GEOLOGICAL SURVEY OF CANADA
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REPORT

ON THE

SURFACE GEOLOGY

SHOWN ON THE

FREDERICTON AND ANDOVER QUARTER-SHEET MAPS

NEW BRUNSWICK.

BY

R. CHALMERS.

OTTAWA
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No. 769.

To Robert Bell, D.Sc., M.D., LL.D., F.R.S.,
Acting Director of the Geological Survey of Canada.

Sir,—I beg to submit herewith a report on the surface geology of the Fredericton and Andover quarter-sheet maps (No. 1 N.W. and No. 2 S.W.) of the New Brunswick series.

My best thanks are due to Principal Harrison of the University of New Brunswick, Fredericton, for barometric readings taken at the Meteorological station under his charge.

I have the honour to be, sir,
Your obedient servant,

R. CHALMERS.

Geological Survey Office,
Ottawa, May, 1901.

NOTE.—*The bearings in this report are all referred to the true meridian and the elevations to mean sea level.*

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INTRODUCTION.

Former investigations in the area.

The investigation of the surface geology of the western part of New Brunswick was begun in 1882-83 and a report relating to it published in 1884, but without maps to accompany it.* The systematic mapping of the surface deposits in the area of the Fredericton and Andover sheets (Nos. 1 N.W. and 2 S.W.) was commenced in 1892-94, but was discontinued till 1898-99 when it was completed. The two sheets referred to being now printed, it is proposed to publish them accompanied by a short report on the surface geology, economic minerals, forest growth, etc., which shall be, for the most part, supplementary to the one issued in 1884.

Character of the investigations.

In carrying out this investigation every accessible part of the area included in the two map-sheets mentioned was traversed and a careful examination of the surface deposits made. The character of the soils, whether these were formed by the disintegration and waste of the underlying rocks or consisted of boulder-clay, or of the later modified deposits, was carefully investigated. The distribution and peculiar characters of the different species of trees growing in the region were also ascertained and noted. On the east side of the St. John river new settlements have been opened up in the area of the Andover sheet since the explorations and surveys of 1882-84 were made, and a number of roads had to be sur-

* Report of Progress, Geol. Surv., Can., 1882-83-84, Part GG.

veyed in addition to those on the map. A considerable body of new data has been obtained in the area, which will be detailed in the following pages.

My assistants in the field were Mr. W. J. Wilson for a short time in 1898 and 1899, and Mr. L. P. Silver, of Kingston, Ont., for four months of the latter season.

PHYSIOGRAPHY.

The region embraced in the two ¼-sheet maps under examination may be characterized as undulating with a gradually ascending surface from the Carboniferous plain north-westward to the South-west Miramichi and the Upper Tobique waters, or the interior highlands of New Brunswick. Three principal topographical divisions may be observed within the region, each with distinct physical features of its own. These may be briefly described as follows:—First, the Middle Carboniferous or sandstone area which is for the most part, level and underlain with rocks in a nearly horizontal attitude. In the valleys of the St. John and Oromocto rivers this area is not more than from 50 to 100 feet above the level of the sea, but it rises gently towards the north-west margin where it attains a height of 600 to 800 feet. Second, a narrow belt of Lower Carboniferous rocks, which comes up from beneath the north-west margin of the gray sandstones. Generally speaking these rocks are higher than the gray sandstones. Eruptive masses protrude in them forming ridges and hills from 500 to 1,000 feet in height above the sea. McLeod and Clarke mountains east of the St. John and Bald mountain, Harvey hill and others west of this river are the most conspicuous, and are intrusive in or near these Carboniferous belts. Along the south-east margin of the gray sandstones described, another band of Lower Carboniferous occurs in which several ridges and hills were also noted. The surface of the country occupied by the last mentioned formation is generally uneven and broken, but the soil is usually fertile. The areas of Lower Carboniferous rocks in the Beccaguimic and Tobique valleys exhibit surface features which are less diversified than those in the localities just described, but at the northern limits of the latter the Blue mountains rise upwards of 1,720 feet above the sea—a prominent mass of eruptive rocks.

Topographical features and divisions.

Lower Carboniferous outliers.

The third area which presents a different topography and has a different elevation from those above referred to, is that occupied by rocks mapped by the Geological Survey as Silurian and Cambro-Silurian

which underlie a large portion of the country within the western and north-western limits of the two map-sheets. The general surface of this area may also be characterized as rolling, though sometimes rising into ridges and mountains. The average height, in and near the St. John valley and west of it, is from 400 to 500 feet, but towards the north and north-east it is from 800 to 1,000 feet or more. The most noteworthy of the higher elevations are Hainsville ridge, Howland ridge, Pole hill, Golden ridge, Kincardine and Birch ridges east of the St. John and Magundy and Blaney ridges, Dorrington hill, Carroll and Pocowogamis ridges and Oak mountain on the west. The soils over a large part of this area are good. Elevations.

Traversing this area in a north-east and south-west direction are wide belts of granite and pre-Cambrian rocks which usually have a greater elevation than the formations on either side. Hills and ridges, lake basins, boulder-strewn moraines, and a coarse stony soil are the prevailing characteristics of these granite areas. The country through which they extend is mostly in a forest-clad, wilderness condition and unfit for settlement. The northern part of the region embraced in the two map-sheets is largely occupied by these granite and pre-Cambrian rocks and rises into a rugged broken plateau from 1,000 to 1,500 feet high or more, the elevation of which increases northward beyond the limits of the Andover sheet. No well defined range of mountains exists in this part of the province, but denuded remnants of that spur or lateral extension of the Appalachian system cross it in the north-western part and are to be seen in Mars Hill just west of the International boundary, 1,688 feet above sea level according to the Boundary Survey, and Moose Mountain east of the St. John 1,490 feet in height, with other hills about the source of Munquart river and to the east. At and beyond the northern limits of the Andover sheet (No 2 S.W.) we reach the south-westerly extension of the interior highlands of the province which trend from here away to the north-east in an irregular range or series of elevations to the headwaters of the Tête-à-gauche and Jacquet rivers, attaining altitudes in some parts of 2,500 to 2,700 feet above the sea. Granite belts. Character and elevation of central highlands of New Brunswick.

The northern part of the Andover sheet covers an area which is still under forest and to a large extent a *terra incognita*. The South-west Miramichi river and its tributaries drain the north-eastern part, while the Tobique drains the north-western. The country here is, generally speaking, broken and elevated, with an average height of 800 to 1,000 feet above the sea, but a number of hills and ridges reach an elevation of 1,200 to 1,500 feet. Mr. Wilson, who examined the

South-west Miramichi valley along some of the lumbermen's portage routes, says: 'The north branch of the South-west Miramichi flows through a broken, wilderness country, with high hills bordering its banks. The average elevation of the country about the head waters of Burnt Hill and Clearwater brooks is from 800 to 1000 feet, with hills rising 200 or 300 feet higher, and the height along the portage road from Pleasant Ridge settlement to the Dungarvon is 800 to 900 feet. Along the main river the banks are comparatively low in many places, but there are numerous high peaks which stand out conspicuously above the surrounding land, such as Louis, Otterslide and Todds mountains. At the junction of the north and south branches the elevation is about 800 feet, where the portage road from Green hill crosses it about 700 feet, and at Boiestown 195 feet.' A large part of the area drained by the South-west Miramichi and the Upper Tobique is unfit for settlement. Beaufort and Golden Ridge, which were at one time supposed to be thriving settlements, have of late been nearly deserted.

RIVERS AND LAKES.

Rivers in the area mapped.

The principal rivers of this part of the province are the St. John, which traverses it from north to south, through Victoria and Carleton counties, and from north-west to south-east in York and Sunbury; the South-west Miramichi, from its source to Ludlow, Northumberland county; the Tobique, from the junction of the Wapskehegan; and the lower part of the Aroostook. The smaller tributaries of the St. John on the north and east are the Nashwaak, Keswick, Nacawicac, Beccaguimic, Shiktehawk and Muniac; on the south and west there are the Oromocto, Pokiok, Eel, Meduxnakeag, Presquille and Des Chutes. In the area of the Fredericton sheet (No. 1 N.W.) the rivers flowing from the southern watershed into the Bay of Fundy or Passamaquoddy bay are the Magaguadavic and St. Croix. The St. John is the great artery, and extends throughout the whole length of the province. It is probably one of the oldest drainage channels of eastern North America, having trenched a deep, wide valley with sloping banks through rocks of different geological ages and different degrees of hardness down to the base level of erosion.

St. John river.

Interesting features of the St. John.

The St. John exhibits some very remarkable features in the lower part of its course. These appeared to be so interesting that some special study was made of them, and a brief description of the tidal phenomena of this river will therefore be given here. As is well known, the tides of the Bay of Fundy affect it as far up as Springhill,

about ninety miles from its mouth, and enter Belleisle bay, Washadamoak, Grand and Maquapit lakes. The rise and fall of these tides were approximately ascertained in the summer of 1897 by Prof. A. Wilmer Duff.* At Indiantown, above the falls at the mouth of the river, the actual range of the tides was found to be 16 inches, and at Springhill 5·2 inches. The height of spring tides in St. John harbour above low water mark is 27 feet and of neap tides 22 feet. Prof. Duff's tables are independent of any datum related to the tides of the Bay of Fundy, however, so that the height and attitude of the tidal waters in the St. John river have no reference to mean sea level or to the tidal survey bench-mark at St. John harbour. Moreover, the tidal range in the river will probably be found to differ in different seasons, and at the same season in different years, as it depends on variable conditions, such as the quantity of fresh water in the river at the time, or the tidal range in St. John harbour or the Bay of Fundy. Until the St. John river is levelled from the mouth to Fredericton or Springhill with reference to mean tide or the bench-mark mentioned, our observations must be regarded as merely approximate.

Bay of Fundy and St. John river tides.

Prof. Duff's Tables.

The discharge of the waters of the St. John over the falls at the mouth is considerably greater than the inflow, notwithstanding, that the barrier is approximately at half tide level. The peculiarity of these falls is that at ebb tides there is a flow from the river over the barrier into the harbour, while at high water the tides from the harbour flow over it up river. The following information in reference to the time and duration of the flow and ebb is given with the Tide Tables for St. John harbour: 'The falls are level, or it is still water at about three hours and a half on the flood, and about two and a half on the ebb. Much depends on the floods in the St. John river and the time of high water or full sea, which is often hastened by high southerly winds.' Between every two high tides therefore the flow over the falls outwards lasts on an average fully seven hours, while the inflow lasts only about five hours. At neap tides the inflow is less, the time being shorter than at spring tides, and the outflow is correspondingly greater. It is during the low autumn level of the river that the tidal fluctuations are most marked, the inflow then being at its maximum as compared with the outflow. Occasionally at the time of spring and fall floods in the St. John river, on the contrary, the inflow is scarcely perceptible, or is not observed above Gagetown, fifty miles up river. Instances are, indeed, known when the river floods reach such a height as to check or swallow up the tidal inflow

Falls at the mouth of the St. John.

Tidal fluctuations in the St. John estuary.

*Bulletin Nat. Hist. Soc. of N. B., No. XV., 1897, pp. 65-82.

altogether. The river then pours out a current through the gorge at the falls incessantly during the twenty-four hours until its waters subside.

Non-tidal oscillations of the St. John river.

But there are other conditions which have to be taken into account in regard to the tidal waters of the St. John and one of these is the oscillation of the non-tidal portion above Springhill. In the year 1898 the writer in determining altitudes in the counties of York and Sunbury above the river level observed some facts which made it doubtful whether high tides in the St. John river were at the same level as the same high tide in St. John harbour. To test this question was a difficult matter, owing to the want of levels or bench-marks along the river. At certain points however the Canadian Pacific railway was found to approach it, and on levelling from the stations at high tides, the following data were obtained which may be regarded as at least approximately correct, showing the height of the river as compared with that of the same tide at high water in St. John harbour:—At Westfield Beach, eighteen miles up river, or fourteen by rail, high tide on October 14, 1898, was found to be 6·60 feet lower than in the harbour mentioned. At the railway bridge, Fredericton, it was 1·77 feet lower than its initial tide at the same harbour. Levellings at Fairville between the Canadian Pacific railway station and high tide in the St. John river; also at Rothesay between the Intercolonial railway and the Kennebeckasis, show the tidal waters at these places to be lower than the same high tides in St. John harbour. The figures are, however, subject to correction, being based only on railway levels.

Levellings at certain points along the river.

The facts regarding the seasonal fluctuations of the St. John from the falls at the mouth to Springhill show that except for a few miles above Indiantown, perhaps as far as the Long Reach, the general rise and fall of the river are dependent, not on the tidal flow, but on the rise and fall of the non-tidal part above Springhill, that is, upon the meteorological conditions which affect alike the rivers and lakes of the province. When the non-tidal part rises the tidal part rises, and when it subsides so also does the latter. The few inches of tidal waters which flow and ebb have but little effect on its general fluctuations. Further, the above data go to show that the waters of the St. John tidal basin between the mouth of the river and Springhill are not level, but have a gentle inclination even at their lowest stages in autumn from tide head towards the Bay of Fundy. Owing to the fact that the outflow is so much greater than the inflow, there is a lowering of the waters during the summer months to a level, for the most part, below that of high tides in the St. John harbour, as shown

Inclination of the river in the tidal portion.

by the measurements at Fredericton, Westfield Beach and Fairville, recorded on a former page, and this is never more than partially compensated by the inflowing tides.

The waters of the great basin of the lower part of this river, of which Grand and Washadamoak lakes are about the centre, seem to be in a state of continual oscillation. Generally speaking, their level ranges between the high tide and mean tide levels of the Bay of Fundy throughout the greater part of the year. In the spring and fall seasons, however, the volume of water poured into this basin from the flooded rivers above is so much greater than can escape through the narrow gorge at the mouth that there is a general rise of the waters throughout its whole extent, occasionally reaching such a height that it overflows the spring tides seeking ingress over the falls at the mouth. During the low summer and autumn level of the St. John, when the waters of the lower part of the basin are, at ebb tides, nearly at mean sea level, the flood tides from the harbour rush in through the narrow gorge at the falls with great rapidity, partially filling the basin for some distance up river, but how far has not been ascertained. Before the basin can be filled, however, the ebb tides set in. At the maximum and before the tide turns, a hydrographic depression would seem to be produced at some point above Indiantown, probably at Grand Bay. Beyond this point the inflowing tides have to move up river on a slightly ascending surface, and must be largely of the nature of an undulation or series of undulations.

Average level of the St. John estuary.

Hydrographic depression.

How long, geologically speaking, have the existing estuarine conditions of the St. John prevailed? To answer this question we have to go back to the beginning of the Recent period. At that time the land would seem to have stood slightly above its present level and one or more drift dams near the mouth held in its waters above the tidal flow. In that part of the St. John valley which is now tidal, a great lake then existed and occupied the basins of Grand and Washadamoak lakes and the Kennebeckasis valley, to which reference is made in a previous report.* Terraces and shore-lines were observed in a great number of places at heights of 80 to 100 feet above the sea. For this body of water I propose the name Lake Acadia. Complete details regarding its limits are still lacking, and I await an opportunity of obtaining these in order to map this lake. Its waters seem to have been fresh until the barrier at the mouth of the St. John was eroded and the land underwent a slight subsidence. Then the sea invaded the lower part of the river valley and the existing tidal oscillations commenced.

When the tides of the Bay of Fundy first entered the St. John estuary.

Lake Acadia.

* Annual Report, Geol. Surv. Can., Vol. IV., (N.S.) 1888-89, pp. 57-58 N.

The South-west Miramichi.

The South-west Miramichi is also an old river, but only the upper part lies within the area of the Andover sheet. A remarkable feature of this river is that it now partially drains a district the waters of which were once very probably tributary to the St. John, that is to say, the upper part of this river, above the junction of the north and south branches may have been drained into the St. John by the Nashwaak or its tributary the Napudogan. The wide granite area at the county line between Carleton and York was at that time probably the watershed between the St. John and Miramichi waters here. Crustal movements and the denudation of this granite area seem to have afterwards diverted the waters of these branches, originally forming part of the Nashwaak, into the South-west Miramichi.

Beccaguimic river.

The north branch of the Beccaguimic river has a singularly tortuous course, the origin of which is difficult to explain, unless we suppose that a part of its waters at one time flowed along the present valley in a reverse direction to what they do now, and thence into the Nacawicac river. Another hypothesis, however, is that the area now occupied by Carboniferous rocks here was, for some time, a basin or sink into which several streams discharged, forming a lake, and subsequently on the upheaval of the district the existing drainage lines were inaugurated.

The Tobique river.

The Tobique river likewise exhibits some peculiar physical features. A large outlier of Lower Carboniferous rocks also exists in the valley of this river, the lower border of which is only seven or eight miles from the St. John river. These rocks like those of Beccaguimic have originally been laid down in a basin, and as the land rose and denudation proceeded the river had to re-cut its channel through them, and great wear and waste of the soft sandstone sediments seem to have taken place.

In the Pleistocene period the valley of the Tobique was partially filled with boulder-clay near the mouth, which formed a barrier, and on the retreat of the ice a large lake appears to have been held in the valley above this barrier extending as far up as the Gulquac, or perhaps, to the Blue mountains. After a time the waters of this lake cut a new passage or outlet through solid rock, now called 'The Narrows,' where the river still flows in a series of rapids, and has not yet reached the base level of erosion.

The Tobique "Narrows,"

A number of peculiar and noteworthy features were observed in other rivers, but it is impossible to present them all in detail. Only two or three more of the tributaries of the St. John will be briefly referred to, and these seem to have had their valleys and probably the drainage which finds outlet by them changed by crustal move-

ments in the later geological periods. The Pokiok is one of these. This river flows from Lake George north-westward into the St. John, in a reverse course to that of the latter, along a channel very little above the general level of the surface, and appears to be of late origin. At its mouth there is a beautiful series of cascades in a narrow gorge cut in granite. It may be that the drainage which now finds discharge by this river has been partially diverted, originally flowing into the Magaguadavic or Oromocto. If this is the case, then the Pokiok river originated as a result of a differential uplift of the belt of rocks extending north-east and south-west at Harvey station, Canadian Pacific railway, which consist largely of intrusives. The flat district to the north-west of this belt, in the southern part of which the two Cranberry lakes lie, seems formerly to have had its entire drainage carried into Magaguadavic and Oromocto rivers. At the present day a part of it is carried to the St. John by the Pokiok river. The Pokiok river.

The Keswick and Nacawicac rivers occupy wide valleys, containing great quantities of stratified gravel, terraced in some places, but often thrown into irregular kame-like forms. These two valleys are joined by another wide valley, or rather the whole constitutes one valley from the mouth of the Nacawicac round by Burtt lake and Upper Keswick, thence to the mouth of the Keswick. Just east of Burtt lake is the highest point, which is 538 feet above sea level. This part of the valley is also heavily drift-encumbered, and resembles a deserted river valley. Viewing this valley as a whole, it is difficult to conceive of the existing rivers and brooks having eroded it and transported and deposited such large quantities of gravel and sand as are now found there; and the conclusion seems, therefore, unavoidable that the rivers must at one time have had a larger volume of water than at present. One hypothesis is that the Nacawicac ran across by Burtt lake, joining the Keswick river and forming part of it. An alternative one is that the St. John may have flowed through this valley for a time. This would imply different relative levels from those which now exist, of which there is but little evidence, though it would appear that the great rectangular block of land bounded by the valley described above and the St. John river may have sustained a differential uplift and became tilted towards the south-east. The Keswick and Nacawicac.

The portion of the region south of the St. John river contains a large number of lakes. Many of these are drift-dammed, but a few seem to be bodies of water ponded by unequal or differential changes of level in the land. Of the latter class are the Cranberry lakes and Cranberry and Oromocto lakes.

Oromocto and probably others. Oromocto lake occupies a singular and apparently abnormal position. It is situated very nearly in the south-west corner of the great Carboniferous area of New Brunswick, its elevation being by aneroid 415 feet above mean sea level. Two miles west of this lake the Magaguadavic river flows along a valley, its bed only 270 feet above sea level, a ridge 550 feet in height intervening. The south-western rim of the Carboniferous rocks has probably sustained a differential uplift here relatively to that to the east. The lake seems to be rock-rimmed, overflowing its basin to the east.

The Cranberry lakes and Lake George are very nearly on the same level, the former being 486* feet above the mean tide level of the Bay of Fundy. These lakes lie in hollows in a plain, the width of which extends from the Harvey hills to Blaney ridge. Big Cranberry has evidently drained eastwards by the gap in the hills just mentioned through which the Canadian Pacific railway runs until quite recently, the old channel which its outlet followed being distinctly seen along the upper part of Lyon stream, which flows into Oromocto river.

Magaguadavic lakes.

Magaguadavic and Little Magaguadavic lakes are bodies of water ponded in an old pre-glacial valley which were dammed by boulder-clay in the glacial period and had since to re-cut a channel for themselves. They are both on the same level, namely, 377 feet above mean tide of the Bay of Fundy.

The Cheputnecticook group.

The Cheputnecticook group of lakes originated from a similar damming by drift at the head of the Ste. Croix river. First and Second lakes and Palfrey are at the same level and are 377 feet above mean tide at St. John. Grand and North lakes, also held in by a drift barrier are about 50 feet higher, or 427 feet above the sea. A number of headlands extend diagonally into these lakes, from the New Brunswick side with deep inlets between, more especially in the First and Second Cheputnecticook. Great quantities of drift occur around their margins and apparently beneath them, and many islands dot their surface. The peculiar conformation of the drift deposits along the New Brunswick border of these lakes is due to the fact that the original basin extends in approximately a north-east and south-west direction, while the ice of the glacial period, which produced the morainic accumulations referred to flowed very nearly due south.

Eel River lakes.

The Eel River lakes are drained northward into the St. John and lie in a north-and-south depression, parallel to that of the Cheputnecticook group. The height of First Eel lake by aneroid is about 520 feet above the sea, and of the second about 550 feet.

*The elevations of the lakes near the Canadian Pacific railway are based on the profile heights, of that line.

Skiff, Bolton Sheogomoc lakes, etc.

About fifty other lakes, large and small, spangle the surface of the granite and adjacent rock-formations of western New Brunswick in York county, as shown on the map, the largest of them being Skiff lake, 650 feet high by aneroid, a beautiful sheet of water with rocky glaciated islets. Bolton lake, Second, Fourth, Fifth and Sixth lakes, First and Second Sheogomoc lakes, Charlie and Davidson lakes have their longitudinal trend north and south to north-west and south-east and show the effects of glacial action in scooping out the boulder-clay or other superficial deposits and forming hollows or depressions, thus producing basins, which caught the drainage waters. Some lakes occupy a depression at the northern base of a stossed hill; others occur on the lee side where the ice ploughed down more deeply, from its greater momentum, into the superficial materials. Whether any actual wearing or scooping of the solid rocks beneath took place it is difficult to say. There was unquestionably a ronnding of the asperities and a polishing of the surfaces of the rocks, but subaerial decay seems to have been the chief agent in the formation of the depressions. The minor topographical features seem, therefore, to be more or less different from those which existed before the ice age; but the larger valleys and depressions, such as those of the St. John river, the Cheputnecticook and Magaguadavic lakes have retained their main preglacial outlines.

CHANGES OF LEVEL.

Changes of level.

Very little evidence regarding changes of level has been obtained in this part of the province, as it is not connected with the sea and no shore lines of known marine origin could be found. Although the tides of the Bay of Fundy now affect the St. John river for ninety miles from its mouth, yet it is difficult—indeed impossible at present, to say whether the sea invaded the valley in the Pleistocene period, as different relative levels may have existed then, and no fossils have been found in the surface beds to indicate whether or not they are marine. Notwithstanding this, however, some data showing probable differential vertical movements of an earlier date were observed. As already mentioned, it is possible that the block of land bounded by the St. John, Keswick and Nacawicac rivers was elevated rather more than the surrounding area, especially on the north-west side, and was tilted somewhat towards the south-east. The Lower Carboniferous rocks on the west side of the St. John river appear also to have been unequally uplifted and this movement has in places apparently raised the margin of the overlying gray sandstones to some extent. Such changes of level are probably connected with the intrusion of the granites and trap

rocks of the region. These inferences are, however, based merely on the changed attitude of what must have formed ancient base-levelled plains, and on altered drainage lines. Similar local movements seem to have taken place on the north side of the St. John, especially east of the Keswick valley.

DENUDATION.

Denudation of the middle Carboniferous area.

The gray sandstones of the Middle Carboniferous period which lie nearly in a horizontal attitude throughout the great triangular area seem to the ordinary observer to have suffered no very great amount of surface erosion and waste. But closer examination will reveal evidence of their having been profoundly denuded, and of the fact that their long exposure to the agencies of decay from the period when they first became dry land to the present day has brought about a great reduction of the surface of these sediments. Indeed, it may well be remarked in regard to this large sandstone area, that it forms the best example of base-levelling which we have in Eastern Canada. The nature of the rocks is such that they wear down nearly at a uniform rate, and the slope, though very gentle, has just been sufficient to enable the drainage waters to carry off the waste materials without trenching too deeply. Most of the hollows and valleys have been partially or wholly filled up in the Pleistocene period however, some with boulder-clay, but the lower with marine sediments during the post-glacial subsidence of the country. The general levelling which the area has undergone, denotes a long continued period of subaerial denudation previous to the ice age.

Denudation of the granite areas.

The granite areas within the limits of the map-sheets seem also to have undergone great disintegration and waste. This implies that the rocks, through which they have been thrust up, were likewise deeply denuded. Some of these granite areas, particularly those west of the St. John river are about on the same level as the slates on either side, excepting of course, isolated summits, while granite boulders derived from these, often in trains and ridges, are found upon the surface of the granite belt and of the formations immediately to the south in immense numbers. These boulders are principally due to the deep-seated decay of the rocks in pre-glacial time, and their distribution has been brought about by glacial action and transportation. As it is not probable that when the granites were thrust up into the slates they reached the surface, the principal portion of the latter must have been decomposed and removed before the former could be attacked by the disintegrating agencies. But these granite rocks themselves appear

to have suffered a large amount of decay before they could furnish the waste material which now lies scattered upon their surface and became transportsd southward by glacial action. From these and other facts it is evident that the amount of denudation in this region has been great, and that it extended over a very long time. It is quite probable also, that a large number of the lake basins of southern and western New Brunswick have been produced by this decomposition process, that isby the unequal decay of the rocks, and the scooping out of the materials from the depressions thus caused in their surfaces by the movements of the Pleistocene ice. These depressions, thus emptied of the materials which occupied them, became receptacles for the drainage waters of the region.

GLACIAL STRIATION.

Striation.

The striæ on these sheets, as will be seen from the following list, trend largely from north to south and, as has been inferred in a former report,* were produced by the ice which has been named the Appalachian system of glaciers. This was a glacier or system of glaciers which gathered upon the north-east Appalachians independently, and flowed outward from the higher portions of New England and eastern Canada to the north-east and to the south. No traces of the action of Laurentide glaciers could be found in the area of the two map-sheets under consideration, that is to say, no boulder-clay, nor transported boulders other than those belonging to rocks lying within the drainage basins of the St. John and Miramichi rivers were observed, though diligent search was made for boulders belonging to rocks on the north side of the St. Lawrence. Several different courses of striæ occur in some localities, but they can be best explained by supposing them to have been produced by the same glacier at different stages of its development, or during its withdrawal.

LIST OF GLACIAL STRIÆ.

(The bearings are all referred to the true meridian).

York County.

List of striæ, York Co.

1. On Hanwell road, one mile and three-quarters from Fredericton, S. 47° E.; height, 150 feet above sea-level.

* Annual Report, Geol. Surv., Can. vol. X. (N.S.), 1897, page 41 J.

List of striæ, York Co.

2. Further to the south-west on the same road, S. 25° E. and S. 30° E.; height, 300 feet.

3. At first cross road, on the same road, S. 30° E. Striæ numerous; height, 400 feet.

4. At branch of Garden creek, S. 20° E. and S. 35° E.; height, 330 feet.

5. A mile and a half north of Garden creek, S. 40° E. and S.; slope slightly to north. On opposite side of road, S. 54° E.; height, 450 feet.

6. On Hanwell road about two miles north-east of Hanwell settlement, S. 44° E. and S. 25° E.

7. On road from Hanwell settlement to Indian Village, half a mile north of forks, S. 30° E.; height, 500 feet.

8. Six or seven miles north-east of Harvey on Hanwell road, S. 30° E.

9. At Maryland settlement, on south-west side of North-west Branch, S. 10° E. and S. 5° W.; height, 230 feet. Slope N.E.

10. On road to Maryland, three or four miles south of Fredericton, S. 30° E. and S. 35° E. In another place near, S. 28° E. and S. 35° E. Still nearer Fredericton, S. 28° E.; height, 360 feet.

11. At Doaktown, south-east of Fredericton, S. 30° E.; height, 250 feet.

12. West of St. Marys at south end of road leading to Heron lake, S. 20° E. and S. 28° E., on different exposures; height 50 feet.

13. On Clark's mountain, S. 45° E. Slope S.E.; height, 350 feet.

14. Along Nashwaaksis river near McLeod's mountain, on road to Stanley, S. 25° E. and S. 30° E. Latter most numerous. Slope S.; height, 420 feet.

15. Near Cloddy, S. 35° E. and S. 40° E.; height 400 feet.

16. On Royal road, a quarter of a mile south of Kingsley P.O., S. 40° E. Heavy and numerous, S. 22° E. Lighter. Slope S.W.; height, 390 feet.

17. On road north of Carleton lake, S. 30° E. and S. 11° W.; height, 630 feet.

18. A mile and a half north of Zionville cross-roads, S. 80° E.; height, 255 feet.

19. In Tay settlement several exposures, S 20° E. and S. 34° E.; height, 400 feet.

20. At P. O., Tay settlement, S. 25° E.

21. South of Birdton, a quarter of a mile south of road to Keswick, S. 35° E.; height, 730 feet.

22. Near brook to south of last, S. 30° E.

23. On road from Cardigan station to Birdton and north of Jones' Forks settlement (between two brooks), S. 38° E. and S. 40° E.; slope to W.; height, 350 to 400 feet.

24. Near junction of this road with parallel road, S. 30° E.; height, 500 feet.

25. South of Cardigan settlement, near brook, S. 30° E.; height 715 feet.

26. From one to two miles south of Stanley village, on straight road to St. Marys, S. 80° E.; height, about 500 feet.

27. Three or four miles south of Stanley village, on road leading down Tay creek and about a mile south of cross-roads, S.

Ten rods further south, S. 10° E. and S. 5° E. Several surfaces with the same striæ,—a splendid exposure; height, 550 feet.

28. West of Stanley village, a mile and a quarter on road to Lime-kiln settlement, S. 10° E.; height, 390 feet.

29. On road going east from Nashwaak river, on south-east corner of sheet No. 2, S.W., half a mile out, S. 15° W; slope W.; height, 430 feet.

30. Just north of the last exposure, other striæ, S. 84° E.

31. On Richibucto road at brook about three miles east of county line, due S. and S. 5° E.; height, 200 feet

32. On east side of Nashwaak river on road to Lower Durham, at first angle to south, S. 13° W.; height 305 feet, (Crag-and-tail projections showing southward movement of ice very distinct.)

33. Twenty rods east of last exposure, S. 26° W.

34. On east side of Nashwaak river at cross road half a mile north of Upper Durham, S. 26° W., S. 46° W. and S. 70° W. This is local striation; height, 205 feet.

35. Along Nashwaak river south of McCallum brook, S. 5° W. and S. 29° W.; height, 480 feet.

36. In Stone settlement where road from Royal road turns to north-east, S. 30° E.; slope E.

List of striæ, York Co.

37. At mouth of McBean brook, due E. This is the course of the river valley here, which the ice followed.

38. Half a mile above Hayes brook, N. 25° E. or N. 26° E.

39. Along St. John river, at large stream west of Springhill, near river level, S. 20° E. One mile east of stream, S. 40° E.

40. At Kingsclear, a quarter of a mile from St. John river, S. 35° E. ; slope, N. ; height, 300 feet.

41. On road leading from Long's creek to Harvey station, Canadian Pacific railway, at second cross roads from St. John river, S. 60° W., or the reverse, stoss side apparently W. ledge broken off abruptly to E. These striæ must be extremely local, the ice which produced them having apparently followed an east-and-west valley very closely. They seem to be very old ; height about 400 feet.

42. On the same road about two miles from the St. John river, S. 40° W., S. 10° E. and S. 5° E. The S. 40° W. striæ seem also to have the stoss side to the S.W.

One to two miles from St. John River, S. 10° E. and S. 30° E. ; height, 240 feet.

43. On road to Oldham settlement, S. 20° E.

44. At Harvey station, Canadian Pacific railway, S. 25° E. ; height, 625 feet.

45. South of Harvey on first cross road to east, S. 27° E. ; height, 1,135 feet.

46. Near Cork station C. P. R., S. 25° E. ; height, 400 feet.

47. On west side of Bald mountain, Harvey, S. 25° E. ; height, 525 feet.

48. About a quarter of a mile north of Harvey station, on road going to Long's creek, S. 25° E. ; height, 525 feet.

49. East of Bald mountain, S. 20° E. ; height, 520 feet.

50. At north end of Oromocto lake, S. 55° E. ; height, 590 feet.

51. A short distance south of last, three sets,—oldest N. 75° E., next oldest S. 15° E., and latest S. 45° E.—all on the same rock surface. These striæ occur on the east slope of a ridge which extends along the west side of Oromocto lake. The N. 75° E. striæ are the heaviest, and are nearly all effaced. The S. 15° E. set are the most distinct, covering the surface of the ledge, while the S. 45° E. striæ

are light and fine. This criss-cross striation occurs in several places in the basin of Oromocto lake. List of striæ, York Co.

52. Near Antimony mines, Lake George, S. 30° E. and S. 20° E.

53. North of Prince William's station, Canadian Pacific railway, S. 30° E.

54. At Jocelyne's brook, S. 10° E. and S. 5° E.; height, 170 feet.

55. Between Lower Prince William and Lake George, S. 30° E. and S. 35° E.; height, 525 feet. Ledges along this road exhibit glaciation continuously for several hundred yards, S. 20° E. to S. 35° E.

56. About half a mile from Cardigan station, C.P.R., on road to Tripp settlement, S. 79° E.; height, 225 feet.

57. Near cross-roads in Tripp settlement, S. 64° E. and S. 87° E. and on another exposure a quarter of a mile north of cross-roads, S. 20° E., S. 44° E. and S. 60° E. Several surfaces occur here between the last-mentioned striated exposure and the bend in the road, S. 64° E.; height at Tripp settlement, 460 feet.

58. On the road from Keswick Ridge to Upper Keswick Ridge, north of second brook, S. 44° E.; height, 280 feet.

59. On the road from Keswick Ridge to Mactaquac stream, a quarter of a mile from ridge road (at red bridge), S. 70° E. and S. 77° E. Several glaciated ledges; height, 200 feet.

60. Near the forks of Nacawicac river, along road leading from Millville to Temperance Vale, S. 40° E.

61. On road from Mapleton settlement to Nacawicac station, C.P.R., (lumber road), two miles west of school-house forks, S. 30° E.; height, 700 feet.

62. At Pike settlement, west of Temperance Vale, S. 5° E.; height, 790 feet.

63. Along the Canadian Pacific railway track, half a mile north-west of Nacawicac siding S. 30° E.

64. At Planeville settlement, about one mile back from St. John river, S. 35° E.

65. On road from Eel River village to Canterbury station, C.P.R., at junction of north and south roads; due S. and S. 40° E.; height, 565 feet.

66. On road from Canterbury station to Hartin settlement, S. 55° E. and S. 40° E.; height, 730 feet.

List of striæ, York Co.

67. On road to First Eel lake, near Graham's Corner, S. 30° E.

68. On Dinnin road, at school-house, S. 40° E.

69. Near cross roads between Grand lake and Forest City, S. 35° E.

70. On the road between Canterbury and Benton stations, C.P.R., north of brook, S. 48° E.

71. On top of Pemberton Ridge, S. 30° E.

72. On road leading from Canadian Pacific railway to Peltoma settlement, three miles south-west of turn of road to Oromocto river, S. 6° W.; height, 360 feet.

73. On road from Scotch lake to Mactaquac P.O., near stream crossing, S. 45° E. and S. 60° E.; height, 450 feet. On another rock surface here, S. 45° E., S. 38° E., S. 28° E. and S. 25° E.

74. About two miles south-east of Upper Queensbury P.O., S. 38° E., and on west side of exposure, S. 20° E.; height, 400 feet.

75. On road going south from Lower Caverhill settlement to St. John river, and just east of a lake, S. 36° E.; height, 650 feet.

76. Near road from Lower Caverhill settlement to Springfield settlement, S. 15° E., also on ledge at cross-roads leading from Staples settlement to this road, S. 18° E., S. 5° E. and S. 15° W.

77. At brook south-east of last mentioned cross-road on Lower Caverhill and Springfield road, S. 28° E. On another exposure near by S. 35° E.; height, 765 feet. These are on the highest part of this road.

78. Near Staples settlement, S. 25° E.; height, 550 feet.

79. South-west of Staples settlement, S. 20° E.; height, 610 feet. In another place near this, S. 30° E.; height, 625 feet.

80. On road from New Zealand settlement to Lower Hainsville settlement, north of former place, S. 55° E.; height, 460 feet. Further north, on granite, S. 65° E. and S. 60° E.

81. West of Scotch lake, one to two miles, S. 40° E.; height, 570 feet.

82. At Mactaquae river, on east side, S. 45° E.

83. On road on south-west side of Keswick Ridge, a quarter of a mile from cross-roads, S. 45° E. and S. 60° E.; height, 250 feet.

84. A quarter of a mile to the north-west of last, S. 20° E. and S. 10° E.; height, 200 feet.

85. At cross-roads east of Scotch lake, S. 48° E. List of striæ, York Co.

86. On road from Mactaquac P. O. to Scotch lake, south of brook running east, S. 30° E. and S. 60° E.

87. Going east on road from Scotch lake, just south of bend in road east of Little Mactaquac brook, S. 40° E.; height, 380 feet.

88. At first cross-road south-east of Mactaquac stream, north of Mactaquac P.O., deep grooves S. 38° E. Lighter striæ, S. 60° E.; height, 250 feet.

89. At next cross-roads to south, on road to Scotch lake, S. 35° E. and S. 50° E.; height, 395 feet.

90. Near cross-roads on west side of mouth of Keswick river, S. 30° E. and S. 60° E.; height, 285 feet.

91. On a hill north of Hayes brook, South-west Miramichi river, N. 30° E., N. 35° E. (Ann. Report Geol. Surv. Canada, Vol. I, 1885, p. 22 GG. No. 65, List of Striæ.) Stoss-side clearly to S.W.; height, 450 feet.

92. One mile from Millville on Howland ridge, striæ S. 35° E.; height, 780 feet.

Northumberland County.

93. At railway cutting near Boiestown, about 200 feet to south of covered bridge, N. 40° E. and N. 50° E. Stoss side, S.W.; height, 200 feet. Northumberland Co.

94. One mile below Boiestown, on south side of South-west Miramichi river, S. 20° E.; height, 260 feet.

Sunbury County.

95. About two miles north of Rushiagonis station, C.P.R., on the road to Fredericton, S. 8° E., numerous parallel grooves; height, 60 feet. Sunbury Co.

96. At end of road in Peltoma or Little Lake settlement, S. 10° E., also S. 60° E. The S. 60° E striæ here like those on the east side of Oromocto lake, are the older and occur along the road for half a mile or more.

97. One mile west of cross-roads in Shirley settlement, S. 32° E., S. 24° E. and S. 10° E.; height, 210 feet.

List of striæ, Queens Co.

Queen's County.

98. Three or four miles north-east of Enniskillen station, C.P.R., S. 30° E. ; height, 460 feet, Several good exposures between this and the old Nerepis road with the same courses.

99. South-east of Enniskillen station, S. 17° E., S. 26° E., on one surface. On another S. 8° E. ; height, 310 feet.

100. On the road between Enniskillen station and Patterson settlement, a quarter of a mile from the latter, there is a conglomerate boulder embedded in boulder-clay, three feet of it uncovered and well striated by ice that flowed southward while it was held in this position. Crag-and-tail projections were noted on it.

101. Still further to the south-west on a road not turnpiked and two miles west of cross-roads, striæ due S. and S. 10° E.; height, 400 feet.

102. On the west side of Nerepis river, about one mile south of Armstrong's corner, S. 33° E.; height, 170 feet.

103. At Headline settlement, S. 40° E.; height, 420 feet.

104. At cross-roads in this settlement on road leading to Armstrong's corner, about half way between these two places, S. 28° E. and near by S. 2° E., S. 10° E., S. 15° E. and S. 20° E.; height, 150 feet.

105. Near third cross-road to east of Kelly's brook, S. 28° E., grooves, S. 23° E., 300 feet.

106. A mile and a half south-east of Darby Gillan's on southernmost road, S. 29° E.; height, 350 feet.

107. At Darby Gillan's, S. 25° E. and S. 28° E. Distinct along road for a quarter of a mile ; height, 330 feet.

108. Near Kelly's brook, on road south-east of Darby Gillan's (see No. 106), S. 34° E.; height, 300 feet.

Twenty rods south-east of last, S. 18° E. and S. 25° E.

Carleton County.

Carleton Co.

109. About a mile south of Debec, S. 15° E. and S. 25° E., the first the older.

110. On the road leading from Debec to Monument settlement, just south of cross-roads leading to Blowdown settlement, S. 15° E.

111. On road from Lower Woodstock to O'Donnell's crossing, C.P.R., and equidistant from both places, S. 25° E.

112. On a hill immediately to the east of Greenville station, C.P.R., S. 15° W.

113. On cross-road below Houlton road (Beardsly road), a quarter of a mile from the south end, S. 15° E.

114. On road to Kilmarnock settlement, about three miles from the St. John river, S. 30° E.

115. South of Woodstock, on second cross road, S. 50° E.

116. In Newburgh settlement at border of sheet No. 2 S.E., S. 5° W.

117. At Woodstock (school-house on map), S. 5° E. and S. 50° E. (latest).

118. In Northampton, S. 22° E.

119. In Campbell settlement, north of Trout brook, in several places, S. 40° E. to S. 10° E.

120. One mile south-east of Rockland on Beccaguimic river, on road to Ashland, S. 9° W. Dislocations of two inches in slates here, downthrow to south.

121. At north end of Scott settlement, near brook, S. 21° E. and S. 24° E.; height, 470 feet.

122. On short road running south-east, half a mile south of Little Shiktehawk river, S. 24° W.; height, 580 feet.

123. On the road north of the same river, on first cross road going from St. John river, S. 30° W.; height, 425 feet.

124. About a mile north of Centreville on road to Knoxford, due south.

125. One to two miles north of Greenfield P.O., due south.

126. North of Wiley brook, on road running north from Argyle P.O., S. 55° E.; height, 1,385 feet.

127. South of Bloomfield corner, on road to Lindsay, S. 15° E.

128. On road south of Maplehurst, due south ; height, 665 feet.

129. On road one mile north of West Glassville P.O., S. 27° E.; height, 670 feet.

130. Near end of road three miles north of Highland P.O., S. 28° E.; height, 950 feet.

List of striæ, Victoria Co.

Victoria County.

131. A mile and a half east of Perth station, C.P.R., on Tobique road, S. 57° W.; height, 425 feet.

132. South of Red Rapids settlement near Trout brook on cross road, S. 5° W.; height, 840 feet.

BOULDER-CLAY, MORAINES, ESKERS, BOULDERS, ETC.

Glacial deposits.

Boulder-clay is spread over nearly the whole area included in the maps, few localities having been found without it. In certain places, however, it has been largely or wholly denuded, and in these the modified deposits were observed to rest on decayed rock material or solid rock. The heaviest beds of boulder-clay occur in the areas of pre-Carboniferous rocks, particularly in the St. John valley, and along its upper slopes where it has escaped denudation by the river. In these places it sometimes attains a thickness of forty or fifty feet. Between the mouth of the Aroostook river and Upper Woodstock, banks of boulder-clay extend along the west side of the St. John for a great part of the distance. In Prince William, York county, it was observed in a similar position with respect to the river valley. In the parish of Canterbury, heavy beds are massed against the north-west slopes of the hills and ridges, and often envelop them. Many of the lake basins and depressions of the area have been partially filled with boulder-clay during the glacial period, though it has suffered a good deal of denudation since. The Cheputnecticook and Magaguadavic lakes, especially, are dammed and held up by great deposits of boulder-clay, and the islands and points of land running out into them appear to be moraines formed during the final retreat of the ice. On the granite belts, coarse beds of this material were noted, the broad area of these rocks west of the St. John often exhibiting mounds and ridges which are built up of partially stratified material intermixed with large boulders. These ridges have been disposed in various directions, partially by the ice at the retiring stage of the glacial period, and as a result of denudation since.

Boulder-clay in the Carboniferous area.

The boulder-clay on the flat Carboniferous areas seems to be more uniform in thickness, and is practically a continuous sheet, though not as thick as in the hilly districts. In the St. John valley and other places where the thickest beds occur, examinations were made with a view of discovering interstratified deposits, if any existed, but none could be found, and here the boulder-clay seems, therefore, to belong to a single

period of glaciation, or to one system of glaciers, namely the Appalachian, described in my last report.* This conclusion is supported by the fact that no boulders from rocks lying on the north side of the St. Lawrence were anywhere observed, all transported materials having been derived from rocks of the Appalachian system.

The boulder-clay seldom has the drumlin-like form here, though a few ridges south of McAdam Junction, Canadian Pacific railway, and in the Magaguadavic valley might perhaps be characterized as drumlins. In general the outward form of the boulder-clay accumulations is irregular, however, this being either their original outline, or one superinduced by subsequent denudation. These forms are due in many cases to the irregularities of the original rock surface, or to some obstruction in the path of the moving ice.

Eskers or Osars, Kames, Etc.

Eskers occur in the parish of Canterbury and Queensbury, York county, also in Wakefield, Carleton county, and other places. The Eel river, or Monument esker, locally known as 'The Horseback,' was described with a number of others in the report already cited.† It extends from First Eel river lake north-westward into Maine, and is the longest and most remarkable esker in the area. Another long, well-developed esker runs along Deadwater brook, and a third follows Fish creek. These seem to be connected with the Monument esker. The esker along Deadwater brook is a regular south-eastward continuation of these. The latter seems, however, to terminate at the head of this brook, or north of Carroll ridge. Eskers.

An esker occurs in the hollow between Blaney ridge and the ridge immediately south of it.

Another was seen in Staples settlement, near the head of Mactaquac stream.

An esker was noted in the parish of Wakefield, Carleton county, just south of Waterville village.

A remarkable esker was observed on the east side of the mouth of Nacawicac river.

The above are the most noteworthy, but numerous shorter eskers and ridges come under notice in different parts of the area, and a large

* Annual Report Geol. Surv., Can., Vol. X. (N.S.), 1897, pp. 39-48 I.
† Report of Progress, Geol. Surv., Can., 1882-83-84, pp. 20-27 GG.

number of kames or ridges of denudation were observed in river valleys, particularly along the St. John. These are briefly described in the report cited. In the valley of the South-west Miramichi, several short broken ridges (kames) are found at the confluence of the Taxis and this river, their general course being parallel to the latter, and their height above its surface 10 to 15 feet. Mr. Wilson says, 'a kame-like ridge of water-worn gravel, 20 to 30 feet high, stretches along the south side of Hayes brook for a short distance back from its mouth, and below this point, low, narrow gravel terraces occur along the main south-west river.'

Remarks on the Glaciation.

Glaciation comparatively simple in this area.

The glaciation of the area embraced within the two map-sheets here reported on is comparatively simple and seems to have been effected altogether by a single ice-sheet, preceded and followed by smaller local glaciers during the periods of gathering and withdrawal. As already stated, no boulders belonging to the Archæan rocks on the north side of the St. Lawrence were observed in the area under consideration, though carefully looked for. The general course of the ice-movement was south-east, but a few were found trending to the east or north-east. In Carleton county, however, it seems to have been considerably influenced by the St. John valley, which here has a general north to south trend, and hence the flow was nearly due south, occasionally swerving to the east or west in localities where it was affected by the local topography. In York and Sunbury counties, the striæ, as a rule, swerve more to the east, but here we sometimes find divergent courses also, these, however, being, in some instances at least, later, in others, earlier than the general striation. On the east side of the Nashwaak river, for example, we find striæ trending from S. 26° W. to S. 70° W., and on the east side of Oromocto lake, three sets occur, which are occasionally observed on the same rock surface as shown on No. 50 (list of striæ). Here the striæ with the greatest divergence from the north-to-south course is clearly the oldest, notwithstanding the fact that they were produced by local ice in the early stage of the glacial period.

Divergent courses.

Along the South-west Miramichi river, near Boiestown, a number of striæ occur closely parallel to the course of the river valley below that place. Here it would seem that the higher grounds, lying between this river and the Nashwaak, must have caused the divergent courses of striæ observed, the ice on the Nashwaak side of these grounds

flowing south-westward, while that gathering on the north-east flowed as above indicated.

MODIFIED INLAND DEPOSITS.

Stratified deposits.

Although it is difficult to conceive of the sea not having occupied a considerable part of the area included in these map-sheets in the Pleistocene period, much of the eastern part being below the 220-feet contour-line above mean tide level, yet the absence of marine fossils renders the question doubtful. Clays, sands and gravel deposited in the order in which they are found in coast districts, and similar in every respect to the Leda clay and Saxicava sands, were observed everywhere below the contour line mentioned, and in some places above it; but the only organic remains hitherto met with are those of a fish in the clays of Ryan's brickyard at Fredericton, which have not yet been identified and may be either fresh-water or marine. In the present condition of our knowledge, therefore, in drawing this contour line on the map, it is best to leave open the question as to whether the stratified beds below the contour line referred to are of marine or fresh-water origin.*

Terraces.

Besides the river and lake terraces, and kames or gravel ridges which will be described on a later page, deposits of gravel and sand, often of considerable thickness, and sometimes with clay beneath, occupy the greater portion of the surface of the region, and mainly constitute its arable lands. Occasionally these exhibit an even and regular surface, but for the greater part they are more or less undulating and conform to the contours of the boulder-clay and rock surfaces beneath, though of variable thickness. Boulder-clay generally underlies them. The deposits of this character are not so abundant here, however, as upon the districts bordering the Bay of Fundy. In the coastal tract great quantities of coarse gritty material, derived from the ancient crystalline rocks, are scattered about in certain localities, constituting a marked feature of the surface beds. In north-western New Brunswick, however, these gravels and sands are of much finer texture and form good soil. Their occurrence on the summits of ridges and elevations, apparently beyond the reach of marine, lacustrine, or fluviatile action is difficult of explanation, unless on the supposition that they were produced by the waters flowing out from the melting glacier or glaciers during its retreat. On some of the slopes they have probably

Coarse gravel and sands.

* The uppermost limit of the marine deposits along the coast of the Bay of Fundy is 220 feet above the sea. (See Report, on the Surface Geology of Southern New Brunswick, Annual Report, Geol. Surv., Can., Vol. IV. (N.S.), 1888-89).

been caused by atmospheric wear and waste, the materials having been loosened by frosts and rains, and in their movement to lower levels year after year have assumed a stratified structure. In these, the finer materials, such as clay and silt, would be carried farthest from the source to lower tracts and form lenticular beds such as are occasionally observed.

River and Lake Terraces.

River and lake terraces.

The terraces along river valleys and on the borders of lakes, composed of stratified materials, have been produced by fluviatile and lacustrine action. The former are well developed in the valley of the St. John, and a large number of them have been described in the report already cited.* They often form a series of from two to five steps or benches along the river's bank and are very beautiful when cleared of forest and clothed in a green sward. The highest are evidently the oldest. Between Woodstock and Grand Falls the terraces are found at elevations of 100 feet to 180 feet above the St. John. The lower are known as river flats or meadows, and have generally a capping of loam. All the terraces seem to have a slight grade down stream, that is, longitudinally, and none were observed of greater length than two or three miles; usually they are much shorter.

How river terraces were formed.

How were the higher terraces formed? This is a question often asked, but not easily answered. That the river, with an open valley, as it has at present, was flooded to the height of the uppermost of these is quite impossible; that it flowed at that level, however, is indisputable, as the terraces are certainly of river formation. The following brief explanation, based on the facts collected in the field, although not new, is tentatively offered.† Previous to the glacial period, the St. John seems to have had its channel as low as it is at present; perhaps, even lower at some places. The glacial period ensuing, the river valleys and depressions were filled partially or wholly with boulder-clay or morainic materials. On the withdrawal of the ice, these barriers in the river valleys obstructed the drainage to such an extent that the rivers had to flow at much higher levels than previous to the glacial period, and probably formed a series, or chains, of lakes along the valleys. Erosion and transportation of the material then began. But though a large portion of the boulder-clay which occupied the valleys has since been carried away and laid down as stratified deposits at lower levels, an occasional barrier, such as that occurring

*Report of Progress, Geol. Surv. Can., 1882-83-84, pp. 27–42 GG.

†*Ibid*, pp. 41–42 GG.

at Grand Falls, is still found, where the St. John has been entirely diverted from its old channel and forced to cut a new one, three-quarters of a mile long in solid rock. It was during the early erosion of these boulder-clay barriers across the river valleys that the higher terraces along the banks were formed in the intervening portions of the valleys. As the process of erosion went on, the rivers reached lower and lower levels and after a time began cutting down into the first-formed stratified beds, transporting the materials still lower down and forming other terraces. These changes have been continually in progress since and the result is, the beautiful series of terraces seen along the banks of the St. John and its tributaries.

In the erosion or cutting down either of the boulder-clay barriers, or of the earliest formed stratified beds, certain portions were left along the sides or river banks which escaped denudation. But besides these, ridges were occasionally left in the centre of the valleys which now form islands, or as I have called them in previous reports, kames. Their more modern representatives are the long, low, narrow islands of river courses. The St. John valley in the Andover and Grand Falls sheets contains the best developed terraces met with along its whole course. The widest are never more than 400 or 500 yards, and the greater number seldom exceed 100 to 150 yards, and, as has been stated, they are of various lengths longitudinally or up and down river. The lower terraces being covered with loam, are called river-flats, and form good arable lands, the higher being generally composed of coarser materials, constitute a poor soil. The terraces along the tributaries are of the same character as those of the St. John valley itself, but are not so well developed nor as high relatively to the adjacent river or stream. The rule laid down in the report already cited, namely, that the width and length of terraces depend on the size of the river, seems, generally speaking, to hold good. In this respect the terraces are very closely related to the post-glacial rivers of this part of Canada.

Great development in St. John valley.

Terraces along tributaries.

Relation of the Inland Stratified Deposits to those of Marine Origin along the Coast.

On a previous page the classification of the stratified inland-deposits was referred to and the difficulty of assigning to them a fresh-water or marine origin was briefly discussed. It was pointed out that unless fossils were found in them they could not be satisfactorily correlated with the known marine coastal beds. There is, however, one aspect of

Relation between inland and marine deposits.

the question to which attention might be directed, as tending to show that such a view should only be tentatively held, and that the absence of fossils does not always prove that such deposits cannot be marine.

In a former report it was pointed out that the beds representing the Leda clay and Saxicava sands, which rest on the Carboniferous sandstones of the coast of New Brunswick are unfossiliferous, or at least no marine shells or other forms of life have yet been found in them. Only in a few localities on the west coast of Prince Edward Island have Pleistocene marine fossils been found in the whole Carboniferous basin, though a large area now forming dry land must have been under the sea, which was doubtless then, as at the present day, inhabited by marine animals. How is it then that these coastal beds, supposed to have been laid down in an area of comparatively shallow waters, and which must have contained the shells of species then living in these coast waters, do not contain them at the present day? The answer would seem to be that the arenaceous clays and the sands which together constitute the stratified deposits lying below the uppermost shore-line of the Pleistocene submergence contain minerals destructive to shells and the tests of marine animals. The absence of lime in these deposits, the quantities they contain of iron, both as an oxide and a sulphate, and their porous character, all conduce to bring about a somewhat rapid and complete dissolution of the animal remains buried in them, and consequenly the beds now appear as wholly destitute of fossils. If these beds, which we now know are marine from their proximity to the coast and their occurrence below the highest Pleistocene shore-lines, were met with in the interior of the country, their mode of origin would be as problematical as that of the deposits in the St. John valley referred to. Both are of similar composition and, so far as can be judged, of the same age, and both unfossiliferous. Why then may not the deposits in the St. John valley occupying the Carboniferous area, a large portion of which lies below the level of the uppermost marine shore-line of the Bay of Fundy and Northumberland Strait, have not also been of marine origin? A low watershed crosses the country in a north-east and south-west direction separating the waters which flow into the St. John from those which fall into Northumberland Strait. This watershed does not appear to have presented a closed barrier in the Pleistocene, however, but probably allowed the sea to invade the St. John valley, especially in the region of Grand and Washadamoak lakes; and if the relative levels of the coast districts and the interior were even approximately the same then as at the present

Absence of marine fossils.

Annual Report, Geol. Surv., Can., Vol. VII. (N.S.), 1895, pp. 112-114 M.

day, a passage for the sea would also exist by the St. John river valley. The sea would probably enter the interior of the province by these and form a bay covering a large area in which the lakes above mentioned now lie, extending up the valleys of the St. John, Oromocto, Nashwaak, etc. If such a bay or interior sea existed here in the Pleistocene it would, of course, leave shore-lines at the 220-feet contour line above sea level, unless a differential uplift or subsidence took place. Shore lines at the supposed limit of submergence were, however, observed only in a few places.

Though the deposits under discussion lying below the 220-feet contour line may thus be correlated to some extent with those of known marine origin along the coast, yet it cannot be stated with certainty that they constitute the equivalents of the Leda clay and Saxicava sand, and in the present state of our knowledge concerning them, it is considered best to map them as interior deposits.

FRESH-WATER DEPOSITS OF THE RECENT PERIOD.

River-flats (Intervales).

River flats along the St. John.

The lowest of the terraces which skirt the St. John and its tributaries, and which are usually the widest and longest are called river-flats or intervales. In the eastern part of the Fredericton sheet they form areas of arable land of considerable extent, on both sides of this river, more especially at Maugerville, Lincoln, at Nashwaak, etc. Above Fredericton and St. Mary's they narrow towards Springhill and Clarke's mountain, but expand again, at the mouth of the Keswick river. This river discharges into the St. John in the midst of wide intervales and among islands noted for their excellent soil and agricultural capabilities. From the Keswick up, they are comparatively narrow, but widen locally in a few places, as for example at the Barony, at Southampton, Woodstock, Florenceville, Perth, Andover and Aroostook Junction. Several islands also along this part of the river are under cultivation and yield large quantities of hay. These and the flats are overflowed by spring freshets occasionally and a thin layer of clay and silt deposited, which serves to enrich them. This material, which is a sandy loam, is often several feet deep, and, being rich in decayed vegetable matter, contains all the elements of a fertile soil.

PEAT BOGS.

Peat bogs.

Although peat bogs are found in many places within the area of the two map-sheets they are mostly small, and have not yet been utilized in any way. A few of those which contain peat in quantities sufficient to be of economic importance may be enumerated.

A bog containing excellent peat lies between Lower Spruce Peak and Howland Ridge, north of Millville.

Another occurs at the head of Mactaquac stream.

A bog, or peaty barren of considerable extent, was seen along Pokiok river, west of the settlement of the same name.

Several small bogs were observed along the St. Andrews and Woodstock branch of the Canadian Pacific railway, especially south of McAdam Junction, also to the east, in the vicinity of Magaguadavic lake.

Similar boggy formations were likewise noted among the sand hills at the mouth of Oromocto river.

AGRICULTURAL CAPABILITIES OF THE AREA.

Agricultural character of the area.

A description of the agricultural character of the area under consideration was given in the report already several times cited,* and but little can be added to it except as regards the north-eastern portion. A considerable number of new settlements have, however, been opened up since the date of that report, and some others extended, principally on the east side of the St. John, in York, Carleton and Victoria counties. West of the St. John the country is thickly settled, except upon the areas of granite and millstone grit, where large tracts are still under forest. In Carleton and Victoria counties the land on the west side of the river is similar to that of the Aroostock valley across the International boundary in point of fertility, and is of excellent quality.

Settlements along the east side of the St. John.

On the east side of the St. John the principal settlements within the area of the Fredericton sheet are along the Nashwaak river and northwards in a belt twenty miles wide or more following the St. John valley. A large tract to the east of the Nashwaak is unsettled. In the region embraced in the Andover sheet, settlements are seen near Boiestown, on the South-west Miramichi, and at Stanley. The

* Report of Progress, Geol. Surv., Can., 1882–83–84, pp. 42–44 GG.

whole of the northern part of York county and of the north-east of Carleton and Victoria counties, nearly to the Tobique river, is unsettled and forest-clad. Mr. Wilson thus remarks on the surface deposits and agricultural character of the part of the region drained by the South-west Miramichi river :—'The greater part of the area being covered with a heavy forest growth, few opportunities are given to study the surface deposits. In the settlements along the south branch of this river, rotten rock is frequently seen, the upper part modified and in places forming a rich soil; only very small areas of boulder-clay were noted, but travelled boulders, well rounded, are common. Between the Taxis river or Greenhill settlement and the main south-west, and in Pleasant Ridge settlement on the east, the soil is generally gravelly with occasional boulders of granite, gneiss, etc., though on the ridges between the streams, which are comparatively level on the summit and in most places free from stones, it is a deep loam with areas of clay in places. In some localities, however, the erratics are too common and interfere with the cultivation of the soil. No large area of boulder-clay was seen in these settlements, but the presence of striæ at Hayes brook, as well as the general distribution of transported boulders, bear evidence of glaciation. On the portage between Pleasant Ridge settlement and Dungarvon river, several large tracts of good farm land were seen, and similar belts are said to occur on the north branch of the South-west Miramichi.

Mr. Wilson's remarks on the south-west Miramichi valley.

'The country north of the main river drained by Burnt Hill brook and other adjacent streams, is not suited for settlement, though there are small areas of good land; for the most part, however, it seemed to be stony and the soil poor. Cedar swamps are common throughout the district, and these are useless as farming lands. Unfortunately, the whole area is held for lumbering operations and is not available for settlement, and the heavy growth of hardwood would also make it difficult and expensive to clear for cultivation. These two obstacles apply to nearly all the best agricultural land in the south-west Miramichi valley.'

In regard to the general character of the land in the part of the province embraced in the two map-sheets, it appears that while much of it is of an excellent quality, other parts are poor and comparatively useless for agricultural purposes. The best is that known as meadow land (river flats or intervales), which occur along the St. John and its chief tributaries and on the Miramichi. This was described in the report referred to and occupies in the aggregate an area of not less than

Quality of the different kinds of soils.

60,000 acres.* All this is under cultivation, much of it yielding hay, which it produces year after year without the addition of any fertilizer.

On Silurian limestones.

Next in importance and in point of fertility to the meadow land are the uplands resting on the Silurian slates and limestones, which extend over a large part of western and north-western New Brunswick. In the area of these uplands on both sides of the St. John river, the principal settlements exist, and many excellent farms can be seen. The underlying rocks generally wear down into a calcareous, somewhat porous soil, well suited for producing mixed crops and for horticultural purposes, hence it is well adapted to the climatic conditions of this country.

On Cambro-Silurian.

Excellent lands likewise rest on those wide belts of rocks mapped as Cambro-Silurian. These rocks, however, often decompose into a clay soil, which in some places is so compact as to be impervious to water. It is not, therefore, so well suited for general crops as the more porous soils of the meadows and Silurian uplands, but is, nevertheless, good for cereals and hay. Some parts of the country occupied by these rocks are stony and boulder-strewn, and unfit for settlement. This remark applies more particularly to the districts east of the St. John river and north of the granite belt. The band of these rocks stretching along the south-east side of the granite contains much good arable land on both the areas of the Fredericton and Andover sheets. In Stanley, York county, and Ludlow, Northumberland county, large tracts of it are still under forest, but the soil, though reported to be heavy, is rich, and wherever cleared yields abundant crops.

On the Carboniferous.

The areas occupied by Carboniferous sandstones as shown in the eastern parts of the map-sheets (No. 1 N.W. and No. 2 S.W.) are characterized by a sandy and gravelly soil in some places, in others they are clayey and heavy. These uplands not infrequently have a sort of hardpan, consisting of boulder-clay beneath the surface, and consequently are sometimes wet and swampy, except in places, where there is sufficient slope to afford good drainage. A large part of this flat-lying sandstone area within the St. John drainage basin is but little elevated above the valleys of the chief rivers which drain it and has a deep soil. On the low watersheds peaty areas usually occupy the surface. The materials which compose the soils and subsoils upon these carboniferous rocks, being largely due to the decay of the underlying strata, contain little or no lime, and hence fertilizers containing this and vegetable or other organic matter should be frequently applied to these lands.

* Report of Progress, Geol. Surv., Can., 1882-83-84, pp. 42-44 GG.

Upon the granite areas, the land is, for the most part, unfit for cultivation, containing numerous boulders of all sizes up to ten feet in diameter, the soil consisting usually of a coarse gritty debris derived from the underlying rocks. East of the St. John river, however, there are some farming districts located on these granite areas in which we observed good soils and thriving crops, but they were found almost invariably in localities where the ice of the glacial period had transported material thither from the Cambro-Silurian and Silurian rocks to the north-west and thus enriched them. Settlements on these lands may be seen at New Zealand, Springfield, Queensbury, Lower Southampton, etc. On granite areas.

FORESTS.

Although it was in this part of the province that the earliest settlements were founded more than a hundred years ago, yet large portions of the area of the two map-sheets under consideration, including some of the best arable lands, are still unsettled and under forest. A glance at the maps accompanying this report, on which the forest-covered areas are depicted, shows better than any written description can do the character and extent of the forest resources of this part of New Brunswick. On the Andover sheet alone an area not less than three-fourths of the whole, principally in the north, east, and central parts is still occupied by a heavy growth of the original trees which existed here when the country was first settle l. Extent of forest covered land.

Following the rule laid down formerly in regard to mapping the forests, we find that in the region under consideration they can be classed in two main divisions :—(1) the original growth or that which existed here at the time the first settlements were formed, though considerably thinned out and depleted by lumbering operations and other causes, and (2), the recent or second growth which sprang up in districts where the older trees had been destroyed by fire or entirely cut away. In many of the places last referred to, where the land is useless for farming purposes the old forest growth should have been preserved, and if some reasonable foresight had been exercised, might be a valuable asset and a source of revenue now. Some of these tracts never were and never will be of any use for agricultural purposes, and have thus been allowed to go to waste as regards forest production. The extensive belt of wooded country known as the central highlands of New Brunswick, which too, is altogether unsuited for agriculture, will probably have its forest growth largely depleted in the near future How mapped.

unless immediate steps are taken to conserve it. Eventually all the arable lands of the province will be taken up, and denuded of forest as settlements advance. This large interior tract should, therefore, be set apart now as a forest and game reserve, before too great inroads are made upon it. For a provincial park and a sporting ground for hunters and fishermen it has no equal near the Atlantic coast of Canada.

A provincial park.

Chief trees of economic importance.

The chief trees of economic value in the area of the two map-sheets are well known, and consist of spruce, hemlock, pine, fir, larch, cedar, etc., of large enough dimensions for commercial purposes; and black and white birch, maple, beech, ash, poplar and others. A few trees of the American linden (*Tilia Americana*) were found growing on the banks of the St. John river below Woodstock, and the walnut, (*Juglans cinerea*), rare or wanting in most parts of the province, occurs in clumps on hillsides in the same vicinity. Elms, often of large size were seen on the intervales and slopes of the river valleys in all parts of the region. In the large forest-covered area of the Andover sheet only limited belts and patches on the east side of the Tobique, and along Burnt Hill brook and McKeel brook on the South-west Miramichi and north of the north branch of the Beccaguimic river show a second or later growth, these tracts having been overrun not many years ago by forest fires.

Mr. Wilson's notes on the forest of the south-west Miramichi valley.

The following notes on the forests of the upper South-west Miramichi are inserted from Mr. W. J. Wilson's observations. 'The greater portion of the area is covered by a dense forest which supplies large quantities of lumber every year. Except in comparatively small areas the forest is composed of original growth. In the south-east portion of the Andover sheet at the head of Cains river, second growth prevails and only occasional clumps of old trees can be seen, although even in this district considerable lumber is cut. Quite an extensive area of burnt land covered with second growth extends along the east bank of Burnt Hill brook, and two other large areas occur on McKeel brook. The latter were recently burned and a large quantity of valuable lumber destroyed. In the eastern part of the sheet, going northward from Pleasant Ridge settlement, spruce with occasionally cedar, etc., prevails for the first four miles; from that point to the Dungarvon river, hardwood ridges and spruce swales alternate every mile or two, the hardwood occupying the ridges between the streams and the spruce woods the river valleys and lower ground. Spruce, however, is generally found mixed with the deciduous trees on the hardwood ridges and when so found is said to make the best lumber, as it is more likely to

be sound and firm. Hemlock was also noted as common on this route. Along the portage road from Green Hill settlement to the Miramichi river the conditions are much the same as on the road just described, except that there are large areas of hardwood, the woods, for the most part, being open and free from underbrush. Black birch measuring from seven to ten feet in circumference, rock maple, six feet and a half, beech, five feet, spruce, six feet and a half, estimated seventy to eighty feet high, and cedar, six feet, around the base of the trunk were noted in this section.

'Along the portage road one to two miles west of Burnt Hill brook the forest is chiefly spruce and fir, with here and there a hardwood ridge, and the same holds true for the country east to Clearwater brook, and down to the Miramichi river by the portage along the Sisters brook, except that near the Miramichi river there is more hardwood. This forest is the scene of active lumber operations, and has been for many years past. The young spruce grow very fast, especially when the larger trees are cut away; and lumbermen go over the same ground every eight or ten years.'

Destruction of the forest on the Carboniferous areas.

On the Fredericton sheet the Carboniferous area has been largely denuded of its original forest growth, and a recent one has replaced it in most localities not cleared and settled. This condition of things is chiefly due to old forest fires. The gravelly and sandy nature of the soil, and the fact that coniferous trees predominate on these lands render the forests occupying them particularly liable to conflagrations in dry seasons. On the granite belt and the tracts lying to the northwest of it the sylvan growth is mostly original, except near railways or old settlements. A strip of second growth follows the St. Andrews and Woodstock branch of the Canadian Pacific railway from the southern border of the sheet nearly to Debec Junction. On the east side of the St. Croix river and Cheputnecticook lakes there is another belt of recent forest, doubtless the result of a destruction of the older trees by fire, also a third along the Gibson and Woodstock branch. These belts together with a patch along the Mactaquac stream constitute the principal areas occupied by a recent growth, all other parts of the wooded country included in this sheet being occupied by the old growth. Much of this old forest has, however, been more or less depleted of the larger timber trees by lumbermen under the regulations of the Crown Lands Department of the province. So long as these forest areas can be preserved from fires, merchantable lumber can be obtained from them by re-cutting the larger trees at intervals of every twelve or fifteen years. Though thus partially thinned out

these large areas of forest lands, nevertheless, form an important asset in the natural wealth of the province.

ECONOMIC MINERALS AND MATERIALS.

Minerals of economic value.

A number of minerals of economic importance occur in the area described, the principal being iron, both hæmatite and limonite, or bog iron ore. The largest beds of hæmatite are those of Woodstock or Jacksontown, which were wrought at intervals between 1848 and 1884. In connection with these iron mines, a blast furnace was erected at Upper Woodstock, where the smelting of this iron, together with the bog iron ore from Maugerville, Sunbury county, was carried on for some years. Considerable quantities of hæmatite still exist in the vicinity of Woodstock.

Bog iron ore.

Bog iron ore is found at Maugerville and Burton, Sunbury county. At the former place occur what are probably the largest deposits in the province. They were examined by me in 1882-83, when pits were opened and work going on. At that time considerable quantities of this mineral were being taken from this place to Woodstock, as mentioned above, to be mixed with the hæmatite ores in the blast furnace then in operation there. Since the Woodstock iron works were closed, however, no use has been made of the Maugerville ore. This mineral is said to occur in the bank of the South-west Miramichi river, one mile below Clearwater brook and nineteen miles above Boiestown, but the extent of the bed has not been stated.

Bog manganese.

Bog manganese is found in small quantity in a gravel bank near the old Government House, Fredericton. It is also reported from Queensbury, York county, and from Lincoln, Sunbury county, but the deposits at the last two places were not seen.

Mr. W. McInnes, of this Survey, reported this mineral from the north branch of the South-west Miramichi, twelve miles and a half above the forks, in a deposit on the river's bank.

Antimony.

Stibnite, or sulphide of antimony, occurs in the parish of Prince William, York county, near Lake George, where it was known to exist as early as 1833. It has been wrought at intervals till about the year 1890, but from all that can be learned, without profit.

Gypsum.

The gypsum deposits of the Tobique valley, which lie just to the north of the Andover sheet, contain extensive seams of coarse plaster, but, except for fertilizing purposes, the gypsum is not as good as

that of Hillsborough. Work is carried on here also in a desultory manner, the sale of the product being limited.

Gold. Gold has been reported from Cross creek and Stanley for many years, and at periodic intervals an excitement is aroused from some supposed new 'find,' followed by more or less prospecting, buying of claims, etc. The last of these took place in the winter of 1898-99. In the following autumn the writer made an examination of this district, but could find no gold at Cross creek, either in the gravels or in the matrix. In the Nashwaak valley, near the village of Stanley, however, a few very fine particles were washed out of the sands in the bed of the river, and also at the mouth of Yerxa brook, where some prospecting seems to have formerly been carried on. These particles were rough and did not appear to have been transported any distance, and there are doubts as to whether they really belong to the district. It is possible they may have been dropped by prospectors and others who have been panning the gravels here at various times within the last thirty or forty years.

Brick clay. Brick clay is common everywhere in the district, but only two kilns were in operation in 1898-99, namely, Ryan's, at Fredericton, where considerable quantities of brick are manufactured, and another at Grafton, opposite Woodstock. These, however, do little more than supply the local demand, which is not great.