the Boar's Back appears to be a series of ridges left from the denudation of a terrace or mass of stratified material which filled the valley to the level of the existing summits of the ridges or higher parts of the valley. But the material must have been worked over previously in some way by water-action to be thus rounded and stratified. Two modes of formation would seem to have prevailed, viz., the building up of some ridges, or what may be termed the constructive process, and the denudation of terraces and gravel banks, or the destructive process, the latter leaving remnants standing as ridges. As already stated, certain facts lead to the inference that the mode of formation, whether constructive or destructive, or both, proceeded not simultaneously, but consecutively, from the upper slope of the valley on either side towards the present river bed. For example, on the west side of River Hebert valley, as has been shown, there are curved and divergent ridges abutting against straight ridges. It would appear that the former must have been formed before the latter, for we cannot postulate any glacial, fluviatile or marine action which would shape them as they now stand on the supposition that they were produced simultaneously. The curving and cross ridges may, therefore, have been the earliest, and may be due to eddying or cross currents, or perhaps to ice-action in the manner that banks are thrown up along the sides of rivers or on the borders of lakes. The straighter ridges were probably formed by more direct currents at a later date.

The Pugwash and Pictou Ridges, etc.

The ridge along the Pugwash River, is about a mile long and one hundred and fifty feet above sea-level. It follows the present stream closely, and consists of sand and gravel probably of fluviatile origin. This ridge seems to have been formed from the denudation of the valley drift.

Pictou ridge.

The Pictou ridge resembles the Boar's Back in some respects. As it lies beyond the region mapped it has not been examined except by way of comparison with the latter. It extends in a general north-and-south course for about two miles, and at the highest part is about one hundred and twenty-five feet above sea-level. Similarly to the Boar's Back it is not one continuous ridge, but two or more, and the materials composing it, while different from those of the latter, nevertheless, bear the same relation to the deposits of the district, as do those of the Boar's Back to the River Hebert valley beds. The Pictou kame contains boulders of granite, diorite, felsite, slate, conglomerate, etc. The peninsula to the east of the gravel ridge seems to have been a sort of "dumping ground" for débris, for it has numerous scattered mounds and short ridges of gravel, sand, etc., which are intermingled with greater or less numbers of transported boulders.

Gravel ridges in New Brunswick.

Turning to New Brunswick, we find gravel and sand ridges in several places in the valley of the Southwest Miramichi River. The most noteworthy of these is one occurring west of Doaktown, on the road running north-westward from that place, and at a distance of five miles from the Southwest Miramichi River. It extends in a nearly northerly course from the confluence of Big Hole and Meadow brooks to Bartholemew River, whether continuously or not we did not ascertain, the country being wooded; and it rises to a height of thirty or forty feet above the level of the surrounding country. This ridge is reported to extend down Barthelomew River for some distance, but was not traced by us.

A prominent ridge along the Southwest Miramichi above the mouth of the Renous River, and others found in the valley of the Little Southwest Miramichi, are evidently due to post-glacial denudation of the valley drift.

The question now arises :—Is there any general law governing the formation of these ridges and accumulations of gravel, sand and other drift materials besides those of ordinary denudation and shifting about of the deposits by fluviatile, lacustrine, marine and subaerial agencies? In the case of those ridges under discussion, a negative answer must I think, be given to this question. Each ridge, or series of ridges, seems to have been formed under the peculiar local conditions to which the materials composing it were subjected during the process of its development. Those met with in river-valleys, as shown, are doubtless due to the action of the rivers, those in lake basins to wave-action, the shove of the ice, etc., while those which may be classed as osar are the result of a complex series of causes which are yet only partially understood. As an illustration of how a ridge may be produced we may take the Boar's Back at River Hebert, which seems to have been formed of material first thrown down by Pleistocene glaciers and worked over by waters flowing out from the melting mass which occupied Halfway River valley. During the ensuing subsidence of the land, the sea invaded this valley and a strait existed by the pass through the Cobequids and along Halfway and Hebert River valleys, when a remodelling of these materials again took place. Subsequently as the land rose, a fresh-water lake seems to have occupied the basin in which Halfway Lake now lies, and its outflow by River Hebert valley again eroded and transported these gravels and sands. It is probably to the latter stage that we may refer the principal erosion which gave the ridges their present forms and contours. Since then the action of River Hebert in cutting down into the deposits occupying its valley, has doubtless produced other changes along its course and given to those ridges nearest the river their present pronounced features.

How these ridges have been produced.

The Boar's Back formed at several successive stages.

The kame at Pictou has not been studied as closely in its relation to the topographic and other features of the district in which it lies as the Boar's Back, but there seems to have been a greater amount of glacial and marine action experienced in its construction, and probably less lacustrine and fluviatile action.

The question of the origin of these ridges is one of great interest owing to their striking physiographic features, and its elucidation independent of pre-conceived theories, would aid in explaining a number of problems connected with the surface geology of the region.

PLEISTOCENE GLACIERS.

The theory of local glaciers upon the higher grounds and floating ice on the lower coastal districts proposed by me in 1885 and 1886* as

Theory of the glaciation of the region.

*Preliminary Report of the Surface Geology of New Brunswick, Geol. Surv. of Can., vol. I. (N.S.), 1885. Trans. Royal Soc. of Can., sec. IV., 1886, pp. 139-145.

a working hypothesis for the explanation of the Pleistocene glacial phenomena of New Brunswick and south-eastern Quebec, may now be considered, with certain exceptions and modifications, as established. It seems capable of explaining and co-ordinating a larger number of facts in the eastern maritime provinces of Canada than the hypothesis of great ice-sheets. There are, however, some anomalous questions regarding the dispersion of boulders on mountains and ridges that it does not account for satisfactorily, but all the divergent courses of striæ can be arranged and systematized under this method of interpretation better than by any other.

In the detailed work carried on by me during the past four years, chiefly in the coast districts of New Brunswick, and in parts of Nova Scotia and Prince Edward Island, a large body of data relating to the glaciation of the region has been collected. This will now be co-ordinated, and an attempt made to show the relation between the several local glaciers which occupied the coast region of the Acadian provinces of Canada during Pleistocene times, and also between these and the ice-mass or *nevé* of the north-eastern Appalachians.

The character of the floating or sea-borne ice which prevailed towards the close of the glacial period, and the courses of movement, or rather the direction in which the heavy packs, or ice-jams, impinged against the rock surfaces, will be shown. It may be remarked, that no striæ or ice-markings produced by the latter have been found above the highest shore-lines of the post-glacial upheaval; they are strictly confined to the lower slopes and marginal areas.

Local glaciers delimited.

In the present report it is proposed, first, to delimit the glaciers which occupied the country at the stage of the Pleistocene when they seem to have had their greatest extension. This will be an attempt not so much to show their superficial magnitude and thickness as to define their eastern and south-eastern margins, especially along the coast between Cape Gaspé and the International boundary at the St. Croix River in the Bay of Fundy.

General movements of the ice.

The ice which covered the Gaspé peninsula, and, indeed, all that part of the province of Quebec lying to the east of the Chaudière River and south of the St. Lawrence estuary, in the Pleistocene period, seems to have been local, although doubtless connected with the larger centre or centres of ice to the west. On the north side of the axis of the Notre Dame Range, it flowed into the St. Lawrence estuary, and here various courses occur showing that the movements were affected by the topographic features of the slope in a marked degree. The estuary must have been open during a part, if not the whole of the year, perhaps, similarly to Baffin's Bay and Davis Strait now, into which the Greenland glaciers discharge. At what height the land stood here at the maximum extension of the ice is uncertain, no facts having yet been discovered in the valley of the lower St. Lawrence bearing directly on this question; but it was probably as high, if not higher, than at the present day. The striæ on this slope trend from N. 64° E. at Montmagny to due N. to N.W at Trois Pistoles, Bic, etc., and in other places to N. 50° W., indicating a wide range in the movements, due chiefly to the inequalities of the surface and to the fact that the glaciers followed the local valleys.

The border of the ice along the lower St. Lawrence during this stage of the Pleistocene cannot have been far beyond the present coast-line.

In eastern part of Gaspé peninsula.

In the eastern part of the Gaspé peninsula, the ice flowed eastwardly, following the courses of the river-valleys there also. Striæ, evidently formed by land-ice, were found in Gaspé Basin with courses as follows:—On the west side, just south of Gaspé village, N. 70° E., N. 75° E., etc. Half a mile north of Cape Haldimand, N. 89° E., N. 83° E. and N. 75° E. On the east side, three miles south of the "Peninsula," so-called, on the road to Cape Gaspé, S. 87° E.; and between that and Grand Grevé, S. 63° E. and S. 65° E. Other striæ or glacial markings occur below Grand Grevé, but they have evidently been produced by floating ice and are described on page 79 M.

The facts respecting the striæ in Gaspé Basin, when combined, show that a local glacier occupied its western end, drawing its supplies from the valleys of the York and Dartmouth rivers. It seems to have thinned out towards Cape Haldimand, the striæ showing a convergence from both sides towards the centre of the basin, and its margin must have lain somewhere in a line between Cape Haldimand and Little Gaspé. On the narrow peninsula terminating in Cape Gaspé, no ice-action is apparent, except the cross striæ produced by floating ice described on a previous page, the surface being covered with angular rock debris due to subærial disintegration. In Gaspé Basin and on the peninsula on the east side we have, therefore, the limit of the land-ice which moved eastwardly off the Gaspé peninsula.

At Cape Maquereau, Baie des Chaleurs.

Following the coast of the Gaspé peninsula southward and westward, till we reach Cape Maquereau, numerous striæ are found there, the average course of which is S. 44° E. and S. 45° E., showing that the ice was still local, and moved off the slopes into the open Gulf of St. Lawrence, or mouth of the Baie des Chaleurs, in a direction at right angles to the coast-line. The margin of the ice was probably nearly coterminous with the then existing coast, which appears to have been slightly higher there also than at present.

The Baie des Chaleurs Glacier.

The Baie des Chaleurs glacier.

The western end of the Baie des Chaleurs depression and the valleys of the Cascapedia, Nouvelle, Metapedia, Restigouche, etc., tributary to it, were occupied by a glacier in the early part of the Pleistocene. The terminus of this glacier was about the 100-foot contour line below the present level of the bay, that is, nearly in a line across from the mouth of the Bonaventure River, Quebec, to Belledune Point, New Brunswick. East of this line on both sides of the Baie des Chaleurs, the striæ indicate ice-movements more directly into the depression of the bay.

To this ice-mass I shall give the name of the Baie des Chaleurs glacier.* Its source was in the Notre Dame Mountains and principally in the drainage basin of the Restigouche River; but it also drew supplies from the Scaumenac, Nouvelle and Cascapedia valleys. The extreme length of the Baie des Chaleurs glacier was not less than 120 miles, but it was doubtless connected with other glaciers or sheets of ice, to the north, west and south, and with the central north-east Appalachian *nevé.* Its width in the Baie des Chaleurs valley, where it was greatest, was 35 to 40 miles, and its extreme thickness was probably 900 to 1,000 feet.

The Northumberland Glacier.

The Northumberland glacier.

Bordering the Baie des Chaleurs glacier on the south-east, along the divide between the drainage basin of the Baie des Chaleurs and that of the Miramichi rivers, and probably coalescent with it, there existed a large glacier in the early Pleistocene to which the above name is applied. Its north-western connection or *nevé* has not yet been traced; but the glacier is known to have descended in a general eastward to north-eastward direction from the region about the headwaters of the Miramichi rivers into the Gulf of St. Lawrence. The southern limit was near the watershed between the Miramichi and other rivers flowing into the Strait of Northumberland and the St. John waters, and extended along by Indian or Lutz Mountain, the watershed of the Isthmus of Chignecto, the northern base of Mount Pleasant, Cumberland county, Nova Scotia, Head of Tatamagouche, Hardwood Hill, west of Pictou, etc. From the mainland of New Brunswick it extended eastward across what is now the Strait of Northumberland and overrode a portion, if not the whole of Prince

* Can. Naturalist, Montreal, vol. X., 1881; The Glacial Phenomena of the Baie des Chaleurs Region.

Edward Island. Boulders and drift from the mainland of New Brunswick occur intermixed in the boulder-clay in the western part of this island, and sparingly as far east as the higher grounds in the central part. The table of striæ and the maps accompanying this report show different sets of striæ, but only those trending eastward have been produced by the Northumberland glacier.

The Magdalen Islands are non-glaciated, and it would seem that the mainland ice has gone no further than the eastern and north-eastern border of Prince Edward Island, the south-eastern part having, apparently, been glaciated by ice which accumulated on the island itself, and, therefore, containing no débris from the mainland intermixed with the boulder-clay. This fact accounts also for the scanty occurrence, or absence of transported or foreign boulders on the higher grounds, although the striæ show eastward movement there. The other courses of striæ will be discussed later on.

Magdalen Islands non-glaciated.

The south-eastern terminus of the Northumberland glacier, therefore, would seem to have been along a line near the coast border from Miscou or Shippegan Island to the mouth of the Miramichi River, crossing the latter probably outside of Portage Island; thence it curved round towards North Cape, Prince Edward Island, and followed the north-east side of the island probably to East Cape. In the depression occupied by Northumberland Strait, it does not seem to have gone farther eastward than Pictou harbour.

On many portions of the area covered by the Northumberland glacier, the ice has been thin and light and had little eroding power, large sheets of rotted rock occurring undisturbed on the mainland as well as on Prince Edward Island.

The depression occupied by the waters of the Strait of Northumberland, appears to have influenced the ice-flow wherever the present depth of the sea does not exceed 100 to 110 feet. Beyond that, the striæ indicate that the ice-movements were independent of the general eastward trend of the Northumberland glacier; hence it is assumed that the latter terminated at or near the 100-foot contour line below sea-level.

It is probable that the source of the Northumberland glacier was in the higher grounds of central New Brunswick. The St. John and St. Lawrence waters interlace in the north-western part of the province, and the *nevé*-ground of this glacier must have been to the north of Lake Nictor. Further investigation is, however, required to settle this point.

The Saint John Valley Glacier.

Passing from the watershed of the Gulf of St. Lawrence to that of the Bay of Fundy, a marked difference is apparent in the character of

The St. John Valley glacier.

the glaciation and of the drift deposits. The general trend of the ice-movement on this slope is south to east-south-east, varying according to the direction of the great valley of the St. John River and the general slopes of the surface. Near the mouth of that river, courses of striæ bearing west of south occur, belonging apparently to a stage when the ice had passed its greatest development and was on the wane.

Area of the St. John Valley glacier.

The St. John Valley glacier was the largest of the sheets occupying Canadian territory south of the St. Lawrence Valley. Its source, or *nevé*-ground, was in the highlands of the northern part of the state of Maine, in the Eastern Townships of the province of Quebec and in north-western New Brunswick. Large tributary glaciers joined it from the valleys of the several affluents. On the north-east side the margin was probably in contact with the Northumberland glacier along a great part of the watershed separating them; on the west it merged into the ice which covered the state of Maine, and may, indeed, have been partially, if not wholly confluent with it, though pursuing, for the most part, a more eastward course. Whether confluent or not, the St. John Valley glacier seems to have been thicker and more massive as we proceed from east to west. This is, no doubt, the result of the more favourable conditions for its development. Proximity to the evaporating surface of the Atlantic, and, of course, a greater amount of precipitation and a higher and better condensing surface, were, doubtless, the predisposing causes for the greater accumulation of Pleistocene ice in the St. John Valley and on the Bay of Fundy coast, as well as westward. The front of the St. John Valley glacier is difficult to trace. It is doubtful whether this glacier surmounted and overrode the whole of that part of the crystalline plateau lying east of the mouth of the Saint John River. It certainly did not do so with the relative levels of this crystalline plateau and the Carboniferous area to the north of it the same as at the present day. There are some facts at hand which tend to show that the latter must have been higher, relatively, when the St. John Valley glacier discharged into the Bay of Fundy. But this glacier, or system of glaciers, became much broken up in its passage through the hills bordering that body of water, as it proved by the divergent courses of striæ along the coast.

Causes of its greater thickness.

Just where the margin of the ice which properly belonged to the St. John Valley glacier lay to the west, or whether it was coalescent with the ice occupying the territory of the State of Maine, it is not possible to determine with the limited amount of data at hand. Further investigations about to be undertaken in western New Brunswick may elucidate this question.

In regard to the glaciation of the plateau along the Bay of Fundy to the east of St. John harbour, if not due to ice overriding it from the St. John Valley and from Grand and Washadamoak Lake basins, etc., then it must be that local ice-masses accumulated upon it which flowed out towards the open waters of the Bay of Fundy. At St. John harbour and west of it, however, the ice margin seems to have extended beyond the present coast-line, apparently stretching out farther and farther as we proceed westwards towards the International boundary. This fact is in accordance with the view that the meteorological and physicial conditions necessary for the production of glaciers were more favourable on the Bay of Fundy coast and westward than in the Gulf of St. Lawrence.

The Chignecto Glacier.

On the Isthmus of Chignecto and in the two arms of Chignecto Bay, and probably extending as far to the south-west as Cape Enragé on the one hand and the mouth of Apple River on the other, there existed a local glacier in the early Pleistocene, the general movement of which was south-westward into the open waters of the Bay of Fundy. Striæ produced by this glacier are found near Shepody Mountain Albert county, New Brunswick, from 500 to 600 feet or more above the present sea-level, and on the opposite shore, in the vicinity of Sand and Apple rivers, from 350 to 400 feet high. In the central parts of the Isthmus of Chignecto, viz., at Westcock, Dorchester Cape and north of Folly Point, striæ, to all appearances produced by this body of ice, also occur at elevations of 300 to 400 feet. The striation is distinct and well defined, and leaves no doubt that it has been caused by a pretty large body of ice flowing in the direction indicated. The Chignecto glacier.

In seeking the source of the Chignecto glacier, or rather the height-of-land which gave it momentum, great difficulties were encountered. At first an attempt was made to explain the glaciation by the action of floating ice; but this agency, while competent to account for certain striæ produced at a later stage of the glacial period in this region, did not seem capable of explaining certain phenomena pertaining to the Chignecto glacier. For example, in Albert county the striæ attributable to the action of this glacier occur on both northward and southward sloping declivities, and cross narrow valleys, such as that of Demoiselle Creek, obliquely. They are met with at altitudes varying from sea-level up to 500 and 600 feet, and are parallel on the higher as well as on the lower slopes on opposite sides of Chignecto Bay. These and other facts which might be cited evince the action of land ice only. At the same time it is not denied that a considerable part of the striation of of the lower grounds on both sides of Chignecto Bay as well as on the isthmus is due to floating ice—in the latter district, indeed, it was chiefly produced by this agency, at a subsequent stage of the glacial period. But on the higher levels, the glaciation seems to be entirely due to land ice.

It has been stated on page 26 M, that the height of the Isthmus of Chignecto, near Northumberland Strait, does not exceed seventy-five to one hundred feet. Some hills and undulations rise to one hundred and twenty-five to one hundred and fifty feet, but on the other hand a large part of the isthmus is low and flat, and not more than fifty to sixty feet high. The elevation of the axis exceeds this but very little, except upon the ridges lying between Memramcook and Sackville, portions of which rise above the 200-foot contour. How then did ice flow south-westwardly off the isthmus into Chignecto Bay, and override the ridges around the head of it, while portions of this ice apparently rose two hundred to three hundred feet above the level of its source? This was one of the problems presented to us in studying the glaciation of this region. To satisfy ourselves regarding the source or *nevé*-ground of the Chignecto glacier, a thorough examination of the isthmus was made, and our investigations extended to Prince Edward Island, to the eastern extremity of the Gaspé peninsula and to the Magdalen Islands. If the gathering-ground of this glacier had been beyond the Isthmus of Chignecto, we concluded it would have striated the higher grounds of the eastern extremity of Gaspé and of Prince Edward Island in its passage southward. No north-and-south, or north-east and south-west striation was found on the higher portions of Prince Edward Island or at Gaspé, however, and the Magdalen Islands were discovered to be unglaciated. On the south-west slope of Prince Edward Island, facing the Isthmus of Chignecto, there are a few scattered striæ, but they seem due to local ice sliding off the island at a later stage. Finding no solution of the problem in this way, we then had to re-investigate the north-eastern side of the Isthmus of Chignecto anew. Numerous striæ are found here, as detailed on the map, but they all indicate the action of floating rather than land ice. It is possible some of the older sets may have been produced by the latter agency, but the rocks are soft sandstone, easily eroded, and these striæ may have been mostly obliterated. With all the data available, therefore, we have been forced to the conclusion that the Chignecto glacier is, after all, one which developed on the Isthmus of Chignecto, and in the depression between that and Prince Edward Island, and as inferred on page 27 M the relative levels of the axis and of the north-eastern part

Gathering ground of the Chignecto glacier.

of the isthmus as well as the bottom of Northumberland Strait must have been higher than at present, and the south-western part and the coast borders of Chignecto Bay lower.

The Chignecto glacier was doubtless a product, partially at least, of the evaporation from the open waters of the Bay of Fundy, and its condensation in this particular locality. This probably caused the formation of such a thick mass of ice under such exceptional circumstances; for, to the south-west of Cape Maringouin it can not have been less than five hundred or six hundred feet thick. But its superficial dimensions were limited, its length being probably not more than forty-five to fifty miles, and its extreme width eighteen to twenty miles.

Peculiar development of Chignecto glacier.

The origin and development of the Chignecto glacier under such peculiar local conditions, are no doubt also partly owing to the fact that the Northumberland Strait to the north-east was, at that time, choked up by the Northumberland glacier, and thus the former was forced to seek outlet to the open waters of the Bay of Fundy. Indeed, it is not improbable that a portion of the Northumberland glacier may have swung round and passed out over the Isthmus of Chignecto towards the Bay of Fundy, as suggested to me by Dr. G. M. Dawson, thus forming the source or head of the Chignecto glacier, though few, if any striæ have been found indicating such a swerving movement, which would really mean a change from a due easterly course to one nearly south-west. On any view of the question therefore, difficulties are met with, and no fully satisfactory solution of the problem of the glaciation of the Isthmus of Chignecto has yet been found.

Glaciation of Nova Scotia.

The glaciation of Nova Scotia.

The facts adduced in regard to New Brunswick glaciers in the early Pleistocene, appear to demonstrate that no ice reached the peninsula of Nova Scotia from the mainland, except those portions of the Northumberland and Chignecto glaciers which impinged on the coasts of Cumberland county, the former in the Strait of Northumberland, the latter in Cumberland Basin. The depression of the Bay of Fundy was not crossed by land ice from southern New Brunswick, nor did ice move across the Isthmus of Chignecto in any direction, but as indicated. Neither has Nova Scotia been glaciated by extra-peninsular ice from the north or north-east, except, perhaps, by some floating ice on the coastal areas. Whatever glaciation it received from land ice, and some districts have been very heavily striated, has been wholly from that which accumulated upon the surface of the country itself.

Local and divergent striæ.

In the portion of that province included in the map, the striation is extremely local and divergent. Ice gathered on the summits of the Cobequids and also on some other elevations such as Mount Pleasant, Springhill, etc., and moved thence in both directions, *i.e.*, northward and southward. Some of the striæ on the slope between the Cobequids and Northumberland Strait may belong to a later date than that of the Northumberland glacier. On the south side of the Cobequids, a pretty large local glacier moved westward from Minas Basin into the Bay of Fundy. Striæ showing the movement of the latter occur at Spencer's Island, S. 67° W. and S. 70° W., etc. To the east, however, a local glacier seems to have flowed off the southern slope of the Cobequid Mountains, crossing the eastern part of Cobequid Bay, and thence passing over the low country traversed by the Intercolonial railway, discharged into the Atlantic in the vicinity of Halifax. Striæ with north-west stossing were observed near Shubenacadie, and thence to the Atlantic coast, showing this ice-movement very clearly.

To the south-west and south of the Basin of Minas, the ice which accumulated on the peninsula moved outwards towards its periphery north-westward, westward, southward and south-eastward. From the South Mountain it crossed the Annapolis Valley, overriding the North Mountain, and passing thence into the Bay of Fundy. Striæ proving this were found at Bridgetown, Annapolis, Digby, Head of St. Mary's Bay, etc. On the South Mountain, at the first-mentioned place the following courses occur:—N. 32° W., N. 47° W., N. 54° W., N. 62° W. and N. 70° W.; on the North Mountain here, N. 22° W., N. 40° W., N. 47° W. and N. 52° W., and near the coast of the Bay of Fundy, N. 57° W. and N. 72° W. The North Mountain is here upwards of one hundred feet higher than the South Mountain from which the ice came, yet granite boulders from the latter, of all sizes up to ten feet in diameter, are strewn over the slopes of the North Mountain down to the shore of the Bay of Fundy.

Glaciation of North Mountain.

At Annapolis, striæ occur on the North Mountain trending N. 32° W., N. 34° W., N. 42° W., etc. The stoss side is to the south-east and the surface is everywhere strewn with granite boulders from the South Mountain.

On the North Mountain at Digby, the striæ run N. 42° W., N. 52° W., N. 56° W. and N. 68° W., the two latter courses being near the coast. Granite boulders from the South Mountain are also abundant here.

At the head of St. Mary's Bay the North Mountain presents a great stoss side to the south-east, the courses of striæ there being N. 70° W., N. 74° W., etc. These show a swerving of the ice-movement in the direction of the deeper parts of St. Mary's Bay. The glaciation along the North Mountain has apparently been heavy, extensive ledges and bosses being deeply grooved and ice-worn.

Near Yarmouth, striæ occur with a course of S. 3° E., showing ice-movement mostly in the direction of the estuaries.

It will be seen that the above courses taken together with those noted by other observers on the south-east coast, clearly point to local ice as having been the glaciating agent in the peninsula of Nova Scotia. The ice on the south-east slope has probably been heavier than on the north-west side during the stage of its maximum extension. Facing the Atlantic ocean, this slope, similarly to the New Brunswick slope of the Bay of Fundy and the New England coast region to the west, was very well situated for the nourishment of glaciers. The free discharge afforded the ice into the sea along its margin, enabled it to erode the rocks over which it passed to a much greater extent than in the interior. This erosion is exhibited in the deep grooves and rounded bosses on the south-east and north-west coasts of Nova Scotia.

Local ice the glaciating agent.

Eastern and South-eastern Limits of the New Brunswick Glaciers.

The limits of the several local glaciers just described, are known approximately at least, and are delineated on the accompanying sketch-map. What was probably the margin of the ice, was located on the east side of Gaspé Basin, the point of land terminating in Cape Gaspé being unglaciated. In the Baie des Chaleurs basin, there is evidence that the local glacier which occupied it did not extend farther to the east than Bonaventure River and Belledune Point, smaller local sheets debouching into the depression from both sides of the bay to the east of that. The ice extended along the peninsula between the Baie des Chaleurs and Northumberland Strait as far as Caraquette, and perhaps partly overrode Shippegan Island; but the northern part of Shippegan and all Miscou Island have not furnished any evidences of glaciation. Just where the ice-border lay in Miramichi Bay, is problematical; it may have been along or near the hundred-foot contour below sea-level, swerving outside of North Cape, Prince Edward Island, and, perhaps, following the north-east coast of that island to East Cape. Thence the limit of the ice doubled and ran towards Pictou harbour, Nova Scotia. The southern margin of the New Brunswick ice coincided with that of the Northumberland glacier, already described, as far as the Isthmus of Chignecto. If we include the Chignecto glacier among the New Brunswick ice-sheets, the border would extend round by Amherst and the mouth of the Maccan River, thence

Limits of the glaciers above described.

following the summit of the low ridge to the south-east of Cumberland Basin as far as Apple River, and, perhaps, to the northern base of the Cobequid Mountains. The probable position of the front of the Chignecto glacier was outlined on page 93 M. On the New Brunswick side of the Bay of Fundy, the ice-border seems to have lain pretty close to the coast west of Cape Enragé, as far as St. John harbour. Here and to the westward it evidently extended out beyond the present land, overriding the islands adjacent thereto. Its extension seaward probably increased the farther westward we proceed until reaching Grand Manan, which the mainland ice appears to have surmounted and glaciated.

Around the peninsula of Nova Scotia, the margin of the land ice was not definitely traced, but it probably extended very little beyond the line of the present coast.

Absence of Terminal Moraines.

Absence of terminal moraines.

No terminal moraines have been observed along the east and south-east margin of the glaciated area described in these pages. Moraines may have existed and have since been denuded and entirely washed away by the action of the sea, during the post-glacial submergence of the coast border, but this is extremely doubtful. The mode of occurrence of the boulder-clay and the distribution of the transported boulders do not afford evidence of any linear arrangement of deposits either as terminal or lateral moraines in the region, except, perhaps, in southern New Brunswick, on the watershed between the St. John Valley and the Bay of Fundy, where small local glaciers left a few irregular ridges at the final retirement of the ice, which may be classed as such. There is a greater or less sporadic distribution of glacial material, but it is very seldom heaped up in ridges or mounds.

Without entering into the vexed question of the mode of carriage of the drift by glaciers, a few observations may be offered regarding glacial transportation in the particular area under review.

Mode of distribution of the drift in eastern New Brunswick.

The mode of distribution of the drift is largely dependent upon the topographic features. In hill or mountain districts which border valleys or plains, glaciers receive an impetus from the steeper gradients, enabling them to erode and often sweep off the débris down to the rock surface, exhibiting the striation and polishing. In the valley bottoms this débris is thrown down and lies until again eroded by the ice, or by rivers or streams. In this case, whatever material the ice carries off one place it deposits in another near by, similarly to a river. Often at the base of declivities, on the lee side, masses of drift have thus been deposited; but occasionally in districts of hilly or irregular surface, the boulder-clay occurs as mounds or lenticular masses on the more level tracts, or again it may be massed against hills on the stoss side; being in all these instances generally well mixed with transported and glaciated boulders and pebbles. In localities glaciated in this manner, which are quite common in New Brunswick and Nova Scotia, there will be found rock surfaces of greater or less area laid bare and highly striated and polished, the material which originally covered them having been wholly or partially removed by the ice. These may be called ice-swept surfaces, in contradistinction to flat surface, over which the ice has distributed the boulder-clay more evenly and through which rock surfaces seldom appear. The latter condition is characteristic of the Carboniferous area of New Brunswick. Here glacier motion has been comparatively sluggish, and the greater portion of the boulder-clay is more local in character. In many parts of this area, the rotted rock lies still undisturbed, and the boulder-clay is often thick and in wide, regularly-distributed sheets. Successive additions of the latter have been deposited here and there also, and the transported boulders are more numerous, as a rule, in the upper part of the deposits, and especially on the surface, the latter feature, however, being doubtless partly a result of subsequent denudation.

From the evidence at hand, it appears that the slopes of the higher grounds of New Brunswick and Nova Scotia have been as a rule more heavily glaciated than the lower coastal districts around the south-western embayment of the Gulf of St. Lawrence—a heavily glaciated district usually presenting many bare ice-swept rock surfaces, while one across which ice has moved sluggishly is deeply masked by superficial deposits. This has been the case especially on the lower grounds of New Brunswick, Nova Scotia and Prince Edward Island, occupied by the Northumberland glacier.

Why there are no terminal moraines in the region.

This sluggish motion and thinning out of the ice near the margins of the Baie des Chaleurs, Northumberland and St. John Valley glaciers, together with the fact that they terminated in the sea in many places, has been unfavourable to the formation of terminal moraines; hence the absence of these deposits in this region.

Relations of the Local Glaciers to the Appalachian Nevé.

Relations of the glaciers described to the Appalachian system.

The glaciers of eastern Canada, just described, evidently had their sources and *nevé*-grounds beyond the boundaries of New Brunswick, in the Notre Dame or Green Mountains in northern New England and the province of Quebec. These grounds have not yet been systematically explored. But they had also local gathering grounds on the watersheds or divides between each glacier, especially on that between the drainage basin of the St. John River and of those rivers flowing into the Strait of Northumberland and Gulf of St. Lawrence, which seems to have been an ice-shed during the whole glacial period. The Northumberland glacier may have had its *nevé* entirely within New Brunswick.

The ice which occupied the region lying to the south of the St. Lawrence Valley, in the early stage of the glacial period, flowed from the higher parts of the Notre Dame or north-east Appalachian Range in widely divergent courses and to different points of the compass, the movements being largely dependent on the topography and relation to the central mass or *nevé*. In the province of Quebec, the ice followed, for the most part, the existing drainage channels, northward, eastward and south-eastward a considerable body of ice passing from the district known as the "Eastern Townships" into the valley of the upper St. John River. In northern New Brunswick, the general trend of movement was from west to east or to north-east, the Baie des Chaleurs glacier flowing nearly due east and the Northumberland glacier eastward to north-eastward. In the southern part of the province, the ice partook of a more southerly course, the St. John Valley glacier moving nearly south-eastward. Further west the courses swerve more and more to the south, the ice having thus a more or less radial movement from the higher portions of northern New England and Quebec. Whether the ice-mass consisted of one confluent sheet, similar to the Greenland sheet of the present day, or of local glaciers, is a question which can only be solved by further detailed observations and mapping of the striæ. That it was thick and massive on the more elevated grounds is highly probable. Indeed, from a comparison of the physiographical and meteorological conditions which prevail in those parts of the world where glaciers now occur, with such as must have existed in the north-east Appalachian region in Pleistocene times, we may infer that it was a very favourable gathering-ground for ice. Three things essential to the production of heavy glaciers seems to have been present here, viz.:—proximity to a large evaporating surface, heavy precipitation, and an area of considerable altitude, serving as a condensing surface. The height of this region was probably greater in the early Pleistocene than at present. Hence a large ice-sheet, or several ice-sheets, must have been devel oped here, which in thickness, though not in superficial extent, was perhaps second to no other in North America.

Glacial conditions of the region in the Pleistocene.

As having some bearing on the question of the evaporation from the Atlantic ocean during the glacial period, or, perhaps, during its later stages, reference may be made to the occurrence of marine shells in the boulder-clay and drumlins near Boston collected by Upham, Dodge and others. These shells were found to be closely similar to species now living in the waters adjacent to the New England coast. May this fact not be taken as showing, that at the time they lived in these waters, the temperature of the ocean along the New England shores cannot have been very far different from that now prevailing? If so, then the evaporation from its surface must also have been as great as at the present day.

Temperature of the New England coast waters in Pleistocene times.

Departure of the Pleistocene Ice.

Whatever changes in the meteorological conditions occurred between the earlier stage of the Pleistocene period, or period of maximum ice accumulation, and that about to be discussed, have left no traces in the phenomena of the region; nevertheless, it is certain that important changes did take place both as regards climate and elevation of the land.

As shown on page 33 M it would seem that soon after the maximum of ice accumulation was reached in the eastern provinces of Canada, a subsidence of the region commenced, which so far as the evidence goes, was continuous not only till the close of the ice age, but for some time afterwards, that is, until the Leda clay was deposited. The subsidence, as stated, was more or less differential, evidence of which is afforded in the divergent ice movements at the breaking up and dissolution of the Northumberland and Chignecto glaciers. The arctic climate of the region during this stage, is also shown by the marine shells found in the boulder-clay at St. John, New Brunswick. The local glaciers which occupied the slopes of the coast region, and the floating ice-packs or ice-jams impinging against these slopes during the closing stages of the ice epoch, when the land stood lower than at present, have scored the rock surfaces, leaving records of their existence and of the attitude of the land at that stage.

Departure of the Pleistocene ice.

Brief descriptions of the striæ produced by local land ice and by floating ice, and of other phenomena pertaining to this the closing or melting stage of the glacial period will now be given, and the different localities where such phenomena were observed noted.

Local Glaciers During the Closing Stage of the Ice Age.

On the south side of the Baie des Chaleurs, striæ, evidently produced by local glaciers during the retirement of the main Baie des

Local glaciers of this stage of the ice age.

Chaleurs glacier, were found at Dundee settlement, south of Dalhousie Junction, in Lorne and Sunnyside settlement in the rear of Jacquet River, in Ste. Louise and Middle River settlement near Bathurst, etc. In these places the ice referred to has slid down more directly into the Baie des Chaleurs depression, uninfluenced by the main Baie des Chaleurs glacier described on page 90 M.

In the Baie des Chaleurs region.

The striæ produced by these glaciers are found upon the slopes at heights varying from 150 to 500 and 600 feet above sea-level, and the ice producing them was probably contemporaneous with the floating ice-packs or jams which impinged against the coast as shown on page 79 M, at the closing stage of the ice age. These glaciers and ice-jams existed and performed their work previous to the deposition of the Leda clay and Saxicava sands, otherwise these beds would have been disturbed and eroded, if not entirely destroyed by them. In several places around the southern embayment of the Gulf of St. Lawrence, the marine deposits referred to are found resting upon rock surfaces which must have been glaciated by local glaciers or floating ice of the character described, showing that they have been deposited at a subsequent stage.

In the region to the west of Northnmberland Strait.

The area which was occupied by the Northumberland glacier, shows some remarkable traces of local ice-movements at the retirement or breaking up of the larger sheet. As has been shown on a former page, the general trend of the ice-movement in the early part of the glacial period here was nearly due east. But we find that in the later or melting period, the glaciers of the higher grounds had swerved round and took nearly a northward course. Intermediate courses were observed at Renous River, Rogersville station, and along the Intercolonial railway to the south, especially at Harcourt, Coal Branch, etc., which tend to show that this swerving of the ice-movements may have been gradual and probably was coincident with a differential change of level of the district. Correlating all the facts, it would appear that as the ice began to diminish in thickness, the axis or watershed between the St. John waters and those falling into the Strait of Northumberland did not subside, and perhaps, was not denuded, to the same extent, as the coast border, and coincident with the decreasing thickness of the ice and this change of level, the movements of the small local glaciers had become entirely governed by the slopes of the country before their final disappearance.

Further, these facts indicate that there was no withdrawal of the ice from this region during a supposed interglacial epoch; on the contrary, that it continued here throughout the whole period of the deposition of boulder-clay without recession.

In the northern and eastern parts of Albert county, and also locally on some of the higher slopes of the ridges traversing the Isthmus of Chignecto, evidences of local glaciers occur whose action took place after the Chignecto glacier had dwindled down and subsidence of the district had set in. Striæ showing local ice-movement towards the lower parts of the isthmus were also observed at Amherst and Fenwick in Cumberland county, Nova Scotia. Farther east, on the slope between the Cobequid Mountains and Northumberland Strait, striæ are met with in numerous places indicating local ice action by northward-moving sheets down nearly to the present sea-level. Local glaciers appear also to have occupied the summits and slopes of the Cobequids and the drainage basin of the Maccan and Hebert rivers, flowing in different directions as influenced by the topographic features. On the borders of Shepody Bay.

Along the Bay of Fundy coast, from Shepody Bay to Passamaquoddy Bay, many courses of striæ were observed which can only be explained on the supposition that they were produced by local glaciers at the closing stage of the ice period. These were noted at Quaco, West Beach, Mispec, St. John, Musquash, Letite and on the West Isles, and exhibit in some of these localities, at least, very divergent striation dependent largely upon the local contours of the surface. The most remarkable of these local glaciers seem to have existed at the mouth of the St. John River. On the west side of the harbour, striæ occur trending to different points of the compass between S. 2° W. and S. 65° E.; on the east side they trend from S. 15° W. to S. 55° W. Convergent movements are, therefore, shown in these sets, varying from S. 65° E. on the west side of the harbour to S. 55° W. on the east side. While it must be admitted that some of these convergent striæ may be due to undertows during the maximum extension of the St. John Valley glacier, the greater number have probably been formed by ice discharging in the harbour as local glaciers. It must be added, however, that in this locality, we have, so far, been unable to differentiate the striæ produced at the period of maximum glaciation from those produced at the later or melting stage of the ice. That local glaciers existed here, however, and extended into the open waters of the Bay of Fundy at the retirement of the Pleistocene ice, is sufficiently proved.* From Shepody to Passamaquoddy Bay.

Reviewing all the facts, it is evident that the theory of local glaciers advancing and retiring, during the later stage of the glacial period, with the coast 100 feet or more lower than at present, will serve to explain all the phenomena. The climatic conditions seem to have been

*Bulletin Geol. Soc. of America, vol. IV., pp. 361-370.

at least subarctic; but an amelioration had set in apparently coincident with the progressive subsidence of the coast in the different parts of this maritime region.

On the P. E. Island coast.

On Prince Edward Island, local glaciers and floating ice were doubtless predominant during the period of subsidence and melting of the ice. The former have left evidences of their existence at New London and to the west and south-west of Richmond Bay; also on the south-west coast of the island at Fifteen Point, Carleton Point, De Sable, etc. From the position of the striæ produced by floating ice with respect to sea-level, the land cannot have been more than from 50 to 100 feet lower than at present at that time.

No deformation of the surface between the later and earlier stages of the glacial period was traceable at St. John, New Brunswick, or on Prince Edward Island, such as that described as occurring in the central Carboniferous area of New Brunswick; but the facts are from limited areas only, and, even if there had been deformation, this could scarcely be discerned.

FLOATING OR SEA-BORNE ICE.

Floating ice.

The theory of striation of rock surfaces by floating ice-masses transported in different directions by oceanic currents, tides and winds as they grounded on the bottom, has long been held, but it is to this day, nevertheless, a subject of dispute among glacialists. It is proposed, briefly, to place on record by descriptions and illustrations certain ice-markings believed to have been produced by floating ice, and to demonstrate, from the local circumstances and peculiar situations in which they occur, that they cannot have been produced by land-ice.

Character of floating ice which striated the rocks of this region.

Floating or sea-borne ice is of several kinds. First, there are the solitary bergs drifted about by currents and tides, which gradually melt and crumble to pieces as they are carried southward from arctic regions into warmer seas; second, ice-floes, pan-ice, or drift-ice made up of low-lying, loose, flat sheets of greater or less area, driven by winds, tides, or currents. These often cover several square miles of the ocean surface. And, third, what for want of a better name I have called ice-jams, which are large masses of floating ice forced into straits or inlets by land ice, or by currents or winds, so compactly, that a jam of this kind moves as one body similarly to land-ice. These are, I believe, often called ice-packs. Ice-jams occur in Smith's Sound, and north of that between the coasts of Greenland and Grinnell Land, and elsewhere in arctic regions. The low, flat sheets of the second class, by being driven into straits and narrow passages may become ice-jams. Ice-packs, or jams appear to be the only kind of floating ic capable of producing regular striæ. The striation of the low-lying ledges in the St. Lawrence estuary, extending north-eastward and south-westward, appears to be due to ice of this character. In the Baie des Chaleurs basin, and on the north-east side of the Isthmus of Chignecto, as well as on the Cape Tormentine peninsula, striation caused by ice-jams prevails. Ice of this kind has also impinged heavily against the north-east and south-west coasts of Prince Edward Island. Separate icebergs, or loose floating ice-masses, do not, as a rule, produce scoring of rock surfaces in the same way as ice-jams. The writer has, winter after winter, for many years investigated the ice phenomena of the south-western embayment of the Gulf of St. Lawrence, but has failed to discover from the action of the coast-ice, or of the loose floating masses driven about by the tides, winds and currents, any evidence of regular striation from these. They remove the asperities and polish rock surfaces, but having little or no sand or gravel adhering to the under sides, their erosive power is insignificant, and they leave no striæ. Ice-jams, on the contrary, are forced over low shoals, or up against low banks, and even across points of land, carrying more or less of the loose gravel, sand, etc., with them, and their pressure and eroding power are in certain places as great as that of land ice. In many parts of the region striæ are met with on the lower slopes, running parallel to the coast, which have doubtless been produced by ice-jams, the margins of which ground along the bank in their onward movement as if impelled by an almost irresistible force. Examples of striæ produced in this way are found at Belledune, Cocagne, along the coast of Prince Edward Island, and in a number of other places.

Where floating ice striæ were observed.

Detailed accounts of the evidences of floating ice as occurring in the estuary of the St. Lawrence, on the south-west side of the Baie des Chaleurs, etc., were given on page 83 M. In eastern New Brunswick, especially on the Isthmus of Chignecto, a number of interesting facts have been observed respecting the action of floating ice. Ice-jams, or packs, have crossed from Northumberland Strait to the head of the Bay of Fundy, and probably also in the reverse direction. The striæ effected by these were observed at Baie Verte, also on the axis of the isthmus, and on the Cape Tormentine peninsula. In the last-mentioned locality, the same ledges exhibit evidences of both northward and southward ice-movements very distinctly. (See list of floating-ice striæ Nos. 9 and 16.) That they cannot have been produced by other agencies than floating ice, is shown by the fact that no striæ corresponding in direction with these have been found crossing Prince Edward Island. The southward-moving floating ice which produced these striæ must, therefore, have come either by the north-west entrance of the strait, or across the low-lying portion of Prince Edward Island, then submerged, immediately to the west of Richmond and Bedeque bays, or by the eastern entrance of Northumberland Strait. In fact it would seem to have come in by both the eastern and north-western passages simultaneously, thus forming the ice-jam already referred to, which sought outlet across the Isthmus of Chignecto into the open waters of the Bay of Fundy. But a portion of the floating ice coming in from the east, must have surged across the then existing shoal now forming the low peninsula of Cape Tormentine and produced the northward-trending striæ there. That floating ice in any considerable quantity came across the submerged Isthmus of Chignecto from the Bay of Fundy to Northumberland Strait seems somewhat doubtful, as no striæ with stossing on the south-west side of the ledges have been met with around the head of that bay. The chief currents and the principal ice and drift transport were apparently from north-east to south-west, into that body of water.*

Floating ice striæ on the coast of P. E. Island.

Around the shores of Prince Edward Island, striæ, evidently produced by floating ice, at a time when the land stood lower than now, are numerous. None of these cross the island in any direction ; but have apparently been formed by floating ice impinging obliquely against both the north-east and south-west shores at the period referred to.

To the west of the Isthmus of Chignecto, or the head of the Bay of Fundy, the action of floating ice could not be traced on the New Brunswick coast border.

General Conclusions.

General conclusions regarding the glaciation of the region.

Summarizing the principal facts relating to the Pleistocene glaciation of the region under review, it is found that at the period of the maximum extension of the ice, there was a general radial movement from the main *nevé*-ground of the north-east Appalachians, northward and eastward into the St. Lawrence Valley, eastward into the south-western embayment of the Gulf of St. Lawrence, south-eastward into the Bay of Fundy and Atlantic Ocean, and southward and south-westward in United States territory.

The St. Lawrence Valley, as far westward as the Thousand Islands, was probably an open channel in the latter part of the glacial period at least, into which ice flowed from the north and from the south.

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*In the spring of 1894, ice-jams were driven into Northumberland Strait, and the passage between Cape Tormentine and Cape Traverse was blocked up by them to a depth of thirty feet, according to newspaper reports and travellers.

Although the Appalachian glaciers here referred to were not of great superficial extent, the ice which occupied New England and south-eastern Quebec seems to have been the thickest and heaviest of the Pleistocene glaciers of eastern North America, developed in these latitudes; and the geographical and meteorological conditions favour the view that it was only surpassed in this respect by the great Cordilleran glacier of the west.

Direction of ice flow.

In eastern Canada, south of the estuary and Gulf of St. Lawrence, the land ice seems to have consisted of local glaciers, and the different parts which streamed outwards from the central *nevé*-grounds have been differentiated and received separate names. That which occupied the Gaspé peninsula and the Notre Dame Range, followed the drainage channels, generally speaking, in its descent northward and southward. Along the lower St. Lawrence, the flow was apparently into the open waters of the estuary, while at Gaspé Basin it was eastward directly into the waters of the Gulf of St. Lawrence.

Separate glaciers.

The western part of the Baie des Chaleurs valley was occupied by a sheet to which the name of the Baie des Chaleurs glacier has been given. South of this and mantling the greater part of the Carboniferous area of New Brunswick and Prince Edward Island, the Northumberland glacier was developed. The great valley of the St. John River and the slopes on either side, were occupied by a sheet of ice which has been designated the St. John Valley glacier. The east and south-east termini of these glaciers were attenuated and were not accompanied by moraines. During the epoch of maximum ice accumulation, the coast border was somewhat higher than at present. Subsidence and differential movements set in towards the closing stage of the glacial period, which, in the Carboniferous plain of central and eastern New Brunswick, are evidenced by a number of swerving courses of striæ. These indicate that the watershed between the drainage basins of the St. John River and the rivers falling into Northumberland Strait, did not partake of the downward movement of the coast border to such an extent as the latter. The striæ which show gradually swerving movements on the flat Carboniferous plain, may be taken as evidence that there was no withdrawal of the ice from the region during the whole glacial epoch. Towards the closing stage, the glaciers became smaller and more detached, and floating ice occupied the bays and straits. The markings left by the latter on rock surfaces, show that the coastal parts of New Brunswick were then from 75 to 150 feet lower than at present. The country around the Baie des Chaleurs and that on the northern coast border of the Bay of Fundy, seem to have undergone greater differential changes of level than the central Carboniferous area of New Brunswick and Prince Edward Island, the latter area apparently occupying a more stable attitude in regard to crustal oscillations. The subsidence inaugurated then was that which continued into the Leda-clay period.

The peninsula of Nova Scotia was glaciated by land ice which gathered upon its surface, and probably by floating ice in the coast districts at a subsequent stage.

A local glacier seems to have accumulated around the head of Chignecto Bay and upon the isthmus of the same name, in the early stage of the Pleistocene, which has been called the Chignecto glacier. Floating ice has also glaciated the isthmus at a later date.

Magdalen Islands non-glaciated.

On the Magdalen Islands no evidences of Pleistocene ice-action, or of the occurrence of boulder-clay, were observed; on the contrary, the rock surfaces are everywhere masked with a covering of their own débris.

The glacial period; was it due to local or general causes?

The cause or causes of the glacial period, or rather of the existence of sheets of land ice in these latitudes in Pleistocene times cannot be discussed here. But it may be remarked that the tendency to eliminate cosmic influences and attribute the refrigeration of the northern part of this continent to geographical or terrestrial causes, characteristic of later studies respecting glacial phenomena, does not seem, so far, to throw a great deal of light on the question, and may after all be only a partial view. If the glacial period be solely due to terrestrial causes, the fact that such causes must be largely of a local character appears to have been overlooked; for, it is not probable that these causes would act synchronously in the whole arctic and north temperate zones as far south as the limits of the glaciated belt. That changes in the elevation of the land, changes in the distribution of land and water, changes in the atmospheric and oceanic currents, a greater or less amount of moisture and precipitation than what now obtains, etc., are, taken together, sufficient to bring about a glacial epoch, such as the phenomena indicate must have existed in Pleistocene times, may be seriously doubted. If it were attempted to show that such terrestrial conditions were sufficient to produce a glacial era locally, on one side or the other of the North American continent, for example, or on both sides of the North Atlantic, the hypothesis would seem to be adequate; but these causes while competent to produce various local oscillations of climate and of glacial conditions, have probably been governed or modified by some general law. It is inferentially certain, therefore, that any hypothesis based on terrestrial conditions which may be propounded will have to include such general or cosmic influences as to affect simultaneously the whole circumpolar and north temperate regions of the earth during Pleistocene time, otherwise glacial conditions cannot have occurred synchronously in both hemispheres, or even on both continents.

Deposits of the Later Pleistocene.

(*M 2 a*). *Stratified Inland Gravel, Sand and Clay (Fresh-water).*

Deposits of the later Pleistocene.

The general character of the stratified inland deposits and their relation to the boulder-clay and other superficial materials of the region, have been discussed in previous reports, and little can be added from our investigations regarding them during the past four years. Almost everywhere above the highest Pleistocene shore-line, and sometimes extending down below it, they mantle the glacial deposits proper and the residuary materials to a greater or less depth. Sections of these deposits are given in my reports on north-eastern and southern New Brunswick,* which are applicable to the area here discussed, it being part of the same Carboniferous field.

Stratified fresh-water deposits.

This member of the surface deposits has not hitherto received adequate study and correlation in glaciated countries, owing largely, perhaps, to the theories at present in vogue. By some geologists these deposits are attributed mainly to glacier action, or rather to the action of waters resulting from melting glaciers; and the terms *glacial gravels, glacial sands,* etc., are not infrequently met with in the literature of the subject. On the other hand, the advocates of great submergences suppose that they have found, in these deposits, and especially in the river and lake terraces which form a part of the series, evidences in support of their hypotheses. Our investigations have not elicited any large array of facts in favour of either view. As stated in previous reports, there is some evidence in the lower portions of the series, in certain places, that the deposits are the product of glaciers, that is, have probably been formed by waters flowing out from the foot of melting and retreating ice-sheets; but by far the greater portion of the series does not seem to have been produced in this way, but rather by agencies which are in operation at the present day. Again, as regards the hypothesis of submergence, all the terraces and other water-laid deposits above the highest post-glacial shore-lines recorded on pages 22-25 M, seem to be explicable on the theory of their having been produced by fluviatile and lacustrine agencies. Terraces along river-valleys, as a rule, slope longitudinally in the direction in which the river

*Annual Report Geo. Surv. of Can., vol. III. (N.S.), 1887-88, p. 17 N; and vol. IV. (N.S.), 1889-90, p. 52 N.

flows; those in inclosed basins can be accounted for by the action of the waters around the margin of existing or extinct lakes. This explanation applies to the formation of terraces at all elevations above the marine limits of the Pleistocene above mentioned, and obviates the necessity for postulating a great submergence of the region. The presence of the boulders met with on these higher levels has sometimes been explained as due to the action of floating ice during this supposed period of submergence, but no boulder-clay or other glacial material occurs, so far as my observations have extended, overlying or interstratified with these terraced and associated stratified deposits. Transported boulders, often worn and glaciated, occur on the surface, it is true, but their presence there I regard as due to the denudation of the original boulder-clay, of which they formed a part, and to subsequent erosion and transport by fluviatile, or lacustrine action, or it may be to the simple wear and waste of the surface deposits alone by subaerial agencies, gravitation causing them to move from higher to lower levels simultaneously with the general lowering of the land consequent thereon.

How formed.

These inland, stratified gravels, sands and clays are, therefore, the result mainly of a long series of complex causes which have been in operation since the close of the glacial period. Eliminating those supposed to have been formed by waters due to melting glaciers, we find that the products of fluviatile and lacustrine action lie chiefly in the valleys and depressions, where the deposits are often thick, and evince the changes and fluctuations of the floods which have produced them. On the higher ground between the valleys, these beds are of varied thickness, from a few inches on some hills and slopes, to many feet in the hollows, and seem, as stated above, to have been formed, to a large extent, by ordinary subaerial agencies, such as frost, rains, the melting of each winter's snow, etc., all of which have a denuding effect when continued year after year. In some hollows they are produced by the wash from the hills, and usually contain lenticular seams of clay. The materials are all derived from the boulder-clay and residuary earths of the region.

White bleached sands.

Upon the Carboniferous area of the eastern maritime provinces, the upper strata of this division of the superficial deposits contains irregular, lenticular, bleached seams of gray or whitish sands, especially noticeable in newly-ploughed fields. This colour is due to the deoxidation of the iron in the materials through the action of the vegetation growing on the surface.* The questions pertaining to the origin and mode of occurrence of these inland stratified beds is a very important one

* Annual Report Geol. Surv. Can., vol. III. (N. S.), 1887-88, p. 17 N.

and we propose to investigate it in still greater detail when we come to study the valley of the upper St. John and the region adjacent thereto.

River and Lake Terraces.

River and lake terraces.

Terraces occur along the Southwest Miramichi River and its tributaries, notably at Doaktown and Boiestown, also along the Renous and Dungarvon rivers, and, in certain places, attain a considerable development. But along the rivers whose drainage basins are entirely within the Carboniferous area, whether in New Brunswick, Nova Scotia or Prince Edward Island, no high or remarkable terraces have been met with.

Mode of origin of.

Reference has been made to the mode of origin of river and lake terraces. These terraces are found to be mainly attributable to the action of the rivers and lakes themselves upon the materials in the valleys in which they lie. Boulder-clay is occasionally met with beneath the river terraces, especially under the higher ones; and it seems also probable that the stratified basal portions of these, at least, may have been built up by deposits of material transported by the waters of melting glaciers during the period of their retirement. Around lake margins, both stratified and unstratified deposits occur in mounds and ridges, associated with or forming part of the terraces or benches. These have been produced by the mechanical expansion or shove of the ice that covers their surfaces every winter.

The discussion regarding the formation of river and lake terraces in previous reports, has been so ample as to include all that is necessary to say on the subject till further observation and study of those so typically developed along the St. John River and in western New Brunswick are completed, when it is hoped additional facts will be obtained enabling us to elucidate some of the problems presented by this very interesting class of formations.

(M. 2 b.) Leda Clay and Saxicava Sand.

Leda clay and Saxicava sand.

In the region bordering Northumberland Strait, the Leda-clay and Saxicava-sand deposits exhibit a marked difference from the beds of the same formation in Baie des Chaleurs basin, or on the coast of the Bay of Fundy. Around these bays the Leda clay is often well developed, ranging in thickness from five or ten to fifty feet or more. The lower part is usually coarse, and contains boulders derived from the boulder-clay or residuary material, and sometimes graduates into the former, or rather is without any sharp line of demarkation separating the two, and not infrequently is unfossiliferous. The upper portion consists of finer materials, as a rule, and wherever these are at all calcareous, marine fossils are present in greater or less abundance. The strata most prolific in marine shells are those immediately in contact with the overlying Saxicava sands. Attempts have been made to classify the Leda clay into upper and lower. Palæontologically, perhaps, such a division is possible, though it may after all be one mainly dependent on the bathymetric conditions under which the marine mollusca existed; but no stratigraphical break such as that occurring between it and the overlying Saxicava sands has anywhere been met with in the Leda clay itself. This and the Saxicava sand almost everywhere consist chiefly of local material derived from the subjacent beds, with more or less transported water-worn sand and gravel, etc., intermingled. In districts occupied by limestones, shales or slates, which in their decay form clay beds, the Leda clay is found especially well developed, and usually contains fossils; where, on the contrary, the underlying rocks are sandstones and grits, the Saxicava sands occur in their greatest extent and thickness, and the Leda clay is thin and irregular, or else entirely wanting.

Scarcity of Leda clay in the region examined.

In the region bordering Northumberland Strait, the Leda clay is seldom met with pure, and then only a few inches in thickness. Wherever these meagre clayey strata occur in the sandstone area, there only have marine shells been found. The Saxicava sand is, however, always present and generally of great thickness, and apparently has been formed in a manner similar to the sand flats of the recent period, *i.e.* along the littoral. The upper strata usually contain coarse material with local and transported boulders. None of these arenaceous beds have hitherto yielded fossils. Indeed only in a few localities on the west coast of Prince Edward Island have fossils been found in the whole Carboniferous basin, and they are few in number. Sections of these beds will now be given in detail, in descending order, and the contained species of shells enumerated:—

Sections of these marine deposits.

At Miminegash, P. E. I.

1. Half a mile south of the point of land at Miminegash Pond a measured section shows:—

(1.) Saxicava sand {Stratified gravel, 4 feet; Fine grained sand, 3 "} ——— 7 feet.

(2.) Leda clay, soft and unctuous, 12 to 15 inches.

The fossils occur in the upper part of the Leda clay, the species being *Saxicava rugosa*, *Balanus crenatus* and a *Leda*, probably *pernula*.

(3.) Boulder-clay, to the beach at high tide level, 20 feet.

At Campbellton, P. E. I.

2. At Campbellton another section exhibits the following series:—

(1.) Saxicava sand {Stratified gravel, 4 to 5 feet; Fine sand, 6 feet or more} ——— 11 feet.

(2.) Leda clay, quite thin, not more than a few inches. In upper part, or between it and the overlying Saxicava sand, the following shells were found :—*Saxicava rugosa, Mya arenaria ? Lunatia*, sp.?

(3.) Boulder-clay, thin.

The bank here is about 25 feet high, but more than half of it is rock.

3. South of Cape Wolf a third fossiliferous bed occurs in which Mr. Wilson found shells of *Macoma Grœnlandica*. A section of the beds is as follows :—

Near Cape Wolf, P.E.I.

(1.) Saxicava sand (gravel and sand), 11 feet.

(2.) Leda clay, thin, the sliding down of the beds prevented measurements being made.

(3.) Boulder-clay, thickness not known, but this and the Leda clay taken together are upwards of 15 feet thick above the beach.

Height of the Pleistocene, or post glacial shore-line in P. E. I., etc.

The highest Pleistocene shore-line on Prince Edward Island is about 75 feet above mean tide (page 25 M) ; on the mainland around Northumberland Strait it is found to be from 125 to 140 feet, the lowest being on the Cape Tormentine peninsula. Marine terraces are everywhere common up to these heights. Shore-lines occur at lower elevations, as, for example, on Prince Edward Island where a well-defined one was observed besides that mentioned above, at about 50 feet above mean tide level, and at Wallace, N.S., on the mainland, distinct, wave-built terraces occur at 130, 120, 110 and 55 to 60 feet, etc.

Scarcity of marine fossils.

Around the head of the Bay of Fundy, the Pleistocene uplift, though differential, was greater than in Northumberland Strait ; but the marine terraces are not well defined, except in a few localities, and have proved so far to be without fossils. Two circumstances have been unfavourable to the preservation of marine shells in them, (1) the heavy tides and currents, and (2) the presence of iron and other minerals in the deposits tending to corrode and destroy them.

Marine beds at the Chignecto railway, doubtful.

In the sections of the marine beds of the recent period exposed at the Fort Lawrence dock, at the west end of the Chignecto marine railway (page 127 M), the Pleistocene marine deposits, if represented at all, are poorly defined and problematical. Certain strata between the boulder-clay and the peat, or forest bed, may be taken either as residuary material or oxidized boulder-clay, or as partly boulder-clay and partly Saxicava sand. The absence of fossils renders this uncertain. There is no doubt that the Isthmus of Chignecto was submerged in the later Pleistocene, but the erosion to which it was then subjected may have prevented the deposition of any but thin beds of marine sediment. The materials of which the superficial deposits of the region, on either side of the isthmus, are composed, are not favourable to the preservation of marine testacea, however, there being little or no lime in them. It is not at all improbable, therefore, that shells

Reasons why fossils are scarce in deposits on south side of Gulf of St. Lawrence.

have been entombed in the marine Pleistocene beds at the head of the Bay of Fundy and around Northumberland Strait, in many places in which they are not now to be found. Shells are abundant there now along existing sand beaches, and in the littoral, and it is only reasonable to suppose that the mollusca of the Leda-clay and Saxicava-sand period lived in these waters. But the deoxidation of the iron which the sands contain and the purifying processes they undergo, rapidly destroy shells when they are once buried in them. The scarcity of Pleistocene shells in these marine terraces, therefore, is to be accounted for mainly from the destructive processes referred to, and not from their supposed absence or paucity in the adjacent seas, during the formation of the terraces.

Terraces in Cobequids supposed to be marine.

Terraces or deltas 171 feet above mean tide level (page 24 M), supposed to be marine, occur at Halfway River at the northern base of the Cobequid Mountains; and at Lakelands, in the pass through which the Springhill and Parrsboro' railway runs, others were observed 223 feet high. In regard to the 171-foot terrace or delta, it may be stated, the materials are stratified gravel and sand which, near West brook, are irregularly bedded, and differ from those composing the Boar's Back, inasmuch as they contain crystalline boulders from the Cobequids scattered throughout the mass. The materials have been brought into the valley by West Brook, and the terraces exhibit faults or dislocations in places, which may be regarded as indicating differential movements since the period of their deposition.* At first it was supposed these deltas or terraces were of lacustrine origin, but a system of levellings showed them to be eighty-five and one hundred and thirty-five feet, respectively, above the bottom of the pass referred to and from forty to ninety feet higher than the summit of the Boar's Back along River Hebert valley. On the lacustrine theory of their origin, we would have to postulate two dams, one to the south, in the Cobequid Pass mentioned, another to the north in River Hebert valley, in order to hold up a lake even at the height of 171 feet. This difficulty at once renders the lacustrine hypothesis of the origin of the terraces untenable. Moreover, it was observed that the terraces extend northward towards the Upper Maccan River, though at a diminishing height, and southward through the pass referred to, apparently increasing in elevation, though considerably broken up and denuded. On the south side of the Cobequids, near Parrsboro', where they face the Basin of Minas,

Difficulties of lacustrine theory of their origin.

*South of Dorchester Cape, Westmoreland county, N.B., in a bank along the shore, faults or dislocations were also observed in the superficial deposits. The materials are a stiff arenaceous, stratified clay, resting on boulder-clay, and the faults, of which there are six or eight, are nearly vertical, the *hade* being slightly to the south-east, with the downthrow to the north-west, that is, on the side away from the Bay of Fundy.

they fall to a level of 130 or 135 feet above mean tide. It seems to me, notwithstanding these inequalities in height, that all these terraces and deltas mark the upper limit of the post-glacial upheaval, or the height of the sea during the Pleistocene subsidence of the land, and are, therefore, marine. The differential elevation shown between these and the shore-lines along Northumberland Strait has been explained on page 30 M. The dislocations in the terraces may be taken as evincing unequal vertical movements. Remnants of terraces, or shore-lines, at the same height as those described, were observed on the west side of the valley through which Halfway River flows. These as well as the front of the main terrace itself have been sorely denuded. They are evidently of the age of the Saxicava sands of the Gulf of St. Lawrence and have been formed under similar conditions.

Later terraces in Halfway River valley.

At a subsequent stage of post-glacial history, as the land rose and the sea withdrew from Halfway River valley it formed a catchment basin and held in a fresh water lake of which Halfway Lake is a remnant. This lake stood about thirty feet higher than the present lake, or eighty-nine and a half feet above mean tide level. Terraces and alluvial flats formed by it encircle the valley now inclosing Halfway River and lake.

Importance of terraces here in relation to differential movements.

The facts respecting the terraces in this locality are of great interest, and if the higher terraces are marine, as they certainly seem to be after eliminating all other theories as to their mode of origin, they are most important in their bearing on the question of differential upheaval in this region during the Post-Tertiary period.

Age of the Leda clay and Saxicava sand

The Leda clay is found in some places resting on rock surfaces which have been striated by the local ice-sheets and floating ice of the closing stage of the glacial period. No disturbance of these beds, which must have been subsequently deposited, seems to have taken place, nor have any intercalated or overlying glacial products been met with in connection with the Leda clay and Saxicava sands. Hence it is inferred that their deposition began about the close of the boulder-clay period and continued for some time after the retirement of the ice from this region.

Correlation of these deposits with the Leda clay and Saxicava sand of the St. Lawrence Valley.

These fossiliferous clays and sands have been closely correlated with the Leda clay and Saxicava sands of the St. Lawrence valley, studied and named by Sir J. W. Dawson many years ago, and seem really to constitute a part of the same series deposited in the southern embayment of the Gulf of St. Lawrence, the only difference in the marine fauna being that in the latter area a few southern species are intermingled with those of the boreal type. The exact relations of a number of these species have not yet been definitely worked out, however, and until further collections of both Pleistocene and existing shells are made on the east coast of Canada, especially in and around the Gulf of St. Lawrence, their value as indicative of the climate of later Pleistocene times, and of the depth of the sea in which they lived is not to be greatly relied on. Some additional dredgings would be important in this connection, as enabling us to correlate the marine fauna now inhabiting the coast waters more closely with that of other regions, as well as with that of the Pleistocene deposits under consideration.

(M 3 *a.*) Fresh-water Deposits of the Recent Period.

River-flats (Intervales).

Deposits of the Recent Period (river-flats). Where observed in New Brunswick.

River-flats skirt the principal rivers of the region to which this report relates, and usually form the best soils. Along the Southwest Miramichi and its tributaries they are cleared of forest in many places and cultivated, and at Doaktown and Ludlow on the main river attain a considerable width. Bordering the Renous River, about thirteen miles from its mouth, fine, wide flats, partly under cultivation, but mainly covered by forest still, were also observed. These nourish a splendid growth of elm, balsam-poplar, yellow birch, etc., and if cleared and properly tilled should be valuable for the production of hay and for raising stock. Flats also occur along the Dungarvon River, one of which, eight miles above its confluence with the Renous, has yielded hay for many years. Similar intervales border the Kouchibouguac and Kouchibouguacis rivers, also the Richibucto, Buctouche and Cocagne rivers. Those along the three last-mentioned streams are largely under cultivation and afford good soil. Excellent farms were seen in the Richibucto Valley, and especially along two of its chief affluents, Nicholas and Coal Branch.

The rivers of Albert and Westmoreland counties do not possess any river-flats worthy of mention, being small and their drainage basins of limited extent.

In Nova Scotia.

In Cumberland county, Nova Scotia, intervales stretch along the Upper Maccan River and occur again at Halfway Lake, where some good farms were observed. Narrow margins of intervale land border River Philip and the Pugwash and Wallace rivers, while in the Deware valley and farther east towards Tatamagouche, some fine alluvial bottoms exist. Nearly all the alluvial soils are under cultivation in Cumberland county.

In Prince Edward Island.

Crossing Northumberland Strait and reaching Prince Edward Island, we find no fresh-water alluviums of note there except along the Dunk and Hillsborough rivers, the former only being within the area of sheet No. 5 S.W. All the valleys of the smaller streams, of course, contain more or less bottom-land, but usually it forms only a very narrow strip. The character of the soil derived from the soft Permo-Carboniferous and Triassic shales is such, however, that it readily crumbles down into a fine loam, and this mantles the slopes and bottoms of the valleys to a greater or less depth, and is almost equal to an alluvial soil. Much of it, indeed, is of the nature of fresh-water alluvium, though for the most part due to subaerial, or atmospheric action.

Mode of formation.

The mode of formation of these deposits has been discussed in former reports. They are in every instance the result of seasonal changes, such as spring and autumn floods due to melting snow, rains, etc, and the sedimentation consequent upon silt transportation from such floods. These carry coarse and fine material, the former being first dropped, the more finely comminuted matter transported farthest and deposited in the lake-like expanses of the rivers, or wherever their flow becomes slackened sufficiently to permit deposition of the fine sediment held in suspension by the waters. In these alluviums stratification is seldom apparent, except where clay is present in greater or less quantity, and in this respect they may be said to resemble the loess of other countries. No fossils have been found in them except stems of shrubs, twigs and leaves, remains of herbaceous plants, etc., all of which belong to existing species.

Peat Bogs.

Peat bogs.

Peat bogs are well developed in the coastal region of the south-western embayment of the Gulf of St. Lawrence, especially in New Brunswick and Prince Edward Island. Besides those described in former reports as occurring on Miscou and Shippegan Islands, at Saint Simon Inlet and at Pokemouche, Tabucintac, Cheval and Escuminac Points, others were noted at the following localities and are delineated on the maps accompanying this report. The following is a list of those observed in New Brunswick:—

Where observed in New Brunswick.

1. An extensive peat bog lies on the north side of Kouchibouguac harbour.

2. Another occurs on the coast about a mile south of the mouth of Kouchibouguacis River and faces the sea.

3. A third occupies part of the peninsula between the estuary of the Aldouane and the coast. This bog is large and raised in the centre and merges into the salt marsh on the shoreward side.

4. On the south of Little Gully at Richibucto Head, inside of the sand beaches, there is a peat bog of considerable extent.

5. Two large bogs occur along the Kent Northern railway, from one to five miles above Kingston, or about 20 or 21 miles from Kent Junction, Intercolonial railway.

6. About six miles north of Rogersville station, Intercolonial railway, and north of the first crossing of Barnaby River, a large peat bog occurs. It is a shallow one and a portion of the area mapped as peat bog forms a shallow lake, spring and autumn.

7. About two miles south of Canaan station, Intercolonial railway, a peat bog crosses the track twice.

8. Peat bogs skirt the lakes at the head of Missaquash River on the Isthmus of Chignecto.

In the interior of the country, flat peat bogs are of frequent occurrence on the watersheds, or undrained portions of the Carboniferous area, but they are usually shallow and the peat thin, poor and dirty, being mixed with the wash from the surrounding slopes. These bogs support a scanty growth of black spruce, haçmatack, etc., especially around the marginal portions. The best and cleanest peat is that found growing on the raised bogs.

In Prince Edward Island.

Proceeding to Prince Edward Island, we find large peat bogs on the north-east side, along the shores of Richmond and Cascumpeque bays. These have been described by Dawson and Harrington.* The precise localities of the largest peat bogs on the island are here noted :—

9. At Lennox Island, Richmond Bay, on the north-east side, a strip of peat faces the Gulf of St. Lawrence. This bog is apparently being rapidly eroded by the sea.

10. At Point Lot 12, there is an extensive peat bog (called the Squirrel Creek bog in Dawson and Harrington's report already referred to), covering an area of certainly not less than 500 or 600 acres. It rises in the centre, and like those on Miscou and Shippegan Islands, at the entrance of the Baie des Chaleurs, is dotted over with small, deep ponds or holes in the peat which remain constantly filled with water. It is also treeless.

11. At Black Bank, east of Stephen Cove, in Cascumpeque Bay, there is also a large peat bog. Along the shore it is seen to be ten or twelve feet deep in places and rests directly on white sand. The bottom layers are full of roots, trunks of trees, etc., in decay. Just at Stephen Point, stumps were observed two feet below low water mark. This bog is also higher in the centre than at the circumference, and treeless. Erosion by the sea is apparently making rapid inroads into it. Mr. Robert Tuplin, who lives in the vicinity, and has been making

*Report on the Geological Structure and Mineral Resources of Prince Edward Island, 1871. By Sir J. W. Dawson and Dr. B. J. Harrington observations on these peat bogs, informed us that a strip of five feet in width or so was annually worn away by the sea. This peat bog is described in detail in Dawson and Harrington's report already cited and its area can be best learned from an inspection of the map.

12. West of Stephen Cove, another large peat bog, the largest on Prince Edward Island, occurs (see map). It is about three-quarters of a mile wide, and, like those of Black Bank and Squirrel Creek, is raised in the centre and without trees.

13. A small peat bog was also seen near Portage station, P. E. I. railway.

All the peat bogs bordering the sea are found to extend down under high tide level and their lower parts contain roots and stems of trees which do not occupy their surfaces at the present day, but which, nevertheless, exist in the low, flat, swampy coastal tracts in the vicinity. In some countries where peat and treeless moorlands exist, attempts have been made to show that these buried forests must have been destroyed by the encroachment of the sea, or by a change of climate, or in some other unaccountable way, before the peat mosses began to grow. But as peat bogs in what may be termed their incipient stages are not infrequent in many parts of the maritime provinces of Canada, on the surfaces of which the same stunted growth of spruce, hacmatack, cedar, etc., prevails as is found in the bottoms of the larger bogs, it is at once evident that the change from a forest-covered or partially forest-covered condition in the early stages of their growth to a treeless condition when they are mature, or rather when the peat has attained considerable thickness, is one due to other causes than those mentioned. Roots and stumps in peat bogs.

Peat bogs are to be seen in all stages of development in this region, from those only a few inches or a foot or two deep, to those upwards of twenty feet deep. The first have always a forest growth upon them when in their natural state, the trees being larger around the margins than in the centre. As the peat mosses grow and the bog increases in thickness, the trees are observed to become stunted, and finally die out wherever the peat is thickest, generally at the centre first, then outwards towards the circumference. The larger and thicker bogs at present have, therefore, a part which is treeless, and a border upon which there is an ericaceous growth, occupied with some stunted forms of spruce, hacmatack, cedar, etc., the latter increasing in size and becoming more and more intermixed with other trees towards the margin of the bog. From this fact it would appear that trees do not, or cannot, grow in peat bogs, and that, therefore, their treeless condition is mainly due to the drowning out of the forest growth which Mode of growth of peat bogs. Why trees do not grow in them.

originally occupied the area on which they lie. The growth of the mosses causes imperfect drainage, the peat in its natural state holding from ninety to ninety-five per cent by weight of water. It is at once obvious that trees will not grow in such a soil, and even if rooted in that beneath the peat, the accumulation of several feet of wet, cold, peat mosses around the base of their trunks and the lack of aeration to their roots must soon result in their death. In the early stages of the growth of the peat bog, there would doubtless be a struggle for the mastery between the forest growth and the *sphagna*; but as peat bogs invariably accumulate in hollows or basins which originally held shallow lakes, and do still, when not wholly occupied with peat, receive, at certain seasons, the drainage of the surrounding area, it will be seen that tree growth in peat, even then, is placed under very unfavourable conditions for its development at anything like a rapid rate. In consequence of this it is only those hardy species found in wet, cold soils, in swampy tracts, that grow at all in those hollows, before or during the incipient stage of the growth of the peat bogs, and their existence is often a very precarious one, liable to be checked or terminated altogether by any untoward or unfavourable change. Hence the growth of peat moss around the roots and basal part of the stems ultimately destroys the trees. They then stand as dead trunks for some time, until decay setting in, they break off at the surface of the bog, the trunks falling prostrate upon it. But the roots, and sometimes a portion of the stump are preserved from decay by the antiseptic properties of the peat moss, or the acids generated by its decay, and are usually found in a sound condition at the present day, sometimes even with the bark intact.

Climate of the region favourable to the growth of the *sphagna*, composing the peat beds.

The great thickness and extent of so many of the peat bogs, or moorlands, near the coast of New Brunswick and Prince Edward Island, shows that the existing climatic conditions are very favourable to the growth of the species of *sphagna* and other vegetable forms composing them. And from the peat, or forest beds, found under the marsh mud at Aulac station, Intercolonial railway, and at the west dock of the Chignecto marine railway, it is evident that somewhat similar meteorological conditions prevailed throughout the recent period. We may even go further back, and infer from the peat beds found by Sir J. W. Dawson under the boulder-clay at River Inhabitants, Cape Breton, that the climate of the coast in the later Tertiary did not differ very much from that which now obtains.

Antiquity.

The peat bogs, or moorlands, are, therefore, of considerable antiquity, having commenced their growth in this region along the coast, as soon as the land emerged from beneath the sea in post-glacial times.

They did not all originate then, however, but at intervals, or from time to time, as the habitat of the *sphagna* and the drainage and other conditions became favourable for their development.

As has already been inferred, the peat bogs indicate a slight subsidence of the coast border within the recent period. The exact amount of the change of level is a difficult matter to ascertain; but the facts point to a depression of from five to ten feet.

Subsidence indicated by the peat bogs.

No use has yet been made of peat in the region embraced in this report. A number of these bogs are easily accessible, some by land and others by water; but the abundance of wood and the proximity of the Nova Scotian coal mines keeps fuel at moderate prices, and there is consequently no use for peat in that way. The day will come however, when it will become valuable, not only for fuel and litter but for other purposes as well. In some parts of Europe it is now utilized in various ways. One of these is as a packing material for the transport of the various kinds of crockery, glass and other articles liable to breakage. Another is in its taking the place of ice in the carriage of perishable articles, such as fresh meat, fish, etc. When cut into fragments it is said to be well adapted for the preservation of these articles in transport in warm weather, either by railway or water. Meat when packed in it, will keep fresh for weeks, and will eventually become dry, the moisture being absorbed by the peat. For the shipment of fresh fish by railway it might be utilized to great advantage on the Atlantic coast of Canada; salmon, cod, mackerel, lobsters, etc., by this means finding a market, not only in the eastern cities of the United States, but in Montreal, Ottawa, Toronto, etc Peat has also been successfully used for preserving fresh fruit; even grapes it is said can be made to retain their freshness unimpared for months if packed in finely pulverized moss litter. Its uses as a non-conductor of heat, therefore, are likely to bring it into extensive requisition in this country in the near future.

Uses to which peat may be put.

In Germany peat has been used for years as an absorbent of the waste liquids and refuse of factories, and in this way it has furnished large quantities of excellent manure in certain districts. An excellent fibre is also now manufactured from some varieties of peat, susceptible of being woven and applicable to other purposes. An enumeration of the manifold uses of peat would prove that this raw material is eventually destined to become of great value in the arts, in chemistry, and in agriculture, as well as for sanitary purposes. Bog land hitherto regarded as worthless, is likely to become valuable property, and flourishing industries promise yet to spring up from the use of this neglected material. When that day arrives the maritime

Uses in Germany.

Value of moorlands.

provinces of Eastern Canada will be able to furnish an almost unlimited supply of peat moss for all the purposes enumerated.

(M 3 *b*.) Marine Deposits.

Dunes, Salt Marshes, Estuarine Flats, Mussel-mud, etc.

Recent deposits (marine)

The recent marine deposits which occur almost everywhere around the coasts of New Brunswick, Nova Scotia, and Prince Edward Island, are among the most interesting of the superficial formations. Their great development in the particular region under discussion is due to several causes, as for example, in the Bay of Fundy region to the extraordinary tides of that body of water and their erosive influence on the coasts, which furnish large quantities of material; in Northumberland Strait to the wear and waste of the land surface supplying abundant arenaceous and other materials to the rivers, streams, etc., which transport them seaward into the littoral of a low, shelving, sea border. It is in the Bay of Fundy region that salt marshes find their fullest development, while sand dunes, eel-grass and mussel-mud flats cover a much greater area in Northumberland Strait, and in the latter district especially, are all apparently of contemporaneous origin. The loose sands of the coast border in the latter region, moved about hither and thither as they are by marine currents, winds and waves, finally reach a comparatively stable position along these low sloping shores, where they are thrown down and form long beaches or dunes parallel to the coast-line with shallow lagoons of greater or less width intervening. While these materials are thus being shifted about in the littoral, a leaching out process is going on, due to the action of the sulphates of the sea water and the acids generated by the decomposing vegetable matter (peat bogs, grasses of salt marshes, etc.) of the coast margin. The lagoons within the beaches are really basins or vats where chemical changes in the ferruginous sands and silts are continually in progress, as these are carried down from the land by fluvial agencies. The bleaching of the sands composing the dunes therefore, while partly owing to mechanical attrition under flowing waters and to the surf; is principally due, perhaps, to the leaching out of the iron in them by decomposing humus. Beds of quicksand near the mouths of the several rivers emptying into Northumberland Strait seem now to be undergoing the purifying process referred to. Wells have been sunk in the dunes at a number of fishing stations, showing in decending order, (1) sand, (2) ferruginous gravel and rotted rock, and (3) gray Carboniferous sandstones *in situ*. The water in these wells is, of course,

Source of materials.

Leaching.

brackish and contains more or less ferruginous matter and other impurities, which have been developed from the chemical reactions alluded to. By these means and by continual attrition, the sands become bleached and whitened, especially in the upper layers of the dunes. The zone or belt in which these coastal deposits lie is of variable width, but they nevertheless form a definite series which, passing from the dry land seaward, may be classified as follows :—

Series of deposits of Recent Period on coast.

1. Salt marsh, bordered on the inner margin in some places by peat, in others by ferruginous sands, silts, clays, etc., the whole having usually a hard-pan beneath.

2. A shallow lagoon, channel or inner passage of the sea, in which tidal currents play backward and forward. This is really a basin or sink, into which the impurities of the land are drained and digested, and where chemical changes are continually in progress from the action of the sea-water and the organic acids brought from the land.

3. A broken strip of salt marsh lining the inner margin of the sand beach or dune.

4. The long, narrow beach of white or grayish-white silicious sands lying parallel to the coast, sometimes in one ridge, but where widest consisting of two or three. These are evidently wave-built and are often protected from denudation by a covering of coarse grasses and carices.

5. Shifting sand-flats in the littoral, wider or narrower according to the slope. Around Northumberland Strait these are of great width, and much of their surface is laid bare at ebb tides. Outside bars or sand ridges are thrown up, too, in most places parallel to those described, at whatever distance from the shore the waves first break during storms. That the material of these dunes and sand-bars is accumulating, seems proved from the fact that the latest or outside ridges are usually larger than the inner and are apparently, in some cases at least, increasing in width; while between tide marks great quantities of loose sands lie ready to be shifted about or thrown up by the waves during heavy storms.

The sand beaches on the north side of Prince Edward Island, are much the same in character and composition as those on the mainland. One of the largest of these, of which Hog Island forms a part, was examined with some care. Here the older or inner ridges of the beach were found to consist of reddish or partially oxidized sands, while those facing the Gulf of St. Lawrence and lately formed, or now in process of accumulation, had the usual whitish or bleached colour. From six to ten parallel ridges of sand were found in this beach, the latest formed being the highest. The width of this beach is from a

Beaches on Prince Edward Island.

quarter to half a mile. Along the inner border of the beach are lagoons, bogs and marshes. Crystalline boulders were met with lying upon the surface of these salt marshes, though no evidences of glaciation were observed on the adjacent shores or islands, rotted rock being everywhere abundant.

The older ridges of the dune or beach referred to, are now clothed with stunted spruce trees and bushes of several species of hardwood, together with ericaceous plants. Those ridges lately formed, are covered merely with coarse grasses or carices.

Local Changes and Conditions of the Dunes.

Changes in the duues.

These shifting sands may be considered under two aspects at least, first, in reference to the navigation and silting up of the rivers and harbours, and secondly, in their relation to the agricultural character of the coastal districts.

Silting up of the harbours around Northumberland Strait.

Generally speaking, it may be stated that all the harbours around Northumberland Strait, *i. e.*, around the coast of the Carboniferous area of New Brunswick, Nova Scotia and Prince Edward Island are silting up. This is the result of two causes, first, the accumulation of material carried down by the rivers and streams and deposited in the estuaries, which may be called *fluviatile;* and secondly, the action of the sea in throwing back these loose sands into the mouths of the harbours and inlets. It is now well known that the sands which are shifted by winds, waves and currents into the mouths of the harbours at Bathurst, Miramichi, Richibucto, Summerside, etc., by heavy storms are a serious obstruction to their free navigation. To show how these sands accumulate, let us take the case of the Richibucto harbour, at the entrance to which a breakwater has been constructed. Beyond the outer end of the breakwater, the sands are thrown into the channel by heavy storms spring and fall. Dredges have been used to clear it out, but the river itself is a most effective agent in this regard, the sands thrown into it by the storms being thus cleared out, partially at least, by river freshets. These filling and clearing out processes continue year after year, and before the breakwater was built, caused a slight shifting of the channel periodically. This shifting or diversion of the channel was a movement away from the direction of the prevailing north-east winds which accompany the heaviest storms. At present, the channel or passage outside the breakwater only is subject to changes of this kind; but in 1890 I found it had been so far shifted as to throw it up against the southern dunes. When it reaches this stage and becomes choked up, the dredge has again to be brought into requisition, and a new and

How caused.

straight channel cut directly from the end of the breakwater. High river freshets aid this operation materially, afterwards the operations of nature just described, of filling up and clearing out will be again repeated. This is one instance among a number which might be cited to show how these sands obstruct navigation.

Effect of sands on value of the land near coast.

In reference to their effect upon the agricultural character of the country bordering the sea, it may be stated that portions of it are almost valueless from the quantities of blown sands drifted over them, often to the depth of several inches. The leaching out, or deoxidation of the iron in these arenaceous strata, referred to on a previous page, also impoverishes the soil, rendering it of inferior agricultural value.

Salt Marshes in Northumberland Strait.

Salt marshes in Northumberland Strait.

The salt marshes of the coast of Northumberland Strait, are quite different from those of the Bay of Fundy, both in regard to their physical character and agricultural value. While the latter are built up mainly by the action of the great tidal wave of that body of water, those under consideration are invariably found in places which are protected from the denuding action of the sea by natural barriers of some kind. The materials of which they are formed may be characterized as silt, with coarse, gravelly, clayey and pebbly deposits of the nature of hard-pan beneath. These marshes are of much less depth than those of the Bay of Fundy, and are usually covered with a thick mat of the roots of coarse grasses and carices. The yield of hay on them is also less, and consists of several species of wild grass only, but does not include timothy (*Phleum pratense*), or upland grass. On the marshes which have been dyked, and from which hay has been cut for a number of years, a change in the species of grasses has taken place, the coarser kinds becoming replaced by those which grow in cultivated fields. The undyked marshes are partially overflowed annually by high autumn tides. The limited area of all these marshes, dyked and undyked, and their precarious and uncertain yield, render them of minor importance compared with the Bay of Fundy salt marshes. The largest salt marshes of this kind along Northumberland Strait, occur at Baie Verte, Shemogue, Aboushagan, at the mouths of the Richibucto, Kouchibouguac and Kouchibouguacis rivers, and in Prince Edward Island, at the head of Hillsborough Bay.

Of limited area.

Bay of Fundy Salt Marshes.

Salt marshes of Bay of Fundy.

The salt marshes of the upper part of the Bay of Fundy, have been formed under quite exceptional conditions, and although classed with those of Northumberland Strait, they are really distinct in character. The great tidal wave of the Bay of Fundy has been the chief agent in producing them. These tides flowing at the rate of five or six miles an hour into the bays and estuaries, are loaded with reddish sediment which is everywhere deposited before they ebb. It is not uncommon for a single tide to lay down an inch or more in certain spots along the river banks. The soft Carboniferous shales around the head of the bay furnish, by their waste, the material necessary for marsh building. The force of the tides prevents the formation of any submarine, or eel-grass flats, such as occur in the shallow waters of Northumberland Strait, consequently at ebb tides, only bare, muddy slopes are to be seen. At high tides the creeks and inlets are filled to the grassy border, at low tides they are yawning, slimy gashes in the earth with tiny streams trickling in their bottoms. In whatever way the waters move, summer or winter, they are always loaded with reddish-gray sediment or mud, and run like a mill-race.

Materials of, how deposited

Area not increasing in historic times.

The area of these marshes does not seem, so far as observations extend, to be increasing seaward since they were first dyked, that is, within the last two hundred years; but it is stated that the estuaries are filling up and becoming narrower. There is a tradition among the old settlers in the Isthmus of Chignecto, that about the time Fort Beausejour (now called Fort Cumberland) was captured by the English in 1755, the Missaquash River was navigable for canoes nearly to its source; but this is not now the case.

Height of these salt marshes.

The salt marshes lie at the height of ordinary spring tides, and portions of them can be overflowed by opening the dykes. Very high tides, such as the one which accompanied the Saxby gale of October 5th, 1869, overflow them altogether. Along the banks of the rivers or estuaries, the land is a few feet higher than the inner or central portions of the marshes, owing to differential deposition of the sediment. The formation or building up of these marshes seems to have taken place coincidently with a slight subsidence of the land here in the recent period. This subsidence is proved by the existence of forest beds below the marsh mud, and, of course, below the level of the Bay of Fundy waters. The boring at Aulac station shown on page 129 M, illustrates this, and in the excavation for the western dock of the Chignecto marine railway the forest bed was found to be thirty feet below the level of the marsh or eight feet below mean tide level. Referring Sir J. W. Dawson's figures given for the level of stumps found *in situ* in this vicinity to mean tide, some are 10·80 feet below it and others only ·30.* At the public wharf at Edgett's Landing near

How built up, and when.

* Acadian Geology, Suppt. to 2nd ed., page 13.

Hillsboro', Albert county, in the mouth of the Petitcodiac estuary, a stump of a tree *in situ* was pointed out to me by J. B. Hegan. C.E., of the Public Works Department, St. John, and found to be 15·32 feet below mean tide level.

The following two sections, in descending order, exhibit the structure of the whole series of the superficial deposits at the Fort Lawrence dock. No. 1 was taken at the east end of the excavation where the marsh mud rests on the slope of Fort Lawrence ridge :— Section of salt marshes and underlying beds, No. 1.

1. Marsh mud, reddish, 2 feet 11 inches.
2. " bluish-gray, 9 inches.
3. " grayish, full of roots of plants and shrubs, 1 foot 8 inches.
4. " bluish, with roots, 2 feet 10 inches.
5. " dark-gray with bluish tint, full of roots and stems. (This corresponds with the forest bed and the overlying bluish fossiliferous clay in the west end of the excavation), 1 foot 8 inches. See section No. 2 below.)
6. Stratified, or partially stratified, gravel sand and clay containing water-worn pebbles, roots of shrubs and plants, etc., 1 foot 11 inches.
7. Boulder-clay, containing local boulders, some striated. Thickness not known; in excavation, about 40 feet.

No. 6 of this section is the most interesting. It is chiefly sand, and is either the boulder-clay changed under subærial action, or it is the representative of the Saxicava sand and Leda clay in the Isthmus of Chignecto, most probably the latter. A few pebbles of granite, etc., occur in it, but apparently only such as are derived from the Carboniferous conglomerate. Its depth beneath the surface of the marsh now is nine feet ten inches It seems to lie somewhat unevenly on the surface of the boulder-clay, and the strata are irregular. The character and position of this part of the series, therefore, denote a considerable interval of time between the deposition of the boulder-clay and that of the overlying marsh mud, during which the Leda clay and Saxicava sands were laid down along the coast borders elsewhere.

Section No. 2 at the south-west end of the excavation, which is only a few yards from the confluence of the La Planche and Missaquash rivers, exhibits the following series of beds :— Section No. 2.

1. Marsh-mud with roots and stems of herbaceous plants, grasses, etc., 12 to 15 feet.
2. Marsh-mud, stratified, gray, and containing marine shells, 5 to 10 feet.
3. Stratified, tough, blue clay containing an abundant molluscan fauna of the following species, *Macoma fusca*, *Mya arenaria*, *Rissoa minuta*, *Nassa obsoleta*, etc., 5 to 6 feet.
4. Peat and forest bed containing stumps and portions of the trunks of hacmatack, black spruce, birch (probably *Betula lutea*) alder, poplar, hemlock, elm, ash, etc. (one stump of hacmatack being 12 to 15 inches in diameter), 1 to 2 feet.
5. Coarse, gravelly, oxidized, reddish-blue clay, partially stratified at summit, resembling the lower part of the Leda clay, but changing into true boulder-clay

below. It contains boulders of sandstone of local origin. Thickness variable, but not exceeding 1 foot

6. Boulder-clay, containing numerous boulders of local rocks, of all sizes, up to 3 feet in diameter, some of them glaciated. Thickness unknown; it probably extends below the waters of Cumberland Basin.

Forest bed under marsh mud.

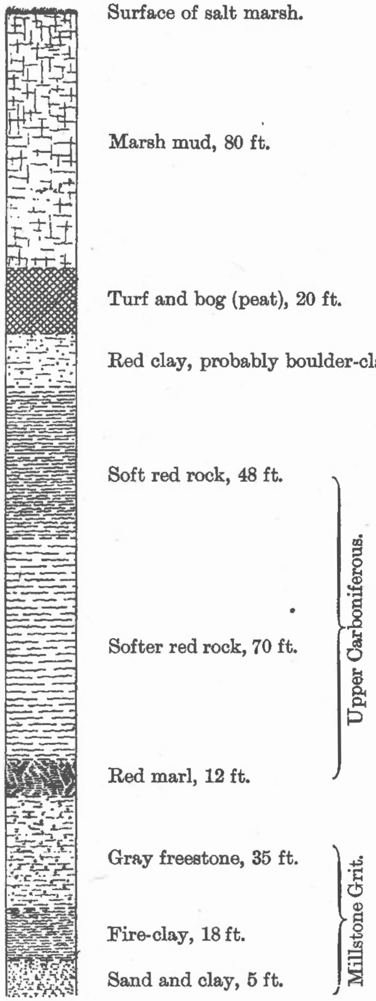
The length of the excavation for this dock is about 300 feet, and the total depth below the surface of the marsh between fifty and sixty (53 feet). The forest bed slopes towards Cumberland Basin about twenty feet within the length of the excavation (300 feet), that is, eight-tenths of an inch per foot, and lies thirty feet below the surface of the marsh at the western end of the excavation, as stated above.

Another section of the salt marsh, with the underlying forest bed, was disclosed in the boring at Aulac station, Intercolonial railway, and is represented on page 129 M by diagram No. I. This section shows the maximum thickness of the marsh mud and forest bed here, the bottom of the former being fifty-nine feet below mean tide level, and the peat or forest bed, which is twenty feet in thickness, lying from fifty-nine to seventy-nine feet below the same datum. This marsh (Tantramar and Aulac) covers an area of not less than sixty square miles, thus showing a large accumulation of material here in the recent period.

Geological conditions of deposition.

Regarding the conditions under which these materials were deposited, it would appear that the marsh mud belongs mainly to a period of subsidence, as already stated, in the early stages of which there must have been an interval of quiet in this part of the Bay of Fundy. The strata of fine blue clay and the well preserved condition of the contained fossils, show that they could not have been thus deposited if they were within the range of the heavy sweeping tides transporting sediment, such as exist at the present day. The shells belong to shallow water species, and it really seems as if the turbid condition of the waters in the upper part of the Bay of Fundy and the extraordinary tides did not exist at that time. It is, therefore, probable that the fossiliferous deposit in question was laid down in a quiet lagoon or recess to which the strong ebb and flow currents, if they existed then in the bay, had no access. There is, however, no abrupt line of separation between the blue fossiliferous clay and the overlying marsh-mud, and the fossils are found to extend locally, but in diminishing numbers, upwards into the lower strata of the latter, disappearing entirely in the uppermost portions. *Macoma fusca* is still met with on the shores of the upper part of the Bay of Fundy in some places, while this and *Mya arenaria* and *Nassa obsoleta* are common in Baie Verte in Northumberland Strait.

Fauna.



SECTION OF THE STRATA AT AULAC, INTERCOLONIAL RAILWAY, PASSED THROUGH IN A BORING MADE UNDER THE DIRECTION OF P. S. ARCHIBALD, CHIEF ENGINEER, I. C. R.

Salt marshes formed during subsidence.

The depth and extent of the marsh deposits indicate that their formation must have extended over a considerable time. This view is compatible with the fact that their accumulation and increase in height or thickness would be coincident with the sinking of the land, which took place in the region since the peat and forest beds grew. Whether these marshes, if now in a state of nature, would be still receiving additions upon their surfaces sufficient to raise their level higher, is a question referred to below. The condition of the older dykes around them and other facts bearing upon the question of a change of level, rather support the conclusion that the land is now nearly stationary.*

Forest Bed Under Salt Marshes.

Forest bed under salt marshes; how it grew.

In regard to the forest bed referred to, it would seem, from a number of facts collected in different parts of the salt marsh area, as well as from the presence of shallow peat bogs along its junction with the uplands, that peaty matter has been continually growing on the inner borders of these marshes ever since they began to accumulate. As the land subsided and the salt marshes accumulated, keeping pace therewith, these peaty margins likewise flourished wherever the drainage or fresh water from the adjacent uplands became stagnant and other conditions favourable to their growth existed. These inner margins of the marshes are rather below the general level of their surface, hence the formation of shallow lakes skirted with peat bogs is a necessary result. From these circumstances, it would seem that peat, or forest beds, may be found continuously at the junction of the marshes with the sloping uplands, from the bottom to the surface. Mr. Alex. Munro, C.E., of Port Elgin, New Brunswick, first drew my attention to this fact.

Chemical changes in materials of salt marshes.

The original material forming the salt marshes has probably, in all cases, been a red loam or mud, a product of the marine and subaerial action which decomposes the soft red Carboniferous sandstones of the region. It appears, however, that the red colour is liable to be changed into gray, in at least some portions of the marshes. This change is brought about by the chemical alteration of the iron oxides into sulphides by the sea water, or by the action of the organic acids on the iron contained in the marsh mud.† We find, therefore, that the inner portions of the marshes consist almost wholly of gray or bluish-gray material, with more or less vegetable matter disseminated, while the outer portions or those exposed to the tidal currents

*Ann. Report, vol. IV. (N.S.) 1888-89, p. 74 N.

†Acadian Geology, 2nd ed., p. 24.

are red. Cultivation, draining and aerating the upper strata, it is said, change the blue mud into red, *i. e.*, the iron compounds become changed from sulphides into oxides.

Blue and red mud.

The blue and red muds often occur in alternate layers, where the tides have been allowed to overflow the marshes periodically. At Sackville the following section of the beds was observed, the series being descending :—

1. Red marsh mud.
2. Peaty matter or humus, graduating into blue clay in places.
3. Red mud or clay, changing into blue clay.

These strata lie under an undrained field, the peaty covering of former surfaces having been overflowed on two occasions, and red sediment deposited. There appears to be a general tendency for the marsh mud to change from red to blue, as above stated, where the marsh is low and flat, and where the precipitation is apt to lie upon it, and the sea is prevented from overflowing. The gray or blue marsh, has, in wet places, a tendency to become covered with a growth of peaty matter and shrubbery.

Agricultural Character of the Salt Marshes.

Agricultural character.

The chief portions of all the larger marshes are dyked, but additions of greater or less extent are constantly being made to some of them. Where the dykes are kept in good order, the marshes are almost as dry as the adjacent uplands. They have long been noted for their great fertility. Hay has been raised on them for one hundred and fifty years or more without the application of manure, and they also yield cereals and root crops abundantly. The soil of the older dyked and cultivated marshes is, however, deteriorating, owing to continual cropping; and those portions of them which have not been overflowed by the tides for many years, are now well nigh exhausted, so far at least as regards the production of hay and cereals. They require, therefore, new and different methods of culture from those hitherto employed.

Methods of improvement.

In the report on Government Experimental Farms for 1890, Mr. F. T. Shutt, chemist, gives analyses of two samples of soils from the Sackville marshes, among those from a number from other localities, and offers some pertinent advice in regard to their improvement, recommending lime, wood ashes, etc. Subsoil ploughing, draining and the application of the fertilizers recommended by Mr. Shutt, as well as barn-yard manure, would all doubtless be highly beneficial, but I am informed that it has been found by experience that the results of this method of tillage are not commensurate with the cost and labour expended, and that the improvement of such large areas of marsh lands as these would be too slowly reached in this way. A scheme inaugurated by the more intelligent farmers of Sackville, seems to afford at once a more efficaceous and economic mode of fertilizing these lands, and promises to bring about important changes in their culture. This is nothing more than flooding them for a year or two by the sea. Where it has been tried, the results have been found highly beneficial. The *modus operandi* is to cut away certain portions of the dykes and open the *aboideaux* (exit gates of the fresh-water streams), allowing the sea to enter and spread a deposit or layer of red sediment over the surface of the marshes, and after sufficient material has thus been deposited then to close the *aboideaux* and dykes and permit the land to dry for a season or two. During the first year after this treatment, only the coarser kinds of grass, chiefly *Spartina stricta* or *alterniflora*, commonly called "broad leaf," grow, but the second or third year the marsh resumes its former covering of meadow grasses and continues for many years afterwards to yield an abundant crop without further cultivation. All this has already been proved by actual experiment, and the fact established that the red marsh sediment deposited by the tides acts as a natural fertilizer. Marsh owners who have thus allowed the tides to overflow their land at intervals have maintained the original productiveness of this kind of soil, in a large measure unimpaired.

Reclamation of swampy marshes.

The reclamation of peaty or swampy marshes lying along the junction of these with the uplands, especially as regards the Tantramar or Sackville marsh, is a work which has been in progress for years, with highly satisfactory results. The process consists first in draining and building *aboideaux* and dykes. The tidal wave with its burden of red mud is then admitted, and a layer from six inches to two or three feet deep deposited. The first year after reclaiming it, the product is chiefly "broadleaf," but afterwards as the salt becomes washed out of the sediment by atmospheric action and the upper strata aerated, the common grasses flourish most luxuriantly.

This mode of reclaiming the newer portions of the boggy salt marshes, and improving those impoverished or worn out by continual cropping, is now being carefully studied by the more intelligent marsh owners, and the result will doubtless be the adoption of practical and systematic methods tending to increase their productiveness. The method just outlined is, so far, considered the cheapest and best, and, indeed, nature's own method of restoring them in a large measure to their original condition of fertility.

Area of salt marshes at

The area of salt marsh around the head of the Bay of Fundy, on the New Brunswick side of the provincial boundary, as ascertained from a careful computation, is about 34,300 acres. These figures include of course, the dyked and undyked marshes; the latter are, however, of small extent, and are merely fringes of the dyked and cultivated portions. Of this whole marsh area, Westmoreland county includes 25,200 acres, and Albert, 9,100 acres. The principal localities of the marshes referred to are along the Missaquash, Aulac and Tantramar rivers in Cumberland Basin, and the Memramcook, Petitcodiac and Shepody River valleys in Shepody Bay. The largest and most important of these is the Tantramar and Aulac marsh; it is also in the highest state of cultivation. head of Bay of Fundy in New Brunswick.

Considerable areas of marsh land have been allowed to go to waste from the breaking down of dykes, the owners, either from want of means, or other causes, permitting them, for want of repairs, to remain in a condition in which the marshes are subject to continual overflow by the tides. These, with the undyked portions might, with the expenditure of some capital, be readily brought under cultivation again and converted into good arable marsh.

Marshes not utilized to best advantage.

The Bay of Fundy marshes, notwithstanding their high value, are not utilized to the best advantage. If better methods of culture were adopted, their productiveness might, in large portions, be doubled. Imperfect draining, continual cropping without manure, allowing portions of them to grow up with weeds and shrubs, are the chief causes tending to their deterioration. The leading agriculturists are, however, becoming cognizant of the fact that their fertility has lessened, and will continue decreasing under existing methods of culture. Hence the reclamation of new or uncultivated portions, and the devising of means for increasing the fertility of the older dyked marshes.

The area of salt marsh bordering Northumberland Strait has not been computed, but it is limited, as already explained.

Natural Dykes.

Natural dykes, their appearance.

Along the estuarine parts of some of the streams falling into Northumberland Strait, notably Shemogue, Baie Verte, etc., occur certain formations called natural dykes, or sometimes "shooting dykes." The most noteworthy examples of the kind observed, are on a stream about two miles north of Port Elgin, called Timber Brook. Here they rise in definite ridges from three to five feet above the surface of the marsh skirting the stream, and continue without interruption for distances of a quarter or half a mile. Trees from six to nine inches in diameter are found growing upon them. The largest dykes occur upon the marshes bordering the estuary, but others are ranged along the base of the ascending slope of drier ground.

Materials.

The materials of which these dykes are composed is altogether local. Along a dry bank they are gravelly or sandy, as the case may be, similar to the materials of the bank itself. On a marsh they are made up of marsh mud, with whatever other débris occurs in this. Newer portions of the dykes were observed to be in process of construction.

How formed.

A careful study of these dykes will show that they must have been formed by the ice which forms on the estuaries of these streams every winter. This ice when grounding on the marshes or shores bordering the estuaries, by its expansion and shove moves portions of the material towards the banks, or away from the centre of the stream This process goes on year after year and is still in operation, and the dykes are thus formed by gradual and successive increments of material. Where the estuary is widest and the ice has the greatest expansion and room for movement they are highest, and if the locality is favourable a dyke will be found on both sides of the estuary. In certain cases the shove of ice-jams from the bay may have assisted in their formation. This explanation applies to all the natural dykes observed on both sides of Northumberland Strait. They are, therefore, of *recent glacial origin.*

Mussel mud.

Mussel mud, where found.

Mussel mud is an estuarine silt, containing great quantities of oyster, mussel and clam shells, the first usually predominating, which occurs in the bogs and estuaries around Northumberland Strait, and at the mouth of the Baie des Chaleurs. Considerable quantities are taken up by dredging and applied to the land by farmers both on the mainland and on Prince Edward Island; but a much more extensive use of it might be made than has yet been attempted, with beneficial effect. Pulverizing and mixing it with barn-yard manure before spreading it over the land, causes it to assimilate more readily with the soil and thus reduces it to a condition in which it becomes more available for plant food. The mussel beds are often deep and furnish an almost inexhaustible supply of this valuable fertilizer. It is especially suitable for the soils resting upon the Carboniferous rocks, which are nearly devoid of lime.

Materials of.

Although known by the name of "Mussel mud" from the presence of the shells of the mussel (*Mytilus edulis*) in the deposits, the designation of *Oyster mud* would really be more applicable, since the shells of the oyster (*Ostrea Virginiana*) predominate. Clam shells (*Mya arenaria*) are also found in it. These are all packed in a paste of mud, sand, etc., containing other organic débris. The whole deposit, as shown by Sir J. W. Dawson, is a formation of the recent period.* Samples of mussel mud from New Brunswick and Prince Edward Island, analysed by Prof. F. T. Shutt, chemist of the Central Experimental Farm, Ottawa,† show that the amount of nitrogen, the chief fertilizing agent in their composition, is small. Its chief value for agricultural purposes is owing to the quantity of lime it contains. The fertilizing value is increased when it is composted with barnyard manure, peat, swamp muck, etc.

Agricultural value.

Agricultural Character of the Region.

Agricultural character of the region.

A large portion of the areas whose surface geology has been discussed in this report, is noted for its valuable agricultural resources. Cumberland county, Nova Scotia, Westmoreland county and the coast district of Kent county, New Brunswick, and Prince Edward Island, have long been remarkable for their excellent farms and the advanced methods of cultivating them.

Most valuable soils.

In general it may be stated, especially as regards the eastern maritime provinces, that those portions of the coast districts on which marine sediments lie are the most valuable to the agriculturist. This arises from the fact that the materials of these sediments have undergone greater comminution in many places from the action of the sea, during the post-glacial subsidence of the land, and also because the deposits are, as a rule, deeper there than upon the higher grounds. There is likewise a greater commingling of organic matter with these soils. Moreover, the facilities for obtaining manures, such as sea weeds, mussel mud, fish offal, etc., for fertilizing the land, are much greater there than in settlements remote from the coast, thus enabling the practical farmer to keep the soil in a higher state of cultivation.

Classification of the soils.

The agricultural capabilities of those portions of New Brunswick included in this report were treated in my preliminary report on the Surface Geology of the province, and a classification of the soils and sub-soils attempted.‡ In a subsequent report, a further classification of the soils was made into (*a*) sedentary, *i. e.*, those formed *in situ* from the disintegration of the underlying rocks, and (*b*) transported soils, or such as have been removed from the rocks to which they belong by glacial, marine, fluviatile or lacustrine action and deposited in new localities.§ The latter prevail in the coast districts of the maritime provinces, and cover large areas adjoining Northumberland

*Supplement to 2nd ed. Acadian Geology, page 17.

†Reports on Experimental Farms for 1890 and 1891.

‡Annual Report, Geol. Surv. of Canada, vol. I. (N.S.), 1885, p. 52 GG.

§Annual Report, Geol. Surv. of Canada, vol. IV. (N.S.), 1888-89, p. 76 N.

Strait and the upper part of the Bay of Fundy. The agricultural character of those portions occupied with salt marshes and recent sand formations has already been described on pages 131 M and 124 M.

Culture of soi in New Brunswick.

Commencing in New Brunswick, we may first note the value and condition of culture of the soils in the coast districts of Kent, Westmoreland and Albert counties.

In Kent County.

In Kent county, the narrow belts cleared along the coast and at the mouths of rivers, are, in some places, covered with blown sand, while in others, swamps and peat bogs prevail. This is especially the case north of Richibucto River. South of that, however, some good farming lands occur on the borders of Northumberland Strait, at Buctouche, Cocagne, etc. Excellent soils are found along the river-valleys, where the slopes are sufficient to allow the drainage waters to escape into the nearest rivers, and where there is always a greater or less breadth of alluvial deposits. But on the flat grounds which lie between the estuaries, notably between the Richibucto and Buctouche, and between the latter and Cocagne rivers, etc., there are also many good farming tracts occupied by a deep, rich, fertile soil.

In Westmoreland County.

The Isthmus of Chignecto contains probably the best farming lands in Westmoreland county, although some parts are sandy and others dry and stony. At Shemogue, Bay Verte, and on the Cape Tormentine peninsula—districts which have long been settled—there are large clearings and well cultivated farms; but those exhibiting the highest degree of culture, and where the occupants seem to be in the best circumstances, are around the head of the Bay of Fundy. On Westmoreland Ridge, at Aulac, Midgic, Sackville and other places around Cumberland Basin, where many of the farmers have a number of acres of salt marsh to the front of, or near their uplands, the condition and yield are very much in advance of the cultivated lands of any part of the country. The same observation applies to the agricultural condition of the districts in the Memramcook and Petitcodiac valleys. Large herds of cattle are raised in this part of Westmoreland, owing to the great yield of hay afforded by the salt marshes, and most of the farmers are in very comfortable circumstances.

In Albert County.

In the eastern part of Albert county, the areas of low land along the coast are narrow in most places, and form mere selvages. At Harvey and New Horton, however, the Lower Carboniferous rocks do not form such a broken country as further to the north, and here we find a considerable area of good farming lands. Benches, or marginal strips of excellent soil, skirt the coast of Shepody Bay and the estuary of the Petitcodiac River, overlooking the salt marshes. The latter, while of considerable extent on both sides of Shepody River and elsewhere, are not utilized to the best advantage. The dykes in many places have been allowed to go out of repair, and portions of the marshes are, consequently, subject to overflow by the tides. Too heavy cropping also, without the application of any fertilizing material, is another evil. In consequence of this, large portions of these marshes have turned into what is known as *blue marsh*, a wet, spongy, fetid formation, and are unproductive. Improved methods of culture, such as have been inaugurated by the marsh owners at Sackville, are required. Despite these things many of the farmers in eastern Albert are in good circumstances, and form intelligent, industrious communities.

Cumberland County, N.S.

Cumberland county, Nova Scotia, comprises as large and thriving a body of farmers as are to be found in any part of the maritime provinces. The slope facing Northumberland Strait is well situated as regards drainage, and the soil, derived as it is mainly from the Upper Carboniferous sediments, is deep, rich and easily cultivated. In the settlements along the coast there are many excellent farms in a high state of cultivation.

At Amherst, Nappan, and in the area drained by the Maccan River, several good agricultural tracts border the salt marshes, and upon the slope there are fine, loamy, arable soils. The Branch Experimental Farm at Nappan, under charge of Col. Blair, is an example. The methods of culture employed there, show what can be done on the farms of the maritime provinces, and the kinds of crops that thrive best.

Soils of the higher portions of the region.

Upon the higher grounds of Kent, Westmoreland and Albert counties, New Brunswick, and Cumberland county, Nova Scotia, we meet with different soils, and in many cases poorer farms, and consequently less advanced methods of cultivating them. Yet in a number of places in the region the uplands really form excellent soil, and where the drainage is good, they are not inferior to that of the coast districts. Upon the Middle Carboniferous of Kent and portions of Westmoreland counties, however, the surface is flat and the drainage deficient; hence the soils are cold, boggy, and in many places covered with a stratum of white or gray bleached sand, under a veneering of vegetable growth. Upon the rolling surfaces, however, there are, as already stated, fair arable soils, though deficient in lime. Along the Richibucto, Buctouche and Cocagne rivers, at St. Anthony settlement, in Kent; and at Irishtown and other places in Westmoreland, the agricultural conditions last referred to are exemplified.

In Cumberland County, Nova Scotia, above the limits of the post-glacial subsidence, we meet with soils and rocks differing somewhat from those of the Middle Carboniferous just described. Here the prevailing surface beds are reddish in colour, being derived either from the Upper or Lower Carboniferous sediments, or from both. The soils are, therefore, lighter, and as a rule, more porous and easily cultivated. The surface is, generally speaking, rolling, and consequently the drainage is better. On these uplands there are many tracts of good land with excellent farms upon them, especially on the slope between the Cobequid Mountains and Northumberland Strait. Certain undrained sandy tracts are barren and remain uncleared. Some of the higher grounds are occupied with boulder-clay, but these when well drained form rich heavy soils. Here, as in New Brunswick, there is a deficiency of lime in the soil, except where the Lower Carboniferous limestones prevail, and they all seem to be largely benefited by plentiful applications of this fertilizing material, as well as by mussel mud and gypsum.

Prince Edward Island.

Prince Edward Island, which is probably the best agricultural portion of the maritime provinces, taken as a whole, contains less waste land in proportion to its area than either Nova Scotia or New Brunswick. The soil is derived almost wholly from the disintegrated Upper or Permo-Carboniferous sandstones and Triassic beds which occupy the island, and is therefore largely indigenous. On the higher grounds, it consists mainly of rotten rock *in situ* with a veneering of stratified material due to the atmospheric and fluviatile agencies which have affected them; while along the coast, boulder-clay, in places capped with marine deposits, generally prevails. It is therefore, usually light, porous, easily cultivated, and well adapted to the production of oats and root crops. Like the soils resting upon the Carboniferous rocks of New Brunswick and Nova Scotia, it is deficient in lime. The farmers of this island fully recognize this deficiency, however, and have been utilizing the extensive deposits of mussel mud which lie in the harbours and creeks. Certain localities where good farms were observed might be particularized, but, in general, it may be stated that the part of Prince Edward Island now in the highest state of culture is that lying near Richmond and Hillsborough bays, especially along both the north-east and south-west coasts. The higher central part does not contain so much good arable land, nor do the districts north of Richmond Bay and east of Hillsborough Bay, though there are many excellent farming tracts in these also.

The agricultural character of Prince Edward Island has been discussed by Sir J. W. Dawson,* who speaks of its fertile soil as a source of great wealth to the inhabitants. In this connection, however, the great facilities for obtaining fertilizers have to be borne in mind. In nearly every bay and estuary, extensive deposits of mussel mud occur.

Fertilizers in P. E. Island.

* The Geological Structure and Mineral Resources of Prince Edward Island. By Sir J. W. Dawson and Dr. B. J. Harrington, 1871.

In addition to this valuable fertilizing material, peat, marsh and swamp muck, seaweeds, fish offal, etc., are extensively employed. When these are composted with the mussel mud a rich manure is produced, which can either be ploughed under and used for root crops or utilized as a top-dressing on the land. The fertilizers mentioned exist in almost inexhaustable quantities on Prince Edward Island, and are accessible to nearly every farmer.

Forests.

The forests of the region included in sheets No. 2 S.E., 4 N.W. and 5 S.W. present some features worthy of consideration as regards the local distribution of the different kinds of trees which grow therein. In the area bordering Northumberland Strait, the sylvan growth is of a mixed character, with a predominance of the coniferæ. The indigenous trees of economic importance are pine *(Pinus Strobus, P. resinosa* and *P. Banksiana)*, spruce *(Picea alba, P. nigra* and *P. nigra* var. *rubra)*, fir *(Abies balsamea)*, hemlock *(Tsuga Canadensis)*, cedar *(Thuya occidentalis)*, hacmatack *(Larix Americana)*, and the deciduous trees, birch *(Betula lenta, B. alba* var. *populifolia, B. papyracea* and *B. lutea)*, maple *(Acer Pennsylvanicum, A. saccharinum, A. rubrum* and *A. spicatum)*, poplar *(Populus tremuloides, P. grandidentata* and *P. balsamifera)*, beech *(Fagus ferruginea)*, ash *(Fraxinus Americanus* and *F. pubescens)*, elm *(Ulmus Americanus)*, oak *(Quercus rubra)*, etc. Besides these there are a variety of native shrubs, some of which, in more southern latitudes, grow to the size of trees, but here, owing to the severe climate of the coasts, become dwarfed. Even the larger trees, strictly indigenous to the country, are found, on approaching the coast, to exhibit striking differences and peculiarities, the more noticeable of which are the prevalence of the coniferæ on the lower grounds, over which winds and fogs from the ocean pass without obstruction, and secondly their shorter and more spreading and stunted size. The prevalence of small black spruce, hacmatack, cedar, white birch and the various shrubs of the country upon the region bordering Northumberland Strait is a characteristic feature. These sylvan forms, together with the occurrence of heavy peat bogs upon the low grounds of the Carboniferous area, show that a certain zone or belt bordering the sea is, to some extent, unfavourable to the development of the large forest trees. In sheltered spots, however, as, for example, upon the Cobequid Mountains and the crystalline plateau of southern New Brunswick, the hill ranges afford protection from the winds and cool vapours coming from the ocean, and a large growth of both coniferous and hardwood trees is found.

Forests.

Species of trees.

Character near the coasts.

Character, inland.

Proceeding inward from the coast, a much greater diversity in the distribution of the forest trees is found. This distribution is evidently affected by several causes, (1) by the elevation, or rather by the protection afforded by ridges and mountains from bleak winds and storms and from the sea air of the coast districts, (2) by the aridity or wetness of the soil, viz., its condition as to drainage, (3) by the physical character of the soil, viz., whether clayey, gravelly, sandy or loamy, and (4) by the mineral composition, in other words the character of the underlying rock-formation, whether calcareous, silicious or otherwise.

Causes of difference.

Effects of soil or rock formations on forest growth.

The relation between the soil, or the rock-formations, and the vegetable growth upon it, is in northern climates, such as the maritime provinces of Canada, difficult, if not impossible to trace; nevertheless, it is observed that certain geological formations are more favourable to the production of certain kinds of trees than others. Calcareous soils, for example, nourish the heaviest growth of both hardwoods and conifers. In New Brunswick, as indeed, in all glaciated countries, however, we cannot determine the exact limits of the areas of the forest growth affected by the geological formations. On the hills and ridges underlain by limestones, we meet with maple and birch groves, intermixed occasionally with spruce. The Cambro-Silurian and the old crystalline belts of rocks traversing the province from the Baie des Chaleurs to the Chiputnecticook Lakes, seem also to mark a boundary in the forest distribution. North of this lies the great area of Silurian limestones, south of it the Carboniferous sandstones. Owing to the larger extent of country which these formations occupy, the soil necessarily bears a closer relation to the underlying rock, and is less intermixed with extra-limital drift; consequently the vegetation and forest growth upon these areas ought to show the effect of each particular kind of soil upon the flora of the country. Have these districts any peculiar forms in their floral productions?

Upon Silurian limestones.

On the Silurian limestones there is observable a paucity of ericaceous plants, of scrub pine and black spruce, and an almost entire absence of hemlock, all of which are abundant on the Carboniferous sandstones, the latter tree, indeed, reaching fuller development on these as regards size and number than elsewhere in the province. White spruce, fir, white pine, the paper birch, and beech appear also to be more abundant upon the Carboniferous area, though common also upon the Silurian uplands. But the striking features of the forests upon the latter are the groves and ridges of birch and maple occuring in almost every part. These are seldom met with on the sandstones except where Lower Carboniferous limestones prevail.

The comparative abundance of ericaceous plants on the Carboniferous areas is doubtless due, in some measure, to the flat surface and consequent imperfect drainage, resulting in the formation of swamps, peat bogs, etc., where these forms of vegetation find a congenial habitat. But the difference in the sylvan growth occupying the drier grounds of the two regions in question is not explicable unless we admit that the geological formation has an influence upon it. On the sandstone area, the hemlock and scrub pine are most abundant trees compared with their distribution upon the Silurian uplands. Black birch, beech, and black spruce also appear to be more common and larger. These facts regarding distribution lead to the inference that the gravelly, silicious soil overlying the sandstones is more favourable to the growth of these trees, or it may be that the limestones are unfavourable, or, perhaps, both causes operate. Upon Carboniferous sandstones.

In regard to the hemlock (*Tsuga Canadensis*) it was pointed out in a previous report* that the distribution of this tree is peculiarly restricted from some cause or causes. Nearly all hemlock trees are found to have attained their full growth. Young or growing trees were observed only in a few localities, especially along Nashwaak and Little Southwest Miramichi rivers. In areas where it has been destroyed it does not grow again like spruce, fir, cedar, hacmatack, etc. These facts indicate that the existence of the hemlock tree in this region is on the wane. All the other forest trees will grow up and replenish the region once more except where it has been overrun by fires. Is the cause of the decadence of the hemlock climatological, *i.e.*, due to recent changes in the mean annual temperature, rainfall, etc.; or to the destruction of the surrounding forests? No satisfactory answer can be given to this question. Hemlock.

The black spruce, which is a tree of the greatest economic value, does not now seem to be so thriving and vigorous as its congener, the white spruce; and the cedar (*Thuya occidentalis*), though common in New Brunswick in all moist low grounds, and also met with not uncommonly in Prince Edward Island, is a tree also restricted in its range, occurring only very sparingly, if at all, in the peninsula of Nova Scotia. Black spruce. Cedar.

The forests in New Brunswick, and, indeed, throughout the Canadian maritime provinces, are undergoing rapid destruction. When the Loyalists landed at the mouth of the St. John River on the 18th of May, 1783, the New Brunswick forest stood almost untouched in all its pristine grandeur, now the original growth has been largely cut Destruction of forests.

*Report of Progress, Geol. Surv. Can., 1882-83-84. Part GG.

away, the coniferæ, especially, having suffered depletion in almost every accessible locality. Only in some parts of the region drained by the Restigouche, and in other remote places, does the original forest growth still remain intact. The old sturdy pines, monarchs of the New Brunswick forest, were the first to suffer. In the days of pioneer lumbering operations, these were felled and one or two pieces of square timber made from each trunk—the remainder of the tree was left to rot. These pines are all gone. The spruce has next been attacked, and since the inauguration of the modern steam saw-mill, the manufacture and shipment of spruce deals to the British market, have together become a large and important industry. The prosecution of this business has, however, brought about a rapid demolition of the spruce forests throughout the province. In some of these depleted areas, *i.e.*, where the larger trees have been cut away, a younger growth is taking its place, however, and as the white spruce grows rapidly, the original forest growth might be replenished in this way, if fires did not overrun the country. Lumbermen state that unless too heavy a cutting is made, the same tract can be re-cut for spruce logs every ten or twelve years, owing to the rapidity of the growth of the white spruce.

How brought about.

Destruction of hemlock.

The hemlock tree is now being subjected to destructive processes also, and is very likely at no distant date to be altogether exterminated. Within the last twenty years, important industries have sprung up in different parts of New Brunswick based upon the use of the hemlock bark for tanning, and large quantities of tanning extract have been prepared for export. To obtain the necessary supply of hemlock bark to carry on this business, the trees are cut down and the bark peeled off, the trunk and branches often being left lying in the woods. Near settlements, some of these trunks are utilized in the manufacture of scantling, boards, etc., and hemlock timber is commonly used for the building of wooden bridges, wharfs and breakwaters, as it is found, when placed under water, to be slow in rotting. But large numbers of these felled trees are not used in any way, and after a time, when their branches become dry, they serve as fuel for forest fires. The destruction of this tree from the last cause is tenfold greater than from all others combined.

Of the cedar.

An extensive industry has within the last decade arisen in the maritime provinces from the uses for which cedar is required. Previous to that date the trunks of the cedar trees were used only, to a limited extent, for foundations to buildings, for telegraph poles, fencing and the manufacture of shingles. But within the period mentioned cedar has come greatly into use for railway ties and fence posts, and the shingle industry has also expanded to enormous dimensions, though it has latterly suffered a reverse owing to over-production. The principal market for cedar wood is in the United States.

The impetus given to the cutting and export of cedar in New Brunswick is also leading to the exhaustion of this tree, and already whole river basins have become well nigh depleted of cedars. As it is a tree which grows very slowly, there will, in all probability, be a scarcity of cedar in the maritime provinces in less than a quarter of a century, if the present methods are continued.

Areas overrun by fires.

From the foregoing statement of facts, it will be seen that very great inroads are now being made on the original forest growth of the maritime provinces. The destruction or depletion by legitimate means, that is, from the ordinary lumbering operations of the country is, however, not exhaustive, but such as could, doubtless, be checked or regulated with a view of conserving the forest. That going on every year from forest fires is vast in proportion and far-reaching in its effects. No regulation seems at present competent to control this evil. Since the great Miramichi fire of the 7th of October, 1825, forest conflagrations have been of constant and almost annual occurrence. The dry, gravelly and sandy areas, underlain by Carboniferous and granitic rocks, have suffered most. Along the Southwest Miramichi River and its tributaries, a large portion of the district occupied by Carboniferous rocks has been overrun by fires, part of it in 1825, at the time of the great fire above mentioned, and part of it at a subsequent date. A second growth of trees now covers some portions of these areas, but this also has, in certain sections, been destroyed by recent fires. Large portions of the country lying between the Southwest Miramichi and Salmon rivers, and the head of the Richibucto River have likewise been devastated in this way.

Along the Intercolonial railway between Moncton and Bathurst, forest fires occur in the woods on both sides of the line at irregular intervals almost every summer, and have thus destroyed the timber over large areas. When this railway was constructed about twenty-five years ago, it passed through virgin forest for two hundred miles of the two hundred and twenty-two between Moncton and Bathurst. The opening of new settlements since that date, the lumbering operations carried on along both sides of the route, and the cutting down of the hemlock for tan-bark, etc., have brought about nearly a total demolition of the original forest adjacent to the railway. After every dry season there is a fire, originating no one seems to know how, and few seem to care, if not personally affected by it. It must be confessed, however, that farmers in clearing up new land, woodsmen, hunters, and fishermen are not careful enough in preventing the spread of fire. The forest is largely coniferous, therefore in dry weather especially combustible, and when fanned by a breeze any fire soon spreads beyond control.*

Difficulties of protecting the forests from fires.

No protection has yet been exercised to guard against these public calamities further than the enactment of a statute, prohibiting under a penalty, the setting of fires at certain seasons of the year; but the expense of properly enforcing this would be beyond the means of the country. Carelessness prevails, therefore, on all sides, and no one takes much interest in the preservation of the forests from a national point of view, or unless it is of some direct benefit to himself. Indeed, it is practically impossible to devise methods of preserving them, owing to the lack of public interest in the matter, and it seems not at all unlikely that the existing condition of things will continue until they are wholly destroyed. Then, and not till then, will the people begin to realize their value.

Rate of the growth in the eastern provinces.

The rate at which a tree grows in the forests of the eastern maritime provinces, is a question sometimes discussed by practical lumbermen in view of forest conservation. Since the cutting down of trees of commercial value below a minimum size or girth is prohibited by law, it follows, that if they are protected till they attain the standard size, this periodical replenishment might be the means of preserving them from total destruction, excepting, of course, the ravages of forest fires. The question then arises, how long does it take a tree such as, for example, the black or white spruce, or the white pine, to attain a certain size; and, having attained a size of say fifteen inches in diameter above the roots in a given number of years, how long would it take it then to reach a diameter of say twenty or twenty-four inches, in other words what is the annual growth of our forest trees in youth and at maturity? No observations have yet been made which enable us to give a definite answer to these questions. There is, however, one locality in New Brunswick, that of the Miramichi fire of 1825, which, from the fact that it is now covered with a young forest grown up since that date, affords a criterion of tree growth upon a given geological formation, viz., the Carboniferous sandstones. But it does not show what the rate is when trees arrive at a diameter of fifteen inches and upwards. It affords data, however, showing the comparative rate of growth of different species during the period mentioned. For example, poplar (*Populus tremuloides*) was found with a girth of fifty-one inches above the roots; white spruce (*Picea alba*), fifty-four inches; black spruce (*P. nigra*), forty-eight inches; fir (*Abies balsamea*), forty inches; red

Growth and size of some species found upon the area of the Miramichi fire.

*It would seem that this region must have been subject to forest fires before the settlement of the country by the white man, if we may judge by the name of the principal river draining it—Richibucto—which in the Micmac means "river of fire."

pine (*Pinus resinosa*,) fifty-two inches; paper birch (*Betula papyrifera*) forty-four inches; sugar maple (*Acer saccharinum*), thirty-five inches; swamp maple (*A. rubram*), twenty-four inches; beech (*Fagus ferruginea*), twenty-four inches; hacmatack (*Larix Americana*), thirty-one inches, etc. As some geological formations and soils are more favourable to tree growth than others, it follows that the rate indicated here is a local and not a general one,—on limestone areas it is doubtless, higher, on swampy coastal areas less. The hemlock, black and yellow birch and cedar have not grown again since the Miramichi fire.

From the foregoing facts, it will be seen that the general rate of tree growth in New Brunswick is by no means rapid, and that it takes even the most healthy and vigorous tree three-quarters of a century, under the most favourable conditions, to attain a size rendering it of commercial value. The slow growing trees, such as black spruce, hacmatack, maple, birch, etc., of course take longer. It has already been stated that lumbermen report being able to re-cut certain tracts of the forest every ten or twelve years and get a new crop of logs off them. This method of re-cutting the timber lands of New Brunswick periodically seems, if properly guarded, to afford a reasonable solution of the problem of forest conservation. For, if regulations prohibiting the cutting and sale of certain timber trees below a given size can be enforced, they might, in this way, become of economic value periodically, without the depletion and entire destruction of the forests as at present.

Slow rate of tree growth.

Forest conservation.

Minerals and Materials of Economic Importance.

In the superficial deposits of the region embraced in sheets No. 2, S.E., No. 4, N.W., and No. 5, S.W. of the New Brunswick maps, the following minerals and materials of economic value have been found, nearly all of which were briefly reported in the Summary Reports of 1890, 1891, 1892 and 1893. These materials may be thus enumerated:—Peat, bog-manganese, bog-iron ore, infusorial earth (tripolite), brick-clays, etc.

Minerals and materials of importance.

Peat is developed in extensive bogs or moors on the coast of New Brunswick, bordering Northumberland Strait, and on the north-east side of Prince Edward Island. These moors have been described in detail on pages 117–122 M, and their mode of origin and economic uses in various arts and industries noted. It is evident that the value and uses of peat, and moss litter, are increasing, and that the product of the bogs is likely to come into extensive requisition as a cleansing, deodorizing and packing material.

Peat.

Bog-manganese.

Bog-manganese occurs in an extensive deposit near Dawson settlement, Albert county, N.B., on a branch of Weldon Creek, covering an area of about twenty-five acres. In the centre it was found to be twenty-six feet deep, thinning out towards the margin of the bed. The mineral is a loose, amorphous mass, which can be readily shovelled without the aid of a pick, and contains more or less iron pyrites disseminated in streaks and layers, though large portions of the deposit have merely a trace. This bed of bog-manganese lies in a valley at the northern base of a hill, and its accumulation at this particular locality appears to be due to springs. These springs are still trickling down the hill-side, and doubtless the process of producing bog-manganese is still going on.

A branch of the Albert railway has been opened up to this mine, and kilns for drying the material were also erected. Operations had, however, ceased at the time of my visit (autumn of 1891) pending the completion of the analyses and tests of this product. Indications of other and similar deposits of bog-manganese further west, about the head of the branch of Weldon Creek have been reported.

Another bed of amorphous bog-manganese occurs near Harvey, in the same county, but it has not yet been opened up.

Bog-iron ore.

Bog-iron ore (limonite) in beds of considerable extent has long been known to exist at Maugerville, Sunbury county, N. B. A brief description of the deposits is given in my report on the surface geology of Western New Brunswick.*

Another deposit of this mineral, the ore being of the nature of ochre, occurs in the banks of the Northwest Miramichi River above Chaplin Island and was referred to in a previous report.† This deposit was re-examined, as it was reported that operations for the preparation of mineral paint from the material were about to be commenced. The ochre has been used for many years locally as a paint and seems to answer the purpose well. Whether it occurs in sufficient quantity to warrant the investment of capital is another question. It seems to be in process of formation still and is being deposited on the rock surfaces along the bank, through the agency of springs and of water trickling out at the contact of the superficial deposits and underlying rocks. Oozing out in this way, it collects in the crevices of the rocks in considerable quantities in certain places. Swamps and small peat bogs lie behind, and it would appear that it is the decaying organic matter from these which yields acids that aid in producing this ore.

*Report of Progress, Geol. Surv. Can., 1882-83-84, Part GG.

†Annual Report, Geol. Surv. Can., vol. III. (N.S.), 1887-88.

Bog-iron ore was also found on the south side of Buctouche harbour, in Kent County, New Brunswick, occupying an area of from five to ten acres. In several openings which were made the deposit showed a thickness of twelve or fifteen inches, and is from one to three feet below the surface of the ground.

To the south of Richibucto Head, another deposit of this material was observed. Bog-iron ore was also noticed by Mr. Wilson on the south side of Kouchibouguac River, near the mouth, and in several other places.

A noteworthy feature of these bog-iron ores is that they seem to be more abundant in the area of Carboniferous rocks than elsewhere.

Infusorial earth.

Infusorial earth, or tripolite, in a thick bed, covers a portion of the bottom of Folly Lake, along the Intercolonial railway, in the Cobequid Mountains, Nova Scotia. This lake is about 600 feet above sea level, and appears to be rock-rimmed. Tripolite is also found at Fountain Lake and Sutherland's Lake further west in the Cobequids.* At the two first-mentioned lakes, efforts have been made to work the infusorial earth to some extent for use as a polishing material, and as a non-conductor of heat in covering for cylinders, etc.

Brick clay.

Brick clay occurs in every part of the district, and usually with the fine sand necessary for the manufacture of brick in the vicinity. In the majority of cases bricks are made from marine (Leda) clay; but in a few places from boulder-clay. Brick kilns were found in operation at Lewisville, near Moncton, at Folly Point, Westmoreland county, New Brunswick, also at Amherst, Oxford, Pugwash River, near Conn's Mills, and at Wallace River, near the bridge of the Oxford and Pictou Branch railway, which crosses it. In Prince Edward Island small kilns were observed at Bloomfield station, also near Indian Point at Bedeque Bay, and a third near Cape Egmont.

Besides the minerals and materials mentioned as occurring in the superficial formations, all new mineral localities, wherever accessible, were examined by me, whether discovered in these or in the older rocks.

Coal seam.

A reported coal seam near Caraquette, Gloucester county, on the south side of the mouth of the Baie des Chaleurs, was examined on two occasions with some care. It occurs in the Middle Carboniferous or Millstone grit rocks, and consisted of two thin seams with a parting of shale between them. The total thickness of the whole, including the black shale, did not exceed sixteen inches. In the hope that the seam or seams might thicken out, eastwards from the bank of the brook in which the outcrop occurs, a trench was opened, following the seam for some distance, and further east a shaft or trial-pit was sunk. The

*Annual Report Geol. Surv. Can., vol. I. (N.S.), 1885, pp. 70, 71 E E.

result of this exploration was not, however, satisfactory, and at present the work has been abandoned.

Silver and gold.

Argentiferous galena occurs in irregular seams, associated with pyritous minerals, on the south side of the Baie des Chaleurs at Elm-tree and Nigado rivers* and at Millstream. A considerable amount of development work has been going on in these places for years, and the ore, according to several assays, yield traces of gold and some silver. Mr. Hoffmann, chemist and mineralogist to the Geological Survey, reports on a specimen from the Millstream mine submitted to him as follows :—" The specimen consisted of iron pyrites together with small " quantities of galena, and apparently trifling amounts of mispickel, " in a gangue composed of white to gray subtranslucent quartz, and a " little dark gray shale. A fair average of this specimen—which " weighed eleven pounds—was found on assay to contain :—

Gold......................0·175 of an ounce to the ton of 2,000 lbs.
Silver.....................9·450 ounces to the ton of 2,000 lbs.† "

Along the Northwest Miramichi River, between two of its affluents, the Tomogonops and Little rivers, argentiferous galena and pyrites occur, in which traces of gold are likewise reported to be found. These minerals are met with under somewhat similar conditions to the pyritous and galena ores on the south side of the Baie des Chaleurs, and appear to be of much the same character.

Magnetite.

A bed of magnetite was discovered a few years ago near the head of Millstream, Gloucester county, but a good deal of it appears to be highly charged with pyrites. Analyses by Prof. Donald, of Montreal, shown me by Mr. W. R. Payne, of Bathurst, gave upwards of 60 per cent of metallic iron with about 10 per cent of silica. Development work was undertaken here four or five years ago, but has since ceased,

The chief minerals of economic importance in the region indicated on the south side of the Baie des Chaleurs, are galena and iron pyrites, and of these there are large deposits in some places apparently in the form of irregular veins, while in others they occur more in the form of beds. The galena invariably carries a greater or less a mount of silver, and traces of gold are also found, apparently in the pyritous minerals.

Supposed gold-bearing deposits at Memramcook.

In the autumn of 1893 I made a cursory examination of the reported gold-bearing deposits at Memramcook, New Brunswick, where a 50-stamp crushing mill had been erected and where operations were in progress. The so-called gold-bearing rocks were found to be Middle Carboniferous, or Millstone grit conglomerates, which lie nearly hori-

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*Report of Progress, Geol. Surv. Can., 1880-81-82, page 21 D, and page 13 H.
†Annual report Geol. Surv. of Can., vol. V. (N.S.) 1890-91, page 49 R.

zontally on the upturned edges of highly tilted Lower Carboniferous rocks. Though I did not see any of the gold, I was informed that it did actually occur in these rocks; but as the mine has since gone into liquidation, there is a disposition manifested to question the reliability of the statements made concerning it.