GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA
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PRELIMINARY REPORT

ON THE

SURFACE GEOLOGY

OF

NEW BRUNSWICK

BY

R. CHALMERS.

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ALFRED R. C. SELWYN, ESQ., LL.D., F.R.S., ETC.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to present herewith a report on the Surface Geology of the Province of New Brunswick, chiefly the result of observations made during the summer of 1884. Illustrative maps showing the character and distribution of the surface deposits, are in course of preparation. These are based on the quarter-sheet topographical maps of the Survey, the surface geology being laid down upon them according to a system of coloring and notation. They will be issued as soon as the necessary data to complete them have been obtained.

My thanks are due to the New Brunswick Railway Company for a free pass over their lines; to Prof. Harrison, of the University of New Brunswick, for a list of barometric readings; to T. G. Loggie, of the Crown Lands Office, Fredericton, G. F. Matthew, M.A., St. John, and Rev. C. R. Matthew, Kingsville, Ont., for information relating to the depths of Grand and Washadamoak Lakes and the Kennebeckasis River, etc.

I have the honor to be,

Sir,

Your obedient servant,

R. CHALMERS.

OTTAWA, May, 1885.

PRELIMINARY REPORT

ON THE

SURFACE GEOLOGY OF NEW BRUNSWICK.

Area explored.

The explorations of the past season (1884) relating to the surface geology of New Brunswick extended to all parts of the province, and a number of important facts were discovered. The area included in the eastern and northern counties was examined more in detail than other portions, partly because its surface deposits had not hitherto been studied, except in a preliminary way, and partly owing to the fact that data of considerable scientific value were found there in the course of the season's investigations, which, it was considered, might aid in solving the perplexing problem of the glaciation of Eastern Canada.

Observations previous to 1884.

The observations of geologists on the glaciation of New Brunswick, previous to 1884, having been largely confined to the southern and western counties where the striæ met with have a general southerly or southeasterly bearing, it was therefore inferred that this direction indicated the general ice-movement over the whole province. The investigations of the season of 1884*, however, show that north and east of the water-shed dividing the waters of the St. John River from those flowing into the Baie des Chaleurs and Gulf of St. Lawrence, there was an easterly and northerly ice-movement during the Ice Age, accompanied by a heavy transportation of drift from the interior towards the coast; that is to say, the water-shed referred to seems also to have shed the ice of the glacial epoch northward and southward, the glacier or glaciers on the southern side moving in the direction of the Bay of Fundy, while those on the northeastern side moved down the opposite slope into the depression now occupied by the Gulf of St. Lawrence. In addition to these ice-movements, however, striæ have been found on the last mentioned slope, indicating a separate and independent ice-flow, either directly northward or southward, which are referred to a later or second period of glaciation. All the facts relating to these will be found tabulated and details given in a subsequent part of this report.

Glaciation of New Brunswick.

* The writer first treated of the glacial phenomena of the northern part of the province in a paper published in the *Canadian Naturalist* in 1881, Vol. X., No. 1.

Quarternary oscillations of level.

The marine deposits along the coast were also studied and facts obtained which serve to show their horizontal and vertical distribution as well as the oscillations of level which the region underwent, approximately, during the Quaternary epoch. The amount of these oscillations is estimated on the evidence of marine fossils, old shore lines, and drift-filled estuaries.

Barometric measurements.

A complete hypsometrical section of the province was made along the Tobique and Nepisiguit Rivers, in which the elevations of a number of the principal mountains and lakes of the interior above sea-level were measured barometrically, and the height of the general surface of the country ascertained with, it is hoped, a tolerable approach to accuracy. Many facts relating to its agricultural character, fauna, flora, etc., were also observed. From the upper waters of the Nepisiguit a descent of the Upsalquitch River was made by way of Portage Brook and Upsalquitch Lake, and the general surface features and agricultural capabilities of that section were noted. A large tract of excellent farming land exists on the upper waters of the Restigouche, as referred to by Mr. R. W. Ells, Report D., (Report of Progress, 1879-80) which will be available for settlement as soon as some means of communication are provided. This tract is sometimes called the "Fertile Belt," but above the mouth of the Patapedia, owing to its remoteness, want of roads, etc., it is yet entirely unsettled.

Agricultural character of northern New Brunswick.

Towards the close of the season (1884) the Madawaska valley was visited and the character of the country along the upper St. John, in reference to its agricultural value, and otherwise, specially observed, and data regarding its surface geology collected. This section of the province, which includes Madawaska county and a part of Restigouche, it may be remarked, comprises some fine intervales and uplands.

Rock-bound lake basins.

The discovery of true rock basins holding small lakes in the Laurentian and Huronian rocks lying to the northeast of the city of St. John, was not one of the least interesting results of the season's operations. Details regarding these, as well as many other matters not referred to here, will be given in the following pages.

Fossils.

Collections of fossils were obtained from the marine clay of the Baie des Chaleurs basin, which are enumerated under the head of "Leda Clay and Saxicava Sand." Among them is a claw of the lobster (*Homarus Americanus*) discovered for the first time in the Leda clay of Restigouche. Specimens of brick-clay for the museum were obtained from brick-yards in operation at St. John, Moncton and Fredericton,

Flora.

and considerable collections of the flora of the province were also gathered, partly by Mr. G. U. Hay, who accompanied me as a volunteer on a trip up the Tobique River, and partly by the writer.

In preparing this report it is considered necessary to revise, to some-

extent, the nomenclature in use pertaining to surface geology, and the new classification and notation are accordingly adopted* which have reference to the sub-divisions of the subject as outlined in the Geology of Canada, 1863, page 887. This classification will be employed in this report and in the preparation of maps illustrating the character, distribution, etc., of the surface deposits, and it is hoped will be sufficiently practical and systematic for all investigations in this branch of geology for some time to come. Details regarding the coloring and notation of these maps will be found elsewhere. The system now adopted will, no doubt, require modifications from time to time as our knowledge advances, and therefore is, to a certain extent, merely provisional, especially that of Division M2 into "fresh-water" and "marine beds," the term "interior, fresh-water" deposits being employed for the present to designate those beds supposed to be of the same age as the Leda clay and Saxicava sand, but which occur in the interior apparently where the sea has not reached during the Quaternary epoch. The evidence as to their fresh-water origin, especially in New Brunswick, is still to a large extent negative, no fossils having been found in them.

Revision of nomenclature of surface geology.

The names "Saxicava sand" and "Leda clay," first proposed for certain beds in the St. Lawrence valley by Principal (now Sir William) Dawson, will be restricted exclusively to the known marine fossiliferous deposits consisting of sand, gravel and clay, which are intermediate between the till or boulder-clay (division M1) and the recent deposits (division M3).

CLASSIFICATION OF SURFACE DEPOSITS.

M 3.

Alluviums, or Recent Deposits.

(*a*)	(*b*)
Fresh-water beds; (fluviatile and lacustrine); marshes, peat bogs, or caribou plains, and river flats (intervales).	Marine beds; salt marshes, sand dunes, estuarine flats, etc.

M 2.

Stratified Sands, Gravels and Clays.

(*a*)	(*b*)
Interior, fresh-water sands, gravels and clays (fluviatile and lacustrine, etc.)	Saxicava sand and Leda Clay (marine fossiliferous beds).

M 1.

Till, or Boulder Clay.

* See Report of Progress, 1880-81-82.

The fresh-water and marine beds, (*a*) and (*b*) of division M 2, are supposed to be largely of contemporaneous formation, and the same remark applies to (*a*) and (*b*) of division M 3.

Moraines and kames are not classed with any particular division at present, as they may belong, partly at least, to either M 1 or M 2. Their occurrence is merely local and phenomenal, and moreover they do not occupy areas of any great extent either on the surface or, so far as observed, beneath it.

The term kame is somewhat enlarged in signification from that used in my last report (Report of Progress, 1882-83-84) and is here employed as including not only kames of the interior, such as those occurring on the higher levels and in river valleys, but also those wide, flat ridges of sand and gravel met with along the coasts of the Bay of Fundy and Baie des Chaleurs. The latter have been regarded by Mr. G. F. Matthew as of marine origin (Report of Progress, 1877-78 E E), and seem to have been at least remodelled by marine currents.

Topographical Features of New Brunswick.

Chief topographical features.

The topographical and orographical features of New Brunswick are largely dependent upon the geological structure and the character of its rock-formations. The more salient points of these may be thus outlined and succinctly stated in general terms: —

Main water-shed.

1. A main axis or central water-shed traversing the province from the extreme northwest corner southeastwardly to the isthmus of Chignecto, or to the Nova Scotia boundary. This low axial ridge, while it has a general northwest and southeast direction, nevertheless sweeps round to the south with an extensive curve in the central part, and in Carleton county, along the upper waters of the South-West Miramichi, approaches near the St. John River, thence, however, extending almost due eastwardly past the northern end of Grand Lake or Salmon River, Queen's county, its course from there being about southeasterly to the isthmus as already mentioned. 2. A northeasterly slope from this water-shed to the coast, drained by the numerous rivers of this part of the hydrographical basin of the St. Lawrence, chief among which are the Restigouche, Nepisiguit, Miramichi and Richibucto; and 3. A southwesterly slope drained by the St. John and its tributaries and also by the St. Croix, Digdeguash, Magaguadavic, New and other rivers into the Bay of Fundy. Traversing this latter slope is a second or subordinate water-shed, referred to in report GG (Report of Progress, 1882-83-84) approximately parallel to the main one described, and constituting a divide between the St. John valley and the Bay of Fundy. It extends from King's county, in the vicinity of Long Reach on

Subordinate water-shed.

the St. John River, southwestwardly to the International boundary and beyond it. Each of these has numerous minor axes or water-sheds, sometimes branching off from the principal one, but often apparently without any connection with it, and irregular in direction; and thus while the chief topographical features of the province are comparatively simple, they nevertheless present in detail many complexities, mountain and hill ranges as well as enclosed valleys running to all points of the compass, and contributing to form, in many places, a highly diversified surface. Height of main water-shed.

The general elevation of the principal water-shed referred to, in which are to be found the highest mountain ranges and peaks in the province, is, in Madawaska and Restigouche counties, 800 to 1000 feet above sea-level; at Nictor and Nepisiguit Lakes, 1,000 to 1,200 feet; from these lakes to the upper waters of the South-West Miramichi, 1,200 to 1,300 feet; on the divide between the Taxis and Nashwaak rivers, 900 to 1000 feet, where the road from Boiestown to Fredericton crosses it, 650 feet; across the central part of the Carboniferous area between the Nashwaak and the head of the Cocagne River, 150 to 300 feet. Between Moncton and Shediac it is 100 to 150 feet; on the ridge between the Memramcook valley and Cape Bald, 125 to 200 feet, and between Cumberland Basin and Baie Verte, 10 to 20 feet. Along that portion of the water-shed lying betwcen the head of the Tobique River and the western limit of the Middle Carbonaceous area, mountain and hill ranges with scattered peaks rise to heights of 2,000 to 2,500 feet above the sea, giving the region, when viewed from some prominent summit, a bold and rugged outline, and leading the observer to imagine the general level to be much higher than it really is. The grandest and most picturesque scenery of the province occurs in this part, that is, between the Silurian area on the north and the Carboniferous on the south, where the Tobique, Nepisiguit and Miramichi rivers take their rise. (See report of Mr. Ells in Report of Progress, 1879-80.)

The height of the second or subordinate water-shed between the St. John River and the Bay of Fundy does not, in general, exceed 700 to 800 feet above sea-level. Several peaks, however, rise to an elevation of 1000 feet; but this water-shed is intersected by transverse, or north-and-south valleys, the bottoms of which are not more than from 300 to 500 feet above the sea. The general features of this region are described in my report on the surface geology of western New Brunswick already cited; but it may be stated, in addition, that the eastern extension of this water-shed is characterized by short, hilly ranges and isolated peaks, which include the Nerepis mountains, as well as Douglas, Bull Moose and Broke Neck mountains, and others east of the St. John River. Between this divide and the coast of the Bay of Fundy are numerous Height of subordinate water-shed.

hills and ridges described in Bailey and Matthews' report (Report of Progress, 1870-71), through which the rivers have cut deep channelways; so that, although as high, and in some instances higher, than the water-parting referred to, they nevertheless offer no obstacle to the drainage from it into the bay.

General Surface Features of the Slopes.

Surface features of slopes.

The more prominent surface features of that part of New Brunswick lying on the northeastern slope of the chief water-shed mentioned, may be briefly stated as follows:—

Northeastern slope.

1. An elevated and rugged district in the interior, about the upper waters of the Miramichi, Nepisiguit and Upsalquitch Rivers, which is from 1000 to 1500 feet in height above sea level, but includes numerous mountains from 2000 to 2500 feet in altitude; (2) an undulating plateau in the north, occupied chiefly by Silurian and Cambro-Silurian rocks, with a height varying from 800 to 1200 feet; and (3) a low, gently undulating, or nearly level area in the eastern part underlaid by Carboniferous sandstones, etc., which has a gradual slope from a height of 400 to 600 feet along the western margin down to the shores of the Gulf. The whole eastern coast region of the province, indeed, from Baie Verte to the mouth of the Restigouche, is low, forming a sort of inclined plane, descending beneath the sea at a low angle.

Southwestern slope.

The southwestern slope exhibits much greater diversity of features, the St. John valley, which extends throughout the whole province from northwest to southeast, being, perhaps, the most noticeable. From the summit of the principal water-shed described, there is a gradual slope to this valley, as also from the shorter divide on the southwest. The highest land is in the Tobique region, and at the head of the Shiktehawk and South-West Miramichi rivers. Mountains and broken ranges traverse this elevated tract in all directions and cross the St. John valley in the vicinity of Mars Hill (1088 feet high), extending into the State of Maine. To the north and northwest, in Victoria and Madawaska counties, the surface is rolling beyond the river valleys, and elevated 800 to 1000 feet on a general level above the sea, with occasional summits, such as the Belleville and Green Mountains, etc., rising considerably higher. To the south of Shiktehawk River the country is also rolling and the general level 600 to 800 feet above the sea. This latter tract, which comprises Carleton county and part of York, has already been described in report GG (Report of Progress 1882-83-84). The area occupied by Carboniferous rocks on the southwestern slope is here, as elsewhere, comparatively low and flat, varying in height from 200 to 600 feet above sea level, but having

a slight descent eastward to the limit of the Cambro-Silurian and other rocks overlapped by it on the south. The country underlaid by these older rocks, again becomes hilly and broken, and is traversed by ridges rising 500 to 1000 feet above the Bay of Fundy, their longitudinal direction being usually parallel to the coast line. These ridges occupy a considerable area in Charlotte, King's, Queen's, St. John and Albert counties, often with intervening valleys parallel thereto or to the coast, as well as those transverse valleys referred to, through which the rivers flow, the bottoms of which, as already stated, are at all levels from that of high tides in the Bay up to 400 and 500 feet above it. The general topography of this coast area has, however, been fully described in former reports (Report of Progress, 1870-71, also Report for 1877-78), and it is, therefore, unnecessary to dwell upon it here. Suffice it to say, that the region referred to, from Shepody Mountain, in Albert county, to the St. Croix River, is extremely rugged and barren, and from the nature of the underlying rocks, much of the soil is poor and stony.

Character of region bordering Bay of Fundy.

Heights of some of the Principal Mountains in or near the Main Water-shed.

From the foregoing outline of the topography of the province, it will be seen that the highest land is that occupying the central part of the northern half, and, as already stated, lies in the area drained by the southeastern branches of the Tobique, the South-West and North-West Miramichi, and the Nepisiguit and Upsalquitch rivers. Bald (Sagamook) Mountain, at Nictor Lake, is 2537 feet above sea level; Mount Teneriffe, the highest peak immedialely south of the Nepisiguit Lakes, is about the same elevation. Numerous other mountains are to be seen in the vicinity of these lakes and along the upper reaches of the Nepisiguit River, their bare red summits often rising 2000 feet high. One of these, about three miles above Indian Falls, or fifty miles from the mouth of the Nepisiguit (also called Bald Mountain), was found to be 1922 feet above the level of the Baie des Chaleurs. From its summit, the Miramichi River and valley, and the Gulf of St. Lawrence, were distinctly visible. On the portage from Nepisiguit River to Upsalquitch Lake, several remarkable mountains were noticed, among them a symmetrical, dome-shaped one, immediately southwest of the lake, stands up conspicuously in the valley, affording a splendid outlook from its summit. Its elevation, according to Hind, is 2186 feet. Upsalquitch Lake is surrounded with peaks, no fewer than ten being visible from its surface. Along the Tobique River, several ranges and isolated mountains also of great beauty were observed. Bald Head, on Riley

Heights of mountains in the interior.

Blue Mountains, Tobique valley.

Brook, is one of the most striking, its elevation, according to Hind, being 2240 feet above the sea. The Blue Mountains form the most prominent feature of the Tobique valley, their highest peak being 1724 feet above sea level, and 1250 feet above the river at their base. The loftiest mountains in this elevated tract, however, occur, according to Mr. R. W. Ells and other explorers, on the Big South Branch of the Nepisiguit, that is, between Nictor and Nepisiguit Lakes on the north, and the Right Hand Branch of the Tobique on the south, where some peaks attain a height of 2600 to 2700 feet above sea level.

View from Sagamook Mountain.

Descent of rivers.

Around the central highlands described, the surface of the country is rolling and broken, sloping away nevertheless almost imperceptibly in all directions from it, the descent, however, being less to the northwest than to any other point. From the summit of Sagamook Mountain, Nictor Lake, one can look over the great Silurian plain to the north and northwest, and see beyond it the elevated range of the Notre Dame and Shickshock Mountains looming up; but the slope from this region is greater towards the Gulf of St. Lawrence than in any other direction, as evidenced by the rapid descent of the rivers. The Nepisiguit River descends 1,000 feet in ninety miles, and the Upsalquitch 800 feet in about forty-five miles. What the descent of the Miramichi waters is was not ascertained, but it must likewise be considerable, especially on the Little South-West. The Tobique descends about 635 feet in its entire length of ninety-five miles.

River Systems and Lake Basins.

Area drained by the St. John.

Miramichi River.

Restigouche River.

Nepisiguit River.

The rivers of New Brunswick are numerous, and some of them large. No country in America is better watered. The St. John is the great artery, draining about 10,500 square miles in the province alone, the total area of New Brunswick being computed at 27,490 square miles.* Next in importance and drainage area is the Miramichi, with its numerous branches ramifying throughout Northumberland county and a part of Sunbury, York, Carleton and Victoria, and draining no less than 5,500 square miles of territory. The Restigouche is the third largest, and while forming the boundary between the provinces of New Brunswick and Quebec for a part of its course, is, above the confluence of the Patapedia, entirely within the first-named province. Its extreme length is about 150 miles, and its drainage area in New Brunswick about 2,200 square miles. Next in size is the Nepisiguit, which is about ninety miles long, and traverses a rugged country, but has a much smaller drainage area than the rivers mentioned. It is, however, the swiftest and most difficult for the *voyageur*.

* Twenty-third Annual Report of the Crown Land Department of New Brunswick, 1884.

Several of the tributaries of the St. John within the province are really rivers of considerable size, such as Oromocto, Nashwaak, Eel, Tobique, Green, Madawaska, etc. The Tobique is one of the largest, rising in the highland region at Nictau Lake and draining an area of about 1,500 square miles. The St. Croix, Digdeguash and Magaguadavic flowing into the Bay of Fundy, are also important streams and along with New River drain the chief portion of the slope on the secondary or southwestern water-shed. Tributaries of the St. John.

In reference to the drainage of the province, however, it appears to have been, in pre-glacial times, somewhat different from that which at present obtains. While all rivers and streams of any size examined, seem, from the depth of their valleys,—often cut into the hardest rocks,—and the presence of till in such valleys underlying the fluviatile deposits, to have had a preglacial existence, nevertheless, the changes produced on the surface of the country during the Ice Age have caused them, in certain places, to leave their old channels and excavate new ones, often through solid rock. Moreover, drainage areas around the heads of rivers, and also lakes, if such existed in pre-glacial ages, may have had larger or smaller catchment basins, and these too may have been partially drained in other directions than by existing water-courses. Further, the greater elevation of the region at that time relatively to the sea level, as evidenced by a number of facts, some of which will now be adduced, enabled the rivers to cut their channels, and the valleys through which they flow, more deeply, by giving them greater erosive power, especially in the lower part of their courses. The facts observed as indicating a greater pre-glacial elevation in the Bay of Fundy region may be summarized as follows:—the estuarine character of the St. John River as far up as Fredericton; the tidal lake-like expansions of Kennebeckasis River and Belleisle Bay along with Washadamoak and Grand Lakes, these bodies of water being the result of the ponding back of the St. John owing to the obstruction at its mouth and the subsidence of the region in later Quaternary times. In pre-glacial ages, Salmon River, instead of emptying into Grand Lake, must have flowed along the bottom of the depression containing it into the St. John, and so with Canaan and Kennebeckasis Rivers. These sheets of water are, therefore, arms of the lake expansions of the Lower St. John, and occupy valleys which were eroded partly by the streams flowing into or through them, and partly by sub-aerial agencies in the period referred to. The maximum depth of Grand Lake, so far as can be ascertained, is about 30 feet; of Washadamoak, about 100 feet; of the St. John River, in Long Reach, 106 feet, but immediately above Indiantown, 198 feet (from the Admiralty charts); of Kennebeckasis Bay, 78 feet, and of Kennebeckasis River, in the deepest part, about 200 feet.

Pre-glacial drainage and river valleys.

Facts indicating a greater pre-glacial elevation of the region.

Grand and Washadamook lakes, etc., how originating.

Estuaries of other rivers.

All the other larger rivers of the province flowing directly into the sea also have estuaries of considerable length, except the Nepisiguit, the probable cause of which will be explained further on. The tide flows up the North-West Miramichi to Redbank, about thirty-five miles from its mouth, and up the South-West about the same distance. Tide head on the Restigouche is twenty-four miles from its mouth; on Richibucto River twenty-two miles; on the Nepisiguit the tide flows up only three miles above Bathurst Harbor. In the Bay of Fundy district the river valleys are penetrated by the sea, to greater or less distances, similarly to that of the St. John,—Magaguadavic as far up as the "falls" at St. George, six miles from its mouth, and the St. Croix to St. Stephen, sixteen to seventeen miles.

Sections of borings made across Restigouche and Miramichi valleys.

The sections of borings made across the Restigouche and Miramichi river valleys during the construction of the Intercolonial railway, and represented in the accompanying diagrams, will also illustrate the question under consideration as to the height of the region in the Tertiary or pre-glacial period.

At the mouth of the Metapedia River, where the Intercolonial railway bridge spans the Restigouche, borings were made which are represented by Fig. III. The borings made for foundations to the North-West and South-West Miramichi bridges are represented by Figs. I. and II.

Depth of river valleys in pre-glacial times.

These sections show that at some period anterior to the deposition of these clay beds, the Restigouche flowed in this part of its valley 70 feet below its present level, and the Miramichi 112 feet below the present sea level.

Conclusions as to greater pre-glacial elevation of region.

Correlating all the facts bearing upon this question in the north and south of the province, they indicate a pre-glacial elevation of the region of 100 feet or more above that of the present day relative to sea level. The depth of the Kennebeckasis and certain parts of the St. John valley which are in excess of this may be taken as indicating a still greater elevation than that given above; but on the other hand it is probable these depressions have been formed wholly by secular rock decay and subsequent scooping out by glaciers instead of by river action.

Probable difference in volume of rivers, notably the Nepisiguit.

But with regard to the drainage of the province it may be stated further, that some of the rivers seem, in pre-glacial times, to have had a larger or smaller volume of water, as the case may be, from one cause or another,—this supposition alone explaining some anomalous facts. Taking the Nepisiguit River as an example, we find that from the Narrows to its mouth, about twenty-five miles, its valley appears to be largely of Post-Tertiary origin. Either the lower part of the river took another course in pre-glacial ages, or the whole river itself has been of smaller volume. The drift holding in the lakes at its head

being of glacial origin, it follows that prior to its deposition and arrangement around their borders a portion of the waters now drained off by the Nepisiguit may have escaped by the Tobique,—Nictor Lake, which is only two and a half miles from the upper Nepisiguit Lake, being 165 feet lower than the latter and apparently connected with it across the water-shed by valleys now drift-filled. In this case, the pre-glacial Nepisiguit would not be as large as its successor, precipitation being equal. At all events, the limited drainage area of this river in comparison to its length, the absence of an old drift-filled channel at or near Grand Falls, and the rock-bound channel still being eroded more deeply at the Narrows, Grand Falls, Middle Landing, Pabineau Falls, etc., together with the fact of its flowing over a rock-bed till within three miles of its mouth indicate, when viewed in relation to other river valleys, the post-glacial excavation of its valley especially in the lower part of its course. It should not be forgotten, however, that for the most part, this river flows through a district occupied by Pre-Cambrian and Cambro-Silurian rocks, which wear down much more slowly than those of other parts of the country.

Examples might be cited, were it necessary, to show that when lakes or drainage basins existing on water-sheds are drained by outlets on opposite sides, as is sometimes the case, if one of these becomes closed by any means, the volume of the other must naturally be increased and excavate a larger channel.

Origin of water-falls and gorges.

The changes in the drainage referred to, have, in some places, resulted in producing water-falls and gorges from the damming up of pre-existing river valleys during the Ice Age, instances of which may be seen in several of the larger rivers. The singular phenomenon of a water-fall at the mouth of the St. John may be partly the result of the pre-glacial outlet being blocked up with till, and partly due to the subsidence of the region. The present outlet, which has been excavated through solid rock to a depth of about 110 feet, is post-glacial in origin. Prior to its formation, the pent up waters of the St. John must have spread over a very large area inside of the barrier and played an important part in the formation of terraces and lacustrine beds. There is reason to believe that during the subsidence which took place when the Leda clay was deposited, the sea invaded the St. John valley and lake region described, as far as the Keswick River, although no marine remains have yet been found above the Long Reach.

Erosion carried on by rivers.

All the rivers of New Brunswick, as already stated, flow over beds of drift which occupy their valleys, and are engaged once more in wearing them down from the high levels to which they were raised by the material thrown into them during the Ice Age. The fact of their flowing over stratified gravel, etc., in certain parts of their courses would

almost seem as if they were filling up instead of cutting down their channels, and locally this does occur to some extent even at the present day, but appears to have played a more important part in their history in early post-glacial times. There is, however, a constant wearing down, as well as a general seaward movement, of the materials of river valleys going on together.

Lakes and lake systems post-glacial.

The lakes and lake systems are so intimately connected with the rivers that the two have necessarily to be considered together. But while we have abundant evidence of the pre-glacial existence of rivers or rather of river-valleys, we have none regarding lake basins. The latter, therefore, have to be studied as if they were solely of post-glacial origin. Nevertheless, that Tertiary lakes existed, or, at least, that the rivers then had somewhat similar sources of supply to those which now obtain, there seems no reason to doubt. The tendency of all lakes, however, is to cut down their outlets and thus drain themselves, and for this reason, few lakes, if any, may have existed, except on the water-sheds, at the close of the Tertiary period. But if the precipitation in this region and the drainage basin of each river were the same then as at the present day, the volume of water carried down during the year would be about the same also. If no lakes existed at their sources, however, the rivers would probably be lower in dry seasons from lack of a reserve supply, and higher during the season of greatest precipitation, and this alone would give them greater erosive power during floods. Their deeply cut rock-channels, and the fact that they nearly all flow over gravelly bottoms now, might be considered as arguing a greater pre-glacial precipitation and erosive action; but the extensive filling up of their valleys during the Ice Age produced changes which render it difficult to institute comparisons, even approximately correct, between pre-glacial and post-glacial drainage, as the rivers here particularly referred to have not had time since to clear out the drift from their valleys. From the traces of former high-water levels found along their banks, such as terraces and water-worn gravel, sometimes thrown into ridges or kames, it is obvious they must have flowed at different heights in the Quaternary period up to 150 to 200 above the present water courses along the larger rivers, and have probably held in lakes or lake-like expansions here and there in early post-glacial time.

Lake basins how formed. Elevations of lakes.

The larger number of the lakes of the province are held up by barriers of drift or morainic materials, and their configuration and depth are largely the result of the denudation and arrangement of such materials by glaciers, as explained in my report already cited. The Nepisiguit Lakes, the most elevated in New Brunswick, being 996 feet above sea level, and 10 to 20 feet deep, have a general east and west direction, corresponding with the course the glaciers pursued in that part of the

country. Nictor Lake, 828 feet above the sea, and 50 to 60 feet deep, has the same trend longitudinally. Upsalquitch Lake is 792 feet above the same datum line, and 55 feet deep, its general direction, however, being north and south. These and the other lakes at the head of the Right Hand Branch of the Tobique River, are all evidently drift dammed, and are surrounded by high mountains and romantic scenery. Great quantities of trout (*Salmo fontinalis*) and fresh-water mussels (*Unio complanatus*), etc., are found in them, and the black duck (*Anas obscura*), the loon (*Colymbus torquatus*) and other species of water-fowl are also common there.

Rock-basins holding lakes, how formed.

Several small lakes, lying in rock-basins, occur in the Laurentian or Pre-Cambrian belt to the north of the city of St. John. Lily Lake, half a mile distant therefrom, occupying an area of 27 acres, 25 feet deep, and elevated 60 feet above sea-level is one; Howe's Lake, 145 feet high, is another; Dark Lake, 165 feet high, a third; also Lawlor's Lake on the site of the Intercolonial railway, and others. These lake basins have evidently been formed by the sub-aerial decay of the rocks *in situ* in Pre-Quaternary times, the softer limestones, graphitic shales and ferruginous rocks having been more deeply acted upon than the gneisses and felsites. During the Ice Age the *débris* was scooped out by the moving glaciers, leaving the depressions wherein lie the lakes. Glacial striæ are invariably found on the southern borders of these lakes, the ice having moved in a southerly direction in this part of the country.*

Caves.

Mr. G. F. Matthew informs me that he regards some of these lake basins as having originated from the formation of cavities in the Laurentian limestones through the agency of running water together with atmospheric decay along certain lines of the strata, the rock above the cavities afterwards falling in or breaking away, and the loose materials having been subsequently scooped out by glacier ice. Caves are still found in these limestones in the vicinity of St. John.

Origin of valleys and inequalities of surface.

The depressions occupied by river systems and also the larger number of lake basins are therefore the result mainly of the wear of the rocks from running water and unequal sub-aerial decay in their natural situation, chiefly in ages preceding the glacial epoch, the softer strata having thus been more deeply acted upon by the degrading influences mentioned. When the ice of the glacial epoch accumulated upon the surface of the country, a thick mantle of rock *débris* is supposed to have occupied the rock surface beneath it, which, becoming partially frozen into its bottom, would be moved along with

* For the theory here adopted regarding the sub-aerial formation of rock basins holding lakes, by the secular atmospheric degradation of rocks, glacial denudation, etc., see Dr. A. R. C. Selwyn, Geological Magazine, vol. IV., p. 94 (1877): R. Pumpelly, American Journal of Science and Arts, vol. XVII., Third series, p. 133 (1879); Dr. T. Sterry Hunt, ibid. vol. XXVI., Third series, p. 190 (1883), etc.

it, thus grooving and striating the rocks, breaking off the irregular knobs and projections which had not been so readily decomposed, and smoothing down to a large extent the asperities of rock surfaces. This moving mass would conform to the various inequalities of the surface over which it passed, scooping out the decayed rock material from many of the depressions formed by such unequal decay and forming hollows, sometimes rock-rimmed, but oftener partly rock-rimmed and partly enclosed by drift. On the retreat of the ice of the glacial epoch, the drainage of the areas surrounding these depressions, in most cases, would find its way into them, thus forming lakes. If the lake happened to be on a slope, the overflow became a river, following some pre-existing river-valley which, as stated on a previous page, would tend eventually to drain the lake by wearing down the outlet. When a lake occurs on a water-shed, however, although it has more than one outlet, it may have no extent of drainage area around it, and its overflow being insignificant, it will, in this country, where the precipitation is always in excess of the evaporation, usually remain full all the year round. The wearing down of the outlets from lakes on water-sheds is a very slow process, more especially if the drainage area around them is small, the outlets in that case being also small; and hence these will be the last lakes to lower their level or disappear, not only from the causes mentioned, but also from the fact that less sediment is carried into them.

Relation of lakes to drainage and precipitation.

In consideration of the facts above stated, therefore, it would appear that the present surface features of the province are largely the result of the operation of such agencies as are seen around us at the present day, augmented and intensified by the exceptional condition of things which existed in the glacial epoch. The "hills and dales," river valleys, lake basins and other depressions have been produced either by atmospheric degradation, or the wearing action of flowing waters, or both, and at the advent of the Ice Age the rock surface of the region must have presented very nearly the same contour as at present.

Glacial Striæ.

The following list includes all the striæ observed, so far as known, throughout the province, except those already recorded by Mr. G. F. Matthew (Report of Progress, 1877–78) and by myself (Report of 1882–83–84). Striæ have been noted in different places by Mr. R. W. Ells, Mr. Chas. Robb, Prof. Hind, and by the late Prof. Jas. Robb, which are embraced in this list and duly credited to them. Those given on the authority of Prof. Robb were obtained from a paper published in the Proceedings of the American Association for the Advancement of Science (1850). The courses are all referred to the true mer-

Striæ, by whom noted.

idian, and the direction of the ice-flow is indicated by the bearings in the proper column. Where doubt exists as to the course the ice pursued, the reverse one is also given, as in the case of Nos. 7 and 10. The "General Slope of Surface" is not to be understood as having any relation to the course of the ice-flow, but simply shows the general contour of the surface where the striæ occur. All the heights given have reference to sea level, unless otherwise stated.

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	ALBERT COUNTY.			
1	In Dawson sett., 5 miles N. of Hillsboro, (Ells.)	S. 54° E.		
2	At Hillside, 1½ miles S. of Turtle Creek, (Ells.)	S. 60° E.	N.	
3	On road from Curryville to Hopewell, near Shepody mountain.....(Ells.)	S. 55° W.		
4	Three miles N. E. of Hopewell Hill.(Ells.)	S. 65° W.		
5	In Woodworth sett., 3 miles N.E. of Hopewell Hill.....(Ells.)	S. 65° W.		
6	At Hillside P. O., N. side of mountain, (Ells.)	S. 30° W.		
7	Three miles from Albert on road to Germantown Lake.....(Ells.)	S. 80° W. or N. 80° E.		
8	At Mary's Point.....(Ells.)	S. 55° W.		
9	On road from Elgin to Golden mountain, 2 miles S. E. of Elgin Corner..(Ells.)	S. 25° E.		
10	Four miles from Albert on road to Salmon River.....(Ells.)	S. 80° W. or N. 80° E.		
11	Near shore at 1-Mile brook below Point Wolf.....(Ells.)	S. 70° W. or N. 70° E.		
	CHARLOTTE COUNTY.			
12	At Beaver Harbor.....older striæ.	S. 54° E.		
	" " .....later striæ.	S. 89° E,		
13	At Back Bay, N. side.....	S. 54° E.		
14	Head of Back Bay.....	S. 64° E.		
15	At Mascareen (apparently later and finer striæ) All these striæ cross the small valleys and fjords of the Bay of Fundy coast nearly at right angles	S. 89° E.		
16	Near Oak Bay .....(Robb)	S. 18° E.		
17	At St. Andrew's, sea shore.....(Robb.)	S. 28° E.		
18	Near St. Andrew's, on upland....(Robb.)	S. 28° E.		
19	At Chamcook Lake.. .....(Robb.)	S. 48° E.		

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	CHARLOTTE COUNTY.—*Continued.*			
20	At L'Etang harbor.....(Robb.)	S. 63° E.		
21	Between St. George and L'Etang (Robb.)	S. 63° E.		
22	At Falls of Magaguadavic River (Robb.)	S. 65° E.		
	GLOUCESTER COUNTY.			
23	At Belledune, on Intercolonial railway, 1 mile E. of Belledune River. Grooves and striæ.....	N. 82° E.	N.	170
24	Crossing these are fine, distinct, but irregular striæ, well preserved on both N. and S. sides of E. and W. *roches moutonnées*.....	N. 3° W.		
25	In another place along railway track, a ½ mile nearer the river, grooves and striæ.....	N. 77° E.	N.	170
26	Cross striæ, fine, but distinct, are numerous here also. They are usually short and broken lines.....	N. 3° W.		
27	At Belledune station, grooves and striæ..	S. 88° E.	N.E.	100
28	Later and finer striæ..... The grooves or ruts of the older set are 8 inches or more in depth, and from 6 inches to 2 or 3 feet wide. The later striæ are fine and irregular, sometimes running into each other, and appear on both sides of the larger and deeper E. and W. ruts.	N. 3° W.		
29	At Belledune, 1 or two miles behind railway station on low E. and W. ridge.	S. 88° E.	N.E.	200
30	At Elm Tree River, N. side along Intercolonial railway.....	N. 87° E.	N.E.	60
31	At same place, on S. side of river, 2 sets. Older set, grooves and scratches.....	N. 87° E.	N.E.	55
32	Later and finer set.....	N. 22° E.		
33	At Millstream, N. side, along railway, grooves and striæ.....	N. 42° E.	N.E.	50
34	At Nigadoo River, grooves, but not distinct.....	N. 40° E.	N.E.	
35	At Peter's River, (N. side of,) 3 miles N. of Bathurst, *roches moutonnées*, grooves, etc.....	N. 42° E.	N.E.	80
36	Tête-à-gauche River, (just N. of,) along railway. Grooving and fine striæ...	N. 22° E.	N. E.	75
37	At Bathurst Harbor, W. side of.....	N. 22° E.	.....	Between tide marks.
38	In Ste. Louise sett., S. side of Nigadoo River	N. 77° E.	N. E.	

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	GLOUCESTER COUNTY—*Continued.*			
39	In same place, further north on N. and S. road	N. 72° E.	N. E.	
40	In same place, at N. end of last-mentioned road	N. 67° E.	N. E.	
41	In Robertville sett.; E. end of southernmost E. and W road	N. 72° E.		
42	In same place, at E. end of most northerly E. and W. road	N. 72° E.	N. E.	400
43	In Dunlop sett.; on N. bank of Peter's River, 2 sets. Older grooves and striæ	N. 57° E.	N. E.	185
44	Later and finer striæ. The earlier chiefly grooves, the later fine striæ	N. 77° E.	.....	
45	At Bald Mountain, three miles above Indian Falls, Nepisiguit, or fifty miles from mouth of river. No distinct grooves nor striæ, but *roches moutonnées* and polishing. Boulders from the W. were seen on this mountain.	E. and W.	N.E.	1920
	KENT COUNTY.			
46	At Weldford Station, Intercolonial railway, and two miles S.	S. 3° W. or N. 3° E.	Flat.	250
47	Halfway between Weldford and Coal Branch Stations, in several places	S. 5° W. or N. 5° E.	Flat.	275
48	At Cocagne beach, by Prof. Jas. Robb, 2 sets.....Older / Later	N. 68° E. / N. 25° E.		
	KINGS' COUNTY.			
49	At mouth of Nerepis River.....(Robb.)	S. 65° E.		
50	At Oxbow, or bend of Nerepis River (Robb.)	S. 50° E.		
51	In Nerepis settlement.....(Robb.)	S. 30° E.		
52	At Hardings, Nerepis River.....(Robb.)	S. 19° E.		
53	At Elmsdale, S. side of Long Reach (Ells.)	S. 75° E.		
54	At Belleisle Corner.....(Ells.)	S. 10° E.		
55	On road from Norton Station to Belleisle Corner, 4 to 5 miles out.....(Ells.)	S. 10° E.		

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	MADAWASKA COUNTY.			
56	Near Madawaska chapel.....(Robb)	S. 75° E.		
57	At Edmundston village, on left bank of St. John.....	S. 65° E.	S.	600
58	In Madawaska valley, 3 miles from mouth of river, on right bank.....	S. 45° E.		
59	In same valley, about 2 miles from mouth of river, on left bank.....	S. 65° E.	N. W.	600
	NORTHUMBERLAND COUNTY.			
60	Along Intercolonial railway, 6 miles N. of Newcastle, and between that and Beaver Brook station..... These striæ are within the drainage basin of the Miramichi on a southward slope.	S. 23° W.	Flat.	300
61	Near same place, another set.....	S. 18° W.	Flat.	300
62	Two miles N. of Beaver Brook station, on right bank of Green Brook..... Striæ in last two places not very distinct; no grooves.	S. 87° E.	Flat.	350
63	At Blackville, central part, along road, on W. side of S. W. Miramichi.....	N. 68° E.	Flat.	
64	At confluence of Indiantown Brook with S. W. Miramichi..... Deep grooves and fine striæ, both in same direction.	N. 73° E.	Flat.	50
65	At the mouth of Hay's Brook, 8 to 9 miles above Boiestown, along right bank of S. W. Miramichi..... Striæ, distinct and well defined.	N. 38° E.	N. E.	480 ?
66	At Rogersville station, Intercolonial railway, 2 to 3 miles N. of.....	N. 83° E.	N. W.	225
	QUEEN'S COUNTY.			
67	At Bupel's Cove, Grand Lake....(Robb).	S. 30° E.		
	RESTIGOUCHE COUNTY.			
68	At New Mills, near Intercolonial railway, in several places, *Roches moutonnées* and grooves.....	N. 82° E.	N.	25–50
69	At Benjamin River, S. of, on post road..	S. 83° E.	N.	
70	One to two miles E. of Charlo River, along main road.....	N. 82° E.	N.	

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	RESTIGOUCHE COUNTY—*Continued.*			
71	At same place, on McPherson's farm.. One groove here in trap rock is 7 feet wide.	N. 82° E.	N.	35
72	At same place, N. branch of river, on second concession road.....	S. 83° E.	N.	125
73	In Dundee settlement.....	N. 77° E.	N.	225
74	In same place, near W. end of settlement, 2 sets.....	N. 77° E. (Older..) S. 68° E. (Later..)	N. N.	325
75	Two miles W. of town of Dalhousie, at intersection of branch railway with road.....	N. 67° E.	N.	80
76	Along Dalhousie branch railway, 2 miles from Junction.....	N. 72° E.	N.	200
77	On Lily Lake road, near Campbellton, 1½ miles from lake.....	N. 77° E.	N.	500
78	On same road on same side of hill, but nearer lake.....	N. 67° E.	N.	575
79	On same road on summit of hill.....	N. 67° E.		600
80	On same road on southern side of summit.....	N. 67° E.	S. W.	550
81	On road to Parker's Lake, 3 miles from town of Campbellton, on N. side of a ridge running E. and W.....	N. 67° E.	N.	500
	ST. JOHN COUNTY.			
82	At E. end of Courtenay Bay, near glass works.....	S. 5° W.	N. W.	Tide Level.
83	At E. end of Courtenay Bay, near old burying-ground.....	N. and S.	N. W.	10
84	On W. side, at foot of Elliott row, St. John city..... These striæ have a difference of 5° in their course on the E. and W. sides of Courtenay Bay, showing effect of uneven surface upon the ice-movement.	N. and S.	E.	Tide Level.
85	In Carleton, St. John, N. corner of public square.....	S. 2° E.	N.	20–30
86	In Portland, St. John.....	S. 15° E.	S.	75
87	In Portland, at outlet of Lily Lake.....	S. 10° E.	S.	60
88	In Portland, on road behind Reed's castle	S. 10° E.	S.	
89	At Dark or Crescent Lake.....	S. 20° E.	S.	165
90	At Spruce Lake.....	N. and S.		175
91	At Sutton's Mills, 4 miles W. of St. John harbor.....	S. 20° E.	N. W.	20–30

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	ST. JOHN COUNTY.—*Continued.*			
92	Near St. John, at brick.yard,.....(Robb.)	S. 20° E.		
93	At penitentiary, E. side of Courtenay Bay.....(Robb.)	S. 10° W.		
94	At South Bay.....(Robb.)	S. 5° W.		
95	At Musquash Mills.....(Robb)	S. 38° E.		
96	E. of Musquash River .....(Robb.)	N. and S.		
97	At Hunter's Ferry, Quaco Lake..(Robb)	S. 32° E.		
	SUNBURY COUNTY.			
98	At Rushiagonish bridge.....(Robb.)	S. 28° E.		
99	Near Gagetown, at old mill.....(Robb.)	S. 40° E.		
100	Near Gillon's, Blissville or Nerepis Road.(Robb.)	S. 28° E.		
101	Two miles S. of last place.....(Robb.)	S. 28° E.		
	VICTORIA COUNTY.			
102	On Blue Mountains, Tobique River, (Hind.)	N. and S. to S. 20° E.		1650
	WESTMORELAND COUNTY.			
103	At Dorchester, on ridge behind penitentiary..... Grooves in places. Ice moved up N.W. face of an escarpment following Memramcook valley.	S. 12° E.	W.	175
104	At Jolicœur, Hall's Hill, polishing and *roches moutonnées*.....	S. 20° W.	N.	110
105	At Aulac, near Fowler's hill..... Ice-movement here was guided by Cumberland Basin and Westmoreland Ridge.	S. 38° W.		80
106	At Cape Tormentine, on Emigrant settlement road, 5 miles from Port Elgin. (Ells.)	S. 2° E.		
107	At Cape Maringouin, near point on E side. (Ells.)	S. 2° E.	E.	
108	Near Sackville, 1 mile S. of Intercolonial railway on road to Maringouin..(Ells.)	S. 12° E.		
109	Five miles N. E. of Dorchester, and 2 miles from Intercolonial railway.....(Ells.)	S. 12° E.		

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	WESTMORELAND COUNTY—*Continued.*			
110	On road from Sackville to Dorchester Copper Mines, 4 miles N. W. of Sackville, 2 sets.....(Ells.)	S. 12° E. S. 3° W.		
111	In second Westcook settlement at forks of road.....(Ells.)	S. 13° W.		
112	On E. side, one mile from Westcook church on road going up hill.....(Ells.)	S. 12° E.		
113	Dorchester, 1½ miles S. of, or ½ a mile S.W. of railway crossing on road going to Cape Maringouin, W. side.....(Ells.)	S. 22° E.		
114	At Fairfield, 3 miles E. of Dorchester (Ells.)	S. 6° E.		
115	At Memramcook Corner, 2 miles E. of, on highlands.....(Ells.)	S. 26° E.		
116	At Boudreau quarry, on road from Rockland to Boudreau, 2 sets..... (Ells.)	S. 12° S. S.		
	YORK COUNTY.			
117	At St. Mary's, near Fredericton..(Robb.)	S. 30° E.		
118	Four miles N. of Fredericton.....(Robb.)	S. 30° E.		
119	Near Maryland .....(Robb.)	S. 30° E.		
120	At Dyer's on Hanwell road.....(Robb.)	S. 30° E.		
121	On old Woodstock road.....(Robb.)	S. 30° E.		
122	At Springhill .....(Robb.)	S. 30° E.		
123	Near French Village.....(Robb.)	S. 30° E.		
124	On hill beyond Indian Village ..(Robb.)	S. 30° E.		
125	Near Naylis' on Royal road .....(Robb.)	S. 33° E.		
126	At Cardigan settlement.....(Robb.)	S. 18° E.		
127	At S. end of Oromocto Lake.....(Robb.)	S. 18° E.		
128	In Harvey settlement..... .....(Robb.)	S. 20° E.		
129	At Hanwell school house, 2 sets..(Robb.)	S. 28° E. S. 63° E.		

No.	LOCALITIES.	COURSES.	GENERAL SLOPE OF SURFACE.	APPROXIMATE HEIGHT.
	YORK COUNTY.—*Continued.*			
130	Near W. end of Oromocto Lake..(Robb.)	S. 48° E.		
131	At mouth of Keswick.....(Robb.)	S. 48° E.		
132	In parish of Prince William.....(Robb.)	S. 28° E.		
133	At Fredericton.....(Hind.)	S. 30° E.	.....	350
134	Four miles out on Miramichi road.....(Hind.)	S. 20° E.	.....	400
135	On Hanwell road .....(Hind.)	S. 30° E.	.....	400
136	On Maryland road in three places.(Hind.)	S. 30° E.	.....	400
137	In Prince William, near antimony mines..(Hind.)	S. 20° E.	.....	400
138	On Gagetown road.....(Hind.)	S. 20° E.		
139	In Harvey settlement.....(Hind.)	S. 20. E.		
140	Opposite Fredericton.....(Hind.)	S. 30° E.	.....	350
141	On road at N.W.corner of Oromocto Lake, 2 sets.....(Chas. Robb)	older S. 30° E. later S. 50° E.		
142	On road from Fredericton to Erina Lake, 2 sets...(C. Robb.)	first... S. 40° E. second N. and S.		
143	In Bird settlement .....(C. Robb.)	S. 45° E.		
144	In Tay settlement .....(C. Robb).	S. 38° E.		
145	Below Fredericton .....(C. Robb.)	S. 30° E.		
146	At forks of Nashwaaksis . ....(C. Robb.)	S. 35° E.		
147	North of Lake George, in two or three places ..... (C. Robb.)	S. 30° E.		

M 1. Till, or Boulder Clay, Moraines, etc.

Distribution of till in northern New Brunswick.

Till is but rarely met with on the surface in the northern part of the province, but usually appears along banks of rivers and in bluffs on the coast of the Baie des Chaleurs, affording evidence from its sheet-like character that it extends under the stratified deposits in an almost continuous bed of greater or less thickness. The heaviest deposit of till known in this district occurs on the coast just north of Nash's Creek, where it attains a thickness of fifty to sixty feet. Another ridge-like mass of till is met with on the left bank of the Nepisiguit River, through which the Intercolonial railway passes by a cutting, showing it to be composed largely of granitic and red sandstone *débris* (local rocks).

Till occurs on the left bank of Nigadoo River at the shore, and is overlaid by stratified beds. It is also seen on the banks of the Tête-à-gauche River, near the Dunlop settlement road. A high bank of till is seen in a cutting on the Intercolonial railway, on the right bank of the South-West Miramichi. Glaciated boulders of granite, felsite, diorite, etc., from the belt of crystalline rocks to the west, occur in this deposit.

At Moncton.

Another ridge of till is met with on the left bank of the Petitcodiac River, behind Moncton, in a cutting of the Intercolonial railway.

At St. John.

At St. John a great mass of till lies on the west side of the harbor, forming a headland known as Negrotown Point, which extends southward from Carleton.

Along the St. John River.

Heavy deposits of till occupy the St. John valley above Grand Falls, as referred to in my last report, forming banks and mounds along the river as far up as St. Leonard's and above it. The village of Edmundston stands upon a bed of till, and the same material occurs abundantly in the Madawaska valley, having been much less eroded along the upper St. John and its tributaries than below Grand Falls.

Along the St. John River from Grand Falls to Andover, and indeed as far south as Woodstock, a ridge, or series of ridges, chiefly of till, which occasionally assumes the appearance of mounds, is traceable. A portion of it has been described in my report already cited, under the head of "Kames."

At St. Croix.

At St. Croix village, York county, and also on the opposite side of the St. Croix River, at Vanceboro, similar ridges occur. The one on the New Brunswick side is 300 paces wide and 50 to 60 feet high above the river, and appears to be some miles in length. Portions are stratified and kame-like.

At the head of the Magaguadavic River, low, wide ridges, chiefly composed of till, are also met with.

Irregular thickness of beds of till.

In some cases these deposits of till rise above the general level, as appears in railway cuttings passing through them transversely; in other cases they are merely the edges of the sheet which spreads over the surface of the country, but which must have been much thicker in river valleys and depressions than on the higher levels.

Its occurrence along river banks.

How is it that accumulations of till, resembling ridges, occur along or near the banks of many of the New Brunswick rivers? Has it been moved about and thrown into these moraine-like ridges by moving river ice during spring floods, when the rivers in the early Post-Tertiary period flowed at a higher level than now? Ridges have evidently been formed in this way in the same situations during the recent period, and shallow lakes are found in some localities with similar ridges around their borders. The latter are, however, in most cases, partially stratified.

On the uplands of the interior of the province, till can be seen almost everywhere forming the lowest member of the surface deposits, but usually thinning out on the elevations, and perhaps disappearing, except locally, on hills and mountains. Accumulations of considerable thickness occur on the slopes, and more especially at the base of the hills and around the borders of lake-basins.

Moraines.

Moraines are met with in all parts of the province, but are not so numerous anywhere as on the water-shed between the St. John River and the Bay of Fundy, especially in York and the northern part of Charlotte counties. In Nictor Lake, one was seen forming a small islet, and another occurs at the western end of the upper Nepisiguit Lake, forming a promontory which is covered by a grove of red pine; also along the Nepisiguit valley small moraines were observed in several places. One at the Devil's Elbow, fifty-five miles from the mouth of the river, stands up in the centre of the valley, kame-like, but is probably underlaid by rock.

Kames.

Classification of kames.

In classifying the kames of western New Brunswick in the report on the surface geology of that region (Report of Progress, 1882-83-84), two principal divisions of these deposits were made. It becomes necessary now to add a third, as explained on a previous page, which will include all those gravel ridges, mounds and hummocks which appear to have been under the sea and partly, at least, remodelled by marine currents. A number of these occur in a well developed condition on the coast of the Bay of Fundy,* and a remarkable one is found in Restigouche county along the bank of the Baie des Chaleurs. Three

* See Report on the Superficial Geology of Southern New Brunswick, by Mr. G. F. Matthew, 1877-78.

divisions or classes of kames will, therefore, be treated of:—(1) those on the higher levels, at the sources or along the upper part of rivers and around lake basins, and which are not confined within narrow valleys, but have usually swampy or peaty grounds on one or both sides; (2) those found in narrow river-valleys which are usually enclosed by high slopes or hills; and (3) kames partly or wholly of marine origin, which appear to be composed of material derived either from pre-existing beds of till along the coast margin, or of gravel, etc., carried down by rivers during that part of the Quaternary epoch when the land stood 150 to 200 feet below its present level relative to the sea. Three divisions of kames.

In the following brief description of the kames examined during the season of 1884, all the courses given are referred to the true meridian, and the heights to sea level. Description of kames.

KAMES OF CLASS I.

1. A kame is seen crossing the highway between Kouchibouguac River and Chatham, at Lake settlement, on the right bank of Little Black River, near its source. Length unknown, the district being wooded; course, nearly east and west; height above general level, 10 to 20 feet; above sea level, probably 150 feet.
2. On the left bank of a small stream (the head of a branch of Portage Brook, a branch of the N.W. Miramichi,), about four miles south of Bartibogue station, Intercolonial railway, a small kame crosses the track; course, about east and west; length unknown; height above sea level, 500 feet.

CLASS II.

3. A kame, or elongated mound, occurs at the Devil's Elbow, Nepisiguit River, which is probably morainic to a large extent; course, nearly east and west, or parallel to the valley; length about one-fourth of a mile; height above the river, 50 to 75 feet, above sea level, 650 feet.
4. Several short, broken ridges (kames), are found at the confluence of the Taxis and South-West Miramichi Rivers, their general course being parallel to the last-mentioned river; height above its surface, 10 to 15 feet.
5. Along the Tobique River, on right bank, between Arthurette and Three Brooks, a number of hills occur in the valley, which are left from erosion of the surrounding deposits. They consist of sandstone beneath, and drift on the summits, chiefly water-worn gravel. Height, 75 to 100 feet; general longitudinal course, parallel to the river. Some of these hills are angular in outline, and there has evidently, been a channel on the west side in early post-glacial times.
6. Opposite the mouth of the Odell River, a branch of the Tobique, a hill stands upon the right bank, apparently in the middle of the Tobique valley. It is composed chiefly of rock, with gravel on the summit and lower end, and is evidently a mass of red sandstone and drift left from denudation.

7. At Gagetown, Queen's county, a mound occurs in the St. John valley. It is composed largely of glacial drift, with water-worn materials on its summit. General course parallel to the river. A marshy flat surrounds it.

8. Mounds or short ridges of gravel occur on the left bank of the Petitcodiac River, at Boundary Creek, along the west side of the Intercolonial railway. A gravel pit has been opened in a terrace here. These mounds are not more than 40 to 50 feet above the river, which is tidal up to this point.

9. A short, low, kame or hummock, 200 to 300 yards long, occurs on the left bank of Memramcook River, just above the angle formed by it and the second stream flowing into it north of Dorchester Corner.

10. Near Hillsboro', Albert County, on the marsh skirting the Petitcodiac River, a kame, called "Gray's Island," occurs. General direction N.E. and S.W.; height, above tide level in Petitcodiac River, 35 feet; length 700 paces, width 220 paces. It is composed of sand and gravel, with small rounded boulders, almost wholly derived from Lower Carboniferous rocks. Being surrounded entirely by salt marsh, it is a conspicuous example of a part of a terrace left from the denudation of the materials around it, of which it formed a part.

CLASS III.

11. One of the longest and most remarkable kames of this group occurs in Restigouche county along the coast of the Baie des Chaleurs, stretching from the Eel River valley to the shore just north of the mouth of Nash's Creek. Length about twelve miles; course nearly east and west; height above the sea at the western end 150 to 175 feet, and at the eastern end 50 to 75 feet. It is intersected by streams in many places, and overlaid by Leda clay and Saxicava sand, the materials of which are often derived from it. This kame runs pretty close to the shore of the bay, except at Charlo and Eel Rivers, receding from it into the second concession, at Shannonvale, and in Dundee settlement appears on both branches of Eel River in the form of hummocks, which abut against the higher ground to the north-west. In the neighbourhood of River Charlo the shoreward side is terraced. The materials of this kame are almost wholly derived from local rocks, and seem to have been first carried down to their present situation by currents from the land, and afterwards partially worked over by the sea.

12. Along the coast of the Bay of Fundy there occur a number of kames of this class, which have been tabulated and described by Mr. Matthew (Report of Progress, 1877-78), but the elevations above sea level were not given. One, extending from Fairville, St. John county, southward nearly to Spruce Lake, and called by Mr. M. the "*middle ridge in Lancaster*," was found to be 175 feet high at the northern end, and 130 to 140 feet at the southern. It is a wide,

flat-topped ridge of gravel and boulders, overlaid by marine deposits, the materials of which seem to have been derived from beds of till in the vicinity, and has been remodelled by the combined action of fluviatile and marine currents along the coast when the land stood at a lower level. In its external features this kame is altogether unlike those of the interior.

13. The extensive gravel deposit known as Pennfield Ridge, Charlotte county, (No. 17 of Mr. Matthew's table) occupies part of the valley or basin between the Magaguadavic hills on the north and those extending along the coast from L'Etang to New River. It appears to be only partially stratified, but is terraced. Height, 175 to 200 feet.

Theories regarding the formation of kames.

The origin of kames, which is one of the vexed questions of surface geology, still continues to be a fruitful source of discussion. Various theories have been advanced to account for them, and the literature of this subject alone is quite voluminous. A study of these phenomena in the Maritime Provinces of Canada for many years has convinced the writer that it is useless attempting to explain all kames as originating from any one general cause, such, for example, as glacial floods, the action of marine currents, etc. On the contrary, I am inclined to regard their formation as due to several causes, which may be, to a large extent, local, arising from peculiarities in the conformation of the land-surface affecting the drainage within certain areas at the close of the glacial epoch and since, and also to marine currents, such as those in the Bay of Fundy, acting upon the drift along the coast line, or that carried down by rivers. I have, therefore, thought it best to arrange the kames met with in New Brunswick into three classes as already mentioned. The probable mode of origin of those included in classes II. and III. has been briefly outlined. It is only those belonging to class I. which present the difficulties referred to, and, in the present state of our knowledge, no satisfactory theory regarding them seems possible. They are, undoubtedly, to a considerable extent, morainic, these and moraines, to all appearance, having been of contemporaneous formation; but, on the other hand, the fact that they occur, so far as my observations have extended, along the heads of streams where there are dead waters, or on the borders of lakes, not being confined within narrow valleys, and usually with swampy or peaty areas on one or both sides, and, moreover, have tortuous courses resembling those of rivers, leads to the conclusion that the streams along which they are found must have, in early post-glacial times, participated in their formation, although the precise mode of action is not evident. Additional data and a closer study of these very interesting phenomena will, no doubt, reveal to the student some general law respecting their origin; all that can be done, meantime, is to collect and correlate the facts bearing upon them.

General Conclusions Regarding the Glacial Phenomena of New Brunswick.

Glaciation of the province.

From the foregoing facts with reference to striæ, till, transported boulders, etc., it is evident the whole area of the Province must have been mantled by an ice-covering in the earlier part of the Quaternary epoch which, by its movement seaward, scarped and scoured the surface, transported drift, and produced marked changes in the physical features, more especially with respect to its drainage. Whether this ice mantle formed one glacier, or a number of smaller local glaciers, each moving as it was influenced by the contour of the land, I will not undertake to say from the data on hand; but the latter view is certainly supported by the greatest amount of evidence. As already stated, two principal and apparently independent systems of glaciation seem to have prevailed, one southward from the principal water-shed of the province, and the other northward. Besides these, however, there have been later ice-movements as evidenced by finer striæ, whether from local glaciers controlled more by minor inequalities of the surface than the larger glaciers, indicating that ice may have slid down the slopes more directly into the nearest depressions, or by icebergs impinging against the coast area when the land stood at a lower level, is doubtful, although certain facts, in connection with the striæ produced, favor the former conclusion. The evidence relating to these later ice-movements, it may be stated, is found chiefly on the northern slope, where the fine striæ with a more northerly course than those of the chief ice masses occur. On the Carboniferous area these markings of the later ice are not very distinct nor regular; but on the slates and crystalline rocks of the Baie des Chaleurs district they are well defined and numerous. They occur in many places on the same rocks as the older striæ and cross the deep wide glacial grooves of the latter going down one side, across the bottom and up on the other side of these, the slope of the land here being northward towards the Baie des Chaleurs basin. In a few cases they were seen to run into each other, but, on the whole, are regular and parallel over areas of many square miles, the direction being towards some point between north and northeast. The ice which produced them, whether small glaciers moving northward or icebergs drifted against the ascending surface of the land, evidently transported but little drift material. The great denuding and transporting agents were the principal ice-masses which moved southeastward on the main southern slope, and northeastward on the northern slope.

Two systems.

Evidence of later ice-movements.

Local glaciers.

On the isthmus of Chignecto there appear to have been local glaciers formed on the higher grounds, which crept down the valleys into the

Bay of Fundy, or rather into Shepody Bay and Cumberland Basin; or icebergs have passed over it during the Quaternary depression, grating the more prominent ridges. Very little foreign drift is met with here however. (See table of striæ, Nos. 103 to 116.)

General sequence of events during Ice Age.

The general sequence of events in the region now constituting the province during its occupation with ice seems, therefore, to have been somewhat as follows:—

(1) The accumulation of a mass of ice on the surface of the country, from what causes will not here be discussed.

(2) The movement of this ice from the higher interior region (in other words, the shedding of this ice by the principal water-shed), towards the coasts of the Bay of Fundy on the one hand, and the hydrographical basin of the St. Lawrence, or the depressions now occupied by the bays and straits connected therewith, on the other. This movement was accompanied by a great transportation of drift, or decayed rock-material, which had been formed on the surface previous to the Ice Age. River valleys were partly filled, and the rivers themselves dammed up. Lake basins were formed, not, so far as the evidence goes, from erosion of the rocks by the grinding power of the ice, but by (*a*) the scooping out of loose materials from hollows in rock, thus forming rock basins, and (*b*) by leaving depressions in the drift occupying pre-existing valleys which afterwards caught the drainage of the areas surrounding them.

(3) On the melting and breaking up of this ice-covering, either smaller ice-masses have slid down the slopes more directly towards the low marginal areas, or into the adjoining seas; or, as the land sank, icebergs may have grated the slopes, especially of the northern and eastern coast areas of the province.

Height of land during Ice Age.

At what height the land stood relatively to the sea during its occupation with this ice-covering does not seem possible to determine with any approach to accuracy from the data at hand, but as the rocks are everywhere striated down to sea-level, and in a few cases below it, and moreover as the depressions now forming estuaries, bays and straits seem to have influenced the movement of the ice, such for example as the estuary of the Restigouche, the western half of the Baie des Chaleurs, Nepisiguit Bay, Shepody Bay and Memramcook estuary, Cumberland Basin, etc., the land must have been as high as at the present day, if not higher during the period referred to.

Inferences respecting ice-movements.

In regard to the ice movement of the glacial epoch in New Brunswick one or two inferences may be drawn, and these are:—

1. That ice will flow down low inclined surfaces even if obstructed by hills and ridges as high as the ground which gave it momentum, provided there are valleys or passes by which it can creep through

to a still lower level. The principal water-shed in New Brunswick is a comparatively low one, the average descent or slope from it to the waters of the Gulf of St. Lawrence being about 14 to 15 feet a mile, while on the southern side, towards the Bay of Fundy, the slope is only 6 to 7 feet a mile. The direct descent, *i.e.*, in a straight line, from the higher portion, however, towards the Baie des Chaleurs is 25 feet a mile, towards Miramichi Bay 12 feet a mile; on the southward slope, from the higher elevation to the Bay of Fundy, it is only about 9 feet a mile. The ice in its southward flow from this water-shed was intercepted (1) by the St. John valley, out of which it had sufficient momentum to rise; (2) by the minor water-shed, between that valley and the Bay of Fundy, which it also surmounted, and (3) by the hills along the coast in Charlotte county and southern Kings. Notwithstanding these obstacles, it seems to have pursued an almost direct course from the grounds of the interior to the Bay of Fundy, crossing valleys, creeping through ravines and gorges, and passing over the small fjords on the coast nearly at right angles thereto. This latter feat it was, of course, the better enabled to perform from the momentum it received from the minor water-shed referred to.

Slopes of surface affecting ice-movements.

2. Although it has been generally supposed that ice scored the whole surface of the rocks beneath it by the movement of the rock *débris* which, partly frozen into it, formed its basal portion, yet there are areas which do not seem to have been scraped or grooved, the decayed rock material lying upon the solid rocks apparently undisturbed. Proofs of this can be seen along the southern side of the Baie des Chaleurs, between Bathurst and Caraquette. In certain places along this coast, especially at Clifton, where bold cliffs present good sections, the undisturbed material alluded to is found overlaid by what appears to be till, while the surface is strewn with transported boulders derived from the Pre-Cambrian and other rocks of the interior to the west. Similar phenomena were observed also in other places.

Whole surface of rocks not glaciated.

3. The thickness of the ice, even when the glacial period had attained the maximum degree of cold, cannot have been very great. In the Restigouche estuary, striæ are found on the side of a hill facing the valley, 600 feet above sea level. Here the ice may have been 900 to 1,000 feet thick,—a less thickness would not explain the facts—and it probably did not much exceed this in any part of the province. The fact of its having enveloped mountains 2,000 feet high in the interior does not require that it should be much thicker, because it would necessarily have a slope on the surface corresponding with the slope of the country from there down to the marginal area.

Probable thickness of Quarternary ice-covering.

M 2. Stratified Interior or Fresh-water Deposits.

Position of these beds in the series.

The sand, gravel and clay beds described under this head are those overlying the till and intermediate in age between it and the alluviums of fluviatile and lacustrine origin. They comprise the gravels and other deposits forming terraces along river valleys and around lakes, which although partly belonging, in some places, to the recent deposits, especially the loamy portion covering many of the intervales, are, nevertheless, supposed to be mainly deposits contemporaneous with the Leda clay and Saxicava sand of the coast series. In other words, while the terraces belong to Division M 2 of our classification, the intervales or lowest terraces periodically overflowed by freshets belong to the alluviums or Division M 3. Reference will also be made to the deposits of stratified sand, gravel, etc., on the higher levels, and their probable origin explained.

Terraces of river valleys.

The terraces of the St. John valley and its tributaries were pretty fully described in my last report already referred to, and it will, therefore, be unnecessary to notice them in detail here. Those of other rivers in the province were examined however, among which were the Restigouche and its affluent the Upsalquitch, the Nepisiguit, North-West and South-West Miramichi, etc. Along these, terraces of greater or less dimensions occur in endless variety of form, some of them very beautiful and affording a considerable breadth of rich soil, but none can compare in elevation and extent, nor in picturesque shapeliness, with those along the main St. John.

A brief description of the terraces of several of those rivers will now be given by way of comparison with those occurring in the St. John valley, described in the above mentioned report. (Report of Progress, 1882-83-84.)

Along Restigouche.

In the Restigouche valley, no terraces were observed more than 50 to 75 feet in height above the river at the nearest point. They are, however, of considerable area, occurring chiefly below the mouth of an affluent or a bend in the river.

Upsalquitch.

The banks of the Upsalquitch have a considerable width of intervale and terrace land. Generally speaking, none of the terraces exceed a height of 30 to 40 feet above the river, and all have a slope down stream corresponding to it. At the upper falls, just above the mouth of Ramsay's Brook, there is one, however, which seems to have been formed under exceptional conditions, the result of a lake-like expansion of the river which formerly existed above this point. It is 65 feet higher than the river at the upper end of the falls.

Nepisiguit.

Along the Nepisiguit also, there are numbers of low terraces,—one observed at the Grand Falls on the left bank being probably the highest.

It is 65 to 70 feet above the river at the upper basin, and consists of gravel underneath, mixed with cobble stones, and capped by a few feet of loam. Area unknown, but apparently limited.

North-West Miramichi.

On the North-West Miramichi no terraces of any consequence are met with till we reach the head of the tide at the confluence of the Little South-West. On both sides of the mouth of the latter stream extensive terraces occur, that on the right being 75 to 80 feet in height above tide level and covering an area of two square miles or more extending up the river some distance. It is composed chiefly of sand, but becomes coarser as we proceed up stream. A lower terrace, 30 to 40 feet in height, and another 18 to 20 feet, lie between it and the point of junction of the two rivers mentioned, the surfaces of which are partially covered with loam. Other terraces were seen along the Little South-West for six or seven miles up, which are of much coarser materials.

Along the main North-West above Red Bank, as far as Chaplin Island, terraces of considerable width occur on both sides. The highest on the left bank was found to be 75 to 80 feet above tide-level, and probably 50 to 60 feet above the river at the nearest point. Lower ones intervene, one of which measured 65 feet in height above tide-level.

The highest of these terraces have probably been formed when these parts of the river valleys were estuaries, with the land 80 to 100 feet below its present level, and the deposits are really marine or estuarine, although deriving their materials from the rock *débris* above which has been carried down by the rivers. The boulders are of granite, gneiss, felsite, diorite, slate, etc., all belonging to rocks of the interior.

South-West Miramichi.

On the main South-West Miramichi, terraces are not seen either till we reach the head of the tide, or confluence of Renous River. Above that they skirt the valley everywhere, but are not high, seldom exceeding 30 to 40 feet above the level of the river at the nearest point. Sometimes three are seen together, one rising above the other, but oftener only two. At Doaktown and the mouth of Taxis River they attain a considerable breadth, and when cleared afford excellent soil. At the latter place mounds or river-valley kames occur.

Petitcodiac.

The Petitcodiac River has some low terraces flanking it which are seen at Boundary Creek (where a gravel-pit has been opened in one), and at Salisbury and Petitcodiac villages.

Tobique.

The valley of the Tobique River exhibits many beautiful terraces as far up as the confluence of the Mamozekel and Right Hand Branch. One was seen immediately above the "Narrows" on the right bank at a height of 40 feet, and a second irregular one somewhat higher. These are lacustrine and have been formed when the river was dammed back by drift and held in a lake. At the foot of the Red

Rapids there are wide intervales on the right bank, composed of gravel, which have a height above the Tobique of 20 to 30 feet. At the mouth of the Wapskehegan, low terraces occur on both sides, that on the right being called "Wapske Flat." At Blue Mountain bend and the mouth of Riley Brook, similar low terraces skirt the river; while at the "forks," a terrace, 5 to 8 feet high and a mile long or more, runs along the left bank, which, at the lower end, is backed by another rising 30 to 50 feet above the river. On the Little Tobique or Nictor Branch a few narrow terraces are seen at intervals, the heights of which are 20 to 40 feet, becoming higher, however, as we approach Nictor Lake, the source of the river. Near the mouth of Cedar Brook, they are 50 to 60 feet above the stream, the valley being constricted there.

Salmon River.

On Salmon River, an affluent of the St. John, a few miles above the Tobique, noteworthy and peculiar terraces occur at Upham's mills, three miles from its mouth, two of which are short ones, resembling artificial embankments. None exceed a height of 40 feet above the stream. Ridges of slate rock were seen to underlie some of them.

Madawaska.

At the mouth of Madawaska River, a series of terraces occurs around the site of Old Fort Edmundston, the two highest of which are respectively 65 to 70 feet and 85 to 90 feet above the St. John, at the confluence of the two rivers. A drift-dam seems to have existed across the mouth of the Madawaska River in early post-glacial times, forming a lake or lake-like expansion above, which has been instrumental in carving out the terraces referred to. The St. John valley above this point becomes constricted and, as stated in my previous report, a lake has probably stretched from here to the Grand Falls immediately at the close of the Ice Age and before the remodeling of the drift into terraces began. The latter lake must have held in a body of water, the surface of which was 90 to 100 feet above the present level of this part of the St. John.

No terraces of any consequence were seen along the Madawaska River as far as the Quebec boundary, but extensive intervales indicate a lake bottom.

Peculiar formation of some terraces in valley of Upper St. John.

Some of the narrow terraces bordering the St. John valley between Grand Falls and Edmundston appear to have been formed by the material washed down from the slopes above them into the lake, which is supposed to have once occupied it, thus forming a bank under the surface along its margin while it remained at its highest level, the summit of which would be levelled off by the action of the lake waters. Atmospheric agencies of this kind alone seem to afford a reasonable explanation of the origin of several terraces in this locality, as they are not near the mouths of tributary streams, and the river valley here is a mile or more wide.

Relation of terraces to the drainage, and size of rivers.

A somewhat detailed investigation of river-terraces in New Brunswick, shows that these formations bear a close relation to the drainage area surrounding them, to the size and depth of the valley, the volume of the river, etc., along the banks of which they are found. The larger rivers, especially when they flow through deep valleys, have invariably the largest terraces and *vice versâ*. The correspondence is so marked that it is comparatively easy to judge, from the size of the river, what the height of the terraces is, the relation apparently holding good not only at the present day, but evidently during all post-glacial time.

Conclusions respecting the origin of terraces.

In my report on the surface geology of western New Brunswick, already several times cited, a theory in regard to the origin of these terraces was tentatively advanced, and a further study of them during the summer of 1884, has brought out the following facts and conclusions, all tending to support it, viz.:—(1). Terraces are usually short, even the highest and longest seldom exceed two or three miles, and they have almost invariably a longitudinal slope corresponding to that of the rivers; (2), the highest terraces, while often having corresponding ones on the opposite side of the river, at about the same level, are, generally speaking, without it; and moreover, each terrace, except in a few cases, seems to have been formed separately and independently; (3), their greater development below the mouths of tributaries and constrictions and bends in the river valleys, and where the flow is most rapid, is a characteristic feature; and (4), their heights, relative to the rivers, are greater where the valleys are narrowest and deepest, and lowest where these are widest.

Erosion.

The data at hand seem, therefore, to lead to the conclusion that the larger number of terraces, along river-valleys, have been formed by the rivers eroding and modifying the drift which occupied these valleys at the close of the Ice Age and since, in the process of re-excavating such drift. After the retreat of the ice, it would appear that the valleys were partly blocked up, the rivers forming lake expansions at heights corresponding to the size of the rivers and depth of the valleys, not exceeding 200 feet along the St. John above that of the river of the present day, but correspondingly less on smaller streams. Erosion and transportation, in other words, the gradual cutting down of their channels to lower levels, would then be sufficient to account for all the observed phenomena.*

Ice-barriers.

It is to be understood, however, that the above explanation is not intended to exclude the supposed existence of ice-barriers damming up river-valleys at certain places during the glacial epoch, which alone will serve to account for the origin of a few of the terraces.

* See report of Dr. A. R. C. Selwyn, Report of Progress 1871-72, p p. 54-56; also Dr. G. M. Dawson, in Report for 1877-78, pp. 145-194 B., for facts and inferences relating to terraces of British Columbia.

Drift-dams seem to have existed at various points along the valley of the St. John about the close of the Ice Age, maintaining the river at an elevation equal to that of the highest terraces referred to. Evidence of one having occupied the valley immediately above the mouth of the Aroostook, was observed, and others appear to have existed between that and Grand Falls, where the terraces are developed on a magnificent scale. The whole St. John valley, indeed, from Woodstock to St. Francis, has been occupied with drift obstructions at the period mentioned. Drift dams.

The former existence of lakes, or lake-like expansions of rivers, (notably along the St. John,) is evidenced, as stated above, by terraces and other phenomena, and the large lake, which is supposed to have been held in between Grand Falls and the mouth of the Madawaska by the drift-dam at the former point, prevented the erosion of the original drift beds in this part of the valley to as great an extent as elsewhere. The clay beds and intermingled materials are less oxidized, and wherever covered by sand or gravel, have generally a bluish tint. This color may be partly due to their calcareous nature, as they are largely derived from the Silurian slates of the district; but it is also probable that at the time of their original deposition they were excluded from the atmosphere, and, lying almost undisturbed since, have retained the colors they then had. The whole appearance of the deposits in question is indicative of their lacustrine character. Lake expansions along rivers.

The materials composing the beds occupying river-valleys and lake-basins were described in my report of 1882-83-84, and shown to be, generally speaking, (1), loam on top, (2), sand and gravel, and (3), clay with probably till in the bottom. One or other of these divisions, is however, often absent. On the higher grounds, where the land is dry, the surface deposits usually consist of (1), stratified sand or gravel of varied texture, with lenticular sheets of stratified clay beneath, and generally till in the bottom. In the hollows on this surface there are often thin clayey or loamy sheets, which have been deposited as the wash from the surrounding slopes. The sand, gravel and till almost always contain boulders of the underlying or subjacent rock. The thickness of these beds varies from a few inches to 10 or 20 feet or even more, but often one or the other of the series is wanting. Generally speaking, the thickness depends upon the nature of the underlying rock, whether hard or soft. The deposits overlying the Silurian and Carboniferous areas constitute a deep soil, while over the Pre-Silurian it is thin and gravelly. Character of materials in terraces and river valleys. On higher grounds.

In the lower parts of the uplands, which are often wet and form swamps ("swales," or "caribou plains"), the series is (1) a stratum of decayed vegetable, or peaty matter from a few inches to several feet in Character of materials on uplands.

thickness; (2) a hardpan beneath, composed of fine sand and clay, and almost impervious to water, usually a foot or two deep; and (3) sand and gravel with boulders, and sometimes till in the bottom, generally closely packed. As on the drier grounds, the thickness of the deposits in the swamps varies, but is usually considerable, the till being evidently much thicker there than upon the low ridges or uplands.

Remarks on origin of stratified beds.

The origin of the till, moraines, etc., was explained under a former head, and in this connexion it may be remarked, as regards the *valley-drift* and the materials occupying the higher levels, that they consist largely of sand, gravel, etc., derived from the till. In the shifting process which large portions of the rock *débris* underwent during the glacial epoch, the elevations would naturally become denuded and greater quantities deposited in the valleys. This valley-drift, when the ice began to retreat, would be arranged into moraines and kames by the smaller local glaciers which would hang about the water-sheds and elevated portions of the country, and by waters flowing therefrom; and in the river valleys and lake basins the work of erosion and remodelling into stratified beds would be carried on and the process of re-excavating the drift-filled river-channels commence. On the higher levels, many lakes and ponds would occupy the hollows, and portions of the drift would thereby be remodelled. Most of these have since become dry by drainage, evaporation, etc. Over all the higher grounds, however, there is almost invariably a stratified deposit of sand and gravel to be found resting on the till of greater or less thickness, which must have been formed from its modification by atmospheric agencies, as, for example, by thaws every spring loosening the materials and moving them down to a lower level; by rains washing down the finer materials to the hollows in which may be found the lenticular clayey patches referred to; but principally, perhaps, by the modification of the till by water resulting from the melting of the glacier or glaciers at the close of the Ice Age. Indeed the conclusion seems unavoidable, that the beds of sand and gravel referred to, with which intercalated sheets of clay occur sometimes locally, all of which are beyond the reach of fluviatile and lacustrine action, must have been produced by some sub-aerial agencies of the kind mentioned.

Probable mode of formation on higher levels.

M 2.—Leda Clay and Saxicava Sand.

Localities of Leda clay and Saxicava sand.

The deposits classed under this head, which usually contain marine fossils, are confined, so far as known, to the coastal area and river estuaries in New Brunswick. For the most part the Leda clay forms detached sheets, of greater or less breadth, and is not spread continuously over the maritime district referred to, but appears better developed at or near the mouths of rivers than elsewhere. In the Baie des Chaleurs basin, the two (Leda clay and Saxicava sand) occur

together in patches all around its southern border and up the Restigouche valley as far as the mouth of the Upsalquitch usually in regular position, that is, the sand overlying the clay. Their greatest thickness, as seen together to the west of Bathurst harbor, is Leda clay, 75 feet, Saxicava sand, 50 to 60 feet; but in the Restigouche estuary at Oak and Battery Points, the Saxicava sand alone is seen to be 150 feet thick. On the banks of the Tête-à-gauche River; the clay is found as high as 90 above sea level, while in St. Ann settlement the Saxicava, or overlying sand, reaches an elevation of 150 to 175 feet. This is the greatest height of these beds in the Baie des Chaleurs district, so far as observed. In the Bay of Fundy region they present similar features and characteristics, but penetrate the interior along the rivers farther, and are nowhere found at greater elevations above sea level than 200 feet. The total vertical thickness of the series in New Brunswick must exceed the above estimate considerably, however, as everywhere along the coast it descends beneath the sea, and some of the richest fossiliferous beds pertaining to the Leda clay are found below high-tide level, as at Charlo and Jacquet Rivers at the Baie des Chaleurs, and Sand Cove on the Bay of Fundy coast.

Greatest thickness of those deposits in northern New Brunswick.

In regard to the materials constituting these deposits, they seem to be derived partly from the denudation of the coast area by the sea, but chiefly from the detritus of the numerous rivers and brooks debouching into the bays and straits along the coast, the thickest accumulation being found at the mouths of rivers and along estuaries. And the nature of the rock or drift-beds, whence the materials were derived, seems to have been influential in determining the character of the Leda clay and Saxicava sand. For example, in the Baie des Chaleurs basin, where calcareous rocks prevail, they have furnished considerable quantities of material suitable for clay, and hence the Leda clay is well developed there, and from its calcareous nature is prolific in well preserved fossils. In the Bay of Fundy region on the other hand, there is a mixture of calcareous and other sediments, and hence it is only in certain localities that we find clay beds and fossils. Along the coast of the central Carboniferous area, the beds, being chiefly derived from the Carboniferous sandstones, are largely composed of sand, hence fossils are rarely, if at all, detected. It is thus apparent that the materials of these clays and sands are largely derived from the rock *débris* of their own immediate neighborhood. Where they overlie kame deposits, they are invariably packed with boulders from them. At the mouths of rivers running through a limestone district, blue calcareous clay prevails, while reddish clay is invariably met with in districts in which red Lower Carboniferous rocks occur. In the middle Carboniferous district the clay is generally grey in color.

Source of the materials of these deposits.

Their relation to the rocks of the country.

Leda clay not divisible with upper and lower.

No separation of the Leda clay into upper and lower divisions seems possible, but in some places the upper portion is yellow or brownish from oxidation by percolation of surface waters and other atmospheric causes. The lower portion indicates deposition in moderately deep, or quiet waters. There would seem, however, to have been a gradual shoaling during the deposition of the Leda clay, the upper part often bearing traces of having been formed in shallow seas, lagoons and estuaries, the material being coarser and boulders not uncommon. The fossils are largely confined to lenticular, muddy strata in the upper portion of the Leda clay.

Fossils.

Saxicava sand.

The Saxicava sand is wholly a shallow water deposit, and contains gravel and small boulders derived from pre-existing drift deposits, and like the Leda clay partakes of the character and even color of these. In the somewhat extensive terraces of Saxicava sand, near Bathurst, the pebbles consist chiefly of granite, felsite and slate. The materials appear to be such as were carried down by the rivers and worn off the coast area by the sea; but, from their greater thickness at the mouths of rivers, principally from the former source.

Scarcity of fossils in it.

The Saxicava sand seldom contains fossils. Mr. G. F. Matthew states (Report of Progress, 1877–78) that *Mya arenaria*, and *Macoma fusca* occur in it on the coast of the Bay of Fundy. In the Baie des Chaleurs sand, fossils were found only in one place, viz., at Benjamin River, and at about its contact with the underlying clay, the species met with being *Mytilus edulis*, var. *elegans* of Sir W. Dawson's list. The Leda clay abounds in fossils here, which are found principally in the upper strata, however, and considerable beds forming the lower portion along the Baie des Chaleurs coast are quite unfossiliferous. These latter are often impregnated with iron or other matter destructive to shells, to which cause they may partly owe their unfossiliferous condition.

Why portions of Leda clay are unfossiliferous.

The following shells were collected in 1884, from the Leda clay of the Baie des Chaleurs basin:—

LIST OF POST-TERTIARY FOSSILS, COLLECTED IN 1884, FROM THE LEDA CLAY OF THE SOUTH SIDE OF THE BAIE DES CHALEURS.*

CRUSTACEA.

1. *Balanus crenatus*, Brug. River Charlo, Beaver Point, Jacquet River, Tête-à-gauche River. Very common.
2. *Homarus Americanus*, Edw. (Claw of.) In railway cutting, near Beaver Point.

* Vide Report of Progress, 1877-78, for Report on the Superficial Geology of Southern New Brunswick, by G. F. Matthew, M. A., containing a list of Post-Tertiary fossils, a number of which belong to the Baie des Chaleurs basin.

Mollusca.

Lamellibranchiata.

3. *Leda minuta*, Fabr. River Charlo, Beaver Point. Rare.
4. *L. pernula*, Muller, " " Abundant.
5. *Mya arenaria*, Linn. " " Common.
6. *M. truncata*, Linn. " " "
7. *M. truncata*, Linn., var. *Udevallensis*. River Charlo, Beaver Point. Common.
8. *Mytilus edulis*, Linn. Benjamin River.
9. *Nucula tenuis*, Montagu. River Charlo. Rather scarce.
10. *Saxicava rugosa*, Lam. River Charlo, Beaver Point. Very common. This and *Balanus crenatus* are the two most abundant species.
11. *Macoma calcarea*, Chemnitz. River Charlo, Beaver Point. Common.
12. *M. fragilis*, Fabr. = *M. Grœnlandica*, Beck. Last two localities.
13. *Yoldia arctica*, Sars = *Portlandia glacialis*, Gray = *Leda truncata*, Brown. Last two localities and Jacquet River. Rare, except at latter place.

Gasteropoda.

14. *Buccinum undatum*, Linn. River Charlo. Not common.
15. *Neptunea despecta*, Linn., var. *tornata*. River Charlo. Rare.
16. *Margarita striata*, Brod. and Sowb. " Very rare.
17. *Natica clausa*, Brod. and Sowb. " Not common.
18. *Serripes Grœnlandicus*, Chemn. River Charlo, Beaver Point. Rather abundant.
19. *Bela harpularia?* Couthuoy. River Charlo. Scarce.
20. *Trichotropis borealis*, Brod. and Sowb. River Charlo. Scarce.*

Mode of occurrence of fossils.

These fossils are usually intermingled and packed together in lenticular strata in the upper portion of the clay, as already stated, so that it is impossible to separate arctic from sub-arctic or other species, and their value, as indicative of the depth of water in which they lived, is not to be greatly relied on. It appears probable, however, that the sea which they tenanted has been comparatively shallow, for not only has the upper surface of the clay been eroded and channelled by currents

* I am indebted to Mr. Whiteaves, Palæontologist to the Survey, for the identification of some of the species and a revision of the above list.

previous to the deposition of the Saxicava sand, but the fossils themselves, in many cases, indicate that they were washed about by currents and thrown together in masses, occurring often compacted two or three inches deep, with the valves mostly separated and broken. Occasionally, too, they seem to occupy pockets or holes in the upper part of the clay and are heaped up sometimes on one side or the other of the larger boulders. The frequent commingling of deep water and littoral species may thus be accounted for, the sea having washed those from shallower waters into greater depths and *vice versâ*.

The fossils indicative of sub-arctic climate.

The assemblage of shells in the foregoing list, along with those recorded by Mr. G. F. Matthew from the same region, indicate that the climate of the Baie des Chaleurs district was probably sub-arctic in character at this stage of the Quaternary epoch, as similar species inhabit the seas on the coasts of Labrador and the south of Greenland at the present day. Nevertheless, its waters must have formed a favourite retreat for marine life, for the shells are not only abundant, but remarkably strong and well developed.

The shells of the Bay of Fundy Leda clay show some amelioration of climate there from that which obtained in the Gulf of St. Lawrence, as shown by Mr. Matthew, so that the existing geographical barriers influenced the character of the shallow-water marine fauna then as they do now. Only a few of the species found in the Leda clay of New Brunswick now inhabit the seas along its coast.*

Marine terraces.

The Leda clay and Saxicava sand often form terraces, usually two or three together, examples of which may be seen near Bathurst, at Charlo River and along the Restigouche, also at the confluence of the North-West and South-West Miramichi Rivers, as well as at many places on the coast of the Bay of Fundy, described by Mr. Matthew.

Sections of marine deposits.

Sections of the deposits under consideration were made at the undermentioned localities. The series is in each case descending.

At Campbellton.

1. At Campbellton, Restigouche county, near mouth of Millstream :—

	FEET.
1. Loamy and sandy material, in places changing to gravel ..	5 to 10
2. Greyish-brown, oxidized, tough calcareous clay, holding fragments of marine shells (*Mya* and *Macoma*), ...	1 to 5
3. Bluish-grey, tough calcareous clay, with fragmentary shells of *Balanus crenatus*, *Serripes Grœnlandicus* and *Macoma calcarea*. Thickness unknown, but above the river level it is	5 to 10
	25

* See Sir J. W. Dawson on the Post-Pliocene of the St. Lawrence valley; Mr. Matthew on the Surface Geology of New Brunswick, *Can. Naturalist;* Also a paper by the writer, *Can. Naturalist*, Vol. X. No. 4.

These beds here form a terrace 15 to 25 feet above tide level in the Restigouche estuary.

2. Another section of the stratified beds was measured in the Restigouche valley, at the Intercolonial Railway bridge, near the mouth of the Metapedia, The course of the Restigouche River, at this point, is about N. 50° E. A hill 400 feet high rises on the right bank sheer from the river's margin. Course of the section N. 40° W., or about at right angles to the direction of the river. At mouth of Metapedia.

1. River, width of, following above course, 210 yards.
2. Intervale on left bank, 5 to 7 feet high; 345 paces wide. Chiefly loam with pebbles intermixed. Sandy loam on summit, and in some places pure sand.
3. Terrace, 12 to 15 feet high; 90 paces wide. Gravelly loam.
4. Terrace, 35 feet high; 50 paces wide. Gravel.
5. Terrace, 45 feet high; 10 paces wide. The same as the last, with boulders.
6. Terrace, 55 feet high; 10 paces wide. The same.

Behind these, a mound rises 175 feet high, apparently composed of till. It is irregular in outline, and occupies a position opposite a gap in the hills behind, through which a small stream flows. These hills rise 400 to 500 feet above the river.

3. Behind the Metapedia Salmon Club house, at the confluence of the Metapedia and Restigouche Rivers, an interesting series of beds occurs, which appears to be partly marine and partly fluviatile. It forms a terrace 160 paces long and 35 wide; height above the Restigouche River, at the railway bridge mentioned, 70 feet, above tide level 88 feet. The following is the succession in descending order:— Behind Metapedia Club House.

	FEET.
1. Fine, friable, yellow or brown earth.....1 to	2
2. Dark grey sandy loam.....3 to	4
3. Gravel, with numerous water-worn pebbles, almost wholly of calcareous slate, from one to six inches in diameter.....12 to	15
4. Sandy loam, becoming clayey in bottom .....5 to	8
5. Dark grey clay, in places bluish, holding marine fossils, *i.e.*, *Mya* and *Macoma*; depth unknown. In cutting.....15 to	20
	49

The above measurements are only approximately correct, the face of the section being denuded.

Nos. 4 and 5 are marine, but Nos. 1, 2 and 3 are probably fluviatile, at least 1 and 2 are closely similar to loams overlying terraces along rivers in the interior, while No. 3 is perhaps the transition deposit. Deposits both fluviatile and marine.

No. 4 has an uneven surface as if it had been eroded previous to the deposition of the overlying beds. On the surface of the terrace, or beach, a transported boulder of diorite, three feet in diameter, and another of trap, one foot in diameter, were seen.

Newcastle.

4. At a brick-yard on the bank of the Miramichi River, just above Newcastle, the following section was measured.

	FEET.	INCHES.
1. Sand, with coarse layers towards the top, and lenticular stratification in some places.....	7	0
2. Reddish-brown clay, the same as No. 3, but oxidized....	5	6
3. Dark grey, finely-stratified, arenaceous clay, with carbonaceous matter. Thickness unknown, height above tide level in river.....	6	6
	19	0

These deposits extend along the bank of the Miramichi opposite Beaubair's Island half a mile or more, with a width of a quarter of a mile, and appear to have been laid down in an eddy or cove while the land stood at a lower level.

Sections in Bay of Fundy region.

Mr. Matthew has given sections of the Leda clay and Saxicava sand in the Bay of Fundy, in the report cited (Report of Progress, 1877-78), from which further information can be obtained.

M 3. Alluviums, or Recent Deposits.

Fresh-water Beds.

Alluviums.

These include all the fluviatile and lacustrine deposits, such as marshes, peat bogs or caribou plains, marl-beds, river-flats (intervales), etc.

Formations around margins of lakes.

Around the margins of the lakes, small areas of marshy or peaty beds occur, formed of sediments washed down from the surrounding slopes, mingled with vegetable matter, such as remains of mosses and ericaceous plants which have grown and died *in situ*. These are increasing in breadth from the causes mentioned, but their extent is, on the whole, inconsiderable. Some lakelets are bordered with a ridge of gravel and sand resembling a kame, which appears to have been formed by the expansion or movement of the ice which gathers on their surfaces every winter against the shores. Phenomena of this kind can be seen at Lake Elsie, Kent county; Spruce Lake, St. John county, etc., also in certain places along river banks.

Intervales.

Extensive intervales, certain portions of which are called marshes, extend along the St. John and other rivers. Some of these were described in detail in my former report. Below Fredericton, more especially in Sunbury and Queen's counties, they form wide tracts,

which are overflowed every spring, and comprise some of the richest lands in the country. Similar intervales are found along all the rivers, occupying a greater or less breadth.

Peat bogs are met with in all parts of the province, and are of various sizes from a mere patch up to areas of many square miles in extent. A few of these may be enumerated, viz :— Peat bogs.

1. At Belledune, Gloucester county, one half a mile long, and 300 to 400 paces wide occurs. Underlain at the depth of 2 to 4 feet by shell marl. Height of the surface of the peat above sea level, 5 to 10 feet.
2. At River Charlo another occurs; length, 1½ to 2 miles along the coast; width ½ to 1 mile.
3. A peat bog crosses the Intercolonial railway about three miles south of Weldford station; width about a quarter of a mile; length unknown.
4. At about a mile or a mile and a half south of Canaan station, Intercolonial railway, a peat bog a quarter of a mile wide crosses it, and some distance further south, another, half a mile wide. These two are merely portions of one bog, and seem to unite a short distance east of the railway.
5. About three miles north of Berry's Mills station, another is crossed by the railway track, which is a quarter of a mile wide or less.
6. A small peat bog occurs at Kent Junction, Intercolonial railway, and several others along the Kent Northern railway. One, about two miles or more in diameter, is seen six to seven miles above Kingston village, Kent county.
7. A peat bog, a quarter of a mile wide, crosses the Intercolonial railway just north of Bartibogue Station, and four to five miles further north another was seen of about a mile in width. These two, I am informed, join to the west, and form an extensive "caribou plain."
8. Near Point Escuminac, Northumberland county, a peat bog several miles in length is met with, referred to by Mr. Ells in one of his reports. It is said to be 30 feet deep.
9. Peat occurs on Shippegan and Miscou Islands, but the deposits were not visited.
10. In the south of the province they are numerous,—a peat bog is crossed by the New Brunswick railway, about halfway between McAdam and Watt Junction, along the dead waters of the upper Digdeguash River. Hillocks of till and gravel occur here and there in it. This is also called a "caribou plain," or "cranberry barren."

Peat bogs are common in the valleys among the crystalline rocks of the southern counties, but they are usually of limited extent.

11. Peaty bogs or marshes occur along the thoroughfares between the two Magaguadavic Lakes, also between Grand and North Lakes, and along the head of Eel River, York County.
12. Behind some sand hills in Lincoln, Sunbury county, peat bogs lie. Their area is small.

13. A peat bog, a mile long, and a quarter to half a mile wide, lies on the N.E. branch of Portage Brook, an affluent of the Nepisiguit River. General direction, N.E. and S.W.; height above sea level, 800 feet. The depression occupied by it once formed a lake-basin.

14. At the head of the Keswick and Nackawicac Rivers there are peat bogs. One, five or six miles east of Millville, is half a mile or more in diameter, and shaky when walked upon.

15. In the St. John valley, in Madawaska county, where it is wide and flat, there are peat-covered areas overlying the stratified deposits. One of these, below St. Basil, forms a tamarac swamp.

16. Along the Madawaska River, five to seven miles from its mouth, "cranberry barrens" occur in the valley. The peaty matter is only a few inches deep, and is underlaid by a clayey hardpan.

17. Peat also occurs at Lawlor's Lake, St. John county, underlaid with marl, as described by Mr. Matthew.

Peat bogs on coast.

In many places along the coast of the Bay of Fundy and Baie des Chaleurs, peat beds are seen to extend below sea level, showing a slight subsidence of the region since the period of their growth.*

Area and character of intervales or river flats.

Intervales accompany every river in New Brunswick with greater or less breadth, and comprise thousands of acres of the very best lands. They are generally composed of sand and gravel underneath, with a covering of loam of variable thickness, and are overflowed every season. The freshets deposit a thin stratum of silt upon them, which, by yearly increments, has given them their present thickness, and there seems no reason to doubt that these intervales have been wholly formed in this way, that is, from the sediments of spring freshets. They often attain a thickness of 5 to 10 feet, and are usually unstratified; they consist of very fine sand and clayey matter which were held in suspension by the waters, till reaching a quiet place they were dropped. The unstratified character may be partly owing to the fact that each layer of silt, as it became dried after the recession of the freshets, was liable to be disturbed by the rains and frosts and blown about by the winds. The roots of growing vegetation would likewise have the same effect; so that ultimately, from the incoherent nature of the materials, they would assume an unstratified, homogeneous appearance. The loam of our river valleys appears to be, therefore, of the nature of the loess of the Mississippi valley and other countries.

Probable mode of origin.

The whole amount of loam or river silt, described in this and the preceding report, already cited, seems thus to have accumulated by yearly or periodical increments in past ages, and in the lower intervales is still accumulating.

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* This subsidence may, however, be chiefly local, and due to a compression of the beds.

Infusorial earth occurs at Pollet River Lake, King's county, and Fitzgerald Lake, St. John's county. At the latter place there is a large deposit. Tripolite.

Marine Beds.

These deposits consist of salt marshes, sand dunes, estuarine flats, etc. The salt marshes occupy a large area on the Bay of Fundy coast, more especially in Westmoreland and Albert counties. The material composing them is largely derived from the waste of the Upper and Middle Carboniferous rocks of this part of the province, and is a reddish-brown mud, in some places varying to grey, which is well described in Dawson's *Acadian Geology*. In other localities it changes to a loam. Along the inner margin, near the drier grounds, the loam or clay is often covered with a peaty deposit, water-soaked a great part of the year. Twigs, sticks, logs and other matter are sometimes found buried up. The level of these marshes is about equal to that of the highest tides of the Bay of Fundy, and their area in Shepody Bay and Cumberland Basin, in New Brunswick, is many thousands of acres. Marshes of smaller extent occur near St. John city. Character of marine beds. Height and area.

Along the Gulf shores, salt marshes are met with in many places bordering the lagoons which are enclosed by the sand barriers interruptedly stretching from Baie Verte to the entrance of Baie des Chaleurs. They occur chiefly at the mouths of rivers, as at Richibucto, Kouchibouguac, Baie du Vin, etc.; but are, on the whole, of small extent compared with those of the Bay of Fundy. The sand dunes and beaches which enclose the lagoons referred to, skirt the shores along the Carboniferous area, but are best developed northward of the mouth of the Richibucto, and from there to Miscou Island form a series of long, low banks, or islands along the coast, chiefly of blown sand. Some of them are covered by a stunted growth of spruce and birch, and also with coarse grasses and carices. On the Baie des Chaleurs coast, these peculiar formations are absent, or rather are replaced by dunes of much coarser sand jutting out into the bay, forming what are called "points." Noteworthy examples occur at Bathurst, Belledune, Heron Island and other places. These dunes appear to have been formed by annual or periodical increments of sand and pebbles thrown up by the waves. Salt marshes. Dunes.

Estuarine flats are in process of formation at the mouths of many of the principal rivers, which are usually laid bare at ebb-tides and covered with eel-grass (*Zostera marina*), ditch-grass (*Ruppia maritima*), etc. In the upper part of the Restigouche estuary a basin five to six miles long and two to three wide exists, which is filled, chiefly with sand, up to the level of low tides. An extensive flat stretches from here to the eastern end of the estuary at Dalhousie, the material becoming finer Estuarine flats.

in that direction. Clay beds are being deposited in the coves bordering it, in which shells of *Macoma fusca* are imbedded. A study of these estuarine deposits would exemplify the formation of the marine Post-Tertiary beds which occur in the vicinity.

Geological Relations of the Surface Deposits.

Relation of surface deposits to the solid rocks.

The geological structure and mineralogical composition of the rocks of New Brunswick have had an important influence upon the character of the surface deposits, and more especially on their agricultural capabilities. In general, an intimate relation may be said to exist between the unconsolidated materials and the strata immediately underlying them; but there are exceptions to this rule to which I shall presently refer. In preceding pages an attempt has been made to show how these loose deposits originated, and it was inferred that they were produced by a

How formed.

series of causes which may be briefly stated as follows:—(1) The gradual decay or degradation of the rock surface of the country chiefly by subaerial erosion; (2) the subsequent shifting and grinding down of portions of these materials, and the abrasion of the rock-surface beneath through the agency of glaciers and icebergs; and (3) the re-arrangement of the uppermost portion of these materials by the action of water, either fluviatile, lacustrine or marine, through which they have been re-assorted and stratified into clay, sand, or gravel beds, etc.

Soils of New Brunswick.

The deposits constituting the soils and sub-soils of the province are mainly divisible into two classes—(1) those which rest upon and are almost wholly derived from the underlying or subjacent rocks: and (2) those which consist, to a considerable extent, of transported materials and have merely a partial relation to the rocks immediately beneath. The first may be found upon the surface of the great Silurian plain which extends from the Gaspé peninsula across the northern part of New Brunswick into the New England States. They also occur upon the central Carboniferous area, but in the case of the latter district it is found that those of local origin are intermingled with a certain proportion of foreign material derived chiefly from the Pre-Carboniferous band to the northwest.

Deposits covering Silurian rocks.

On the Silurian area referred to, the deposits under consideration are largely made up of the *débris* of the calcareous slates which they cover and to which the soil, in a large degree, owes its fertility. These slates are traversed, however, by numerous dykes of felsite, dolerite and other eruptive rocks, the *débris* of which has been intermixed with these calcareous materials. The superficial deposits mantling this tract of country are often deep, more especially in the interior, and while in some places tolerably free from boulders, in others there is a large admixture of them derived chiefly from the intrusive rocks mentioned.

The land is high, as already stated (800 to 1,000 feet), except along the immediate coast of the Baie des Chaleurs, and having a rolling surface is generally well drained by the numerous streams which traverse it.

Deposits overlying Carboniferous area.

On the Carboniferous plain a tolerably deep and uniform covering of surface deposits is found, principally furnished from the destruction of the underlying strata. Disseminated through them, however, but chiefly scattered about over the surface, occur boulders derived from the Cambro-Silurian and Pre-Cambrian rocks to the west, and which have been transported thither by glaciers or the force of running water as stated above. The general surface of this region is low and flat, rising gently from the coast to a height of 400 to 600 feet. The rivers have cut deep trenches or channel-ways through it, and usually their banks have gently rounded, flowing outlines forming long slopes, a result of the softer nature of the rocks. On the level tracts between the river valleys, swamps and peaty barrens extend over large areas, in which the soil and sub-soil seem, so far as examined, to be composed of materials such as (1) peaty matter, (2) clay, gravel, etc., and (3) till, the whole constituting cold, barren land. From the character of the rocks which have furnished the surface deposits overlying the Carboniferous area, it will be seen that they contain little or no lime in their composition, and hence the soil is, except along the river banks, not by any means to be compared, as regards fertility, to that constituting the Silurian uplands.

Different geological relation of soils in southern New Brunswick.

In the southern part of the province, the relations between the superficial covering and the rocks beneath occur under somewhat different conditions. The geological formations there traverse the country in comparatively narrow bands, and the ice of the glacial epoch, having crossed these nearly at right angles to their strike, considerable rock *débris* has, by this means, been moved from the surface of one formation southward to that of another. To such an extent has this transportation of materials prevailed that it is only on the hills and ridges that the loose materials bear any direct relation to the rocks beneath. There has, therefore, been a greater intermingling of the materials belonging to the different geological formations of this district, those of each belt overlapping, as it were, the adjoining rocks to the south, although in a very irregular manner. It is also observed that the quantity of material derived from each rock-formation in this, as well as in other parts of the province, is directly in proportion to the yielding nature of each kind of rock to the sub-aerial and other erosive influences to which it has been subjected, and that consequently those which were more easily decomposed have furnished the largest quantities of surface materials and *vice versâ*. The Carboniferous sandstones and shales, as well as the slates of the Silurian series, have suffered

greater denudation than the Pre-Cambrian and eruptive rocks. Unfortunately, a large part of the country on the northwestern side of the Bay of Fundy, is covered by hills and ridges composed of the latter, and the surface is, therefore, hilly and broken, and, except in the valleys, it is usually strewn with boulders.

Agricultural Character, Forests, etc.

Soils and flora.

The general features and agricultural character of western New Brunswick were given in some detail in the report already referred to (Report of Progress, 1882-83-84, GG.), and I shall now proceed to describe the soils and flora of the remaining portions, treating the former according to their geological relations. Reference will also be made to the natural fertilizers, such as lime, gypsum, marl, etc., wherever they occur in workable quantities.

Northern New Brunswick.

In that large tract referred to in the north of the province occupied by Silurian strata, which includes Restigouche and Madawaska counties and portions of Victoria, Carleton and Gloucester, the surface is undulating and the soil, as already remarked, deep, with clayey beds in places, but is more usually a gravel, carrying greater or less quantities of pebbles; and being largely derived from the limestones and slates beneath, is highly calcareous, so much so, indeed, that only on the alluvial flats and peaty swamps would lime as a fertilizer be of any benefit to it. Intervales and terraces of greater or less width, affording excellent soil, skirt all the larger rivers traversing it. The whole area is well watered by rivers and streams, and well drained. Limestone is abundant, and kilns at Petite Roche, Elm Tree River, Belledune and other places, supply the local demand for lime, very little of which is used, however, as a fertilizer. The best lands in this district are in the interior, especially along the upper Restigouche and St. John waters, including the western part of Restigouche, Madawaska, Victoria and Carleton counties. The tract bordering the lower Restigouche and Baie des Chaleurs is dry and stony, from the presence of the *débris* of trap rock intermingled. (See Mr. Ells' report and maps, Report of Progress, 1879–80).

Natural fertilizers.

The natural fertilizers found in this section are lime, marl, and gypsum, the latter occurring, however, only along the southern border on the Tobique River, in Lower Carboniferous shales.

Forest trees.

The chief forest trees on the more elevated and drier grounds in this tract of country, are white spruce, balsam fir, white and red pine, white, black and yellow birch, poplar, beech, two or three species of maple, white cedar, American mountain ash, American hop hornbeam, two varieties of the shad bush (*Amelanchier*), two species of with-rod (*Viburnum*), yew (*Taxus*), etc.; on the swampy grounds we find spruce

(*Picea alba* and *P. nigra*), fir, white birch, poplar, white cedar in abundance, ash, alder, willow, red osier dogwood, sweet gale, etc., while on the intervales, along the streams, elm and balsam poplar are very common. Around the margins of clearings and on waste grounds, two or three species of cherry (*Prunus*), elder (*Sambucus*), hazel-nut (*Corylus*), sumach, etc., are met with. The growth of trees is generally large and the woods dense, and "hardwood ridges" consisting principally of birch, maple and beech, with a few spruces and firs intermixed, are prominent features of these forests. Groves, consisting chiefls of the sugar or rock maple (*Acer saccharinum*), are frequent, not only within the limits of the Silurian uplands, but in almost every other part of the province, and considerable quantities of sugar and syrup are manufactured from the sap which is obtained from these trees by tapping them every spring, in March and April. Heath plants are not by any means so abundant as in other districts in the province, the area of peaty grounds being less. The almost total absence of hemlock (*Tsuga Canadensis*) and the scarcity of black spruce (*Picea nigra*), and several shrubs common elsewhere, —among them the sweet fern (*Myrica asplenifolia*)—is remarkable.

Agricultural character of central crystalline tract.

Skirting the Silurian area, just described, on the south, and lying between it and the Carboniferous series, is the belt of ancient rocks already mentioned, which is, for the most part, covered by forest. These rocks extend across the country from the Baie des Chaleurs to the Maine boundary, and from their structure and more crystalline character from a more elevated tract than the series on either side, more especially in the central part of the province. Having been crossed nearly at right angles by glacier-ice, they have furnished large quantities of their *débris* to the soils overlying them as well as to the district immediately to the south east. Much of the area they occupy is hopelessly barren, being rugged and strewn with blocks of all sizes in great profusion. This remark applies, more particularly, to those portions underlaid with granitic, felsitic and other eruptive rocks; but there are other tracts occupied by Cambro-Silurian slates, covered by soil, which, although hitherto considered, to a large extent, valueless from an agricultural point of view, are found actually to comprise some of the best farming land in the province. Reference has been made to settlements situated upon land of this kind in York county in my former report, and it may here be stated that other settlements have likewise been formed upon it, such as Dunlop, Dumfries, Tête-à-gauche, etc., near the Baie des Chaleurs, in Gloucester county. Mr. Ells also mentions the occurrence of belts of good land overlying the Cambro-Silurian rocks, on the Renous, Sevogle and other branches of the Miramichi River. The region traversed by these belts

is generally flat and the soil usually stony and liable from its clayey nature to be wet in rainy seasons; nevertheless, certain tracts, when once cleared and brought under cultivation, form perhaps the strongest and best soil in the coountry for hay and cereals. It is possible, situated as some of these tracts are near the southwestern limit of the great Silurian plain just described, that portions of the calcareous material from the latter may have been transported thither in the Ice Age, to which, in some degree, they may owe their fertility.

Trees on crystalline belt.

Respecting the forests on the area described, it may be remarked that a difference is at once apparent to a botanical eye when they are compared with those of the Silurian area. Hemlock spruce, black spruce, white and red pine, and other trees, which are rare or altogether absent on the latter, in some localities, are here common forms. Hardwood ridges are less frequent and great stretches of the interior hilly country are barren and almost denuded of forests by fires. Heath plants are more abundant in the valley bottoms and in bogs among the hills.

Soil on Lower Carboniferous.

The narrow band of Lower Carboniferous sediments, which borders the main triangular-shaped area of the Middle Carboniferous formation, crumbles down into a rich, friable soil, containing, usually, considerable quantities of calcareous matter. A wide area of these reddish beds occurs in the Tobique valley, and a smaller one on the Beccaguimic. In some places the belts are so narrow that they are wholly overlapped by *débris* from contiguous rocks; but, in general, the presence of materials derived from them is easily recognised, owing to their reddish color and their effect upon the fertility of the district. The agricultural capabilities of the Tobique outlier have been much extolled by Gesner, Hind and others. During an exploration of that river, in the summer of 1884, it was noticed, however, that many farms in the district, after having been partly cleared and buildings erected thereon, were subsequently abandoned. The cause of this was not ascertained, but it cannot be denied that, while the region is of a highly fertile character, its remoteness and inaccessibility militate against its successful settlement. Portions, however, are flat and imperfectly drained, the resutt of the existence of a clayey hard-pan forming the sub-soil. Only where the land has sufficient slope to drain it well, are really good farms available, and in localities characterized by a surface of this kind there are some thriving settlements.

The bands of these rocks, stretching along the southwestern rim of the middle Carboniferous basin in York, Sunbury, Kings and Albert counties, comprise tracts of excellent farming lands, which have been described in previous reports.

The mineral fertilizers occurring in them are gypsum, at the Plaster

Cliffs, Victoria county, and at Petitcodiac, Westmoreland county, Hillsboro', Albert County, etc.; also lime and marly shales in the last mentioned localities.

Forest growth on Lower Carboniferous.

A luxuriant growth of wood is generally found upon soil derived from these rocks. White and black spruce, hemlock, white, yellow and black birches, two or three species of maple, which, with beech, usually form groves, are the commonest trees on the uplands, and cedar, hacmatac, ash, etc., on the low grounds.

Soils overlying Middle Carboniferous series.

The soils which overlie the Middle Carboniferous series are almost wholly derived from the disintegration of the grey sandstones and conglomerates below, and partake in a large degree of their coarse silicious nature. The area occupied by them, which comprises fully one-third of the province, is, generally speaking, flat, with a gentle slope towards the Gulf of St. Lawrence. Low, wide undulations, having a general east and west course, are met with over a large part of the area, but more especially south of the Miramichi River. The soil is, for the most part, deep, but often stony; and when level, usually has a clayey hard-pan forming the sub-soil upon which water lies, giving rise to peat bogs, "caribou plains," or "barrens." The best lands for agricultural purposes are those met with along the banks of rivers already described, where the natural drainage is sufficient to carry off the surplus waters due to precipitation. With a copious supply of lime, in which the soil overlying these rocks is almost entirely deficient, together with organic manures, it becomes excellent land for hay and grain. Several tracts might be particularized, such as Nappan valley and Doaktown, in Northumberland county; St. Louis, Richibucto and Buctouche, in Kent; the Petitcodiac valley in Westmoreland, etc.

The farms along the coast and around the estuaries in this district are, all things considered, much better adapted for general agricultural purposes than those of the interior, as manures and fertilizers of different kinds are to be obtained there, which are beyond the reach of farmers occupying the latter. Oyster beds, forming what is called "mussel mud," "Mussel mud." are common everywhere in the lagoons and creeks, and yield a material of highly enriching qualities for the heavier clay soils. The calcareous skeletons of fish are often applied to the land also with great advantage. Much benefit is afforded the drier gravelly soils, too, by supplying them with quantities of vegetable matter from the wet bogs and swamps, more especially if it is first formed into a compost by mixture with barn-yard manure.

Drainage.

But the principal cause of the superior quality of the land along the coast and river margins, within the Carboniferous district, lies in the fact that it is better drained than that of the interior overlying the same formation. And here, it may be remarked that the

general question of the drainage of the land in New Brunswick is an important one, and next to the quality of the soil is worthy of the highest consideration by the practical agriculturist. In a country such as this, where the precipitation is so much in excess of evaporation and absorption for the greater part of the year, unless some means of escape is provided for the surplus waters, either naturally or artificially, more especially for those arising from thaws every spring, they lie upon the flat clayey surfaces till late, not only retarding farming operations, but keeping the ground cold and materially hindering the growth of vegetation. If the spring and summer continue wet, crops on the low lands are thus rendered almost worthless and cannot mature properly, and the character of the land and the climate are often condemned when in reality the defects are largely owing to imperfect drainage.

Selection of farms.

The chief considerations, therefore, in selecting land on which to carry on agricultural pursuits most successfully in this province are (1) the quality of the soil, by which is meant its physical characteristics, whether clayey, sandy, loamy, etc.; (2) its height above sea level, aspect, etc.; and (3) its drainage. Unless land is well drained by streams or rivers, although the component materials of the soil may indicate a high fertility, yet it will be found unprofitable. One of the physical conditions rendering the soils overlying the Lower Carboniferous and Silurian rocks so much more valuable, agriculturally, is, no doubt, the excellent drainage resulting from their rolling surface.

Flora of Middle Carboniferous areas.

The flora of the Middle Carboniferous area, including the sylva, presents some features different from those of other parts of the country, especially of the Silurian tracts, as already mentioned. The trees are characterized by the prevalence of hemlock spruce, scrub pine (*Pinus Banksiana*), white birch and poplar; and on the flat, swampy grounds, by hacmatac (larch), cedar, scrubby black spruce and dense masses of ericaceous plants. The peat bogs are often without any but herbaceous forms, and are, no doubt, shallow lake-basins filled with decayed vegetable matter, chiefly mosses, and bordered by stunted spruce and hacmatac trees. In some of the bogs, dead trunks of the trees referred to occur standing amidst the wet sphagnous mass, showing that some change in the condition of the bog, or in the climate, has taken place since they began to grow, unfavorable to their existence. The change may have been very slight, perhaps caused by the increased growth of sphagni around their roots, or to a difference in the drainage, as their existence, which at best is but a precarious one, would be easily terminated.

Soils of Permo-Carboniferous rocks.

The eastern part of Westmoreland county is underlaid to a considerable extent by Upper or Permo-Carboniferous sediments,—rocks similar to those of the chief part of Prince Edward Island,—which fur-

nish perhaps, all things considered, the most friable, easily cultivated and productive of the soils of the Maritime Provinces of Canada. The land in the vicinity of Sackville, and the slopes of the ridges between that and the Nova Scotia boundary, also the peninsula of Cape Tormentine, and the coast region thence westwardly as far as Cape Bald, are covered by a soil largely derived from these rocks, and comprise many excellent and highly cultivated farms. Contiguous to these are the extensive salt marshes of Tantramar and Missiquash, already alluded to, a large portion of which is dyked.

Dyked marshes.

The tract of country lying between the central Carboniferous area and the Bay of Fundy, extending from Albert county on the east, to the St. Croix River on the west, and including the southern part of Albert, a part of Kings, Queens, and the whole of St. John and Charlotte counties, is underlaid by rocks of different geological ages, nearly all of which are remarkable for their highly altered and crystalline character, and forming in general a rugged, broken and boulder-strewn surface. The chief topographical features and agricultural capabilities of this section were described in some detail in previous reports (Report of Progress, 1870–71, also for 1877–78), by Prof. Bailey and Mr. Matthew, and it was seen that while the valleys are generally fertile, the summits of the hills are often bare, and the slopes usually strewn with stones, nevertheless, when once cleared and brought under cultivation, the soil is often productive. The valleys, which are sometimes of considerable width, have generally a rich loamy soil, and near the coast, the creeks and inlets contain salt marshes, which, when reclaimed, are similar to the dyked marshes of Westmoreland and Albert.

Soils of district along Bay of Fundy.

The surface of Charlotte county is almost similar to that of St. John and the western part of Kings as regards its soil and agricultural character. Large portions of it are boulder-strewn, and among the hills are peat bogs and barrens, rendering considerable tracts almost worthless for agricultural purposes. Overlying the Cambro-Silurian band there is some good soil when it is once cleared of boulders.

The northern margin of the area now described, which is overlapped to a greater or less distance by *débris* from the Lower Carboniferous sandstones, comprises the best land in it. In Kings county there are some excellent farms along the Kennebeckasis, particularly at Sussex Vale, which is sometimes called the "garden" of this county. It is a wide, flat-bottomed valley, which at one time must have contained a lake, the land being chiefly alluvium. The rivers in these counties are usually skirted with a greater or less breadth of intervale, and the country is extensively settled, notwithstanding the sterile character of much of the soil, by a thrifty, enterprising population, and agriculture is now receiving more attention than formerly.

Soil of Kings county.

Natural fertilizers in southern counties.

The natural fertilizers are lime, manufactured near St. John, in several places, from Laurentian limestone, and marl, found in some of the shallow lake-bottoms, notably at Lawlor's Lake.

Flora.

The flora presents no marked contrast to that of the interior portions of the province, except that a few arctic or sub-arctic forms seem to find a more congenial habitat there than in the interior, owing, no doubt, to the chilling influence of the arctic current which here runs along the coast, and to the fogs which prevail in the Bay of Fundy, causing a lower summer temperature. This area is now almost wholly denuded of its timber, and the forests everywhere are but thin and straggling.

MATERIALS OF ECONOMIC IMPORTANCE FOUND IN THE SURFACE DEPOSITS.

Bog iron ore.

Bog iron ore (limonite) is of frequent occurrence in the alluviums overlying the Carboniferous rocks, more especially in the vicinity of the St. John River, the beds sometimes attaining a thickness of two to three feet.

Wad.

Wad, or bog manganese, is found at Queensbury, York county, and in one or two places in Sunbury county. It likewise occurs on the north branch of the South-West Miramichi, 12½ miles above the forks, in the river's bank.

Tripolite.

Infusorial earth (tripolite) is found at Fitzgerald Lake, St. John county. The Lake has been drained dry by the St. John Water Company, exposing a considerable bed of earthy tripolite. It also occurs at Pollet River Lake, Mechanics' Settlement, King's county. (See analysis by Mr. Hoffmann, Report of Progress, 1878-79, p. 5 H.)

Marl.

Marl is met with at Lawlor's Lake, St. John county; also at Belledune and River Charlo in the Baie des Chaleurs district. (Report of Progress, 1879-80, p. 42 D.) Its occurrence may be looked for in shallow lakes in limestone districts in other parts of the province.

Brick clay.

Brick clay occurs in a number of places both in marine and freshwater beds. Leda clay is manufactured into brick at Campbellton, Restigouche, Bathurst, Newcastle, Moncton and St. John, while clay, apparently of fluviatile origin, is wrought for similar purposes at Fredericton, Woodstock, Shiktehawk and elsewhere on the St. John River.