GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

SECOND REPORT

ON THE GEOLOGY OF A PORTION

OF THE

PROVINCE OF QUEBEC.

BY

R. W. ELLS, LL.D., F.G.S.A.

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ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., etc.,

Director of the Geological and Natural History Survey of Canada.

SIR,—I have the honour to transmit herewith my second report on the Geology and Mineral resources of the Eastern Townships. It embraces the work of the past two years, and is intended to accompany the north-east quarter-sheet map of a part of the province of Quebec, which is the continuation to the northward of that published in 1886. Many miles of coast line have been surveyed, both along the shores of the St. Lawrence and on the islands lying in the channel, and a great extent of country has been traversed along the roads, many new ones having been opened up since the compilation of the map by Mr. Barlow in 1868. These have been plotted and reduced by Mr. N. J. Giroux, C.E., P.L.S., who has ably assisted me throughout the entire work, and these additions to the map render it much more complete and accurate.

Our thanks are due to many persons, more especially to the owners and managers at the various mining centres, for much kindness and for courteous assistance in furnishing statistics and other valuable information. The area north of the St. Lawrence has only been cursorily examined by us, collections of fossils having been made at several points.

I have the honor to be,

Sir,

Your obedient servant,

R. W. ELLS.

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PROVINCE OF QUEBEC.

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The work of the past two seasons has been for the most part confined to that portion of the province lying to the south of the St. Lawrence River and embracing the counties of Megantic, Dorchester, Bellechasse, Levis, Montmagny, and l'Islet. In its economic aspect it includes the Chaudière gold-field, the asbestus deposits of Thetford and Broughton, and the iron and copper deposits of Leeds. A great part of the district, viz., that lying to the north-east of the Chaudière River, was examined by Mr. James Richardson in 1868. His report is the latest official publication in detail on that section of the country. In view, however, of the many new facts pertaining to the structure and the age of the several rock formations of the Eastern Townships which have been obtained since, the statements put forward in that report now require considerable modification. **Area described.**

Along the St. Lawrence, our examinations of the south shore extended from Pointe au Platon, about thirty-five miles above Levis, to River du Loup. Of this section a carefully paced compass survey was made as far east as Ste. Anne de la Pocatière, while on the north side our examination extended from the mouth of the Jacques Cartier River to Cape Tourmente. The group of islands which occupy the central portion of the river between Quebec to opposite St. Thomas were also surveyed from Orleans Island to Crane Island, both inclusive. **Surveys.**

The extension northward of the several geological formations described in the preceding report* was carefully traced. The extension of the anticlinal there, and previously in 1863† and in 1867,§ described as that of Sutton Mountain was found to continue, with a nearly direct course, to the rear of l'Islet, where our examination ended in this direction; displaying for a considerable part of the distance the series of crystalline schists, chloritic, talcose, and micaceous, which characterize

* Geol. Surv. Rep. 1886. Part J.
† Geol. of Canada, 1863, p.p. 247, 251.
§ Rep. of Geol. Survey, 1867-68, p.p. 7A and 8A.

it to the south-west. It is concealed at several points, however, by the overlap on the west of the black slate and quartzite series, regarded as of Cambrian age; while on the east it is flanked for a great distance by the volcanic portion of what is now described as Lower Cambrian. These rocks extend continuously to the north-east and constitute, in part at least, the gold-bearing series of the Eastern Townships. In this series there occurs a very considerable development of volcanic rocks, diorites, serpentine, &c.; but the areas of the latter, north of the great masses of Thetford, are comparatively limited. All the known areas of serpentine were carefully examined with a view to the presence of asbestus in workable quantity, and small veins were seen in nearly every locality; but the conditions for successful mining appear much less favourable in the smaller and detached masses than they are in those at the great mining centres of this industry, viz., at Thetford and Coleraine.

Objections to the term "Quebec Group."

The name "Quebec Group," which has for so many years been applied to much of the rocks of this portion of the province of Quebec, has become so misleading and unintelligible in view of the many new facts brought to light concerning its composition and structure, by the study of the past fifteen years and the many changes rendered necessary in consequence, that its further use appears not only undesirable but to a certain extent objectionable. It was applied by Sir W. Logan to a great series of sediments which were deemed to lie somewhere about the horizon of the Calciferous and Chazy formations. Dr. Selwyn and others, have, however, since 1876, pointed out that it has been found to embrace rocks ranging from the Pre-Cambrian to the Hudson R. or Loraine, both inclusive. An almost entirely new arrangement of the different formations which make up the group is therefore imperative. In the case of such portions of the original group, the horizon of which has been definitely determined, the proper name of the formation can be readily applied, while in the case of such portions, either distinctly fossiliferous, or closely related areas the exact position of which in the Geological scale may be doubtful, the terms Levis or Sillery, with their system classification, may be retained.

Various reports on the area in question, extending over a period of sixty years, have appeared from time to time, among which may be more particularly mentioned the following:—

Reports bearing on the subject.

Dr. J. T. Bigsby, 1827, Geol. Soc, London, Vol. I., p. 27. On the Geology of Quebec and vicinity.

Capt. Bayfield, R. N., 1845. On the Transition rocks, Canada.

Sir W. E. Logan, 1843., Geol. Rep., pp. 18-19.

" " " 1844., Geol. Rep., pp. 19-33.

" " " 1845-46., Geol. Rep., pp. 101-114.

E. Emmons, M. D., 1847. Am. Mag., Geology of the Montmorenci.

Sir W. E. Logan, Geol. Rep., 1849-50. Geology of South side of the St. Lawrence, between the Chaudière River and Temiscouata Road.

" " " Geol. Rep., 1850-51. On the gold of the Chaudière Valley.

" " " Geol. Rep., 1852-53. On the geology of the North shore of the St. Lawrence between Montreal and Cape Tourmente.

Logan and Hunt, 1855. Esquisse Geologique.

James Hall, 1858. Communicated 1855. Can. Nat., Vol. III., Notes on the genus Graptolites, etc.; also Geol. Rep. 1857.

E. Billings, 1860. Can. Nat., Vol. V., p. 301. On some new species of fossils from the limestones of Pte. Levis, opposite Quebec.

Sir W. E. Logan, 1860. Can. Nat., Vol. V., 1860, p. 472. Remarks on the fauna of the Quebec group, and the Primordial Zone of Canada, addressed to J. Barrande.

T. S. Hunt, 1861. Can. Nat., Vol. VI., p 91-95. On some points in American Geology—the Quebec group paralleled with the Taconic system of Emmons.

Logan, Barrande and Hall, 1861. Can. Nat., Vol. VI., p. 106. On the Taconic system, and on the age of the fossils found in the rocks of Northern New England and in the Quebec group.

Sir W. E. Logan, 1861. Can. Nat., Vol. VI., p. 199. Considerations relating to the Quebec group and the Upper copper-bearing rocks of Lake Superior.

E. Billings, 1861. Can. Nat., Vol. VI., p. 310. On some of the rocks and fossils occurring near Phillipsburg, Canada East.

E. Billings, 1861. Can. Nat, Vol. VI., p. 344. On the occurrence of graptolites at the base of the Lower Silurian.

Dr. T. S. Hunt, 1861. Can. Nat., Vol VI., p. 374. Mr. Barrande on the Primordial Zone in North America, and on the Taconic system of Emmons.

Dr. T. S. Hunt, 1862. Can. Nat., Vol. VII., p. 78. Note on the Taconic system of Emmons.

James Hall, 1865. Sec. II., Can. Org. Remains. Graptolites of the Quebec group.

E. Billings, 1861-65. Pal. Fos., Vol. I., p. 57. On some new species of fossils from the Quebec group, where their probable position from fossil evidence is stated.

" " " Pal. Fos., Vol. 1., p. 185. New species of fossils from the limestones of the Quebec group from Pt. Levis and other localities in Canada East.

" " " Pal. Fos., Vol. 1., p. 207. New species of fossils from the Quebec group in the Northern part of Newfoundland.

Jules Marcou, 1862. On the Taconic rocks of Vermont and Canada.

E. Billings, 1863. Can. Nat., Vol. VIII., p. 19. On the Parallelism of the Quebec group with the Llandeilo of England and Australia, and with the Chazy and Calciferous formations.

Sir W. E. Logan, 1863. Can. Nat., Vol. VIII., p. 183. On the Rocks of the Quebec group at Point Levis, letter addressed to Mr. Barrande.

T. Devine, 1863. Can. Nat., Vol. VIII., pp. 95 and 210. Description of a new Trilobite from the Quebec group.

Sir W. E. Logan. Geol. of Can., 1863, p. 225. The Quebec group.
" " " " p. 884. Supplement.
" " Geol. of Can., 1866, p. 3-5. Divisions and characters of the Rocks of the Quebec group.
Prof. H. Y. Hind, 1865. On the distribution of the Quebec group in New Brunswick.
James Richardson, 1866. Geol. of Can., p. 30-33. On the Geology of the Quebec group in the Eastern Townships.
" " 1866-69. Geol. of Can. On the region South of the St. Lawrence, between the Chandière River and the Temiscouata Road.
Dr. T. S. Hunt, 1878. Sec. Geol. Sur. Penn., Part I. Azoic rocks.
Dr. A. R. C. Selwyn, 1877-78. Geol. of Can., p. 2a, 9a. Observations on the Stratigraphy of the Quebec group and the older Crystallines of Canada, also 1881 Can. Nat., Vol. IX, p. 17.
Thos. Macfarlane, 1881. Can. Nat., Vol. IX, p. 91. Canadian Stratigraphy.
Dr. A. R. C. Selwyn, 1880-81-82. Notes on the Geology of the Eastern portions of the Province of Quebec.
R. W. Ells, 1881-82. Report on the Geology of the Gaspé Peninsula.
Dr. T. S. Hunt, 1883. Trans. Roy. Soc. Can. The Taconic question in Geology.
Dr. A. R. C. Selwyn, 1882. Trans. Roy. Soc. Can. The Quebec group in Geology.
Mr. F. D. Adams, 1880-81-82. Notes on the Microscopic Structure of some rocks ofthe Quebec group.
Sir Wm. Dawson, 1883. Appendix to Harrington's Life of Sir W. E. Logan, the Quebec group.
Dr. Selwyn, 1883. Reply to Sir Wm. Dawson.
Prof. Jules Marcou, 1884-88. Various papers on the Taconic question. and on Canadian geological classification.

It will be readily seen from the above list that the bibliography pertaining to the several formations found in the area under consideration is very considerable. Many of the reports have long been out of print, and are now inaccessible to the great majority of readers. In order that the subject may be more intelligible, we have thought it advisable, therefore, to present a short summary of the various opinions held by the great number of scientific workers in this field, and expressed, from time to time, in the publications above enumerated. More particularly is this thought to be desirable, in view of the great difference in the opinions stated in regard to the structure of the area in the report of 1863, and in sundry papers since 1877 by Dr. Selwyn, and which have reference more especially to that peculiar series of rocks known as the "Quebec Group." This term was first introduced by the late Sir Wm. Logan in 1860, and applied to a series of rocks, first particularly studied near the City of Quebec, and especially developed on the South side of the St. Lawrence opposite that city, which presented so many difficulties as to the correct interpretation of its structure

and position, as to warrant the giving of a special name to the rocks which composed it. The investigations of this group, which had been begun some years before that date, had always presented problems very difficult of solution, owing to the fact that it was held to embrace a great variety of rocks differing very widely in character from those in the immediate vicinity of the St. Lawrence, and to include both the fossiliferous shales near that river and the great series of crystalline rocks of the interior, or the prolongation of the Green Mountain Range of Vermont, which enters Canada near Sutton Mountain, and extends with some interruptions to the extremity of the Gaspé Peninsula. These were regarded as the equivalents of the fossiliferous series near Quebec, their different aspect being supposed to be due to a profound metamorphism by which not only the contained fossils were completely effaced, but their entire physical character altered from the ordinary shales, sandstones and conglomerates of the original deposits to the most highly altered schists, quartzites, dioritic and gneissoid rocks. The upper part of the series was also held to embrace sediments, which contained fossils of Utica or possibly Hudson River age, so that the curious anomaly was presented of one single group name which comprised rocks ranging from what has now been determined to be as old as the Huronian to the upper part of the Cambro-Sliurian. An abstract of the views referred to will be presented under the latter heading.

The several geological systems recognized in the area examined during the past season are:— Systems recognized.

F. Devonian.
E. Silurian.
D. Cambro-Silurian.
C. Cambrian.
A. B. Pre-Cambrian.
Crystalline and Igneous rocks, volcanic and plutonic.
Superficial deposits.

F. Devonian.

In describing the distribution of the Gaspé series (see Geol. of Can., 1863, p. 427-29) allusion is made to an out-crop of fossiliferous limestone, which is found on the north bank of the Chaudière River, about midway between the Famine River and the village of St. George. The fossils from this locality were examined by Mr. Billings, who pronounced their aspect to be Devonian rather than Silurian.

During the past season, the extent of this outlier and its relations to the associated slates of the locality have been carefully ascertained. It was found to have a breadth along the face of the hill of about twenty chains, and to rest unconformably upon the black and grey slates and greyish sandstones of St. George, the basin-shaped synclinal, with the beds curving along the face of the cliff, being readily seen when viewed from the opposite side of the river. The underlying slates at this point dip south-east at a high angle.

Extent of the Devonian areas.

No fossiliferous rocks of a similar horizon appear on the south side of the Chaudière in any direction, in so far as yet observed, the outcrops of Silurian slates at the narrows of Lake St. Francis, decribed in Part J, Vol. II, Geological Survey, 1886, being the nearest in point of age. To the north-east the limits of the St. George basin could not be clearly determined, owing to the covering of soil and forest, but it is apparently of no great extent in this direction, as no indications of such rocks are seen on the road which extends for twelve miles up the east side of the Famine River, the rest of the country in this direction being an almost unbroken wilderness.

Further to the north-east, on the road leading to Ste. Justine, between the townships of Langevin and Ware, a very limited exposure of similar fossiliferous limestone rests on the black slates and hard grey sandstones. This is on lot 32, range IX, Langevin, at the summit of the ridge, midway between the crossing of the brook at the head of the Famine River and the corner of the road to Ste. Justine church. The breadth of this outcrop is not more than twelve to sixteen feet, and it is about the same in length.

These are the only areas of rock which may be said to belong to the Devonian system that are known to occur anywhere throughout the whole of the country to the south of the St. Lawrence, which is included in the north-east quarter sheet of the Quebec map. The exposures just described resemble patches which have escaped denudation. From the fossils collected in 1886 by Mr. Ami from the Chaudière locality the following species have been recognized :

Polypi.

Fossils.

1. *Favosites Gothlandicus*, Lamarck	Dev. and Sil.
2. *Favosites*, sp. indt	
3. *Syringopora Hisingeri*, Billings	Dev. (Cornif.)
4. *Diphyphyllum*	"
5. *Cyathophyllum* (?) sp	"
6. *Heliophyllum*, sp. indt	"
7. Crinoid fragments	

Brachiopoda.

8. *Orthis*, sp. indt	
9. *Strophomena rhomboidalis* Wilckens	Sil. and Dev.
10. 11. *Strophodonto*, 2 sp.	Devonian.
12. *Productus* (?)	"
13. *Spirifera duodenaria*, Hall, var. or N. sp.	
14. *Spirifera gregari*, Hall, " "	
15. *Spirifera*, sp. indt	
16. *Atrypa reticularis*, Linn.....Dev. Some resembling *A spera*, Schl.	
17. *Leptocelia flabellites*, Conrad	Dev.

Lamellibranchiata.

18. *Paracyclas*, sp.	Dev.
19. *Pterinea textilis*, Hall, var	Dev. and Sil.

Trilobita.

20. *Proetus crassimarginatus*? Hall	Dev.
21. *Phacops*, sp. indt	Dev. and Sil.

From the collection determined by Mr. Billings, in addition to the forms above enumerated we have :

Favosites basaltica, Goldfuss	Dev. (Cornif.)
Diphyphyllum arundinaceum, Billings	" "
Zaphrentis, sp. indt	Dev. and Sil.
Helsophyllum Oneidaense, Billings	Devonian.
Orthis seriatula, Hall	Dev.(Cornif.)
Chonetes, 2 sp	
Productus, small form	Devonian.
Spirifera acuminata, Hall	Dev. (Cornif.)
Cyrita, like *C. rostrata*	" "

E. SILURIAN.

No rocks which could definitely be pronounced of Silurian age were seen in the area embraced in this quarter-sheet map. The red shales mentioned in the Geol. Can., 1863, p. 205, the horizon of which was regarded as probably about that of the Medina from the fact that they overlie the Hudson River shales on the Becancour River and at other places, were carefully but unsuccessfully examined along that stream for fossils. The most northern area, that in the seigniories of St. Jean des Chaillons and St. Pierre des Becquets, shews, in some of the smaller streams, the same character of red shales. From the known unconformity of the red shales of the Becancour to the underlying Loraine shale, it is probably safe to assume that they Areas of Silurian.

represent some portion of the Silurian system. Owing to the general lack of exposures, however, the extent of the areas so occupied must be largely conjectural.

D. Cambro-Silurian.

Former views.

Many of the remarks in Part J, Vol. II., Geological Survey of Canada, 1886, on the character and distribution of the rocks formerly supposed to belong to the Upper Silurian system, will apply equally to the area at present under consideration. On the map of 1869, which is the latest published by the Survey of a large part of this district, the area occupied by rocks of Silurian age included all that portion of the province lying between the state of Maine and a line drawn from near the north-west end of Lake St. Frances to the intersection of the Quebec boundary by the North-West Branch of the St. John River, in the township of Talon, crossing the Chaudière a short distance west of the village of St. Francis, Beauce. From the point mentioned in Talon, the northern limit of the Silurian was thought to extend in a tolerably direct course to the north-east, keeping along the international line to the northern part of Lake Temiscouata; the area being regarded as forming the prolongation in this direction of what was then held to be the great Silurian basin, lying to the east of the Sherbrooke and Stoke Mountain anticlinal.

The statements in Geol. of Can, 1863, p. 427–29, relative to the structure and age of the strata along the Chaudière River, in which the great series of slates, quartzites and felspathic rocks, now regarded as in part constituting the lowest portion of the Cambrian, are classed as of Silurian age, cannot now be accepted as correctly interpreting the geological structure of this area, since it has been ascertained that no clearly recognizable Silurian rocks exist in this area at all, while, in the portion of the province lying to the south, such areas are confined to limited and at times closely infolded basins.

Two principal areas.

The formations pertaining to this system, and found in the area south of the St. Lawrence, range from the Hudson River downward to the Cambrian. The area may be readily divided into two portions, an eastern and western, the former including all that series which extends between the central anticlinal presently to be described and the United States boundary, the latter that situated between that anticlinal and the St. Lawrence River.

Eastern area.

The former portion has been briefly alluded to in the preceding report, 1886,* and is the prolongation to the north-east of the great Cambro-Silurian area which lies between the Stoke Mountain range

* Geol. Sur. of Can., Vol. II, Part J, 1886.

and the Cambrian rocks of Lake Megantic and vicinity. In their northward extension these sediments present characters very similar to those already described for the southern area, consisting largely of dark-grey and blackish, sometimes plumbaginous slates with greyish sandstones, the former sometimes ochre-spotted and displaying, on weathered surfaces, the characteristic striped or banded aspect already referred to. Calcareous rocks are, as a rule, absent, though on the Upper Chaudière they are occasionally seen, and they have been reported by Mr. A. Webster, formerly of the staff of the Geological Survey, as occurring on the North-West Branch of the St. John River, a short distance below the Lac de la Frontière. The western limit of the principal area of these rocks on the Chaudière is supposed to be the valley of the Famine River, whence they are well exposed on the roads leading up the Chaudière and Du Loup streams, extending in this direction along the Kennebec road to the vicinity of lots 37-40, Kennebec Road Range, Linière. The western boundary, north of the Famine, presumably follows the course of that stream to a distance of several miles beyond the crossing of the road to Langevin, whence curving round, the Cambro-Silurian rocks widen out towards the head waters of the Etchemin River, the line between these and the Cambrian crossing the road from Mailloux to St. Magloire, about half a mile west of the latter place. The country in this direction is entirely unopened, except by the road to St. Magloire, through Roux and Mailloux, and that through Cranbourne and Ware to Ste. Justine or Langevin. Further north, no waggon-road exists south of the Taché road, but in the northern part of Roulette and Montmagny an old foot-path extends through the northern part of these townships, past the south end of Lac au Crapaud, in the direction of Lac à la Frontiere, on the N. W. Branch of the St. John. On this path, about the line between ranges VI and VII of Talon, blackish clay slates, presumably of this series and similar in character to those described further south, appear. This outcrop probably marks the western limit of the Cambro-Silurian area in this direction, as the dark grey graphitic limestone already referred to as occurring on the St. John waters, is found a few miles further to the north-east, associated with similar slates. The country lying east from Ste. Justine and St. Magloire, in the valley of the Daaquam River, is generally low and apparently unbroken by any prominent ridges which might indicate the presence of areas of the metamorphic Pre-Cambrian rocks. Hay swamps are numerous and the banks of the stream are frequently lined with alders for some distance inland. From the notes of Mr. A. Webster, who descended the Upper St. John from Little Lake St. John, at the head of the South-West Branch, which stream forms the boundary between Maine and

Upper waters of the St. John River.

Observations of Mr. A. Webster

Quebec for about twenty-five miles, we learn that much of the country in that direction is also low and that rock exposures are rare, much of the water in the river being sluggish. Where observed, the ledges consisted of greyish sandstone and clay-slate, which from their description resemble very closely the rocks described as occupying the great Cambro-Silurian basin of the south-eastern part of the province. The Upper St. John is navigable for canoes only when the water is high. On both occasions, when we visited the Upper Chaudière, the water in the St. John was so low that we could not examine that stream. The route followed by Mr. Webster, in 1880, was by a road from Jersey to the new settlement of St. Zacharie de Metgermette, by way of Lake Abenaquis, which is at the head of the Abenaquis stream, an eastern branch of the Famine River. The land about this lake is stated by him to be generally good, the rocks in places being arenaceous slates and grey sandstones similar to those seen abont St. George and Jersey on the Chaudière River. Boulders of green chloritic, epidotic and quartzose rock, which may have been derived from the ridges in the adjoining state of Maine, were observed. About Little Lake St. John, crops of oats, wheat and potatoes seen at the end of August were reported excellent, a similar soil, with clay slates underlying, being noted as at the settlement further west. It is very probable that in the valley of the Upper St. John, as well as in that of its main branch, the Daaquam, on the west, the rocks and the soil are similar. East of St. Magloire, the rocks seen were fine cleaved clay slates, having a north-west dip. On the North-West Branch of the St. John, between Lac à la Frontière and the main river, hard, altered greenish-grey sandstones were observed, with bands of greenish-grey clay slates, all dipping S. E. $< 75°-80°$; and containing, a short distance below the lake, interstratified beds of argillaceous, bluish-black limestone much cracked and traversed by seams of calcspar. The specimens of limestone from this locality resemble very closely the Cambro-Silurian limestone of Cookshire and Eaton, in which microscopic fossils were found, and which have been described in the last Report.*

Central area.

Another area of somewhat similar rocks, separated from those just described by a ridge of Cambrian, is formed by the prolongation to the north-east of the St. Francis area, which, extending from the upper part of Lake St. Francis, through Lambton and Tring, reaches the Chaudière in a gradually narrowing band about midway between St. Francis and St. George. The rocks in this area consist for the most part of bluish-grey and blackish slates, at times ochre-spotted, with grey sandstones, presenting at times the characteristic banded

* Geol. Survey, 1886, Vol. II, Part J.

aspect on smoothed surfaces noted in the central basin to the south-east. What has been regarded as a narrow band of these rocks crosses the Chaudière and extends up the west side of the Gilbert River for a short distance, though its northern limit cannot be definitely ascertained, owing to the inaccessible wilderness character of the country in this direction. As a rule, these rocks are not so highly felspathic or quartzose as those of the underlying Cambrian system, although in places they carry quartz veins. An apparent unconformity between the rocks of this series and the harder quartzites which underlie them is seen at the south end of the lake in lot 3, range III, of Tring, the bluish slates dipping S. 35° W. $<$ 30°, while the underlying quartzite dips S. 20° E. $<$ 20°. Full descriptions of the rocks of this series have been already given in the Annual Report, 1886, Part J, and need not here be repeated. South of the Chaudière their structure is apparently that of a basin bounded on either side by well defined ridges or areas of Cambrian sediments, one of which is seen to cross that river just below the mouth of the Famine, while the other is well developed about the village of St. Francis, Beauce, and for several miles to the south-east. Its extension west of that village will presently be described. Certain areas of red and green slates and grey sandstones, which cross the Chaudière near the Colway River and extend to the north-east into Cranbourne, present features very similar to those found in the Sillery rocks of Quebec, and may indicate a synclinal of these sediments in this direction.

St. Lawrence area.

The second area of the Cambro-Silurian rocks above referred to as that in the vicinity of the St. Lawrence presents at several places many features differing from those in the area just described, and the formations are, forthe most part at least, presumably of a later age, as indicated by the abundance of fossils found at many points.

St. Nicholas, fault.

On the south side of the St. Lawrence, two miles above the wharf at St. Nicholas, which is about twelve miles above Lévis, the contact between the grey, sandy shales and sandstones of the Loraine and the red, green and black shales of the Sillery formation is well seen both on the beach and in the cliff. The beds along the line of fault for several yards are much crushed, but the general dip of the two series is S. $<$65°-90°. From the Loraine shales a small collection of fossils sufficient to show their horizon was obtained. These have been examined by Mr. H. M. Ami, who has recognized the following species :—

Fossils.

Columns of *Glyptocrinus*, prob. *G. decadactylus*.

1. *Arthrograptus quadrimucronatus*.
2. *Diplograptus*, sp. nov, (*D. Latior.*)

3. *Leptæna sericea*, Sowerby.
4. *Orthis testudinaria*, Dalman.
5. *Zygospira Headi*, Billings.
6. *Ambonychia radiata*, Hall.
7. *Orthodesma parallelum*, Hall.
8. *Modiolopsis*, sp. indt.
9. *Trinucleus*, sp., large form.

Utica-Trenton outcrop.

The rocks of this horizon occupy the shore continuously for nearly three miles and a half, the high dip, S. 10° E. < 50°-60°, being maintained. The strike of the strata being almost along the shore, no great thickness of beds is exposed. At the end of this distance a sharp overturn fold occurs in the grey beds, followed by a line of fault which brings up a series of highly bituminous black and brown limestones and dark shales, with hard, blackish or greenish cherty beds like those seen at the Marsouin, the dip of which is S. 15°-30° E. < 55°-80°. These contain fossils, among which were observed :—

1. *Dicranograptus ramosus*, Hall.
2. *Climacograptus bicornis*, Hall.
3. *Dicellograptus sextans*, Hall.
4. ? *Corynoides calycularis*, Nicholson.
5. *Leptoboloid* shell. Too imperfect for specific and generic reference.

St. Antoine and Ste. Croix.

The peculiar bands of cherty and shaly rocks from which these fossils were obtained extend along the shore in the direction of St. Antoine de Tilly for nearly a mile and a half, and at their most southerly outcrop are underlaid by the usual grey shales and sandstones of the Loraine formation, there being probably a line of fault at this place. Above this the latter are well exposed in the cliffs and on the river flats at low tide, where they can be seen to run in straight lines obliquely across the river towards the north shore for nearly a mile in some places. The strike of the several beds to the vicinity of the St. Antoine wharf is quite uniformly to the S. W. < 50°–70°, though several well defined anticlinals are seen in this distance, but above the wharf, the angle of the dip begins rapidly to decline to 30°, whence the beds become more horizontal, till at St. Croix wharf the inclination is not more than 6°-8°, the direction of the dip being south and the river flowing past the basset edges of the strata. For several miles north of St. Croix wharf the flaggy sandstones are thickly covered with fossils, from which the following forms were obtained :—

1. *Discina*, sp.
2. *Leptæna sericea*, Sowerby.
3. *Strophomena alternata*, Conrad.
4. *Orthis testudinaria*, Dalman.
5. *Orthis emacerata*, Hall.
6. *Zygospira Headi*, Billings.
7. *Anazyga recurvirostra*, Hall.
8. *Bellerophon bilobatus*, Sowerby.
9. *Murchisonia gracilis*, Hall.
10. *Ambonychia radiata*, Hall.
11. *Orthodesma parallelum*, Conrad.
12. *Lyrodesma*, sp.
13. *Trinucleus*, sp. nov.
14. *Calymene senaria*, Conrad.
15. *Dalmanites* or *Encrinurus*, sp.

Above Ste. Croix, towards Pointe au Platon, the shores of Ste. Croix Bay are generally low and boulder-strewn, and but few ledges are seen. The more westerly trend of the shore as we ascend the river traverses the lower beds of the Loraine or Hudson River formation till near the extremity of the point, which forms the sharp angle of the river below and opposite Port Neuf, where the upper beds of the Utica formation proper appear. These are highly bituminous, brownish-grey shales, with bands of hard dolomitic limestone, containing graptolites, and in character are like the rocks seen on the north side of the gorge below the Montmorency Falls. Only one fossil form was obtained from this point, viz., *Orthograptus quadrimucronatus*, Hall. These beds are very nearly flat or dip to the S. W. $< 2°$. They continue along the shore above the wharf for a mile, above which our measurements did not extend, as the next course of the river traverses the Loraine shales again, repeating the section seen at Ste. Croix. Pointe au Platon, therefore, and the cliffs in the immediate vicinity represent the only typical Utica rocks seen on the south side of the river in this direction. From the fault above St. Nicholas the line of contact there described between the Loraine and Sillery formations extends apparently in a direct line, as indicated on the geological map, 1866, to the Becancour River, where it is seen about fourteen miles above the mouth. On this river the rocks of the newer series are grey sandstones and shales, like those about Ste. Croix, and contain an abundance of fossils of like species, among which were found a *Diplograptus*, resembling *D. Hudsonicus*, a *Crania*, and a *Lingula*, *Orthis testudinaria*, *Zygospira Headi*, *Ambonychia radiata*, and a *Trinucleus* like that from Ste. Croix, besides a branching and frondose species of monticuliporoid coral.

Pointe au Platon.

Fault.

Becancour River.

These rocks are in contact by a fault, with the red, green and black shales and hard sandstones of the Sillery formation, which extend thence up the Becancour to the line of the Grand Trunk Railway at Lyster.

Jacques Cartier River to Pointe-aux-Trembles.

The country bordering the St. Lawrence on the north side from Portneuf, which is opposite Pointe au Platon, to Quebec is well described in the Geology of Canada, 1863. The paced section of the shore during the past season, from the mouth of the Jacques Cartier River eastward, passes over brownish and blackish bituminous shales, holding graptolites, with *Leptobolus insignis*, as far down as a point seventy-five chains west of the wharf at Pointe aux Trembles, where these sediments are immediately underlaid by grey nodular limestones of Trenton age. Throughout this distance the Utica beds are nearly horizontal or range in dip from 2° to 8°, but show several low anticlinals on either side of Ecureuil Point, with several local twistings of the strata. The Trenton beds of Pointe aux Trembles are also thrown into a series of low undulations, the dips ranging from 10° to 20°, but near the northern exposure these become more abrupt, reaching angles of 40°. The contact between the Trenton and the Utica to the east of Pointe aux Trembles is sixty-four chains from the wharf, and is well seen for several hundred yards along the beach, the direction being at this place almost with the course of the shore. The whole exposed breadth of the Trenton anticlinal of Pointe aux Trembles is therefore only 140 chains. The beds at this place are simply a mass of fossils, many of which are beautifully preserved. A few forms only were picked up in our traverse among which were:—

Trenton fossils from Pointe-aux-Trembles.

1. *Heterocrinus simplex*, Hall, var. *Canadensis*, Billings.
2. *Monticuliporoid corals*, several sp.
3. *Leptæna sericea*, Sowerby.
4. *Strophomena deltoidea*, Conrad.
5. *Strophomena alternata*, Conrad.
6. *Orthis testudinaria*, Dalman.
7. *Dalmanites callicephalus* (?), Green.
8. *Calymene senaria*, Conrad (= *C. Blumenbachii*, Brongn.).
9. *Asaphus platycephalus*, Stokes (large sp.).
10. *Ceraurus pleurexanthemus*, Green.

Pointe-aux-Trembles to Cape Rouge.

Below this, to near the contact above Cap Rouge, the shore is generally low and marshy, with great mud flats, strewn with Laurentian boulders, and with points every few hundred yards composed of the same. Occasional ledges of brown and black shales of Utica aspect are seen, which, at about two miles and a quarter above the Cape Rouge contact, shade upward into greyish shales, with beds of greyish sand-

stone of the usual Loraine aspect. These dip south-easterly < 40°-50°, and one mile above the contact, hard, cherty shales are seen, with beds of conglomerate, from the pebbles of which *Orthis testudinaria* and *Leptæna sericea* were collected. Near the contact the beds are black and greyish shales and grey sandstones, which along the line of fault, as above St. Nicholas, are much crushed. The line of fault at this place is beautifully seen on the beach at low tide.

Fault above Cape Rouge.

The rocks on the north side of the St. Lawrence, extending between Ancient Lorette and Cape Tourmente, were more particularly studied by Messrs. Giroux and Ami, who made careful collections of fossils at various points. Among these were Lorette, Charlesbourg, Templeman's Quarry, Montmorency Falls, Ste. Anne de Beaupré and St. Joachim. The distribution of the Trenton, Utica and Loraine formations, as given in the Geology of Canada, 1863, was found to be generally correct.

North side St. Lawrence River below Quebec.

At Ancient Lorette the Laurentian gneiss occupies the bed of the St. Charles River, below the bridge at the gorge, which is reached by a flight of steps from the west bank. The gneiss is here overlaid directly by the Trenton formation, the lower beds of which for several feet are made up of recemented *débris* from the underlying gneiss, and these gradually pass upward into the highly fossiliferous, dark-grey, bituminous limestone. These rocks dip south-easterly < 10°. To the east of the village the gneiss also shows along the north side of the road leading to Charlesbourg for a mile or more. The Trenton horizon of the Lorette limestone is well seen from the following list of fossils collected in a short time from the beds at the foot of the fall, and which have a Black River facies in their lowest portion :—

Ancient Lorette

Trenton rocks on Laurentian gneiss.

Fossils from Lorette.

1. *Prasopora lycoperdon*, Vanuxem (*P. Selwyni*, Nich.).
2. ? *Batostoma Ottawaense*, Foord.
3. *Pachydictya acuta*, Hall.
4. Several other branching *Polyzoa*, indt.
5. *Discina Pelopea*, Billings.
6. *Lingula Philomela*, Billings.
7. *Leptæna sericea*, Sowerby.
8. *Strophomena alternata*, Conrad.
9. *Orthis testudinaria*, Dalman.
10. *Orthis*, sp. nov.?
11. *Skenidium* ?. sp.
12. ? *Zygospira* or N. .G ; This form occurs at Montmorency, both above and below the falls, and at Beauport, Charlesbourg, etc.
13. *Atrypa hemispherica*, Hall.
14. " " var. or n. sp., without plications along the

anterior margin, but marked by a few prominent concentric lines of growth.

15. *Bucania punctifrons*, Emmons.
16. *Bellerophon bilobatus*, Sowerby.
17. *Conularia Trentonensis*, Hall.
18. *Theca*, n. sp. This species occurs in the Black River limestone of St. Joseph Island, Lake Huron, and elsewhere.
19. ? *Ctenodonta dubia*, Billings.
20. ? *Pterinea Trentonensis*, Emmons.
21. *Ambonychia*, sp., with numerous fine flexuous lines radiating from the umbonal region to the anterior margin, where they are most prominent.
22. *Lituites undatus*, Emmons.
23. *Endoceras proteiforme*, Hall.
24. *Primitia Canadensis*, Jones, var. *nana*.
25. *Beyrichia*, sp. nov. ?
26. *Asaphus platycephalus*, Stokes.
27. *Ceraurus pleurexanthemus*, Green.
28. *Calymene senaria*, Conrad (= *C. Blumenbachii*, Brongn.).
29. *Encrinurus vigilans*, Hall.
30. *Dalmanites callicephalus*, Green.
31. *Trinucleus concentricus*, Eaton.
32. *Illænus Milleri*, Billings.

Lorette to Ste. Foye.

The road from Lorette to Ste. Foye shows but few ledges. After descending the slope of the ridge on which the former village is situated, the country is low towards the line of the Lake St. John Railway. A few outcrops of brown bituminous shale were, however, seen in ditches and cuttings, and these were of Utica aspect.

Lorette to Charlesbourg.

From Lorette to Charlesbourg no rocks are seen other than those of the Trenton and Utica formations, with the exception of the ledges of Laurentian gneiss north of the road already referred to. At a small brook about one mile west of Charlesbourg church brown bituminous shales contain *Leptobolus insignis* in abundance, with *Orthograptus quadrimucronatus* and a *Climacograptus*—all Utica forms. Similar rocks are seen fifty yards north of the church, dipping south-easterly at an angle of 40°, and striking almost directly across the road. From these were obtained, in addition to the forms noted above, *Leptograptus flaccidus*, a *Strophomena*, a specimen like one from the Montmorency Falls, *Bellerophon bilobatus*, *Leperditia* (*Primitia*) *cylindrica*, *Triarthrus Becki*—all species of Utica age. About 500 yards north of the church, on the east side of the road, Templeman's quarry is situated in dark-

Fossils.

grey limestone, the beds being nearly horizontal. The limestone strata, which are highly fossiliferous, are separated by thin partings of black shale, an occurrence common to this formation at other points. A natural pit, over eighty feet deep, in the bottom of the quarry, gives a good section of the strata, and the owner stated that the same character of rocks extended all the way to the bottom, or at least as far as he could ascertain, and that he did not know on what the limestone rested, as the bottom of the formation had not been reached. From the beds of the quarry the following species were obtained :— Templeman's quarry.

1. *Pachydictya acuta*, Hall.
2. *Ptilodictya falciformis*, Nicholson.
3. *Prasopora lycoperdon*, Vanuxem (= *P. Selwyni*, Nicholson.).
4. *Crania*, sp. indt., parasitic on *End. proteiforme*.
5. *Endoceras proteiforme*, Hall.
6. *Schizocrania*, or *Discina*, sp.
7. *Lingula riciniformis*, Hall.
8. *Leptæna sericea*, Sowerby.
9. *Strophomena alternata*, Conrad.
10. *Strophomena ?* n. sp., same species as at Montmorency.
11. *Orthis testudinaria*, Dalman.
12. *Calymena senaria*, Conrad.

South of Charlesbourg the slope of the hill to the flat country, as at Loretto, shows ledges of brown bituminous shales of the Utica, with south-easterly dip $< 45°–50°$. Beauport, Parent's quarries.

Near Beauport the Trenton limestone is seen in great ledges along the road leading to Montmorency, in a nearly horizontal position, while the Utica shales, somewhat highly inclined, occur a short distance south of the road. From Parent's quarries, at this place, Mr. St. Cyr, of Quebec, has obtained both Trenton and Utica forms, among the former of which may be mentioned :—

1. *Prasopora lycoperdon*, Vanuxem.
2. *Amplexopora discoidea*, James.
3. *Lingula obtusa*, Hall.
4. *Strophomena deltoidea*, Conrad.
5. *Camerella hemiplicata*, Hall.
6. *Conularia Trentonensis*, Hall.
7. *Orthoceras anellum*, Hall, or a closely allied sp.
8. *Calymene senaria*, Conrad.
9. *Ceraurus pleurexanthemus*, Green.
10. *Asaphus platycephalus*, Stokes.

From the beds of Utica at this place were obtained :—

1. *Schizocrania filosa*, Hall.
2. *Leptæna sericea*, Sowerby.
3. *Lyrodesma pulchellum*, Emmons.
4. *Endoceras proteiforme*, Hall.
5. *Asaphus Canadensis*, Chapman.

Montmorency Falls.

The rocks of the Montmorency Falls, near the junction of the Montmorency River with the St. Lawrence, eight miles below Quebec, have for many years been the subject of geological investigation. The contact of the horizontal beds of the Trenton with the Laurentian is well seen in the river at the brink of the fall and for several miles up the stream, while at the foot of the fall the Trenton beds are almost entirely absent, and the overlying Utica is brought against the face of the Laurentian cliff, which here has a vertical height of about 260 feet, but in a highly inclined position, having a dip of nearly 60°, a state of things which can only have been brought about by a heavy fault. This fault can be traced westward past Beauport, whence it trends to the north-west, and strikes just across the rear of Charlesbourg, the beds at which place have already been described. Carefully located collections of fossils have been made on several occasions, both from above the falls and below in the gorge, but no species known to be older than Trenton have been found, and it seems clear, from the evidence of the fossils and from the character of the sediments, that the conclusions stated by Sir Wm. Logan in the Geology of Canada, 1863, as to the structure at this place, and subsequently by Dr. Selwyn in sundry papers, are clearly maintained.

Contact of Trenton and Laurentian.

Fault.

River above the falls.

Above the falls the bed of the river is composed of true Laurentian gneiss, which is seen on the very edge of the cliff when the water is low, while the banks of the stream on both sides are made up of the Trenton limestone, which is highly fossiliferous. The lowest beds of the Trenton in places consist of a re-composed rock made up of the *débris* of the Laurentian gneiss, cemented with sand and calcareous matter. These beds rest directly upon the gneiss, and frequently fill up irregularities in its surface. They range from a foot to three feet or more in thickness, and shade upward into the fossiliferous limestone of the Trenton, from the lowest beds of which the following species were obtained :—

1. *Pachydictya acuta*, Hall.
2. *Prasopora lycoperdon*, Vanuxem.
3. *Solenopora compacta*, Billings.
4. *Lingula curta?* Hall.
5. *Leptæna sericea*, Sowerby.
6. *Strophomena alternata*, Conrad.

7. *Orthis testudinaria*, Dalman.
8. *Orthis pectinella ?* Conrad.
9. *Anazyga recurvirostra*, Hall.
10. " ? Form not recognized, but very common here and elsewhere, and often referred to *Zygospira modesta*, Say.
11. *Vanuxemia*, sp. indt.
12. *Conularia Trentonensis*, Hall.
13. *Bellerophon bilobatus*, Sowerby.
14. *Bucania punctifrons*, Emmons.
15. *Murchisonia gracilis*, Hall.
16. " *perangulata*, Hall.
17. *Orthoceras*, sp. cf, *O. anellum*.
18. *Harpes*, sp. portion of glabella and cephalon.
19. *Encrinurus vigilans ?* Hall.
20. *Asaphus platycephalus*, Stokes.
21. *Ceraurus pleurexanthemus*, Green.
22. *Illænus Milleri*, Billings.

Ravine below the falls.

In the beds in the cutting on the road west of the bridge and in the cliffs in front of Mr. Hall's house at the head of his steps, *Trinucleus concentricus* is very abundant.

Below the falls the Trenton limestones are almost entirely wanting in the section, the fault having obliquely cut the measures and brought the Utica shales with a thin band of the upper Trenton against the foot of the cliff. Occasional patches of hard sandstone or grit are seen in the lower part of the face of the cliff of Laurentian gneiss, but these appear to be portions of the lowest bed of the Trenton mentioned above, rather than the remains of any older formation, while the cliff is for the most part flanked by the thin limestones and black or brown bituminous shales of the lower part of the Utica. A ravine makes in on the east bank from the front of the fall for some distance, and marks the line of division between the Laurentian and the fossiliferous sediments. From these latter a good collection was made, both from the bottom and the east side of the ravine, among which are recognized :

1. *Hyalostetia*, or similar sponge spicules.
2. *Diplograptus*, sp.
3. *Climacograptus*, sp.
4. *Reteograptus Eucharis*, Hall ; small form.
5. *Orthograptus quadrimucronatus*, Hall.
6. Plate of a *cystidean* or *crinoid*, resembling *Glyptocystites* or *Glyptocrinus*.
7. *Lingula curta*, Hall.

8. *Leptobolus insignis*, Hall.
9. *Leptæna sericea*, Sowerby.
10. *Orthis testudinaria*, Dalman.
11. " ? A form apparently new and occurring in the Trenton and Utica from the Falls to Lorette.
12. *Serpulites dissolutus*, Billings.
13. *Illænus*, sp.
14. *Calymene senaria*, Conrad (= *C. Blumenbachii.*).
15. *Triarthrus Becki?* Green.
16. *Primitia*, sp. Apparently undescribed.

Mr. Ami remarks that the above fauna is pre-eminently Utica in facies, with an evident admixture of a few Upper Trenton species obtained from the lowest calcareous beds which crop out in the ravine. From the presence of certain typical Utica forms, no doubt can exist as to the exact horizon to which the strata there seen belong.

Section from foot of fall to mouth of river.

The section of brown bituminous shales which extends along the north side of the gorge between the foot of the fall and the mouth of the river shows a probable repetition of the Utica beds near the outer extremity, and here the fossils found indicate a Utica horizon similar to that found on the east side of the ravine. These beds are, therefore, repeated by folding or by fault, indications of which latter are seen nearly midway between the foot of the steps and the mouth of the stream. It is also probable that both faults and folds occur in the space between this shore and the Island of Orleans, occupied by the north channel of the St. Lawrence.

The fossils obtained from the soft, brownish marls and disintegrating shales of the point at the mouth are as follows :—

1. *Diplograptus*, sp. indt.
2. *Climacograptus*, sp.
3. *Orthograptus quadrimucronatus*, Hall.
4. *Leptobolus insignis*, Hall.
5. *Endoceras proteiforme*, Hall.
6. *Triarthrus Becki*, Green. Common.

Montmorency Falls to Cape Tourmente.

Further to the east, the Trenton is well exposed at Chateau Richer, from the beds of which much of the rock for the construction of the Lévis forts was taken, and which contains characteristic fossils. These are overlaid by the Utica, and at Ste. Anne de Beaupré the latter is followed by the greyish, sandy shales of the Hudson River or Loraine formation, the beds being similar to those seen at St. Pierre and Ste. Famille, on the north side of the Island of Orleans. At the River Ste. Anne also, at the road crossing, and in the creek three miles east of

St. Joachim, near the cheese factory, the Loraine formation is well displayed. According to the map prepared by Prof. Laflamme the Trenton occurs in limited areas directly upon the gneiss both on Ste. Anne River and on the Friponne, a small stream flowing down the mountain a short distance west of Cape Tourmente. The Utica also occurs on this stream, and a list of fossils from this spot is given in the Geology of Canada, 1863, p. 160. At Cape Tourmente itself the beds resting upon the gneiss consist of about twenty feet of conglomerate, grit and impure limestone, the former cemented by calcareous matter, just as on the Montmorenci, but yielding, in so far as searched, no fossils.

Trenton on Laurentian at Cape Tourmente.

The most important area of Cambro-Silurian and Cambrian rocks, however, is that which occurs to the west of the great anticlinal of Pre-Cambrian strata, and which extends thence to the River St. Lawrence, occupying much of the flat country lying to the south-east of that river. This area embraces a large part of what has been styled in the earlier reports of the Survey the non-metamorphic portion of the Quebec Group, which was divided into the Levis, Lauzon and Sillery formations, all of which belong to lower horizons than those which underlie much of the flat plain contiguous to the river above the village of St. Nicholas, the strata of which, with their characteristic fossils have just been described.

Sillery and Lévis formations.

Descriptions of many of these rocks have been fully given in the publications of the Survey, enumerated on pages 2–3. They present a great similarity of aspect throughout their entire extent, not only to the extremity of the Gaspé Peninsula at Cape Rosier, but even on the Island of Newfoundland, where they are well developed, and where favorable facilities are afforded, especially in the northern part of the island, for deciphering the peculiarly complicated structure of this group. They have been carefully studied there, first by Mr. Jas. Richardson in 1859-62, and subsequently by Mr. A. Murray, C.M.G., for some years director of the Geological Survey of the Island, whose map, published in 1877, contains the latest information bearing on this question as regards that locality.

Newfoundland.

With the object of rendering as clear as possible the many conflicting statements which have arisen concerning the horizon and stratigraphical relations of this peculiar group of rocks, a brief abstract of the views held from time to time by the several observers in this field is here regarded as desirable.

The earliest account of the rocks around Point Lévis and Quebec is found in a paper by Dr. J. Bigsby, read before the Geological Society of London, December, 1827. They are there described as "1st, a slaty series, composed of slates and grauwacke, occasionally passing into a brown limestone, and alternating with calcareous

Dr. T. Bigsby, 1827.

conglomerate in beds, some of which are charged with fossils; 2nd, a conchiferous brown and black limestone, sometimes based upon a calcareous conglomerate; 3rd, Gneiss." The author's chief reason for supposing the slaty series superior to the limestone is that "the latter is, in some situations, in immediate contact with the gneiss, while at others it passes into beds of the first series above mentioned, the conglomerate of which contains organic remains derived from the conchiferous limestone." The slaty series is said to "occupy the whole of the southern shore of the St. Lawrence, the Island of Orleans, and a considerable portion of the north bank of the river, including the ridge upon which Quebec is placed. In that neighborhood the mass of the deposit consists of a black and brown slaty limestone, inclined at very high angles, and alternating with semi-crystalline limestone and various conglomerates. The limestone contains several varieties of crystallized carbonate of lime, intermixed with quartz crystals and occasionally traversed by seams of bituminous matter, and near Cape Rouge and on the Plains of Abraham and Kilgraston, some of the strata consist of red and green clay slate. In the calcareous conglomerate, organic remains are mixed with fragments of clay slate, and the beds alternate with compact grey limestone and quartzose layers."

Earliest description of the rocks about Quebec.

"On the south side of the St. Lawrence, the slaty limestone of Quebec is no longer seen, but several new beds of conglomerate present themselves, one of the lowest of which contains trilobites, encrinites, corallines and other fossils, associated with vegetable impressions, probably of *fuci* and *amansiæ*."

"In the schistose beds near the mouth of the Etchemin are thin seams of coal. The horizontal conchiferous limestone is included between the slate series and the gneiss."

From the character and fossils of the limestone above described, Dr. Bigsby concluded it was the equivalent of the Carboniferous limestone of the English geologists.

Capt. Bayfield, 1843.

In a paper by Capt. Bayfield, R. N., published in the *Geological Journal*, 1845, on the transition rocks of Canada, the author states that "the Silurian limestone was traced from Lake Huron, where it contains the characteristic fossils of that formation, eastward across the Ottawa to Quebec, and was seen at various intermediate points along the north side of the valley of the St. Lawrence. The limestone at Pointe aux Trembles, six leagues above Quebec, contains, among other fossils, *Calymene Blumenbachii* and a species of *Chætetes*, which M. DeVerneuil informs me is allied to *C. petropolitana*. The limestone here dips to the south-east, conformably to the grauwacke which contains *Leptæna sericea* on the opposite side of the river. This latter

circumstance, together with the statements of an anonymous writer in the Canadian Review, that the limestone near the Falls of Montmorency declines gradually from the horizontal position till it finally dips at a high angle beneath the grauwacke on the opposite or south side of the river, and that a conglomerate, wholly composed of re-cemented fragments of limestone, containing the organic remains peculiar to Beauport, the Falls of the St. Charles and Indian Lorette, is one of the alternating members of the grauwacke or slate series, inclines us to assign to this limestone a position inferior to the grauwacke and slate, and low down among the Silurian strata. Considerable difficulty has been felt in admitting this, because the limestone has so very generally been found in nearly horizontal strata, resting immediately upon primitive rocks, in very near neighborhood to the highly inclined grauwacke and slate, but on the other hand it must be remarked that it has never, so far as we know, been found overlying the latter conformably."*

Early views of Sir W. Logan, Rep. Prog, 1843.

The first notice of these rocks on the part of the Geological Survey appears in the Report of Progress for 1843, published in 1845 by Sir William Logan, when the view was expressed that "the rocks of Point Levis came out from beneath the limestone of the St. Lawrence, and belonged to an apparently older horizon;" but in a foot note it is stated that "the bulk of evidence points to their superior position, which would make them the equivalents of the Hudson River and Loraine shale formation." In Report of Progress 1844, pp. 17-30, the characters of the several groups of rocks, which occur along the south side of the St. Lawrence, are very fully given under the head of conglomerate limestone, pillar sandstone and graptolitic shales, more particularly for that portion of the coast east of Cape Chat, and the statement is made on page 19 that there are "indications that as the south side of the St. Lawrence continues to present up to Quebec the same slightly oblique course to the run of the ridges, it is not improbable other divisions may crop out above Cape Chat which have a lower geological position than the strata in its vicinity," and on page 21, in speaking of the coaly matter which occurs in these strata and which was at that time thought by certain persons to be indicative of the presence of coal in this group, it is stated that "the rock containing it is supposed to be the equivalent of a part of the Hudson River group of the New York Geologists."

Rep. Prog, 1844.

Rep. Prog, 1847-48.

In Report of Progress, 1847-48, p. 57, the following statement is made regarding the age of the metamorphic portion of the Eastern Townships rocks: "The facts which have been detailed in the eluci-

* The slaty rocks of Quebec city, at that time supposed to be the same as those of Lévis, have recently been stated to underlie the limestone uncomformably by Mr. Jules Marcou.—A. R. C. S. See Memoirs Boston Nat. Hist. Soc., Vol. IV., 1888, plate fig. 8.

dation of the structure of the Green Mountains in their Canadian prolongation, would appear to make the plumbaginous sandstones and titaniferous red slates of the Seraphine range, in the seigniory of St. Hyacinthe, which are within a mile and a half of the Trenton limestone of that vicinity, equivalent to that of Granby; and these rocks, with their chromiferous calcareo-chloritic bands, to the dolomites and chloritic quartzose rocks of Kingsey, Shipton and Sutton; these again to the serpentine and quartz rocks of Potton, from which it would follow that the whole of the Green Mountain rocks, including those containing the auriferous quartz veins, belong to the Hudson River group, with the possible addition of the Shawangunk conglomerates." In their extension, it is stated on page 58 that "these recognized rocks of the Hudson River group have a continuous run from Lake Champlain along the south bank of the St. Lawrence to Cape Rosier."

Rep. Prog, 1849. In the Report of Progress, 1849, p. 18, a similar view is expressed under the head of Economic Materials, in connection with the reported presence of coal at Murray Bay and Bay St. Paul. The statement is there repeated that "a band of calcareous rocks of the age of the Trenton limestone of New York, which is well ascertained to be far below the Carboniferous deposits of North America, carried its outcrop in a continuous line from Grenville, on the Ottawa, to Beauport, below Quebec, on the north side of the St. Lawrence; and that another formation, contemporaneous with the Hudson River of New York, superior to the Trenton limestone, but also far beneath the same Carboniferous deposits, extended from Point Lévis to Cape Rosier." On page 32, the description of the series of rocks, which is stated to occupy the greater part of the country east of the Richelieu between the mountain belt and the St. Lawrence, may be given in condensed form as follows:—

1. Dark grey shales, interstratified with grey thin-bedded sandstones, often calcareous, and weathering yellowish-brown, and with grey, yellow weathering limestones. This series is fossiliferous, and holds shells and graptolites, and appears to be terminated by a set of bituminous shales and black limestones.

2. Grey, green and occasionally red shales with thin calcareous layers, with possibly a considerable deposit of red shale occasionally at top of the series. These shales appear occasionally to hold bands of calcareous conglomerate, cracks in which are filled with indurated bituminous matter.

3. Hard sandstones, varying in color from light grey to iron grey and sometimes slightly greenish; fine-grained and bedded, coarse-grained and massive; occasionally a conglomerate, the pebbles of which are frequently composed of Trenton limestone and contain Trenton fossils, sometimes these rocks are so calcareous as to be burnt for lime.

4. Red and green shales, which are frequently interstratified with bands of light grey fine-grained sandstone, frequently calcareous.

5. Coarse-grained green sandstone, with scales of mica and spangles of plumbago, interstratified with red and green shales. The color of the sandstone appears to be due to the presence of chlorite; but red layers as coarse as the green, and holding nearly as much chlorite, are in some parts interstratified. The beds of both colors, which are almost always massive, are in general calcareous and often present bands of coarse conglomerate, with quartz pebbles, which sometimes appear to become mingled with pebbles and even boulders of grey limestone holding fossils, probably of the Trenton formation.

These rocks, in a highly metamorphic condition, were also, at that time, stated to constitute the mountain belt, "the inferior bituminous shales becoming plumbaginous slates, the grey sandstones being probably converted into quartz rock and talcose quartz slates, and in relation to this siliceous zone, there appear to be, in the metamorphic district, two magnesian belts shewing dolomite and serpentine, the equivalents of which in the unaltered rocks require farther investigation; the red slates and green sandstones seem to become chloritic, epidotic and ferriferous slates and less schistose forms of rock, and from the geographical position of what have been called the Corneous rocks, it appears not improbable they may be referable to this part of the deposit; but a larger number of facts must be ascertained before the various divisions of the metamorphic rocks can be clearly traced to their unchanged equivalents. The whole belong to the Lower Silurian age, and they are followed by others, which are shown, by the fossils held in some parts, to be Upper Silurian."

In the Report of Progress for 1852-53, the only reference to rocks of the Quebec Group is in regard to the mass of red and green shales, with the green sandstones, which extends from Cape Rouge along the river to Point à Pizeau, the age of which was supposed to be that of the Oneida conglomerates of the New York series. These rocks, which extend back from the river in the direction of Ste. Foye, were held to overlie the calcareous conglomerates, sandstones and black shales of the city and cliffs of Quebec, or their supposed equivalents, the rocks of Point Lévis, across the river, which were again held to be above the Trenton-Utica beds of Pointe-aux-Trembles, or to be about the horizon of the Loraine shales. Rep. Prog, 1852-63.

In connection with the Paris Exhibition of 1855, a small volume, "Esquisse Géologique," relating to the Geology and Mineral wealth of Canada, was published by Logan and Hunt, in which, on page 49, it is stated that "an anticlinal axis divides the palæozoic formations of Canada into two basins. Upon the line of this axis the most recent Esquisse Géologique, 1855.

formation, except the tertiary strata, is the lower part of the Hudson River Group, known by the name of the Loraine or Richelieu shales. In the valley of the Yamaska, an outcrop of Trenton limestone marks the anticlinal which separates the two basins. Not far to the east of this limestone, a series of sedimentary rocks which constitute the upper part of the Hudson River Group, is found, resting on the Richelieu shales, but which does not exist in the western basin, from which they have probably been removed. This series is composed of massive sandstone, greyish, often calcareous, associated with grey slates, green and red, toward their upper portion, and with other black shales, bituminous and graptolitic. In some portions of this formation the sandstone becomes a conglomerate and encloses large fragments of the lower fossiliferous formations. More often, however, the sandstones pass into a bituminous limestone,.....which contains fossils. This limestone is interstratified with siliceous and bituminous dolomite, which weathers yellow and contains carbonate of iron, and the dolomite seems in places to be replaced by a ferruginous and siliceous carbonate of magnesia. These are the rocks which form the cliffs of Quebec and Point Lévis, and have a thickness of over 300 metres."

"This formation at Quebec is succeeded by red and green shales, with thin bands of calcareous matter, and intercalated towards the summit with great masses of quartzose sandstone, often calcareous, and colored by a mixture of argillaceous matter which is greenish or reddish. This series of sandstones and shales, which has a total thickness of 1000 metres, has been named by Logan, the Sillery group, and appears to be the equivalent of that which has been named by the New York geologists the Shawangunk or Oneida Conglomerate, which in Central New York lies between the Richelieu shales and the Medina sandstone."

The comparative absence of organic remains in the Sillery formation was at the time noticed, these being principally confined to what was regarded as coprolitic matter, which was also held to occur with the graptolites of the underlying shales of Point Lévis.

These rocks were stated to extend to the extremity of the Gaspé Peninsula, and to be overlaid unconformably by over 2000 feet of fossiliferous Upper Silurian sediments, which in turn were followed by the Devonian and Carboniferous formations of the Bay of Chaleurs area. The whole was supposed to form a gradually ascending series from the Trenton limestone of the vicinity of Quebec to the Carboniferous of New Brunswick.

On page 56 *Ibid*, in the chapter on the Metamorphic Rocks it is stated, "that the rocks of the mountain region have been much metamorphosed and rendered crystalline by chemical action, so that the fossils are no longer recognizable. The rocks thus metamor-

phosed belong to the Hudson River group and to the Sillery formation." And again: "The changes which these sedimentary beds have undergone are often very remarkable, some of them passing into chloritic, micaceous and talcose schists, others into felspathic, hornblendic and epidotic rocks."

Prof. James Hall, 1855.

In 1855, Prof. James Hall presented his report on the series of graptolites collected at Point Lévis in the preceding year. This was published in the Geological Survey Report, 1857, in which the various graptolites of that locality are considered as belonging to the Hudson River group.

Conclusions arrived at by Mr. E. Billings.

During the years 1856-57, extensive collections of fossils were made from the rocks at Point Lévis, as well as from what were regarded as their equivalents near Philipsburg on the lower part of Lake Champlain and about Missisquoi Bay. These comprised not only graptolites but a considerable series of trilobites and other organic remains, the systematic study of which was undertaken by Mr. E. Billings. The result of his examination showed that, while the greater portion were new species, of those that were determinable, five were known in the Chazy limestone, and twelve in the Calciferous rocks of the Ottawa Valley, while the aspect of the undetermined species indicated rather the base than the upper portion of the Lower Silurian, as had so long been supposed. The conclusion was therefore reached by Billings that these rocks belonged really to the base and not to the summit of the Champlain division, and that the Lévis rocks were really older than the Trenton limestone.

Logan's views of the structure about Quebec, 1860-61.

These conclusions were first announced by Sir W. Logan in a letter to J. Barrande, and published in *Canadian Naturalist* December 31, 1860, vol. v., p. 472, and subsequently in the *American Journal of Science*, II, vol. xxxi, March, 1861, where the opinion was expressed that "this series of rocks, to which the name 'Quebec group' was now applied for the first time, represented a great development of strata about the horizon of the Chazy and Calciferous, brought to the surface by an overturn anticlinal fold, with a crack and dislocation running along the summit, by which the Quebec group is brought to overlap the Hudson River formation."

Course of the great fault.

The fault by which this overlap is produced is said to "come to the boundary of the province, not over a couple of miles from Lake Champlain. From this it proceeds in a gently curving line to Quebec, keeping just north of the fortress. Thence it coasts the north side of the Island of Orleans, leaving a narrow margin on the island, of the Hudson River and Utica formations. From near the east end of the island it keeps under the waters of the St. Lawrence to within eighty miles of the extremity of Gaspé. Here it again leaves a strip of the Hudson River or Utica on the coast."

Supposed age of the Quebec group, 1861.

It was there further stated that "the rocks along the south side of the river are arranged in a series of parallel synclinals, with many overturn dips, separated from one another on the main anticlinal by dark grey and black shales and limestones." From the fact that these shales and limestones, formerly regarded as of Hudson River age, apparently separated the synclinals of the Quebec group rocks, it was supposed that these must be considered older, and it was suggested that "the shales and limestones which may be subordinate to the Potsdam may represent the true primordial zone of Canada." In Vermont these rocks which were there recognized as the equivalent of the magnesian portion of the Quebec group, had long been regarded by Emmons as older than the Bird's Eye formation, a point now considered to be very fairly established by the new discoveries made near Quebec.

First division of the Quebec group.

With the new fossil evidence thus obtained, the history of the Quebec Group, by which name this series of rocks has since been known, assumed at once an entirely new aspect. The five divisions of the grauwacke series, given in Report of Progress for 1849, were now divided into two portions, of which the four first were styled "the Lévis formation," while the last was called "the Sillery." The details of the former are given in Geol. of Can., 1863, p. 227-29, where it is sub-divided into seventeen parts, having a total supposed thickness of 5,025 feet, at the summit of which was placed a series of greenish sandstones and red and green shales called the Sillery, with a total thickness of about 2,000 feet.

Views of Prof. Jules Marcou, 1861.

The published correspondence between Logan, Hall and Barrande called forth a reply from Prof. Jules Marcou, in a letter addressed to Barrande, and published in Trans. Boston Nat. His. Soc., 1861, in which marked exception was taken to the new views of Logan. In this letter Prof. Marcou discusses the age of the rocks of northern Vermont and their extension into Canada about Philipsburg, regarding these as of the age of the middle portion of his Upper Taconic, and "far below the Potsdam sandstone."

As the result of his study of the rocks about Philipsburg, Marcou claimed that the limestones of that vicinity as well as those of Highgate and Swanton, in Vermont, occurred simply as lenticular masses, with a framework of slate enclosing them, and that there appeared in the series a blending of the first and second faunas of the primordial zone. This peculiarity, he considered, was an illustration of the theory of colonies, first put forth by Barrande in Bohemia, by which colonies of the second fauna were enclosed in strata which contained the first, and he proposed to call these colonies, which were confined principally to the lenticular masses, "Precursors of Creation," that is the occurrence of species or generic types which received their full development only during the following period.

The same peculiar conditions of structure were held by him to apply to the rocks of Point Lévis and vicinity; the red, brown, green and black shales, with thin beds of sandstone, being held to represent the lower part of the Upper Taconic.

Prof. Marcou's theory of "colonies."

The theory of colonies held by Marcou to apply to the Philipsburg rocks was also extended to those of Point Lévis, two zones being established in this locality, of which the primordial fossils were principally obtained from a mass of limestone found on the Harlaka road in rear of the church of St. Joseph, and styled by him the "*Redoubte.*" This lenticular mass was regarded as a *lenticular primordial* of about the same age or a little younger than the lenticular primordial found in the Georgia slates of Swanton, Vt. The associated slates, limestones and magnesian conglomerates were considered to be a little higher in the series than the Georgia slates which represented the lower portion of the Upper Taconic.

His views of the structure of the Quebec and Lévis rocks

The presence of three other *lenticular primordials* in rear of Point Lévis, which occur between what is now the cemetery and the Main street, was noted, and it was claimed that these contained fossils which represented centres of creation or colonies pertaining to the second fauna, while the strata, together with the graptolitic shales and associated beds which extend to the shore of the river, were held to constitute the Point Lévis group, and to be contemporaneous with the Philipsburg group of Vermont and Missisquoi county.

The rocks of the city and citadel of Quebec, and of the plain in which Beauport, Charlesbourg and Indian Lorette are situated, consisting largely of black shales, holding, in places, large boulders of limestone, were regarded by him as the equivalents of the Swanton slates of Vermont.

The views of Logan as to the complicated and folded structure of the rocks in rear of Point Lévis were not admitted by Marcou, who held that there was "no repetition of beds in this locality, and no synclinal axes," "and that the few foldings in the cliffs near the ferry are mere accidents, confined to a distance of a few feet, and without any effect upon the whole mass of the strata." The apparent discordance in direction between the slates and the limestones, at their contact, was held to be due to the globular form of some of the lenticular masses of the limestone which were enclosed, "the slates following the direction of the globular mass instead of running in a straight line, which gives to the whole, at first view, a sort of discordance of stratification which in truth does not exist."

Billings' reply to Marcou.

This letter of Marcou's drew forth a reply from Billings which appeared in the Can. Nat. 1863, vol. viii, in which he paralleled the strata of the fossiliferous Quebec group with those of the Llandeilo of

Similar rocks in Australia and England.

England and Australia, and with the Chazy and Calciferous formations of America, and showed conclusively, from a careful examination of the large collections of fossils from various points in the group that their position was really in the lower part of the Lower Silurian, instead of the upper where they had long been placed, on the one hand, or in the Primordial, beneath the Potsdam, on the other hand, as was maintained by Mr. Marcou. This view of Billings was concurred in by the leading English and Australian geologists who had found precisely similar forms in the strata of both countries where they could be definitely located. As for the occurrence of Chazy and Calciferous forms, Billings found that none of these occur in the neighborhood of Quebec, but that, in what he regarded as the equivalents of the group in Newfoundland, in the east, and near Philipsburg in the west, a few species found in both these formations were observed in the upper and lower beds respectively. He regarded the group as a "peculiar development of strata, the upper limit of which can scarcely be newer than the Black River, while the lower horizon is probably not far from the middle of the Calciferous."

Their Lower Silurian age asserted.

Geology of Canada, 1863.

In the Geology of Canada, 1863, p. 225-97, the views regarding the structure and stratigraphical position of the several rock formations which were then known as the Quebec Group are given in great detail. Their exact horizon is not however clearly defined, since "while from their geographical position, apparently superior to the Hudson River formation, these rocks belong in reality to an older group, which is developed to a great extent in Eastern Canada, and presents somewhat different characters in the various parts of its distribution." As the rocks were still under examination, the views there expressed were liable to modification as new facts might be brought to light. The group was divided into the Lévis and Sillery formations.

Thickness and character of the Lévis division.

Of these, the Lévis, which was held to compose the bulk of the group, was supposed to have a thickness of 5025 feet, and was subdivided into seventeen parts, in ascending order from the series of green and purple calcareo-magnesian and fucoidal shales, with limestone conglomerates at the base, to the red and green shales and sandstones which were supposed to shade upward into the overlying Sillery formation, provided the series was not an inverted one, of which however there appeared to be no definite proof, unless it might be the presence of an *Obolella*, which had the aspect of a Calciferous form in some of the shales of the supposed upper portion. As regards the position of the Sillery, it was there stated that "at the summit of the Lévis is an apparently interstratified series of greenish, drab-weathering sandstones with associated shales of different colors. In their upper part, the sandstones exceed the shales, varying in character from fine to

Supposed upper position of the Sillery.

coarse, containing small pieces of black and green shales, and with quartz pebbles, generally of small size and occasionally passing into a well defined conglomerate." "The sandstones are sometimes micaceous, with small spangles of graphite. They are frequently massive, the sandy layers being separated by partings of reddish and greenish shales, and are supposed to have a total thickness of about 2000 feet."

The distribution and characters of the rocks of this group are given in the volume above cited, throughout their whole extent in Canada, from their first appearance, north of the Vermont boundary to the extremity of the Gaspé peninsula, and the supposed positions of several anticlinals, by which the structure was rendered exceedingly complicated, were defined. As in the earlier reports, the great area of crystalline schists and associated rocks of the interior or mountain portion of Eastern Quebec was regarded as the metamorphic equivalent of the fossiliferous sediments of the vicinity of the St. Lawrence; that portion which is now held to constitute the oldest member of the townships series, viz., the Sutton Mountain Range, being supposed to represent, if not the whole, a portion at least of the Sillery formation. This aspect of the question has been discussed in the Report for 1886, but more fully in earlier papers by Dr. Selywn, see p. 8. In regard to the structure of the Shick-shock Range in the eastern section, while, as in the case of Sutton Mountain, it was regarded as a synclinal, it was not held to be necessarily of Sillery age, but might represent some of the finer masses which overlie the limestone conglomerates of the Lévis.

Supposed age of the crystalline rocks of the interior.

To the south-west, the group was made to include the series of limestones and shales about Philipsburg, together with the conglomerates, composed largely of their debris, the former of which had been regarded by Marcou as Primordial, and these were supposed to represent the lowest portion of the Lévis division. They here rest upon the Potsdam formation of this locality, known in part as the red sandrock of Vermont. The structure at this point is exceedingly complicated and has been a fruitful source of controversy.

Age of the Philipsburg rocks.

To the east, in Newfoundland, the sequence appeared to be more regular, the strata being in a nearly horizontal attitude over considerable areas, and much greater facilities are, in consequence, afforded for the study of the several formations. The characters of the various beds and their relative order of sequence, as shown along the shores of Belleile Strait, are given on pp. 287-93 (Geol. of Canada, 1863) from which it appears that the Laurentian gneiss, etc., of the north side of the strait is overlaid by the Potsdam formation, representing the red sand rock of Vermont and the Beauharnois sandstone, with an aggregate

Sequence in Newfoundland.

Thickness of the several divisions in Newfoundland.

thickness of 624 feet. This is succeeded in ascending order by the Calciferous limestones, etc., with a thickness of 1570 feet, which in turn are followed by a series of rocks, the Point Rich limestones, the position of which, as compared with the beds of Quebec, appears uncertain, but which in character and position are very closely allied to the Philipsburg limestones, and which have a total thickness of 1010 feet. These are succeeded by a series of grey sandstones and shales with limestone conglomerates, which are the undoubted equivalents, both in fossils and position, of the Point Lévis rocks, as well as of some portions of those near Philipsburg, with a thickness of 1400 feet.

To these apparently succeed the greenish sandstones and associated shales which represent the Sillery in this direction, and which were presumed to constitute the upper portion of the Lévis formation. As, however, the beds near their contact are tilted at a high angle, this apparent position is not fully established, as the next rocks in the sequence are those of the metamorphic series, so that it is possible that, by an overturn, the Sillery, which in places comes against the metamorphic rocks, may be properly regarded as a lower portion of the Lévis instead of an upper. Or possibly, what may be quite as likely, two distinct series of sandstones and quartzites, presenting considerable points of resemblance, have been confounded and both placed in the Sillery formation, of which one may really represent the upper part of the Sillery proper, in accordance with the supposed apparent structure at many points, while the other may belong to the underlying formation.

The age of the group near Quebec is again stated (see p. 233, Geology of Canada, 1863) to "be about the horizon of the Chazy and Calciferous formations. The strata are brought to the surface by an overturn anticlinal fold, with a crack and great dislocation running along its summit, by which the group is made to overlap the Hudson River formation."

Quebec group divided into Lévis, Lauzon and Sillery, 1866.

Subsequently (see Report of Progress, 1866, p. 4), for convenience, the Quebec group was divided into three parts—a lower, middle and upper—known by the names Lévis, Lauzon and Sillery, the lower of which was held to contain the Philipsburg limestones, the black slates above them, and that portion of the Levis shales and magnesian conglomerates included in the numbers 1–9 of the Orleans Island section described in Geology of Canada, 1863, p. 227. This lower division was distinguished by its general black and dark color, and furnished nearly all the fossils found in the Quebec group.

Lauzon, character of rocks.

The middle or Lauzon comprised the remaining divisions of the section mentioned above (Nos. 10-17). This was held more especially to comprise rocks of red, green and purple colors, poor in fossils, only three being known at that time, two *Lingulæ* and one *Obolella*, which

occurred near its summit, and in its metamorphic condition it was characterized by the ores of the more valuable metals. Near the base a mass of greenish glauconite shales occurs locally both on the Island of Orleans and at Point Lévis, while to the westward, the rocks appeared to be more magnesian than in the vicinity of Quebec. In this direction it was held that the black shales and limestones of the Lévis series were often immediately succeeded by a thick mass of dolomite, associated with diorite, the former of which, in the more metamorphic portions, was supposed to be replaced by important masses of serpentine, with soapstone and potstone. These magnesian deposits were also supposed to occur at two horizons in the Lauzon—one at the base, the other at the summit, and both were held to be accompanied by metallic ores. Sandstones, often a hard quartzite, occur as interstratified portions of both the Lauzon and Lévis divisions, and have often a considerable thickness. Many of these, while presenting features resembling the Potsdam sandstones, are clearly interstratified portions of the so-called Lévis formation. Metalliferous zones.

The characters of the unaltered Sillery have been already given. In their altered condition these were still supposed to constitute the great bulk of the chloritic and epidotic schists and quartzites, and to pass, towards their summit, into more or less perfect gneiss. Considerable difficulty having been found in separating the magnesian bands at the summit of the Lauzon from the Sillery division, since the line of division came naturally between this band and the other rocks of the Lauzon beneath, it was regarded as most expedient to include the upper magnesian band in the base of the Sillery formation. The same view of the age of the gneisses of the Sutton Mountain section, as the altered portion of the Sillery with a synclinal structure, was expressed by Dr. Hunt. (See *Canadian Naturalist*, vol. vii, 1862.) Character of the altered Sillery.

In Pal. Fos., 1861-65, p. 69, the occurrence of *Obolella pretiosa* is mentioned in a series of olive and greenish slates at the Grand Trunk Railway bridge over the Chaudière River, as well as in similar slates at Cape Rouge. These slates are stated to be interstratified with the Sillery sandstone as an upper part of the Quebec group, but the question as to whether this is their true position was left an open one. This specimen and a species of *Lingula* were the only fossils at that time known from the Sillery formation. The new views expressed as to the age of the Quebec group, resulting from the finding of such an extensive series of fossils, evidently gave rise to much confusion relative to the interpretation of the structure of the group, a fact clearly revealed by reference to the correspondence between Barrande, Hall and Logan, already referred to, the tendency at first being apparently to put the great bulk of these rocks into the Primordial zone, owing to Pal. Fos., 1861-65. Fossiliferous slates of the Chaudiere.

the presence of so many species of Primordial aspect. This tendency was, however, to a large extent corrected by the able work of Mr. Billings and by the more careful collecting of fossils. The results of his examination of the many new species found in the Lévis rocks are stated in detail inPal. Fos., vol. i, p. 57-96, where a full discussion of the subject from the palæontological standpoint is given. The conclusion therein arrived at regarding the age of the group was "that the true place of the Lévis formation is between the Potsdam and the Trenton, and not below the Potsdam, as still maintained by some observers." At the same time he pointed out the perfect identity of the species found in the slates and limestones of Cow Head, Newfoundfoundland, where these rocks had been studied by Mr. Richardson in 1862, and later by Mr. Murray, with those found in the rocks of Point Lévis; as also the fact that the fauna from other points in the vicinity, while somewhat different, was closely related, indicating that they could be placed in the Quebec group, though not in the Lévis formation.

Conclusions of Billings as to the position of the Lévis, 1865.

Subsequently, in the consideration of the fossils from the northwest coast of Newfoundland, the parallellism between these rocks and those of Point Lévis is stated by Billings to be so close that there is no doubt the strata of the two localities belong to the same horizon. Owing to the greater horizontality of the measures, the facilities for deciphering their true structure were supposed to be much greater than at Point Lévis and the sections given in the Geology of Canada, 1863 were re-cast, and may be given in a condensed form, as follows:

Rocks of the group in Newfoundland.

	FEET.
Quartzites, limestones, dolomites and slates of Potsdam age....	2,020
Magnesian limestones, dark grey and blackish grey limestones, representing the Calciferous formation.....	1,839
Light yellowish grey, grey and whitish, magnesian limestone, bluish-grey and black bituminous limestone, representing the intermediate beds between the Calciferous and Lévis, Upper Calciferous.....	1,361
Grey calcareous sandstones and black slates, also intermediate beds.....	700
Grey and white limestone conglomerate, black shales, etc., the shales holding the graptolites of the Levis shales, the conglomerates, the trilobites and other fossils of the similar rocks of Point Lévis.....	700
According to Billings, these are the true equivalents, of the Lévis shales and conglomerates.	
Greenish sandstone and red shales, Sillery.....	2,000

In Geol. Can. 1863, p. 879, a further comparison is made between the rocks of the Quebec group as seen in Quebec and their development

in Newfoundland, from which we learn that the lower portion or Potsdam of the latter locality is, from its lithological characters and the presence of *Paradoxides*, held to be clearly the equivalent of the red sand rock of Vermont. The graptolites, simple and compound, of the upper part of the section also leave but little doubt that these strata are the equivalents of those of Point Lévis, while at the same time the presence of *Maclurea ponderosa*, a thick-shelled and peculiar gasteropod, is common to these as well as to the Stanbridge conglomerates east of Philipsburg. The limestones of div. 2 (see above) contain fossils of Calciferous age and can be assigned to the base of that formation, while those of Philipsburg would belong to its summit. This clearly establishes the fact that the Philipsburg and Stanbridge series are newer than the red rock of Vermont, a view which is not contradicted by the stratigraphy or structural arrangement in the vicinity of Philipsburg. It follows from a consideration of the facts just presented, as is pointed out by Billings, Pal. Fos. p. 65, that "the rocks of Point Lévis, viz., the Point Lévis conglomerate limestone and graptolitic shales, are at least 2000 feet above the true Calciferous formation." From the fossils alone, he says, he "should judge that the Lévis formation immediately succeeds the Calciferous, though the physical evidence seems to show that this is not the case."

Comparisons between Quebec, Newfoundland and Philipsburg.

Position of the Lévis in regard to the calciferous.

Further, if we consider the section of the rocks of Philipsburg and vicinity (pp. 844-46, Geol. of Canada, 1863) we find that the conglomerates of Division D., which are elsewhere stated (p. 852) to be the Stanbridge conglomerates, are made up of the debris of the limestones constituting the upper part of division C. of the Philipsburg series, and regarded (see above) as of the Upper Calciferous horizon. This, of necessity, would place a physical break of considerable extent between the Upper Calciferous formation and the Lévis conglomerates; and as we have seen, from the statements and comparisons just made, that the conglomerates of Lévis, Stanbridge and Cow Head, in Newfoundland, are all of the same horizon, we must infer that those of Lévis, together with the associated graptolitic shales, are superior at least to the Upper Calciferous limestone of the Philipsburg series.

Further comparisons between Lévis and Philipsburg.

In support of the views just expressed, the paper by Billings (see *Canadian Naturalist*, 1861, vol. vi, p. 310), "on some of the Rocks and Fossils occurring near Philipsburg, C.E.," may be cited. These rocks are there divided into two series, "1st, Magnesian Limestone and Underlying Slate; 2nd, Blue thin-bedded and nodular limestone. The first division which constitutes the lower beds of the series, is found along the eastern side of Missisquoi Bay, and consists of "magnesian limestone, often arenaceous" and with quartz veins, interstratified with nearly pure limestone; also limited areas and lenticular masses of hard white or

Rocks of the Philipsburg, views of Billings.

yellowish-white sandstone, intercalated with the limestone. The thickness of the series is estimated to be not much less than 400 feet. Succeeding these are the thin-bedded, dark-colored limestones of No. 2, in which have been found about forty species of fossils which show this part of the limestone series to be the equivalent of the upper part of the Calciferous sand rock. On p. 315 *ibid.* he shows that the fossils from division, No. 2 agree very closely with those from the limestone No. 2 of Lévis, and establishes by this fact that the general aspect of the whole of the fossils from the two localities is the same, while at least one-half of the speices are common to both, and then states clearly that "he holds limestone No. 2 of Philipsburg to be the equivalent of limestone No. 2 of Lévis. This statement would undoubtedly hold good were the Lévis fossils obtained from the matrix of the rock. But in *Canadian Naturalist*, 1860, vol. v, p. 301-02, in enumerating the fossils from the Lévis limestone, he says: "All the specimens described in this article were found in the conglomerate limestones near Point Lévis, opposite Quebec. It is not yet decided whether the fossils occur in the boulders of the conglomerate or in the matrix."

Philipsburg conglomerates of same horizon as those of Lévis.

That these fossils are, however, in many cases at least, clearly in the pebbles as distinct from the paste of the conglomerates is evident, and it is from this apparent neglect to distinguish between the limestone proper and the limestone pebbles of the conglomerate that much of the confusion and uncertainty appears to have arisen. This is also, to some extent, doubtless due to the early statement of Sir Wm. Logan, in Can. Nat., 1860, vol. v, p. 472, that he had satisfied himself, "notwithstanding the conglomerate aspect of the bands of rock which contain our new fossils, that the fossils are of the age of the strata."

Fossils from the pebbles of the Lévis conglomerates.

It must be remembered, however, that the problem was not even then considered as conscluisively solved, and subsequent researches have shewn that some at least of the fossils found at Lévis in the pebbles of the conglomerate are of the age of the Upper Calciferous limestones, from the débris of which the conglomerate are partly made up. This fact therefore must of necessity assign both the Stanbridge and the Lévis rocks to a later period.

Such, in brief, is the history of this interesting group of rocks down to the year 1868. In the meantime, Mr. A. Murray had assumed control of the Geological Survey of Newfoundland and had begun the systematic study of the rocks of the same group as developed in that colony which were first studied by Jas. Richardson in 1860-62.

In the reports of the Newfoundland Survey, 1864, pp. 49-50, Sir Wm. Logan presents in tabular form the relative position of the several members of the Quebec group as then understood, in which he places it above the Upper Calciferous and intermediate between that forma-

Geol. Sur. of Newfoundland, 1864.

tion and the Chazy. The division of the group into three parts was given, of which the Lévis was regarded as the lowest and held to comprise the limestones, and black shales of Point Lévis, Orleans Island and Philipsburg, containing graptolites, trilobites, etc., which were, for the most part, identical with the Skiddaw slates. The second or Lauzon, once a part of the preceding, but now separated from it on account of its great mineralogical importance, was distinguished as the metalliferous zone of the Lower Silurian of North America. It embraced magnesian rocks, such as dolomites, magnesites, serpentines, diorites, chloritic and steatitic beds, with micaceous and gneissic strata and rich cupriferous slates, with gold and silver, nickel and chromium. It yielded only two fossils, an *Obolella* and two *Lingulæ*, and was overlaid by 2000 feet of sandstone and conglomerate, interstratified with green and red shales, which constituted the Sillery formation, but was apparently destitute of fossils. The opinion is again expressed that over a large part of its distribution the Quebec group is crystalline and metamorphic, and the characteristic minerals are found in both the altered and unaltered portions.

Views of structure held by Sir Wm. Logan, 1864.

In Mr. Murray's Report, 1873, page 336, the opinion of Mr. Billings, 1863, as to the age of certain fossils sent from Newfoundland is quoted thus: "These rocks are the upper part of the true Calciferous, and lie next below the Lévis formation, comparing them to divisions H, I, K, L, M, of the table on p. 879, Geol. Can., 1863, while the succeeding fossiliferous limestone conglomerates, limestones and shales of the Lévis are regarded as divisions N, O and P of the same table.

Geol. Surv., Newfoundland, 1873. Structure of the Quebec group, A. Murray.

It will be seen from all the evidence adduced from so many sources that the true position of the Lévis was very conclusively established both on palæontological and stratigraphical grounds as distinctly newer than the Calciferous, and this conclusion has been sustained by the most recent examination.

In 1868, Mr. Jas. Richardson, assisted by Mr. McOuat, began anew the study of the formations along the south side of the St. Lawrence, in the area comprised between that river and the boundary of the state of Maine, and extending from the Chaudière River on the west to the Temiscouta road which crosses the country southward from River du Loup to Temiscouata Lake. The result of this work appeared in the Report of Progress for 1869, accompanied by a map, in which the various formations there found are grouped on an entirely new plan, and supposed to extend from the base of the Potsdam to the Upper Silurian, both inclusive, the former of which was now made to include much of what had hitherto been regarded as belonging to the Quebec group. This was divided into three portions, a lower, middle and upper. The results of this exploration were briefly summed up by

J. Richardson, 1868-69.

New views of structure.

Sir Wm. Logan in his introductory report for 1869. In this report, the central axis, since found to be the extension of the Sutton Mountain anticlinal, is still described as a synclinal in the Sillery, following the old view of the structure of this range, and extending along the middle of the area "with a breadth of from two to twelve miles, affected by several minor undulations, and presenting a ridge of broken country, much covered by forest and little fitted for purposes of agriculture." On the south-east side of this ridge, the Lauzon was supposed to emerge, having a breadth of one to six miles and was followed by the black shales and limestones of the Lévis formation, which in turn were overlapped to the south-east by what was regarded as the Upper Silurian area of the Eastern Townships, but which is now known and described as of Cambro-Silurian age. The structure between this central ridge and the St. Lawrence is thus described: "On the north-west side, the Sillery is followed by the Lauzon only, in circumscribed and isolated portions, without the Lévis formation; the Sillery being in contact for a great part of its distance with what is now supposed to be a lower and unconformable series of rocks. Like the rocks of the Quebec group this lower series consists of red and black shales, limestones, sandstones and conglomerates, having an arenaceous base and limestone pebbles. It was formerly classed as belonging to that group, and it is only on the evidence of its fossils that it can be placed in a lower horizon. Some of these fossils are of known primordial species, and all have, in the opinion of Mr. Billings, an undoubted primordial aspect, but the manner in which they occur does not at once produce a satisfactory conviction that they determine the age of the deposits. The fossils, with but few exceptions, are in the pebbles of the conglomerates, which though derived from the destruction of primordial rocks may not possibly lie in such now. The series seem almost to stand in place of the Lévis, but the want of conformity shewn by the contact with the Sillery, and the occurrence of a *Salterella* in an even-bedded limestone would seem to carry the preponderance of evidence the other way. Provisionally, this series will be considered primordial, and as belonging to the upper part of the Potsdam. It consists, in ascending order, of the following divisions:—

Structure south side of the St. Lawrence.

Supposed areas of Potsdam rocks.

1. Red and green shales, surmounted by even-bedded grey limestones, in which a species of *Salterella* occurs, with black phosphatic nodules.
2. Grey sandstone, with black shales interstratified with conglomerates, having a calcareo-arenaceous cement, and holding limestone pebbles, with occasional black phosphatic nodules. The limestone pebbles hold fossils of primordial type.

3. Grey, quartzose sandstones, passing into quartzite, which are often of a conglomerate character, with limestone pebbles, holding fossils like those of the previous division. The beds are occasionally interstratified with black shales.

These deposits present themselves between the Sillery ridge and the St. Lawrence, in a belt of country extending the whole distance examined, with a breadth in one part of twelve miles. In this they are arranged in two main synclinal forms with many minute undulations, and they are overlaid uncomformably by two long synclinals of the Lauzon and Sillery, one of them with a stretch of sixty miles."

The above are the latest views published by the Geological Survey as to the age and structure of the rocks of this group, prior to the report of Dr. Selwyn in Rep. Prog., 1877-78, pp. 3A-9A. It is evident that much of the confusion which has arisen as to the correct interpretation of the geological structure of south-eastern Quebec is due to the opinion expressed in the first years of its study, viz., that the rocks of the Sutton Mountain range and of its extension to the north-east were arranged in synclinal instead of anticlinal form. This error in turn doubtless arose from the confounding of several distinct formations of sandstones and quartzites in one general group, subsequently styled the Sillery, a mistake first pointed out by Dr. Selwyn in the report just alluded to. Another source of error, and possibly the most considerable, was the assumption that the metamorphic rocks of that area must of necessity be the equivalents of the unaltered sediments of the St. Lawrence region, a theory which once suggested, seems to have been unhesitatingly maintained, although for its support, unnecessary inversions of strata, and profound chemical changes were requisite. That there is no marked lithological resemblance between the schists and other crystalline rocks of the central anticlinal and the ordinary sediments of the Lévis, Lauzon and Sillery, is a fact patent to any one who has ever studied the geology of the two areas.

New views of structure by Dr. Selwyn, 1877-78.

The new views of structure regarding the rocks of the Quebec group, put forth by Dr. Selwyn in the Rep. Prog., 1877-78, may be here briefly noted, owing to the great importance of the changes there made in the stratigraphical relations of the original divisions of that group. Three distinct series were recognized in descending order, as follows:

"1. Lower Silurian, held to represent the comparatively unaltered and fossiliferous portion.

2. The Volcanic Group, probably Lower Cambrian, including the coarse, thick-bedded, felspathic, chloritic and quartzose sandstones, and siliceous shalesof various colors; differing much in character from the more shaly though often similarly colored sediments of the first division, with dioritic and serpentinous rocks, crystalline dolomites, etc.

Cambrian and probably Pre-Cambrian first recognized.

3. The Crystalline Schist Group (Huronian ?), embracing the chloritic, micaceous, siliceous and other schists, also imperfect gneisses, white and grey crystalline, micaceous dolomites, and magnesian limestones, which constitute the main anticlinal of the region, and can be traced north-east through Sutton Mountain to the rear of Point Lévis."

In addition to the pointing out of the mistake which had for so long been made in the grouping of so many widely differing horizons of sandstone and quartzite in the Sillery formation as the upper portion of the Quebec group, the opinion was expressed (page 4A) that no sufficient evidence existed of any kind for the separation of the Potsdam areas indicated in the Report 1869, although the possibility of the occurrence of rocks of that age in the great mass of the fossiliferous series was admitted. In this Report the direction of the principal fault by which the Utica beds of the north side of the Island of Orleans are brought against the Lévis shales and conglomerates, and which had hitherto been held to pass in rear of the Citadel of Quebec, was changed to pass in front of the city and to reach the north side of the St. Lawrence, about one mile north of Point à Pizeau at Wolfe's Cove. The correctness of this view has since been clearly established by the finding of fossils in the city of Quebec, not only in the Cove Fields and in front of the new Parliament Buildings, but also in the cliffs bordering Champlain street, along the side of the River St. Lawrence, all of which present forms similar to those found in the rocks along the north-west side of the Island of Orleans and indicate, doubtless, a similar horizon.

Position of the great fault changed to rear of Citadellin Quebec.

The lithological aspect of the strata at Quebec and Point Lévis also shows the probable difference in the age of the rocks on either side of the river, since, while the beds which make up the cliffs of Cape Diamond, and for some distance up the river from that point, as well as those seen in excavations along the Cape Rouge Road, in rear of Spencer Wood, present the usual aspect of the black bituminous shales, with their peculiar fauna of graptolites of Utica-Trenton types. The characteristic red and green shales which form the cliffs at Point Lévis are seen to reach the west shore of the river at the depression of Wolfe's Cove, where they rest upon the newer bituminous shales and limestones, the contact being evidently due to a profound fault by which the highly graptolitic beds and associated limestone conglomerates, seen along the line of the Intercolonial Railway, below the lower ferry, are cut off before reaching the shore above Cape Diamond. In the red beds and associated strata at Point a Pizeau, which constitute the cliff in front of the church at that place, *Obolella pretiosa* occurs, a form precisely similar to that found at the Chaudière Railway bridge, as well as at the falls below, on that stream.

Difference in character of the rock along shore above Quebec.

Fault at Wolfe's Cove.

The line of this fault to the west of the point where it reaches the shore at Wolfe's Cove is indicated by Dr. Selwyn as passing to the north of Ste. Foye and thence south-westerly to the river again, where it crosses above Cape Rouge. This point may be said to be about two miles above the Cape, whence crossing to the south side of the river the contact is seen in the cliffs, about two miles south of the mouth of the River Rouert, and not far from the church of St. Nicholas. Thence it extends south-westerly in the direction of Lake Champlain to Missisquoi Bay. Fault at Ste. Foye.

In many respects the most important paper relating to the fossils of this group is that by Prof. Lapworth, published in the Transactions of the Royal of Society Canada, for 1886. This paper embodies the results of the examination of a large suite of specimens, mostly graptolites, collected along the shores of the St. Lawrence at various points from Point Lévis to Cape Rosier by Mr. T. C. Weston, but including also a few labelled from the vicinity of Cape Rouge, collected by Mr. Billings, and certain poorly preserved specimens from Cape Breton by Mr. Fletcher. The graptolites have been arranged by Prof. Lapworth into three zones and one sub-zone as follows: Prof. Lapworth, 1886.

Zone I, Cape Rosier Zone.—Zone of *Dictyonema sociale* and *Bryograptus*.

Zone II, Ste. Anne Zone.—Zone of *Phyllograptus Anna*. Graptolites from the rocks three miles above Ste. Anne.

Zone III, Griffin Point or Marsouin River Zone.—Zone of *Cœnograptus gracillis* including

Sub-Zone III A.—Rocks of the Cove fields and St. John's Market, Quebec, and the north side of the Island of Orleans.

Of these the first is considered to represent the oldest or to be of the horizon of the Cambrian, principally from the presence of *Dictyonema sociale*, a *Clonograptus* and a *Dichograptus*, two of which are regarded as new species. This *Dictyonema* has not, in so far as is yet known, been figured from the Point Lévis beds, the most westerly point from which it is reported being Matane. Graptolitic zone I., presumably Cambrian.

Zone II is regarded by Prof. Lapworth as newer than the preceding by a well marked interval, and as much older than Zone III. None of its species are common to the other zones, so far as known, nor are they known in European equivalents of these zones. The species determined, which are principally from Ste. Anne des Monts, are all well known Point Lévis species, according to Prof. Hall, and pertain to the corresponding Arenig-Skiddaw of the English Survey. Zone II. base of Cambro-Silurian.

The third zone is also distinguished apparently by a fauna peculiarly its own, "the presence of a single one of which is sufficient to settle the age of the rocks in Great Britain, and in all likelihood in America." Zone III.

The rocks of this zone have been long regarded by the Geological Survey as belonging to the horizon of the Utica or Hudson River, and are so described in earlier reports. This view was derived from the similiarity of the contained graptolites to those found on the Hudson River, at Norman's Kill, which was first pointed out by Prof. Jas. Hall, to which position the New York geologists have always assigned the strata of that place. Prof. Lapworth holds that while there is no doubt that the fossils found in the rocks of Zone III belong to the second Ordovician or Cambro-Silurian fauna, they are newer than the graptolitic strata of Point Lévis, that is, they belong to the Trenton-Utica instead of the Calciferous-Chazy fauna on the one hand, or of the Utica-Hudson on the other.

Zone III. presumably Trenton-Utica.

The position of Zone III, the equivalent of the Norman's Kill rocks, is, according to Lapworth, about the middle of the Llandeilo formation, above the Arenig and below the Caradoc, or in Canadian geology, about midway between the base of the Point Lévis phyllo graptus beds and the summit of the Loraine or Hudson River group.

Sub-zone A.

The position of the Sub-zone A appears to be difficult to decide. Prof. Lapworth says "the specimens are all of Llandeilo-Bala age and the general facies indicates a horizon about the summit of the Cœnograptus or Marsouin beds zone." He says, "the association of forms reminds me of that of the highest Glenkiln or lowest Hartfell beds of the south of Scotland. I should imagine that they follow on at once upon the Cœnograptus beds without a break. Indeed, it is possible that *Cœnograptus* may be detected among them,* but, judging from the British phenomena, this is doubtful. It is not unlikely that these Cove-field beds mark the transition from the Marsouin beds into the lowest zone of the Black River and Trenton limestone. The presence of a form identical with or closely allied to the *G. amplexicaulis* of Hall, points in this direction."

"There is nothing in the Cove-fields or St. John's market fauna that reminds us in the slightest degree of the fauna of Point Lévis. The fossils are the fossils of the Marsouin River fauna or second Ordovician fauna, and have not a species in common with the first Ordovician fauna—the typical fauna of Point Lévis."

Prof. Lapworth summarizes the results of his investigations on the fossils from the various localities as follows:

Conclusions of Prof. Lapworth as to the horizons of the graptolites.

"1. The graptolites of the collections examined are all derived from rocks of greater antiquity than the so-called Utica and Hudson River rocks, if we regard these as typified by the fauna hitherto described from the graptolitic rocks of Lake St. John, Canada, and those of the Valley of the Mohawk, in the State of New York.

* Found by Mr. Ami in 1888 on the north-west side of the Island of Orleans.

2. There are two grand faunas represented in the collection, viz.: Two grand faunas represented.

A. The so-called Quebec fauna of the Calciferous-Chazy formations of Cape Breton, Cape Rosier, Point Lévis and Ste. Anne, which answers to the fauna of the British Upper Tremadoc and Arenig rocks and their European equivalents.

B. The Griffin Cove, Marsouin River and Norman's Kill fauna, which answers to the faunas of the middle zones of the European Ordovician or Cambro-Silurian rocks.

3. In each of these grand faunas are found two sub-faunas, those of the lower fauna being the most distinctly separable. Two sub-faunas.

A. Quebec or Calciferous-Chazy fauna:—

Sub-fauna 1. Cape Rosier, and Barasois River zone of Calciferous age. Tremadoc rocks of Great Britain, and *Ceratopyge* and *Dictyonema* beds of Norway.

Sub-fauna 2. The Ste. Anne River Zone of Point Lévis age, typical Arenig of Great Britain. *Phyllograptus* beds of Scandinavia.

B. Trentonian, Marsouin River or Norman's Kill Fauna:—

Sub-fauna 1. The Cœnograptus Zone of Griffin's Cove and the Marsouin River, answering to the Middle Llandeilo beds of Great Britain and the Glenkiln beds of Scotland, etc.

Sub-fauna 2. The Cove-fields and Island of Orleans sub-fauna. Apparently destitute of *Cœnograptus gracilis*, and answering to the highest Llandeilo or lowest Caradoc beds of England.

4. The last of these sub-faunas shews evidence of transition into the Utica-Loraine graptolitic fauna of the Mohawk Valley, New York and of Lake St. John, Canada."

Concerning the position of the upper division, formerly the Hudson River and Utica of Logan and Hall, Prof. Lapworth says:—"It appears at present that we are destitute of any clear evidence that true Utica and Hudson River strata occur anywhere along the south side of the St. Lawrence from Gaspé to Quebec, all the strata seeming to be older in point of time than the Utica proper, as typified by the rocks of the Ottawa and Lake St. John. As to the two formations of the Trenton and Utica, being mapped in New York and Western Canada essentially on lithological grounds, it is exceedingly probable that the line between them differs greatly in true geological age, when followed from Quebec to Ottawa and New York; so that in some localities, where the Trenton limestone series is poorly developed, the Utica of that locality actually descends to and includes the Norman's Kill and Marsouin Zone. But this is a fact for future investigation. The facts as they stand, relate Lapworth's conclusions as to the upper divisions formerly supposed to be Hudson River or Utica.

the Marsouin and graptolitic shales to the Trenton, rather than to the Utica slates, as at present understood."*

Quebec City rocks.

"The so-called Quebec rocks, of the town of Quebec, as typified by the fossils forwarded from the Cove fields and St. John's Market, are not of Quebec age at all. They are probably the newest rocks represented in the collection, and possibly shade upwards from the Marsouin graptolitic shales of Orleans Island and Cape Rouge.† They appear, however, to be of greater antiquity than the Utica shales of Lake St. John, answering to the basement zone of the British Bala, instead of to the middle zone, which seems to be the place of the Lake St. John shales."

General conclusions.

From a careful consideration of all the facts presented in the valuable paper of Prof. Lapworth, it is evident that in the main the Geological position of the associated rocks, as constituting a lower portion of the Cambro-Silurian system given in the preceding pages, from both the stratigraphical and palæontological evidence, is clearly maintained by the latest determination of the graptolitic fauna, with the possible exception of the lowest or *Dictyonema* zone, which from the presence of three species only is considered by Prof. Lapworth to belong to a lower formation. Of these species, two, a *Clonograptus* and a *Dichograptus*, are apparently new, and as yet undetermined, and their occurrence need not therefore be considered conclusive as determining exact zones. The presence of *Dictyonema* appears, then, to be the only reason why those portions in which this form is known to occur, otherwise intimately associated with strata holding Cambro-Silurian fossils, and which have so long been regarded as belonging to that group, should be removed from their apparently proper position in the series and placed in a different geological system; and in view of the wide range *Dictyonema* is known to possess, we may well hesitate before deciding upon such a separation, unless confirmatory stratigraphical evidence can be presented.

Distribution of the unaltered Quebec group rocks.

The rocks which have been described above, as belonging to the unaltered Quebec group, form a belt along the south side of the St. Lawrence, having a breadth of from twelve to twenty-five miles. Their characters have been given with great fulness in the reports already reviewed.

Work of the past two seasons.

During the past two seasons, but more especially in 1888, much time has been devoted to a systematic study of the several divi-

* All the stratigraphical evidence shows that the beds in question are above the Trenton limestone. They probably represent a downward development and great thickening out of the Utica proper of Lake St. John, Ottawa and New York.—A. R. C. S.

† In regard to the fossils from bituminous shales said to be from Cape Rouge, there is probably some mistake in the labelling of the specimens, the rocks of that place being the oldest of the fossiliferous Q. G. series.—R. W. E.

sions of the group and its contained fossils, more particularly in the vicinity of the St. Lawrence River, where magnificent sections are afforded along the south shore, as well as on the group of islands lying midway in the channel. Of all of these, and of the main shore, carefully paced surveys were made as far as the River Ouelle. These surveys have now been plotted to a uniform scale of twenty chains to the inch, as it was found that on any smaller scale the many complicated folds and faults which everywhere affect these rocks could not be indicated. The object of these surveys was to determine, if possible, the true relative positions of the Lévis and Sillery conglomerates, sandstones and shales, the results of which may now be given in some detail. Coast surveys.

In the vicinity of Lévis, St. Joseph, and on the extreme south-west end of Orleans Island, the series of shales, black, green and grey, with hard, generally thin bands of yellow weathering, dolomitic limestone, and beds of greyish limestone conglomerate, usually known as the Lévis formation, is well exposed. The slates are generally easily recognized on smoothed weathered surfaces, from their usually greenish shade striped with black, and in certain portions, more particularly the black bands, they are thickly covered with impressions of graptolites and other fossils as lingulæ, discinæ, etc. These peculiar rocks, while occasionally seen at other points, have not apparently a wide distribution along the coast or adjacent country between Levis and River du Loup, at which place our examinations during the past season ended. The beds of limestone conglomerate which are associated with these are generally thin, and frequently occur as lenticular and often local masses, thinning out rapidly at either extremity. About Lévis these conglomerates occur in a series of outcrops between the river front and the road to the south-east of the forts, about one mile and a-half distant, and their distribution and synclinal arrangement have been very clearly indicated by Sir Wm. Logan in the atlas accompanying the Geology of Canada, 1863. Since that time, however, the building of the Lévis forts has disclosed outcrops, at that date concealed, some of which have been found to be richly fossiliferous, and these have thrown additional light upon the vexed question of the structure and relative position of the various beds in this area. Rocks of Lévis and vicinity. Limestone conglomerates.

In the section accompanying the map of the distribution of the limestone conglomerates at Lévis, just referred to, the series of anticlinals which occur on the line of section between the river and the middle fort, is indicated. Four well defined axes can be recognized in this distance, two of which at least are completely overturned. Of these the most easily recognized is that along the cliff which fronts or overhangs the road between the Victoria hotel at Point Lévis and St. Four anticlinals at Lévis.

First anticlinal.

Joseph. On the road going up this cliff, along the stone wall, about 300 yards south of the lower ferry, the overturned arch of this fold is clearly seen near the sharp bend at the top. Above this, toward Point Lévis, the same overturned and at times crushed beds, which indicate the crest of the anticlinal, are also well exposed; these beds along the road, near the toll-gate, have yielded a considerable variety of forms, among which the following are easily recognized :—*

RHABDOPHORA.

Fossils from below Victoria Hotel, Point Lévis.

1. *Diplograptus tricornis*, Carruthers.
2. " sp.
3. " *folium*, Hisinger (as of Nicholson).
4. *Glossograptus ciliatus*, Emmons.
5. " sp. indt.
6. *Trigonograptus ensiformis*, Hall.
7. *Clonograptus rigidus ?* Hall.
8. *Climacograptus*, sp. indt.
9. " *scalaris*, Hisinger.
10. *Nemagraptus*, sp.
11. *Dichograptus ? ramulus*, Hall.

BRACHIOPODA.

12. *Orthis*, Sp. allied to *O. Hippolyte*, Billings.

A short distance below the Victoria Hotel, in the black and green shales overlying the red, were found :—

1. *Phyllograptus typus*, Hall.
2. *Dichograptus*, sp.
3. *Tetragraptus brachiatus*, Hall.
4. *Didymograptus constrictus*, Hall.
5. *Dawsonia*, sp.

From conglomerate band west of the toll gate were obtained :—

1. *Crinoidal columns.*
2. *Leptæna decipiens*, Billings.
3. *Euomphalus*, sp.

Lowest Lévis zone.

The fossils above enumerated were obtained partly from the limestone bands and partly from the black and green shales, and should properly represent the lowest portion of the Levis formation as dis-

* These fossils have been examined and determined by Mr. H. M. Ami.—R. W. E.

tinguished from the Sillery, since directly underlying them are the red and green Obolella shales which form the anticlinal near the Victoria hotel, and with which are associated the beds of Sillery sandstone. These red shales, in rear of the hotel have also yielded graptolites, but owing to the crushed nature of the beds, the former are badly preserved and much distorted, and have not yet been determined. *Obolella pretiosa* is also found here.

Rocks south-east of Point Lévis.

From the Victoria hotel, the road going up the steep hill in the rear to the south-east passes over these red and green shales, and a short distance beyond the most westerly of the three Lévis forts, the peculiar grit and sandstone known as the "Sillery sandstone" occur in several well-defined ridges extending eastward at intervals for about three miles, and separated from each other by beds of red and green and sometimes black or grey shales. The character of these sandstones has already been given, and they sometimes pass into a fine conglomerate made up for the most part of pebbles of quartz with pieces of shale. These different kinds of rock are well seen in the quarries to the south-east of Point Lévis. Tracing these outcrops of siliceous rock they are found to be, in every case observed, lenticular masses, sometimes very limited in extent, but occasionally of very considerable area, enclosed in the red shales in the same way as on the west side of the river at the Sillery quarries. It is plain, therefore, that the Sillery sandstones and associated red shales are part of the same formation. Now, if we examine the series of anticlinals which occur between the lower ferry of Lévis and the middle fort we find these red shales cropping out in nearly or quite every case where the anticlinals occur, and dividing the synclinal areas which hold the graptolitic shales and associated limestone conglomerates, thus clearly indicating the lower position of the red shale series. In order to prove conclusively the synclinal structure of the Lévis graptolitic shales, carefully located collections of fossils were made at various points, more particularly along a line of section between the Intercolonial Railway and fort No. 2, from which the following results have been derived.

Association of Sillery sandstones with red shales.

Intercolonial Railway cutting below Lévis.

A "Tetragraptus zone" is seen in a cutting on the Intercolonial Railway 1600 paces below the lower ferry or I. C. R. station. These overlie a thin band of limestone conglomerate and are in turn overlaid by a heavy band of the same, the paste of which is highly siliceous and in places almost a quartzite with scattered pebbles of limestone: a short distance further west, these shales and conglomerates are underlaid by heavy beds of hard Sillery-like sandstone and grit. The fossils in this cutting are abundant and the zone is one of the lowest in the Lévis series. Among the species collected the following have been definitely recognized:—

Fossils.

1. *Dichograptus octobrachiatus*, Hall.
2. " *Richardsoni*, "
3. *Goniograptus Thureaui ?* McCoy, or n. sp.
4. *Tetragraptus serra, Brongt.* (= *T. bryonoides*, Hall.)
5. " *quadribrachiatus*, Hall.
6. " *approximatus*, Nicholson.
7. " *fruticosus ?* Hall.
8. *Clonograptus flexilis*, Hall.
9. *Phyllograptus typus*, Hall.
10. *Lingula Irene*, Hall.

The beds of shale from which the above fossils were obtained occur on the northern side of the most westerly synclinal in the Lévis rocks. Passing southward along the line of railway about 700 yards, an offset of eighty paces to the south-east, brings one to the steep pitch and curve in the road from Lévis to St. Joseph. Here, in the cliff just to the right of the main road, looking down the river, are highly fossiliferous black and green slates which lie on the east side of the overturned synclinal basin along the centre of which the road to St. Joseph extends. The similarity of these beds to those just described will be evident from the accompanying list of forms there obtained; the zone may, for the sake of reference, be styled the " Didymograptus zone " :—

Road from Lévis to St. Joseph.

Fossils.

1. *Didymograptus bifidus*, Hall.
2. " *extensus*, Hall.
3. " *furcillatus*, Hall.
4. " *pennatulus*, Hall.
5. *Tetragraptus Bigsbyi*, Hall.
6. " *fruticosus*, Hall.
7. " *serra*, Brongt.
8. *Phyllograptus typus*, Hall.
9. *Clonograptus*, sp.
10. *Dictyonema*, n. sp. (allied to *D. delicatulum* Dn., preoccupied.)
11. *Lingula Irene*, Billings.
12. " *Quebecensis*, Billings.
13. ? *Siphonotreta micula*, McCoy.

On the continuation of this cliff, one hundred and fifty yards to the west, the following were obtained :

1. *Dendrograptus*, sp.
2. *Dictyograptus*, cf. *D. Homfrayi*.
3. *Tetragraptus serra*, Brongt.
4. *Lingula*, allied to *L. Quebecensis*.

5. *Linnarssonia*, sp.
6. *Lingula*, sp.
7. *Shumardia granulosa.*

Further west, in front of Carriere & Laine's foundry, a further collection was made as follows : Fossils from cliff facing the foundry, Lévis.

1. *Tetragraptus quadribrachiatus*, Hall.
2. " *Bigsbyi*, Hall.
3. " *serra*, Brongt. (= *T. bryonoides.*)
4. *Diplograptus dentatus*, Brongt. (= *D. pristiniformis*, Hall.)
5. *Dictyograptus*, n. sp.
6. " *irregularis ?* Hall.
7. *Dictyonema delicatulu ?* Dn. sp. (Species preoccupied 1881, Lapworth.)
8. *Nemagraptus capillaris.*
9. *Leptobolus ?* n. sp.
10. *Lingula*, n. sp.
11. *Orthis*, sp.
12. *Lingula Quebecensis*, Billings.
13. " *Irene*, Billings.
14. *Shumardia granulosa*, Billings.

Ascending the cliff near this point by a flight of steps, a band of red shales is seen near the brow of the hill. To the east, on the summit of the cliff, above the other localities, thin bands of limestone conglomerate occur and the crest of the first anticlinal passes through this point. Continuing the section towards the front street in the city of Lévis a series of greenish-grey shales, striped with black, is passed over, which extends to the city hall. Here excavations have been made in beds of shales associated with limestone conglomerate, many of which are thickly studded with graptolites , among which were determined : Fossils from City Hall, Lévis.

1. *Didymograptus extensus*, Hall.
2. *do* *pennatulus*, Hall ? (= *D. Murchisoni*, Carr.)
3. *do* *bifidus*, Hall.
4. *Tetragraptus serra, Brongt.* (=*T. bryonoides.* Hall.)
5. *do* *Bigsbyi*, Hall.
6. *do* *fruticosus*, Hall.
7. *do* *denticulatus*, Hall.
8. *Dichograptus octobrachiatus*, Hall.
9. *do* (?) *Richardsoni*, Hall.
10. *Phyllograptus typus*, Hall.
11. *Lingula Quebecensis*, Billings.

From the pebbles of the associated limestone conglomerates were obtained Crinoidal columns, *Orthis*, sp. *Salterella*, sp. *Illœnus*, sp.

From the shales associated with the limestone conglomerates of the middle fort were obtained :—

1. *Phyllograptus typus*, Hall.
2. " *angustifolius*, Hall.

and from the associated greyish and black shales,
Lingula Quebecensis, Billings.

Positions of the several anticlinals at Lévis.

The axis of the second anticlinal in this section is in the town of Lévis about a fourth of a mile back from the edge of the cliff on the road up from above the lower ferry, the opposing dips being clearly seen and the underlying red Sillery shales showing in the streets. The axis of this should cross the road from the city hall to fort No. 2, near the Catholic church. Limestone conglomerates again occur on this road, ten chains south-east from the main back road in Lévis and rest on both sides upon the red slates; this marks presumably the crest of the third anticlinal. The fourth occurs near the corner of the road a short distance west of the fort No. 2, where hard gritty beds with red and green shales are exposed overlaid on the eastern side by the usual Lévis black and striped grey shales and limestone conglomerates in thin bands, the synclinal structure of which, and their overlying position in regard to the red slates, can be well seen in the trench along the east side of the embankment which connects the different forts. Thence to the east of fort No. 2 the limestone conglomerates and fossiliferous shales are well exposed in low ridges, the structure of this portion to the St. Henry road being doubtless an overturned synclinal, since on that road just beyond the toll gate the red shales and sandstones of the Sillery again occur.

Lévis shales and conglomerates overlie the Sillery.

The general dip of most of the beds in this line of section is to the south-east, and at first glance the series would appear to be a regularly ascending one. At several points, however, the overturned position of the beds is very evident and thus gives a key to what we believe to be the true structure as indicated above. That the limestone conglomerates and associated shales occur in synclinals is very clear from the section exposed in the cutting in the Intercolonial Railway at St. Joseph station where the northern end of a synclinal is cut directly across.

Sir Wm. Logan's section

The anticlinal structure of the greater part of this section is well shewn on the map of Lévis, published by Sir W. Logan in 1866, though the overturned synclinal in the eastern portion is not there indicated, the red shales being represented as coming in upon the Lévis conglomerates and fossiliferous shales in the upper portion of the group.

The fossils above described, while apparently not very greatly differing in their horizon, may be all regarded as pertaining to the Lévis formation, the lowest division being that found just below the Victoria hotel where the relationship to the red shales of the upper part of the Sillery is very close. On the shore below St. Joseph are several localities from which fossils were obtained, of which the lowest is very similar to that near the Victoria hotel. This is on the west side of the cove where the brook which crosses the I.C.R. at Harlaka Junction enters the St. Lawrence about one mile and a half north-east of that place. Here the graptolites occur in a band of black and green shales in places irony and interstratified with red and green shales of the upper Sillery, and contain, besides the graptolites, *Obolella pretiosa*, the same as found in the shales of Point Lévis and at Point a Pizeau. These presumably represent the lowest zone of graptolites in the Pointe Lévis section. The species determined are:— Shore below St. Joseph. Fossils.

1. *Tetragraptus serra*, Brongniart.
2. *Didymograptus extensus*, Hall.
3. *Obolella*, prob. *O. pretiosa*.
4. " sp.

On the shore, half a mile to the west, certain bands of black and greyish dolomitic shales with green and brown slates are thickly studded with graptolites, among which are:—

1. *Phyllograptus angustifolius*, Hall.
2. *Tetragraptus serra*, Brongniart.
3. " *approximatus*, Nicholson.
4. " *Bigsbyi*, Hall.
5. " *quadribrachiatus*, Hall.
6. " *Hicksi*, Lapworth.
7. *Didymograptus*, allied to *D. furcillatus*, Lapworth.

In the cutting in the snowshed on the Intercolonial Railway, half a mile west of Harlaka junction, a series of red, green, black and brown shales occur, the red portion of which is evidently of upper Sillery age, since they contain enclosed beds of Sillery sandstone a short distance to the south-west. They also hold fossils, from which a cursory examination revealed the presence of:— Snow-shed cutting west of Harlaka Junction.

1. *Lingula Quebecensis*, Billings.
2. *Phyllograptus typus*, Hall, with other forms.
3. *Tetragraptus serra*, Brongniart.

The foregoing lists of fossils from various points will give a fair idea of the fauna of the typical Lévis rocks. Other collections were made from the interstratified beds of conglomerates, but as these were in all cases from the limestone pebbles, and not from the matrix, their value in determining exact horizons from these rocks is doubtful. It may, however, be said that while several of the former, more especially of the trilobites, have a Cambrian aspect, many of the others have a distinctly Cambro-Silurian character, and in some of the pebbles, graptolites of the kind found in the lower zone from the Intercolonial Railway cutting were obtained. The forms obtained from the pebbles in the various bands of conglomerate will be enumerated in a subsequent page.

Character of the fossils from pebbles in the limestone conglomerates.

The red shales and Sillery sandstone series, which are now held to underlie the fossiliferous Lévis rocks just described, first appear at the Victoria hotel, which point may be taken as forming their most northerly limit along the south side of the St. Lawrence, in the vicinity of Lévis at least, since to the northward they are almost entirely and directly overlaid by the Lévis shales and conglomerates; but on the roads going south-east toward St. Henry, of which there are two, one straight out past fort No. 2, and the other following up the valley of the Etchemin, the Sillery rocks are well displayed. For a space of nearly four miles, ridges of sandstone and grit form prominent features in the landscape, and break the otherwise monotonous character of the flat country between Lévis and St. Henry. On the Etchemin River these areas of sandstone first commence one mile below the Intercolonial Railway bridge. To the west of Lévis the red shales form conspicuous cliffs in the direction of Hadlow, near which place the interstratified beds of sandstone come to the railway. Thence toward Chaudière junction, along the line of the Intercolonial, formerly the Grand Trunk, alternations of red, green and black shale, with areas of sandstone, occur, to within one mile and a-half of that point, or almost to the railway branch crossing to Breakey's mill. All these beds along the railway have a very regular dip to the south $< 35°$ $60°$. Beyond this place the country is covered by clay to the junction, where a small cutting in black and green shales shows the presence of *Obolella*. Along the south side of the St. Lawrence the ridges of Sillery sandstone continue to the mouth of the Chaudière, having a breadth southward on that stream of one and three-fourths of a mile, or to the Grand Falls below the Grand Trunk Railway bridge. At the falls, which are over heavy beds of red and green shale, holding *Obolella pretiosa* with thick, interstratified beds of grey sandstone, the strata dip S. $< 40°$, the sandstone and grit being largely developed below this point to the mouth of the Chaudière. To the west of this river they continue along the south bank of the St. Lawrence for

Sillery sandstones and shales.

Lévis to Chaudière Junction.

Chaudière River, lower part.

about three miles, when the exposures of grit and sandstone cease, the shore above showing beds of red, green, black and grey shales. Along this part of the river the diverse dips visible show this portion of the Sillery formation to be thrown into a series of folds, equalling those which are found in the the rocks at Lévis and below that place. On the St. Lawrence section above the Chaudière, after passing the outcrops of sandstone, the red and green shale series extends to a point two miles above the wharf at St. Nicholas, where the fault from the north side of the river brings them into contact with fossiliferous strata of Hudson River age, the particulars of which have already been given. To the south of the St. Lawrence, along the line of the Grand Trunk between the Chaudière and the Becancour rivers, but few outcrops of rocks are visible. Where seen they consist of red, green and black shales, with an occasional low ridge of hard Sillery sandstone, similar to what is visible at the railway bridge on the Chaudière, and where the inter-stratified beds of black and green shale contain abundance of *Obolella pretiosa*, with *Protospongia fenestrata*, *Lingula* and two species of *Phyllograptus*. This fauna may be classed as that of the upper Sillery.

West of the Chaudière River.

Fossils from Chaudière at Railway Bridge

On the west or Quebec side of the St. Lawrence a carefully paced section was made along the shore from that city to the mouth of the Jacques Cartier River. The part more particularly referring to this group of rocks is that included between Wolfe's Cove, two miles above the city, where the fault between the rocks of the citadel and those of the Sillery formation reaches the shore, and a point one mile and three-quarters above the mouth of Cape Rouge River, where the fault between these rocks and the Hudson River formation comes to the river from the vicinity of Ste. Foye. In this section, which apparently comprises all the members of the Quebec group visible on the north side of the river, no trace of the Lévis fossiliferous shales and conglomerates is seen. The section is presumably an ascending one from the contact fault above Cape Rouge to the extremity of Point à Pizeau, though several local faults in the upper Sillery portion have complicated the structure somewhat.

Cape Rouge to Wolfe's Cove.

The lowest rocks seen in this section, according to this view, are hard quartzose sandstones, calcareous in the joints, and associated with black, grey and green shales and occasional thin bands of limestone, and holding a band of limestone conglomerate four feet thick, which is made up of small pebbles of hard grey limestoneand white quartz, in a very hard, greyish, siliceous paste, the whole differing greatly in aspect from the conglomerates of Lévis. The quartzites form a ridge or hill, over which the road up the river from Cape Rouge passes, and along which the beds are well exposed. They dip south-easterly $< 50°$-$80°$. Occasionally pebbles of greyish limestone are scattered

Characters of the rocks near Cape Rouge.

Cape Rouge village.

through the quartzite. These rocks extend along the shore toward Cape Rouge for nearly a mile, beds of green, grey and black shale predominating in their upper part, many of which are covered with fucoids, and approaching the mouth of Cape Rouge River a few beds of dark-red shale are seen. Along the road going up the steep hill above the village the black, green and grey shales are well seen in the cuttings, but, though closely examined, no graptolites or other fossils were found. Following the shore northward, these shales clearly underlie the dark-red and green shales of the headland from which this locality takes its name, and they shew, a short distance further east, interstratified beds of Sillery sandstone, in which the Sillery quarries are situated. Thence these alternations of red and green shales and sandstones extend almost to Pointe à Pizeau, the sandstones terminating about half a mile west of the road leading to the Sillery church at this place. The lenticular and often local character of the sandstones already noticed is well seen in this section. From Point à Pizeau to Wolfe's Cove no sandstones show, the rocks being red, green and black shales. From these, in the cliff in front of Sillery church, *Obolella pretiosa* was obtained, the rocks being precisely like those at the Grand Trunk Railroad bridge over the Chaudière. The strata along this part of the section are thrown into several folds, and faults, generally local and probably of small extent, are visible at several points. The areas of sandstone in rear of Sillery are in no case of any great thickness, that in which the quarry is located being probably as thick as any; its surface breadth on the road to the west is 320 paces, with an estimated vertical thickness of about 250 feet, in which, however, several partings of shale occur. The contact of these red and green shales of the Sillery series with the black bituminous shales and dark-brown bituminous limestones of the citadel series is well seen fifty paces north of the forks of the road leading up the hill from the head of Wolfe's Cove, a deep gully marking its probable course, and the fault extends thence through the grounds of Spencer Wood in a direct line to the forks of the road east of Ste. Foye, whence it changes its course and passes to the north of that village, 100 yards from the main road, changing again a short distance west, and extending thence to the St. Lawrence above Cape Rouge, as already indicated. By the fault north of Ste. Foye the grey shales and sandstones of the Hudson River series are brought into contact with the red and green shales of the Sillery.

Point à Pizeau.

Fault at Wolfe's Cove.

Rocks of Quebec City.

In the report of 1863 the shales, limestones and conglomerates of the Citadel and city of Quebec were supposed to belong to the upper part of the Lévis formation, and to underlie very closely the red shales of the Sillery, though their true position was even then regarded as very doubtful.

The subsequent study of these rocks by Dr. Selwyn brought some new facts to light, from which, both on stratigraphical grounds and from the evidence of fossils collected at several points in the city, it was decided that the position of these rocks was much newer and altogether above the Lévis and Sillery strata. Additional large collections of fossils from various points in the city were made during the past season by Messrs. Ami and Giroux, the result of the examination of which, and some points in regard to the structure, will be given further on.

Recent collections of fossils at Quebec.

From Wolfe's Cove the red and green shales of the Sillery cross the St. Lawrence and appear on the east side at Point Lévis, where their distribution has already been given, and none of the graptolitic shales or conglomerates of the Lévis series have been recognized on the north side of the river, these being confined in this area to the town of Lévis itself, where they rest on the red and green shales, as described, whence they extend to St. Joseph and along the shore for about two miles below, as indicated by the fossils enumerated on page 58K. Thence crossing the south channel of the St. Lawrence, they constitute a limited area in the extreme south-west end of the Island of Orleans, the southern margin of which is seen to be terminated by a well-defined fault between the limestone conglomerates, with their associated fossiliferous shales, and the red and green slates, near the foot of the stairs leading up from the head of the small cove east of the hotel. On the north side of the island these Lévis rocks are terminated by the great fault which brings up the black bituminous shales and limestones, which have been formerly described as of Utica or Hudson River age, and which are the undoubted extension of the rocks of the city of Quebec. From these Lévis rocks at the end of the island the following fossils have been obtained :—

Absence of true Lévis rocks on north side of St. Lawrence River.

Island of Orleans south-west end.

1. *Clonograptus rigidus*, Hall.
2. ? *Dichograptus octobrachiatus*, Hall.
3. *Dichograptus* ? *Richardsoni*, Hall.
4. *Ptilograptus plumosus*, Hall.
5. ? *Tetragraptus serra*, Brongniart.
6. *Dawsonia*, sp. indt.
7. " *acuminata*, Nicholson.
8. *Acrotreta*, sp. nov.
9. (?) *Turrilepas*, sp., fragments, with the surface marked by concentrically arranged lines of growth.

On the south side of the ledges on which this hotel is built Mr. T. C. Weston obtained *Loganograptus*.

Leaving for the present the development of these rocks as seen along the shores of the St. Lawrence and the several islands which lie in the

channel below Quebec, we will examine the structure of the group as displayed in the sections along the Etchemin and Chaudière rivers.

Etchemin River section.

On the first of these streams the rocks of the Sillery, more particularly the sandstones and associated shales, have already been referred to as extending upward to within one mile of the railway bridge on the Intercolonial Railway. Above the last exposure of the Sillery sandstone formation the red, green and black shales extend for fifty chains, beyond which, to the bridge, grey, green and black shales, probably representing a slightly lower series, occur. The great falls of the Etchemin occur ten chains below the bridge, and the green and black shales here have yielded to Mr. Weston *Obolella pretiosa*, a form similar to that from the Sillery of Point à Pizeau. Above the bridge the green, black and grey shales extend to a small brook about two and a fourth miles below St. Henry village, the dips all along being south 20°–50°. At this brook the red and green shales again come in on the south side of the anticlinal and extend up to the village, in which space several foldings are seen, but the general character of the red, green and black shales is maintained throughout. Above St. Henry the river flows for several miles through intervales, and exposures are rare both on the stream and on the road between St. Henry and St. Anselme. Just above the village the stream makes a great bend of nearly two miles to the south-west, and then resumes its regular course. Three-fourths of a mile above the upper part of the bend, black and green and grey shales, with hard bands, occur, with a bed of limestone conglomerate, in which Mr. Weston, in 1877, obtained from the pebbles:

Fossils from between St. Henry and St. Anselme.

1. *Leptæna sericea*, Sowerby.
2. *Orthis platys*, Billings.
3. *Camerella varians*, Billings.

The associated shales form a peculiar band, which is repeated three times on this river in the next three miles, the intervening space being occupied by red and green shales of the Sillery formation. From the black shales near a grist mill close by the upper exposure, which is a half-mile above the great gorge of the upper fall, the following graptolitic forms were obtained:—

1. *Dicranograptus*. cf. *D. clingani*, Carr.
2. *Climacograptus bicornis?* Hall.
3. *Diplograptus cf. D. mucronatus*, Hall.
4. " sp. indt.; Polypary with closely arranged thecæ,
5. *Dicellograptus sextans*, Hall.
6. " *Moffatensis*, Carruthers, var. *divaricatus*, Hall.
7. " sp. indt.; same form as found in similar rocks from Crane Island.

At this point sharp faultings are seen on both sides of the exposure of black shales, and thence upward the stream shows a succession of red and green shales for several miles above St. Anselme. Toward Ste. Claire beds of grey, green and black shales occur, with bands of hard quartzite of considerable extent, which latter will be described later. Faults.

The occurrence of these black fossiliferous strata on this river is peculiar. At no other point south of the St. Lawrence have they been observed, but on the north side of Crane Island, about one mile above the church, and again on the south side, one mile east of the wharf, precisely similar shales are found containing similar forms. From the north side of the island a small collection yielded : Similar rocks and fossils on Crane Island.

1. *Dicranograptus cf. D. Nicholsoni*, Hopkinson.
2. *Dicellograptus sextans*, Hall.
3. *Dicellograptus Moffatensis*, Carruthers, var. *divaricatus*, Hall.
4. *Dicellograptus*, sp. indt.

A peculiar feature accompanying these black shales is the presence of heavy beds of blackish, very hard, cherty shale, precisely similar to that seen at Griffin Cove, Gagnon's beach and the Marsouin. The presence of *D. sextans* at all these places shows the horizon of the Etchemin shales to be not far removed from the rocks of the localities mentioned, and their position at this place is doubtless that of a repeated synclinal upon the red and green Sillery shales, complicated somewhat by faulting. Cherty beds.

From the red and green shales underlying the black shales just described, Mr. Weston, in 1877, collected *Obolella pretiosa*, fragments of a *Tetragraptus* allied to *T. Headi*, Hall, and the funicle of a *Clonograptus* allied to *C. rigidus* or *C. flexilis*.

The sections on the Chaudière River above the Grand Trunk Railway bridge present, for the most part, rocks of the upper Sillery horizon. Near St. Lambert green sandstones, interstratified with the usual red and green shales, occur, in which Mr. Weston has found an *Obolella* like the form at the bridge below. Above St. Lambert black and green shales, like those on the upper part of the Island of Orleans, near Patrick's Hole, contain graptolites, with fragments of *Obolella* or *Lingula*. Between this and St. Bernard beds of limestone conglomerate, with green and black shales, the pebbles of which contain fragments of Orthis-like shells and Crinoid stems, are found, the associated shales containing *Phyllograptus Anna* and *P. angustifolius*. These indicate a probable synclinal of Lévis rocks at this place, while the underlying Sillery formation is affected by a series of foldings such as are seen to the east on the Etchemin. Sillery shales and fossils. Chaudière River section.

The relative positions of the Sillery and Lévis are well observed in the sections between Lyster and Somerset, on the west, and the Craig road, which passes through Leeds. On the line of the Grand Trunk, between Lyster and Stanfold, the red and green shales and hard sandstones of the Sillery are well exposed at intervals. To the westward of Lyster they show down the Becancour River to the fault, between this formation and the Hudson River rocks, about ten miles from the mouth of the stream. Along the railway these rocks form the western side of a synclinal basin, the eastern edge of which appears at Inverness and St. Sophie. On the road east of Lyster to Ste. Agathe the characteristic red and green-striped shales are seen at intervals to the road leading north between ranges xii and xiii Nelson. Blocks of trap are scattered along this road, outcrops of which occur in places on range xi. The dip of these red slates is south-easterly. One mile south of Ste. Agathe Corner ledges of bluish-grey dolomitic slates and limestone conglomerates dip S. 10° E. < 50°, the pebbles containing traces of fossils, which, however, were not determined, but the rocks look like those of Lévis, and these undoubtedly overlie the red slates of the Sillery. On the road leading south-east from Ste. Agathe to the Craig road these bluish-grey slates, which strongly resemble those of Brompton Falls, below Sherbrooke (see Report 1886), extend for quite three miles, in which probably several low undulations occur, to a well-defined synclinal, the dips being E. and N. 60° W. These slates are like those associated with the limestones of the Arthabaska area, and a short distance east of the synclinal they rest upon limestone conglomerates and grits, with hard bluish-grey slates like those near Ste. Agathe. Further to the north-east these rocks extend towards St. Patrick, and reach the road to Ste. Marie about four miles north-east of St. Sylvester. In some of their undulations these doubtless connect with the fossiliferous strata and limestone conglomerates of St. Bernard, already described. In the vicinity of St. Patrick they rest to the east upon the red and green slates and sandstones of the Sillery.

Lyster and Stanfold.

Ste. Agathe.

St. Sylvester.

St. Patrick.

In St. David a mixture of limestone conglomerates and dolomitic shales of various colors, red, green, grey, etc., occurs, in which very diversified dips are seen, indicating abrupt folds or faults. These probably indicate the synclinal at this place, and they also rest upon the red slates of the Sillery to the west. On the road from Leeds village to Inverness the eastern limit of the synclinal is bounded by red and green Sillery shales and hard sandstones, one mile and a-half east of Glenloyd Mill, where these rocks dip W. < 30°. In the fields a short distance west of this, ledges of limestone conglomerates, presumably the extension of those seen on the road from Ste. Agathe to Craig road, occur. At the mills on the River Becancour the rocks are greyish and

St. David.

Leeds to Inverness.

bluish-grey-striped massive slates, like those of the Brompton Falls on the St. Francis River, which thence extend south-westerly to Inverness Corner, where beds of limestone conglomerate also occur, with a north-west dip, and resting on hard green and black slates, which are now regarded as constituting a portion of the Cambrian system, the red and green shales being apparently overlapped by the black slates and conglomerate series. Glenloyd mill.

In the vicinity of Somerset, and between that place and Ste. Sophie, a tract of tolerably flat country extends, with a breadth of several miles. In this area beds of the graphitic limestone and black shales occur, similar to those described as occupying the basins of Arthabaska and Danville. These can be traced to the north-east in rear of Ste. Julie, but there they apparently terminate. They overlie a series of blackish-grey slates, which are like those described as occurring in the Wotton area of the last report, and which in turn rest upon the red shales and sandstones along the east side of the Grand Trunk Railway east of Stanfold. Somerset and Ste. Sophie.

To the east of Somerset, in the direction of Ste. Sophie, these dark limestones rest upon a series of highly altered schists and schistose quartziferous shales, which constitute a high ridge extending towards St. Norbert, and thence form the high belt of hills toward Halifax. In this direction also the red slate series is wanting, and the limestones are in apparent contact with what we have called the Pre-Cambrian series.

From the evidence obtained from so many widely scattered localities, the position of the red slates and sandstones of the Sillery beneath the fossiliferous beds of the Lévis, both upon the mainland and on the upper end of the Island of Orleans, can be assumed with considerable certainty, both on stratigraphical and on palæontological grounds, for, while numerous faults are found, some of which are of great extent, and great overturning of the strata, the overlying position of the Lévis is so often seen in places where their relative positions can scarcely be reversed, that the conclusions above stated are, it is believed, no longer a matter of doubt. Lower position of the Sillery.

Before we take up the consideration of the south side of the St. Lawrence below Quebec and the several islands in the channel, a brief statement of the stratigraphy as now held may be given for the better comprehension of the structure of the St. Lawrence section. Ascending sequence of strata of the fossiliferous Quebec group from Cape Rouge northward.

Beginning, then, with what we regard as the lowest members of the group, viz., the beds near the central fault above Cape Rouge, we have in ascending order:

1. Black, green and grey shales, with hard and heavy bands of greyish, sometimes yellowish-white quartzose sandstone, which are thickest

in the lower portion, and with occasional thin bands of limestone conglomerate, the pebbles being generally small and the paste highly quartzose. The quartzites have occasional scattered pebbles of greyish limestone.

Lower Sillery

2. Greenish, greyish and blackish, with occasionally dark-reddish or purplish-tinted shales, with bands of hard greyish sandstone, generally fine-grained, and in thickness from one inch to a foot, the massive quartzites being absent and many of the greenish layers being covered with fucoidal markings, well seen on the shore above Cape Rouge and in the cutting along the road above that village.

3. Bright-red shales, often with thin greenish or greyish bands, which in places are calcareous. The rocks on a smoothed surface, have a striped red and green aspect; in the upper part occasional beds of a foot or more of hard green-grey sandstone occur.

4. Red, greenish-grey and black shales, with interstratified masses, often lenticular, of greenish and greyish Sillery sandstone, ranging in thickness from two feet upward, in which the Sillery quarries are located. This is the typical Sillery sandstone, which ranges from a fine-grained homogeneous rock to a fine quartz conglomerate, much of the rock being characterized by the presence of small flaky pieces of shale and scattered small pebbles or large grains of clear quartz, the bands of sandstone being separated by partings of various colored shale. The local and lenticular character of the sandstone is well seen in the Sillery section, some of the heaviest beds inland thinning out before reaching the shore in either direction. In the upper part, at Sillery church, *Obolella pretiosa* occurs, from which point an anticlinal crosses the river to Point Lévis, and appears in the cliffs at the Victoria Hotel, where the same *Obolella* is found.

Upper Sillery.

Lévis.

5. The Lévis shales and conglomerates of Lévis city and the shore and cliff below South Quebec and St. Joseph and the west end of Orleans Island, the synclinal disposition of which has already been described.

Upper Chazy or Lower Trenton.

6. The black and greyish-striped or banded shales, overlaid or associated with the black and graphitic shales and limestones of the Arthabaska and Somerset synclinal, which latter do not appear in the Point Lévis and Quebec sections.

Trenton-Utica.

7. The black or brownish bituminous shales and limestones of the city of Quebec and north-west side of the Island of Orleans of Trenton-Utica age.

The south shore of the St. Lawrence below Lévis displays, for several miles, strata abounding at certain points with graptolites, the principal forms of which have already been enumerated. Thirty chains below the lowest fossil locality, or three miles below the ferry

wharf at St. Joseph, a well-defined fault is seen, the strata in the intermediate space being thrown into several sharp folds. This fault brings up a series of limestone conglomerates and shales, which in aspect resemble the rocks of divisions 1 and 2 of the Cape Rouge section. The conglomerates here occur in thin bands, of which the first has a thickness of fifteen feet in the cliff, thinning into three feet on the beach. Band 2, separated from this by thirty-three feet of greenish and greyish shale, is eleven feet thick, and is made up of large and small pebbles of siliceous dolomite and grey limestone, in a hard siliceous paste. Band 3 has nearly all its pebbles of dark-grey limestone, with calcite and thin pieces of shale, with a thickness of ten feet, and is flanked on the south-east side by grey sandy and quartzose flags and green-grey shales. The series dips S. 65° E. < 55°. The pebbles of the conglomerate yielded fragments of trilobites, which have been examined by Mr. Ami and found to be portions of *Olenellus Thompsoni* with *Olenoides* or *Microdiscus*. The hard quartzose sandstone on the east flank contains also scattered pebbles of greyish limestone.

Shore above Beaumont.

Fossils.

The fault at this place apparently marks the eastern limit of the fossiliferous or graptolitic shales of the Lévis formation, and no beds of Lévis aspect appear east of this point, as far as our observations extended during the past season. Between this and Beaumont green and grey slates, with thin, hard bands of quartzite, and occasionally thin, grey limestones and fine limestone conglomerates occur, which represent the rocks of division 2. From certain hard, sandy beds, one mile east of the conglomerates, numerous graptolitic forms were obtained, most of which were, however, fragmentary and difficult to determine. They are, however, similar to others found near St. Michel with *Obolella pretiosa*, and may, therefore, be assigned generally to the fauna of the Sillery.

Eastern limit of the Lévis on the shore.

In this space the strata are most intricately folded; the green hard slates and sandstones constituting the lower part and showing at times in the anticlinals, while in the synclinals the red and green striped shales come in. A mile and a-half west of Beaumont Brook, ten anticlinals can be seen in the space of fifteen chains, the rock being the hard greenish-grey shales and hard quartzite beds of division 2. The apparent plasticity of the rocks at the time of their folding is here remarkably displayed, since the beds curve in sharp bends without the smallest indication of crushing or cracking, the hard sandstones apparently being precisely the same on the concave side of the arches as in the convex. Many of the green shales associated with the red along this part of the coast are thickly marked with beautiful impressions of fucoids. The beds of the Sillery sandstone do not appear, though heavy beds of hard grey quartzite show at intervals,

Beaumont.

but these are apparently the equivalents of the lower part of division 1 of the Cape Rouge section. Frequent faults occur, and below Beaumont Brook these are repeated every few chains, their position being in many cases marked by a jog in the coast line, which follows the line of the fault, and a similar series of green, grey and red shales is repeated several times.

Beaumont to St. Michel.

But little variety occurs in the character of the rocks between Beaumont and St. Michel de Bellechasse. Repetitions of green, grey and black shales, with hard quartzites and occasional thin bands of limestone conglomerate form the anticlinals, and red and green shales with thin hard bands of calcareous sandstone, and reddish limestone, at times dolomitic, shew in the upper part. These rocks strike from north to north-east across the south channel of the St. Lawrence, and reach the south side of the Island of Orleans, between St. Laurent and its east end, called Traverse Point, the strata of that section being identical with those of the shore just described. One mile east of the wharf at St. Michel, green, grey and black shales and thin hard sandstones, overlaid by reddish shales, contain fossils, among which were recognized:

Fossils from St. Michel.

1. ? *Dichograptus ramulus*, Hall.
2. *Dendrograptus*, sp.
3. *Dawsonia*, sp.
4. *Obolella desiderata*? Billings, or a closely allied species.
5. *Obolella pretiosa*, Billings.
6. *Acrotreta*, sp.

Half a mile further east, in a band of black shale, *Dictyonema*, *cf.*, *D. delicatulum*, Dn. (preoccupied), and a species of *Bryograptus*, are found.

St. Michel to Vallier Point.

From this to the extremity of the point, two miles below the wharf at St. Michel, the usual series of black, green and red shales occupy the shore. At the point a well defined anticlinal brings up the black, green and grey shales of division 2. These extend across the strike to the mouth of the Boyer River, near which another crushed anticlinal in similar rocks is seen. Thence to Vallier Point, which is the west extremity of Bellechasse Bay, the rocks of division 2 are continuously exposed, being overlaid to the south along the road, beyond St. Vallier Church, by the red shales and sandstones of the Sillery. Twenty chains south of Vallier Point these older rocks are overlaid by the red shales on the shore of the west side of the Bay, whence they extend to Berthier Village. East of Berthier to St. Thomas the shore is entirely occupied by the red and green shales, and grey or occasionally brown sandstones of the true Sillery of division 4. They strike along the shore, which keeps nearly along the crest of an anticlinal for

Berthier to St. Thomas.

several miles. In the Village of St. Thomas these shales have yielded *Obolella pretiosa* and sponge spicules. Thence to L'Islet the same rocks are continuously exposed, the headland of Cape St. Ignace being composed of the Sillery grits. Near L'Islet, in the green shales associated with the red, *Obolella pretiosa* and an allied form probably *O. desiderata*, were found at several points, the rocks in the intermediate space being thrown into a series of anticlinals with south or north dips at angles of 60° to 85°. St. Thomas to L'Islet.

East of L'Islet the red and green shales present heavy ledges which form prominent ridges along the shore for some distance, and extend to the Trois Saumons River. At the L'Islet wharf the associated sandstones contain an interstratified bed of fine limestone conglomerate four to ten feet thick, with small pebbles of limestone and quartz, which shades off into grit. Along this part of the coast the strike follows the shore line, the dip being S. 30° E. $<$ 60°–80°. Between Trois Saumons and the brook one mile to the east, the green and black shales with thin hard bands occupy the shore, an anticlinal occurring midway, and thence east to near the wharf at St. Jean Port Joli the ordinary red and green shales of division 3 are seen. Slightly lower beds occur at the wharf at St. Jean, with thin beds of hard grey limestone; but 150 paces east red and green shales again come in and extend to within five miles of the church of St. Roch des Aulnets. At this place a series of anticlinals show on the several points bringing up the lower beds of division 2, with bands of greyish limestone holding remains of small trilobites, among which an *Agnostus* was recognized. These are associated with black and green shales, and they are repeated at intervals for one mile and a-half along the shore, when a fault and sharp anticlinal again bring into view the red and green shales which extend thence to St. Roch. L'Islet to St. Roch. Fossils.

In these red and green shales *Obolella pretiosa* also occurs, and near St. Roch the beds of hard Sillery sandstones have associated beds of limestone conglomerate, which now begin to constitute an important feature in the Sillery rocks of this area. In no part of the shore have we found any rocks which, from their lithological character or their contained fossils, should be assigned to a lower horizon than the lower Sillery. From this to River du Loup the shore presents the same general aspect, except that the quartzites which have a considerable development to the south of St. Michel and St. Thomas come to the shore above St. Roch, owing to a sudden change in the strike northward towards the St. Lawrence at this place. This northward change of strike extends from a point four miles west of St. Roch to the St. Roch Post Office and Brook, which is two miles east of the church. Beyond this the strike rapidly assumes a more St. Roch to River du Loup

easterly direction, which continues along the shore. By this deflection the heavy beds of quartzite, with the associated red and green shales which form the prominent ridges to the south from St. Gervais to L'Islet are brought to the coast, and thence extend to and beyond River du Loup. In all this stretch of coast from St. Michel to River du Loup no fossils other than *Obolella* and sponge spicules have been found, with the exception of a small collection of bivalve shells and fragments of trilobites near Notre Dame du Portage, and some indistinct graptolites associated with *Obolella*, at the crossing of the Ruisseau de L'Eglise, on the Intercolonial, and three miles east of St. Paschal station, among which were *Climacograptus*, sp., *Diplograptus*, sp., *Nemagraptus*, sp. indt., *Didymograptus*, (?) sp.

Notre Dame du Portage.

Fossils.

In the collection from Notre Dame du Portage the following genera were recognized:—

1. Obscure graptolite, with a long stipe.
2. *Lingula*, sp. nov. (?), (a small narrow shell, with brown test and lamellar lines of growth.)
3. *Obolella*, like a young specimen of *O. pretiosa*.
4. *Orthis*, sp.
5. Strophomenoid shell.
6. Fragments of a pteropod-like organism.
7. *Beyrichia*, sp. (With prominent crescentic sulcus and eccentric lobe.)

The relations of the areas of quartzose sandstones, and red and green shales of this interior belt to the typical Sillery of the coast section, may now be considered; and this is an important point, since in the Report, 1869, as already pointed out, these rocks were in part regarded as of Potsdam age, on the evidence of *Salterella* in the pebbles of the associated conglomerates and supposed markings of *Scolithus*. South of Lévis, the ridges of Sillery sandstones, which are often of considerable extent, occur as lenticular areas, and extend on the St. Henry road for about three miles. To the south of this, along the Etchemin, the sandstones do not apppear till we reach the vicinity of Ste. Claire; the intervening space being occupied by the series of red, green and black shales, already described. Eastward to St. Charles junction, the rocks described on the coast section about Beaumont, shales of various colors are found, but a couple of miles east of St. Charles, ridges of the Sillery sandstone rise from the flat country to the south of the railway. Between St. Charles and St. Gervais red shales occur, which, along the course of the Boyer River, extend to St. Henry. A low ridge of the Sillery is seen near the road to St. Gervais, about two miles

St. Charles to St. Gervais.

south of St. Charles. At St. Gervais a very considerable de-development of this highly quartzose sandstone begins, the composition of which, except for its rather more siliceous aspect, is precisely like the rock of the Sillery quarries, small pebbles and grains of quartz, and pieces of greyish or black shales, often of considerable size, being found. As with the typical Sillery of the shore, the hard quartzites are interstratified with red, green and black shales. South of St. Gervais, towards St. Anselme, these rocks terminate about three-eighths of a mile from the corner, beyond which the red and green shales continue to St. Anselme. About one mile north of the road between St. Anselme and St. Henry, and a short distance west of St. Anselme, a heavy boss of trap cuts through the shales, with which are associated at this place beds of sandstone and grit of Sillery aspect. Along the road leading south-west from St. Gervais, Mr. Weston obtained the usual Sillery fossil, *Obolella pretiosa*, from the green and red shales. Between St. Gervais and St. Raphael, the quartzite forms conspicuous white weathering ridges, their interstratification with the red, black and green shales being well seen at the brook and mill, one mile and a half north-east of the former place. Here, Mr. Weston also obtained *Obolella pretiosa*, a Linguloid shell, crinoidal fragments and a *Buthotrephis*. The same *Obolella* was obtained from interstratified shales in quartzite at River du Sud, beyond St. Raphael, also near St. Francois church, at St. Thomas and at Berthier, the specimens being in all cases precisely similar to those found at the railway bridge on the Chaudière.

St. Gervais to St. Anselme.

St. Gervais to St. Raphael.

Between St. Thomas and L'Islet the ridges of quartzite and shales form a range of hills, just to the south of the back concession road, about two miles and a-half from the Intercolonial railway. About St. Aubert these quartzose rocks vary much in character, at times being hard and siliceous, at others resembling the typical Sillery rock. Considerable areas of limestone conglomerate are associated with them near this point, as well as in the ridges three miles south of St. Thomas. They first show along the shore road in conspicuous beds on the road between St. Jean Port Joli and St. Roch, about three miles below the former place, where they are clearly an interstratified portion of the red and green shale and sandstone series of the Sillery formation. The conglomerates are composed of pebbles of quartz, greyish limestone and sandstone, cemented by a gritty and highly quartzose or sandy paste. On the Elgin road, which goes south about four miles below St. Jean, hard quartzose sandstone, with limestone conglomerate and red and green shales, occur at intervals to the railway. South of this, exposures of sandstones are also seen, but at the corner of the back road leading across to St. Aubert, great ledges and ridges of this quartzose sandstone come in. This rock, while weathering white, is, on fresh

St. Aubert.

Elgin Road.

fracture, a brownish grey, in which respect it resembles the bands of Sillery sandstone on the Island of Orleans, below St. Jean. The associated conglomerates are made up of large and small pebbles of greyish and sometimes brownish sandy limestone, sandstone and quartz and the mass of the sandstone contains bits of shale and pebbles of quartz, like the typical rock of Sillery; the associated black and green shales west of St. Aubert contain *Obolella pretiosa* also.

Change in strike.

Near St. Aubert these rocks change their strike and run towards, the coast, reaching it above St. Rochs, as already described. Further east a repetition of these show in similar conspicuous ridges and rounded hills, which rise abruptly from the flat plain along the line of the Intercolonial between St. Roch and Ste. Anne de la Pocatière. In many places the ridges of quartzose sandstone west of and in the vicinity of Ste. Anne have interstratified beds of limestone conglomerate, like that near St. Aubert. These ridges of conglomerate and quartzite west of Ste. Anne have an anticlinal structure, the opposing dips to the north and south being well seen on the road half a mile west of the church. The anticlinal in the underlying red and green Sillery shales is also seen just on the rise of the hill south of the church, and again one mile east of the village. That these beds of shale, quartzite and conglomerate are of the horizon of the Sillery further west is seen in the presence of *O. pretiosa*, as well as in the general character of the strata. In the conglomerates, many of the pebbles are derived from some lower band of limestone conglomerate. The same peculiarity was observed in the rocks of the Brandy Pots, lying in the St. Lawrence off River du Loup, where precisely similar beds occur as at Ste. Anne. The same character of sediments occupy the country about Kamouraska and the back country, showing along the several roads running southward towards the boundary. These have already been described fully in the report of Mr. Richardson, 1869. On the road from River du Loup to Lake Temiscouata they occupy the section between the St. Lawrence and nearly to the crest of the ridge at St. Honoré, midway to the lake, alternations of red, green and black shales, with great areas of whitish weathering quartzose sandstone, being visible at intervals; but at St. Honoré, the underlying black, wrinkled slates of the Cambrian anticlinal come into view, and extend southward to the vicinity of St. Louis de Ha Ha. This country has been worked out by Messrs. Bailey and McInnes.

Ste. Anne de la Pocatière.

River du Loup to Lake Temiscouata.

Orleans Island to Crane Island

The islands which lie in the channel of the river below Quebec form a chain nearly forty miles in length, extending from Orleans Island to the Isle of Cranes, which is opposite to St. Thomas and L'Islet. Of these Orleans Island is the largest, having a length of twenty miles from the South-West Point to Point Traverse, and a breadth in its widest

part of about five miles. Along its shores, three rock formations are recognized, viz., that on the north side, hitherto regarded as of Utica or Hudson River age; that on the south-west end, known as the Lévis; and that of the south, and, in fact, comprising nearly the whole of the island, which we regard as the Sillery, and probably, in great part, its lower portion. The rocks of the Levis formation of the south-west end, with their contained fossils, have already been described on p. 59 K The rocks of the south shore to Traverse Point are identical in character with those of the shore from above Beaumont to St. Michel, being, in fact, the extension of those across the river channel to the island. Like those of the mainland, they also contain *Obolella pretiosa*, with fragments of graptolites, at several points, but no traces of the Lévis rocks proper are seen below the fault which cuts off this formation east of the Island Hotel. The Sillery sandstones are but slightly developed. On the line of section between St. Jean and St. Famille, and at the eastern half of the island, the general structure is seen to be that of a double anticlinal, affected by various minor folds, along which, at two points, hard Sillery sandstones come to view. On the north-east end of the island, heavy beds of coarse, green, sandy shales, passing at times into a shaly sandstone, occur along the road between St. Famille and St. François. These are associated with red and green shales along the shore, in which respect they are like the Sillery, and at the east end of the island include a band of limestone conglomerate twenty feet thick, which in aspect is like that described from St. Aubert and St. Anne de la Pocatière. It is probable, therefore, that the great bulk of the sediments on this island is the true equivalent of the Sillery formation. The rocks of the north side which are separated from those just described by a well-defined fault of considerable extent, are divisible into two portions. Of these the lower series, stratigraphically, is the black bituminous shale and brown limestone of the extreme north-west end, called False or West Point. The rocks extend along the road towards St. Pierre for seventy chains, where their contact with the green and grey shales of the Lévis formation takes place. At a small brook about half a mile further east, the limit of the black bituminous shales is seen, a fault separating them from the grey and green-grey shales. Below this point, greyish and greenish shales and sandstones of Hudson River age occupy the shore, and show along the road down the north side of the island for several miles above Ste. Famille. They are also seen on the road traversing the island to St. Jean for nearly three-fourths of a mile south of Ste. Famille Corner, the exposures not being continuous, but below Ste. Famille they are readily seen for one mile and three-fourths to the sharp bend in the road

Orleans Island, three formations.

North side of Island.

Hudson River rocks.

to the southward and a small brook, where they are brought into contact with the red and green shales of the Sillery by a fault. This fault is well seen on the shore two miles east of Ste. Famille, the rocks of Hudson River age being greyish sandstones and shales, with beds of greyish limestone, which are much crushed along the line of contact. Graptolites of Hudson River type occur in the shales at this place.

Concerning the age of the greyish beds of this section there can be but little doubt. They are identical in character with those from the opposite or north side of the St. Lawrence, as well as those of Ste. Croix, above Quebec, which contain typical Hudson River forms. But the Utica age of the blackish shales and limestones is still somewhat uncertain. Large collections of fossils were made from these strata during the past season, which show them to be of the same horizon as the rocks of the Citadel Hill, Quebec, as well as those of the north side of the Gaspé Peninsula, of the Marsouin River, Griffin Cove, and Gagnon's Beach.

Probable age of the black shales and bituminous limestones of the north side.

The black shales and limestones below the village of St. Pierre, which should underlie the Hudson River strata, are not visible along the north side of the Island, owing probably to the great stretch of mud flats in this direction; but they should occupy a portion of the North Channel, and be brought into place by a fold or anticlinal in this direction, which repeats the Hudson River beds of the north side.

From the conclusions of Prof. Lapworth it seems probable that the horizon of the black shales is that of the upper part of the Trenton or transition to the lower Utica, but closer study of the fossils from Quebec will be necessary to definitely determine their exact position.

Rocks of the south side.

Between the fault which cuts off the Lévis on the south side, east of the Hotel, and the village of St. Laurent, five miles and a half distant, sixteen well defined anticlinals are recognized in the rocks along the shore. These consist for the most part of red, green, grey and black shales, with hard bands of grey sandstone which are sometimes of considerable thickness, like the strata of Point à Pizeau and Sillery. In some of the anticlinals, the hard grey quartzose sandstone and green shales of the lower part of the Cape Rouge section are brought to view, and occasional beds of hard siliceous limestone conglomerate, like that above Beaumont, come to the shore in beautiful folds, overlaid in the synclinals by the red and green shales of the upper Sillery series.

St. Laurent to St. Jean.

Below St. Laurent, toward St. Jean, the shore for some miles is occupied by the red shales. Midway, black and green shales hold *Obolella* and imperfect graptolites, the rock resembling that of the Chaudière Bridge. Below St. Jean, the red and green rocks continue to the mouth of the Delphine River, beyond which the series of green,

black and grey shales and quartzose sandstone, which constitute divisions 1 and 2 of the Cape Rouge section, come in and extend in a series of folds to the eastern extremity of the island, around which they are well exposed to the cove at the north-east end.

St. Jean to Ste. Famille.

A section on the road between St. Jean and Ste. Famille passes over two well defined ridges separated nearly midway by a flat half a mile in width, through which a brook flows eastward. The southern portion of each ridge is composed of red and green striped shales, underlaid by green-grey shales and hard sandy beds, indicating the two anticlinals noted above.

Madame Island.

Madame Island and Isle Reaux lie to the south-east of the east end of Orleans Island, and distant from it one and a half to two miles. The former, or more westerly, has a length of 130 chains and a maximum breadth of thirty chains. The latter has a length of 225 chains and a breadth of about twenty-five chains. At low tide, extensive reefs of shale and sandstone extend in all directions, and nearly connect the two islands. They are both generally flat, but each has a low ridge extending along the centre of the island. Madame Island is composed entirely of grey, green and black shales, probably of division 1, with several prominent reefs of hard quartzose sandstone off the east end, similar to those found at Traverse Point on the east end of Orleans Island. These reefs curve across the flats at the east end, and then bend sharply to the eastward, where they skirt the flats to the southward of Reaux Island, being visible at low tide.

Reaux Island.

The rocks of Reaux Island are slightly higher in the series, being black, green, grey and red shales, like those near St. Michel on the main land, and contain *Obolella pretiosa*, as at that place. In neither of these Islands do beds of limestone conglomerate appear. Grosse Isle, which is the seat of the Quarantine Station, lies one mile and a-half south-east of the east end of Reaux Island. This island, with Patience, the Brothers, Barrier, Two Head, Canoe, Mill, Race, Margaret and Cliff islands, forms a chain lying about the centre of the River, and showing rocks of general similarity. On all of these islands, some of which are of small size, the strata are greatly folded. In the Report of 1866–69, the most of these rocks were assigned to the Lauzon division of the Quebec group. The rocks of Grosse Isle may be described as fairly representing the rest of the group.

Grosse Ile.

Along the north side and forming the greater part of a ridge which traverses the central and western half of the island, grey and greenish sandy shales, holding scattered pebbles of limestone, occur in places forming a tolerably coarse sandy grit, like that in the north-east end of Orleans Island. This, probably, represents the lowest part of the series, succeeding which, on either side, are beds of greenish-grey sandy shales.

holding many pebbles of limestone and passing gradually into a true shaly limestone conglomerate. These directly underlie the limestone conglomerates proper, which occur in beds from two to ten feet thick, associated with red, green and black shales, hard sandstones and dolomitic limestone. The general aspect of these rocks is similar to the conglomerates of Beaumont and the east end of Orleans rather than to those of Lévis. While several foldings occur, the general structure of the island is that of a double anticinal, the synclinal extending through the centre, and being occupied by the red and green shales of the upper Sillery, without the beds of sandstone. These red strata occupy most of the south side of the island, more particularly east of the Quarantine wharf; the extreme west point, which is a small island at high tide, being composed of green grits like the rock of the northern ridge. The limestone conglomerates are especially developed on the north-east shore, where they extend west for fifty chains from the eastern extremity. From the pebbles, small fragments of trilobites were obtained, but no fossils preserved sufficiently for determination.

Patience Island

Patience Island lies to the north of Grosse Isle, five-eighths of a mile distant. It consists of a central ridge of the same green sandy shales and grit, flanked on either side by the slaty conglomerate, with heavy beds of limestone conglomerate on its eastern end, where the rocks are thrown into a series of sharp folds, the synclinals being occupied by red and green shales. The same rocks are seen in each of the Two Brothers, which lie midway between the eastern ends of Patience Island and Grosse Isle. On Barrier Island, sixty chains north-east of the latter, only the green sandy shales remain, in which, however, the anticlinal structure is visible.

Two Head Island.

On Two Head Island, which presents to the west a bold, almost impassable cliff of the hard, green, shaly sandstone, these rocks are flanked on the south side by the pebbly shales, but on the north by a very complicated set of limestone conglomerates, and red and green shales. The arched structure of the conglomerates is beautifully seen at several points, and especially in a small detached islet off the east end, where the rocks have been cut squarely off, and present a very fine section, showing the green gritty shales at the base, the pebbly green slates and red beds above, and the limestone conglomerates at the crest of the anticlinal.

Crow and Heron islands.

There are two small islets, Crow and Heron, to the north-east of Two Head; the most westerly of these, Heron, shows a synclinal at the western end, from which the limestone conglomerates have been swept away, the green, sandy shales remaining. On Crow Island the north side is occupied by the usual green, sandy beds, while the south shows red and green shales of Sillery aspect. The structure of this islet is

also a synclinal. Further east, Canoe Island lies to the north of Crane Island, and has a length of 125 chains and a maximum breadth of twenty chains. The rocks present a very complicated series of foldings, but are very uniform in character with those just described. Limestone conglomerates are found in small patches at various points all round the island, resting upon the green, sandy shales, and pebbly conglomerates, as on Grosse Isle. From the pebbles of the conglomerates at the east end fragments of *Olenellus Thompsoni* were obtained, in which respect they resemble the beds above Beaumont and at the east end of Orleans Island. Canoe Island.

To the south-east of Grosse Isle are Cliff and Margaret islands, the former being a prolongation of the latter, but separated by a narrow channel. Cliff Island is composed almost entirely of the green, sandy shales, which form a bold, rugged cliff along the north side, and in which an anticlinal structure is apparent running through the centre. On the south side these are flanked for a short distance by the pebbly shales. The underlying green shales extend across to Margaret Island, and form a ridge at the north-west end for three-fourths of a mile, underlaid on the beach to the north by a series of black, green and grey shales of division 2 of the Cape Rouge section. The south-east side of the island is flanked by the red, green and grey shales of the Sillery. The foldings of the east end of the island are very complex, the succession as seen in the other islands being repeated in cross-section four times in twenty chains. No fossils were obtained by us from these rocks, though Mr. Richardson reports finding *Phyllograptus angustifolius* and other species in the rocks of the south side. These must have come from some bands on the flats below high water mark, which overlie the red and green shales as at Lévis. The extreme length of Margaret and Cliff Islands is two miles and three-fourths, with a breadth in the widest part of twenty-five chains. To the south-east of the east end of Margaret Island, and between this point and Crane Island, lie four small islands. Of these the first is ten chains from the shore, and has a length of about eight chains. It consists of green shales, flanked by red, and forms the southern side of a synclinal between this and Margaret Island. The next in order is Middle Island, about the same size, also consisting of green, sandy and red shales. Race Island has an anticlinal structure, the lowest rocks being the green, sandy shales, already described, flanked by the pebbly shales, the red beds being absent. Mill Island, a short distance east of the last, is the same, but has a patch of the red shales and limestone conglomerates on each side, flanking the anticlinal; while Haystack Island, separated by a narrow channel from Mill Island, shows also an anticlinal structure in the green shales.

Cliff and Margaret Islands.

Islands between Margaret and Crane Islands.

The last remaining island of the group, viz., Crane Island, which is connected by a considerable stretch of marsh with Goose Island to the east, differs somewhat from those just described, and which, from their similarity, evidently represent the crests of a series of anticlinals in the lower Sillery rocks. The rocks of Crane Island were regarded by Mr. Richardson as belonging to the Lévis and Lauzon divisions, with a band of Potsdam at the western extremity. They may be briefly described as follows. Along the south shore from the western end to a point three-fourths of a mile east of the wharf, are green, grey and black shales, with thin, hard, sandy bands, like those of division 2 of Cape Rouge, which apparently form an anticlinal extending through the centre of the island, and flanked by the red and green shales of division 3 or lower Sillery. At the extreme western end heavy beds of hard, grey quartzite appear, which resemble the hard bands of division 1. These are flanked along the north side by red, green and grey shales, like those of St. Michel, of which they are without doubt the equivalents. These rocks overlie the green and black shales, the latter occupying the flats and the cliff, the former extending along the course of the island inland, and crossing to the north shore forty chains west of the church, or about one mile and three-fourths from the west end. Sixty-five chains west of the church at this point, where the road comes down to the beach, a band of black shales, with hard, cherty beds, precisely similar to those described on the Etchemin, occur. Evidences of faults between these and the red and green shales are plain, and in character these black beds represent those of the Marsouin. They are fossiliferous, containing graptolites of the following species:

Crane Island.

Fossiliferous black cherty shales.

1. *Dicranograptus*, cf. *D. Nicholsoni*, Hopkinson.
2. *Dicellograptus sextans*, Hall.
3. " *Moffatensis*, Carruthers.
4. " var. *divaricatus*, Hall.
5. " sp. indt.

These are distinct in character from the other rocks of this section from loose pieces of which *Obolella* were obtained. On the south side of the island, sixty chains east of the wharf, a similiar band is seen, but this appears to be intermediate between the green, black and grey shales of the lower series and the red and green shales of the Sillery formation, due probably to a fault. Crossing the island from near the church, red and green shales are exposed for about ten chains, then black, green and grey shales of the anticlinal to the south side of the island, upon which the red and green shales are again seen along the shore. Should these black graptolitic shales be the equivalents of the

Utica-Trenton, their positions must be due to a sharp fold or fault between Canoe and Crane Islands, precisely similar to the infolded bands of like character seen on the Gaspé shore below Tartigo River.

There yet remains to be considered the peculiar group of rocks of the City of Quebec, concerning the horizon of which considerable difference of opinion has arisen within the last half-dozen years. In order to find, if possible, some definite clue to their true age, Messrs. Giroux and Ami were instructed to make a carefully located collection of fossils from various points, and from their observations the following conclusions are derived. Quebec City rocks.

The country along the lower part of the St. Charles River, to the north of the great escarpment, is occupied, in part at least, by true Hudson River sediments. These are seen near the foot of the escarpment in contact with black bituminous shales, limestones and calcareous conglomerates, at a point between Côte de la Negresse and Côte Sauvageau, fifty paces west of Tower No. 4, and a little east of a small gully and brook. The fault between the two sets of rock is well marked by a change in the character of the sediments and by a clearly defined difference in strike of the two series. This point marks the most easterly observed contact of the Hudson or Loraine shales proper, with the rocks previously indicated; but to the west this is seen on the slope of the hill, near Ste. Foye, as already noted, where, however, the contact is with the red and green shales of the Sillery formation. On the line of section between Côte d'Abraham and Champlain street, near and a little west of the city wall, large collections of fossils were made at Côte d'Abraham, the rear of St. John Market, in St. Patrick street, and at the Drill Shed, just beyond the Grande Allée, where the following species were obtained, and have been examined by Mr. Ami. Fault north of the city. Fossil localities.

Between the Grande Allée and the Drill Shed.

In black, carbonaceous, flaggy strata, alternating with films of carbonaceous shales, the beds inclined at an angle of 50° south, rock, iron-stained. Drill shed.

1. *Diplograptus foliaceus ?* Murchison.
2. " *angustifolius ?* Hall.
3. " sp. indt.
4. *Climacograptus, cf. C. confertus,* Lapworth. About fifty thecæ in the space of one inch, polypary parallel-sided, and with numerous crowded serratures. Rather common.

5. *Climacograptus perexcavatus*, Lapworth.
6. " *bicornis*, Hall, var.
7. *Dicellograptus ?* sp. indt.
8. *Dawsonia campanulata*, Nicholson.

From between St. John Market and St. Patrick street.

1. *Diplograptus foliaceus*, Murchison.
2. " sp., cf. *D. rugosus*, Emmons.
3. " sp., cf. *D. confertus*, Nicholson.
4. " sp. resembling *D. mucronatus*, Hall, but with longer slender spines, which extend outward at an angle of 50° to the axis of the polypary from the angle of aperture of the thecæ.

St. John Market.

5. *Climacograptus bicornis*, Hall.
6. " " var. *caudatus*, Lapworth.
7. " *perexcavatus*, Lapworth.
8. " *scalaris*, Hisinger. var. *normalis*, Lapworth.
9. *Dicellograptus sextans*, Hall.
10. *Corynoides calycularis* ? Nicholson.
11, 12, 13. *Lingula*, 3 sp. All apparently undescribed, and characteristic of these rocks.
14. *Obolella* sp. A small and nearly circular species of this genus appears to be represented.
15. *Acrothele ?* sp. A shell resembling a closely related but smaller species from the Beccaguimic River, N. B.
16. *Orthis*. Fragments of one or more species of this genus occur in the limestone conglomerate band near the St. John Market.
17. *Leptæna*,, n. sp. A diminutive species closely resembling that found in the black limestones of the Beccaguimic River, N.B.
18. *Leptæna sericea ?* Sowerby. A large form similar to that which occurs in the Utica and Hudson River formations of Ontario, the Island of Montreal and vicinity. This *Leptæna* occurs in the limestone conglomerate bands, which are interstratified or dovetailed in the black bituminous graptolitic shales, and the association of species at this place is totally different from that met with in the localities above mentioned.
19. A small brachiopod with broad hinge line, semicircular outline, elevated beak, flattened anterior margin, and sides with thread-like radiating striæ, and still finer, crowded concentric lines.

20. *Illænus*, sp. A nearly entire cephalic shield of a species of this genus, which appears to be undescribed, occurs in the pebbles of the limestone conglomerate. The glabella is nearly square in general outline, rather abruptly rounded anteriorly and apparently broadly rounded in front, rather gently convex, bearing a small tubercle a little in advance of the neck furrow. The species bears a considerable resemblance to Barrande's *Illænus Bouchardi*, but may be distinct from it and from other species recorded from Canada.

21. Pleura of a trilobite of doubtful generic reference, perhaps related to the genus *Illænus*.

22. *Hydrocephalus ?* or perhaps a new genus. This collection contains a mould or impression of a diminutive trilobite, one-eighth of an inch in length, whose head and the remainder of the body are sub-equal. Cephalon rather strongly convex, semi-elliptical in outline, length and breadth sub-equal. Pygidium very small, semi-circular; body made up of five thoracic segments, which are apparently destitute of spines and tubercles, and decreases in size from the head to the pygidium. It was first referred to *Æglina*, but subsequent investigation led to its separation from that genus. It is here provisionally referred to the genus *Hydrocephalus*, but a better suite of specimens would no doubt reveal its true generic affinities.

23. *Cyphaspis ?* or *Holometopus ?* A very imperfect specimen. It occurs in a four-inch band of linguliferous limestone and is probably an undescribed species.

24, 25. Two species of entomostraca occur, associated with No. 23. One a large and rather conical form, probably a *Primitia*, and a smaller one, most likely a *Beyrichia*, with a deep sulcus posteriorly,

A subsequent collection from the same locality contain the following species:—

1. *Diplograptus Whitfieldi*, Hall.
2. *Crinoidal fragments.*
3. *Lingula*, sp. nov.
4. *Acrothele* (?), large form, n.sp.
5. " small do.
6. *Orthis*, sp. indt.
7. *Stricklandinia*, sp.

8. *Ampyx*, sp. (pygidium of).
9. *Trinucleus*, sp. (portion of ornamented border).
10. *Cheirurus* (?), sp. (portion of glabella).
11. *Asaphus*, sp. (pleuræ of large species).
12. *Bathyurus* (?), sp. (pygidium).
13. *Cyrtolites*, or allied genus of discoid gasteropod.

Cote d'Abraham.

The collection of fossils from Côte d'Abraham, in which are several monticuliporids, has also been examined by Mr. Ami. In it he also recognized :

1. *Orthis*, sp., cf. young specimen of *O. testudinaria*, Dalman.
2. *Leptæna sericea*, Sowerby.
3. *Asaphus*, sp., portions of pleura of a species of this genus.

Mr. Ami has also made a preliminary study of sections of a number of the monticuliporids.

Stratigraphical positions of the several conglomerates.

With reference to the fossils from the bands of limestone conglomerate, of which a very complete list has already been published in the Geology of Canada, 1863, it may be said that during the past two seasons good collections were made, not only from the beds about Lévis, but from several of the islands, from the Beaumont shore and as far down as Ste. Anne de la Pocatière, where the conglomerates are associated with the Sillery sandstones. From the lithological and fossiliferous character of the associated strata, it would appear that bands of conglomerate of several different horizons occur. Thus the beds of Lévis are intimately associated with the highly graptolitic shales of the Lévis formation, which we have found to constitute the upper part of the Quebec group, and overlie the red shales and sandstones of the Sillery. At Ste. Anne the conglomerates are associated with the Sillery sandstones as an integral part of the red shale series, and presumably belong to a lower horizon, as is also the case with the bands on Canoe Island and Grosse Isle, together with the other islands of the group. On the Beaumont shore, as at the contact above Cape Rouge, the beds of conglomerate are in the green and black shales, which contain thin, hard quartzose bands, the stratigraphical position of which is below the Sillery red shales, while in the city of Quebec the conglomerates are distinct from all these, and have a newer aspect, more properly belonging to the Trenton-Utica period, as proved by the character of the associated fossiliferous shales. While some of the fossils obtained from the limestone conglomerates, both of Lévis and other places along the shore to the east, have an undoubted Cambrian aspect, it may be

said here that, in so far at least as the collections made during the past season are concerned, all these Cambrian forms come from the pebbles and not from the paste. Thus at Fort No. 1, in rear of Lévis, pebbles of two pounds weight contained *Salterella*, but other pebbles from the same mass showed large Orthoceratites, with a diameter of two to three inches, while other pebbles again were well rounded pieces of an older limestone conglomerate. Limestone conglomerates.

In pebbles taken out of the conglomerates of the east end of Canoe Island the following species were found : Canoe Island.

Salterella pulchella, Billings.
Olenellus Thompsoni, Hall.
Microdiscus, sp.

The association of the conglomerates here is with red and green shales and hard sandstone of Sillery aspect.

From the conglomerates on the shore, midway between Beaumont and St. Joseph the pebbles yielded *Olenellus Thompsoni*, Hall, and *Olenoides* or *Microdiscus*, the associated rocks being green and black shales and hard quartzose sandstone. Beaumont shore.

From the pebbles in the conglomerates of Fort No. 3, in rear of St. Joseph de Lévis, were obtained :— Fort No. 3, Lévis.

1. *Salterella rugosa*, Billings.
2. *Orthoceras*, sp. like *Xerxes*, Billings.
3. *Cyrtoceras Syphax*, Billings.
4. " *Metellus*, Billings.

From the low ridge west of the high ridges which bound the Catholic Cemetery on the west, in rear of St. Joseph, were obtained : Lévis, near cemetery.

1. *Orthis Mycale*, Billings.
2. " *electra?* Billings.
3. *Camerella calcifera*, Billings, Lévis form.
4. " *polita*, Billings.
5. *Holopea*, sp. indt.
6. *Cyrtoceras Alethes*, Billings.
7. " ? sp. nov., (annulated).
8. *Bathyurus quadratus*, Billings ; portion of head and body.
9. " *Saffordi*, Billings ; several pygidia.
10. " *bituberculatus*, Billings : several heads.
11. " *Timon*, Billings ; pygidium.
12. ? *Conocephalites Zenkeri*. Billings.

West end of Orleans Island.

From the west end of the Island of Orleans:

1. *Orthis apicalis*, Billings.
2. *Orthis*, sp. indt.
3. *Camerella polita*, Billings.
4. *Cyrtoceras*, sp. indt.
5. ? *Asaphus canalis*, Conrad; a nearly entire pygidium of a trilobite probably identical with this species.

Conclusions.

From a consideration of the many facts presented in the preceding pages in regard to the structure of the Lévis and Sillery divisions of the "Quebec group," a comparison can now readily be made with the rocks seen along the south side of the St. Lawrence to Cape Rosier, the description of which, east of Métis, was given in the Geological Survey Report of 1881-82. For although at that time it was strongly suspected that the true position of the Sillery formation was beneath the Lévis, it was held that, in view of the opinion which had prevailed for so many years to the contrary, it would not be wise to make such a change without the most convincing proof. This change in stratigraphy we now consider to be so thoroughly established, that but little, if any, doubt can exist on the subject; and upon this interpretation of the structure much of the difficulty which arose as to the correct understanding of the points stated in Prof. Lapworth's paper on the graptolites now disappears. From Métis to Cape Rosier the great bulk of the rocks, with the exception of the portion between Marsouin and a point about three miles below Griffin Cove, together with certain other limited areas clearly marked by characteristic fossils of an upper series, belongs to the Sillery formation, and much of it to the lower portion of that division, and entirely below what we regard as the fossiliferous or graptolitic Lévis formation of the city of Lévis and the south-west end of the Island of Orleans; and at only one point, viz., three miles above Ste. Anne des Monts, do we find what may be regarded as probably a Lévis zone. The rocks of Cape Rosier, in which the *Dictyonema sociale*, *Clonograptus*, etc., were found, as well as those two miles below Great Matane River, where similar forms occur, represent divisions 2 and 3 of the Cap Rouge section and the Beaumont shore, as well as of the the strata on the south side of the Island of Orleans, consisting of black, green and grey shales, with some red beds, together with the grey limestones and hard, greyish quartzites, while the associated limestone conglomerates are like those seen at Beaumont and at the east end of the Island of Orleans. This character is maintained with great uniformity for the entire distance west of Marsouin, though at certain points the Sillery sandstones and red and green shales representing division 4 are more highly developed

Sillery underlies the Lévis formation.

Rocks of the south side of he St. Lawrence to Cape Rozier.

than at others. The rocks of this section would, therefore, both on the evidence of Prof. Lapworth from the fossils, and from the comparison with the stratigraphical sequence of the Cape Rouge rocks, belong to a portion of the Cambrian system, probably representing the upper and middle divisions of that system, while the overlying Lévis graptolitic shales and limestone conglomerates would represent the lower portion of the Ordovician or Cambro-Silurian system. The lowest Cambrian would, therefore, come into its natural place upon the flanks of the pre-Cambrian ridges, which constitute the high lands of the interior anticlinal axis described in the preceding report and in subsequent pages of the present one.

Cambrian age of the Sillery.

Three zones of conglomerate limestones can also be clearly defined, viz.: 1st, that associated with the green, black, grey and reddish or purple shales, in which the pebbles are very varied as regards size and character including sandstone, quartz and limestone trap; 2nd, that of Lévis proper, already well described; and, 3rd, that of the city of Quebec, which differs in character from each of the other two. In the pebbles of the first, *Olenellus Thompsoni* is found at various localities, and it is probable that the pebbles of conglomerate found in the conglomerates of the Lévis series are derived from these beds.

Three zones of limestone conglomerate.

Cambrian zone

From the conglomerates of zone 2, that of Lévis and the west end of the Island of Orleans, a much greater variety of fossils is obtained, including species which belong to a higher or later horizon, while their association with the Lévis graptolitic shales sufficiently indicates their stratigraphical position. In the same way, the interstratified position of the conglomerates of the Citadel hill, in Quebec, or zone 3, with the highly fossiliferous strata found at different places in the city, which present a distinctly newer aspect than the Lévis, fixes relatively the position of this zone.

Lévis zone.

Trenton-Utica zone.

The relations, or rather the exact horizon, of these Citadel rocks is still to some extent doubtful. Large collections of fossils were made during the past year, which show the presence of a fauna distinct in character and species from that found in the true Loraine or Utica formations, on the one hand, and from the Trenton or Chazy, on the other. The stratigraphical position of these beds does not afford much assistance in working out the problem, since while it may be safely asserted that they are closely related to the rocks which occur along the north side of the Gaspé peninsula, below the Marsouin, and on the north-west side of the Island of Orleans, which have long been regarded as of Utica or Hudson River age prior to the paper by Prof. Lapworth on this subject, there appears to be no palæontological evidence by which they could be definitely assigned to either of these

Quebec city rocks.

Their stratigraphical relations.

horizons. They are brought by the great St. Lawrence and Champlain fault directly against the red, green and black shales of the Sillery formation, wherever seen on the Gaspé shore, as well as at Wolfe's Cove, below Sillery church, while on the Island of Orleans this fault brings them against the fossiliferous rocks of the lower part of the Lévis formation. In character of sediments also the rocks of the city of Quebec differ from those of the Utica in the fact that the former have a large development of bituminous limestone, while the latter in the vicinity are mostly brown, black and occasionally greyish shales, with only occasional bands of hard dolomitic limestone. They are equally different from much of the limestone of the Trenton as seen at Beauport, Lorette, etc. While the fossils are of species distinct from those of the formations just named, several of them, according to Prof. Lapworth, would seem to indicate the lower portion of the Trenton formation by their affinities, and some of the Monticuliporids collected during the past season have the aspect of the lower Trenton rather than of the Utica. It would, therefore, appear that these rocks are a peculiar development above the Lévis, and about the age of the Trenton formation, but the exact horizon of which, from the fossils yet obtained, is exceedingly difficult to determine.

Probable horizon indicated by their fossils.

In the list of fossils enumerated by Prof. Lapworth in his paper on the Graptolites, Trans. R. S. C., Sec. iv., 1886, a mistake has evidently been made in the labelling of some specimens which are said to be from a point half a mile above Cape Rouge. These fossils indicate beds of the Trenton-Utica or Marsouin zone, but no such strata are anywhere to be found in the vicinity of Cape Rouge, since from that village to the contact fault, nearly two miles above, the shore is occupied by the lower rocks of the Sillery or Cape Rouge Section, while above this for several miles the brownish-grey shales and greyish sandy beds of the Hudson River formation occur, similar to those seen on the south side of the river, about two miles south of St. Nicholas. This correction is deemed necessary in view of future explorations for fossils in this direction.

C. Cambrian.

Character.

The characters of the rocks which have for several years been regarded as constituting the Cambrian system of eastern Quebec are given with considerable detail in Rep. of Progress. 1877, Dr. Selwyn, pp. 5 A and 6 A, as well as in Annual Report, 1886, Part J, and the areas now under discussion are but extensions to the north-east of those there described. They consist for the most part of hard quartzites, often bluish-grey in color, veined in all directions with quartz, and

frequently containing an abundance of clear blebs of glassy quartz; they do not present the pebbly character so often seen in the beds of the Sillery formation, and they have occasionally a purplish shade and are interstratified with purple, greenish and black slates. A considerable area of green, sometimes schistose quartz-veined slate also occurs at several localities near the base of the series. At times the black slates, associated with the white or gray quartzite is finely micaceous, yet differing in character from the mica schists of the underlying system. These are well seen on the roads leading from the Craig Road to the several stations on the Quebec Central Railway. Limited outcrops of greyish sub-crystalline limestones are found occasionally in the first and second concessions north of Beauce Junction and in the township of Mailloux along the road leading north-east from the village of Buckland, and also near West Broughton. In all these places they are associated with the black slates and quartzites and have been burned for lime for local purposes. Black slates and limestones.

The volcanic portion of the Cambrian, is also well developed in this direction, but is confined, for the most part, to the eastern side of the anticlinal. It is marked by the presence of frequent outcrops of trappean rocks, often concretionary in character and of greyish or reddish-brown colours. These rise into several lofty peaks, among the most conspicuous of which may be mentioned Broughton Mountain, on lot 25-26, range X and XI, of Broughton and Moose Mountain in the north-west part of the township of Cranbourne, to the north of the great bend of the River Etchemin, whence the volcanic rocks extend for some miles in a series of lofty ridges and hills to the north-east and south-west, though in the former direction, owing to the wilderness character of the country it was found impossible to outline this part of the series definitely. Serpentines also occur in connection with these rocks both massive and as agglomerates, though to a very limited extent as compared with their great development to the south-west. The large areas of serpentine rocks apparently extend northward no further than the township of Thetford. Small outcrops only occur on the Bras and Des Plantes branches of the Chaudière in Vaudreuil in connection with diorites which, in the form of dykes and bosses, form areas of considerable extent in this vicinity. Volcanic portion.

North of the Chaudière the Cambrian rocks are divided, for some distance, into two portions by the ridge of Pre-Cambrian schists which marks the prolongation northward of the Sutton Mountain anticlinal, and which crosses the Chaudière in the vicinity of Beauce Junction. South of the river in St. Elzear and St. Frederic, these rocks, at times, apparently conceal the older schists nearly to the vicinity of St. Chaudière and vicinity.

Severin, while further south, areas of Cambrian rocks form overlapping patches or closely infolded basins in the Pre-Cambrian. In Tring and Vaudreuil the Cambrian is concealed over a considerable area by the Cambro-Silurian rocks which extend north-east from Lake St. Francis while further to the east it is overlapped by the rocks of the eastern Cambro-Silurian area which continues thence to the boundary of Maine.

North of the Chaudière the western boundary of the lower Cambrian is somewhat difficult to trace, but it apparently follows a somewhat irregular line to the Etchemin being unconformably overlapped by the Sillery red slates, conglomerates and sandstones, the contact of the two series being near the village of Ste. Claire. Thence the line extends towards St. Lazare, crossing the road to Buckland near the Abenaquis River, beyond which the lower Cambrian quartzites and shales form the high ridge between St. Damiens and Buckland. Further to the north-east, the road leading from Armagh to Mailloux crosses the strike of these formations. Good sections of the Sillery sandstones and red and green shales are seen on this road for several miles southeast of Armagh Corner, being well exposed at the crossing of the Rivière du Sud, one mile and a half distant, where their folded structure is beautifully displayed. South of this stream the red and green shales are seen for two miles further, beyond which the Mailloux green and black altered slates of the Cambrian are found, though exposures are very rare, to the corner of the Taché road near Mailloux church. Further to the north-east, on the road south from St. Thomas, the northern limit of these rocks is seen about one mile north of the Taché road. Further east on this road, the line between these and the upper Sillery rocks crosses about three miles east of the village of St. Marcelle.

St. Lazare to Buckland.

Road south of St. Thomas.

The Taché road extends north-easterly through the townships of Mailloux, Montmagny, Patton, Arago, Garneau, etc. South of this road the only settlements are St. Magloire in Roux, and St. Pamphile on the Elgin road, near the boundary of Maine.

Taché Road.

The Cambrian rocks apparently conceal from view the schists of the underlying anticlinal, or lap completely round the northern extremity of the Pre-Cambrian ridge, which gradually declines in elevation in this direction, about the middle of range I, township of Rolette, a few miles south east of St. Paul de Buton, since no rocks of the older series are seen on the track which extends south-east past Lac au Crapaud, Cambrian and Cambro-Silurian sediments only being visible in this direction.

Rolette.

Throughout the entire area of these lower Cambrian rocks no fossils have yet been found by anyone.

No fossils yet found.

In lithological characters, part of these resemble, in many respects, those of the coast series of Nova Scotia, while in part they resemble

the lower portion of the Cambrian of New Brunswick. The most that can be said of them stratigraphically is that they are intermediate between the chloritic and micaceous schists of the central anticlinal and the overlying rocks of the Sillery, from which they differ considerably in character. Resemblance to the Cambrian of New Brunswick.

Much of the strata just described, north of the Chaudière, were considered by Richardson in 1869 to be in part of Sillery age, and in part to belong to the Potsdam formation. While there is presumably a considerable interval separating the two horizons, as at that time understood, there are certain beds in both formations which possess many points of resemblance to each other. This question has, however, been pretty fully discussed in previous pages, and no further remarks are here necessary. It may, however, be added, that much of the confusion which has prevailed in regard to the true position of these rocks has been due to the apparent similarity and consequent grouping into one formation of all these sandstones and associated shales. On the old view as to the composition of the Sillery formation, it was quite correct to say that much of what was then so called was older than the Lévis, though it did not follow that all of what then was called Sillery should be placed in the same horizon. Views of Richardson, 1869.

Considerable difficulty has been experienced in fixing the position of certain black slates which are closely associated with the chloritic and micaceous schists of the central anticlinal. While in places somewhat micaceous, they differ in character very considerably from the rocks which we have called Pre-Cambrian, and at certain points a manifest unconformity between the two series is evident. This is well seen on the road from Broughton station on the Quebec Central Railway to Harvey Hill, the regular strike of the underlying chloritic rocks being nearly east and west, where the overlying black slates, with which are associated beds of greyish limestone, at times strike nearly north and south. On this account, and because of the much greater metamorphism of the lower series, an attempt to separate them has been made; and while, in the absence of fossils which might be conclusive, no other evidence than that presented can now be adduced, this separation will serve to distinguish the crystalline schists which are often richly metalliferous, from the slaty series, which has as yet proved comparatively poor in this respect, if we except the quartz veins which may be, and presumably in many cases are, auriferous or carry argentiferous galena. Black slates of the central area.

Concerning the Cambrian age of the serpentine belt, several of the remarks just made will also apply. The serpentines are apparently associated with two different groups of rocks; thus, certain areas are associated with great masses of concretionary as well as massive diorites, Volcanic portion of the Cambrian.

in which the latter largely predominate, as in the Moose Mountain and Etchemin districts. The associated rocks here are green, black and red slates with hard quartzites, which at first glance resemble some portions of the Sillery formation. Somewhat similar red slates also show near the Colway, on the Chaudière, where also diorite and serpentine in small outcrops are seen; near these, also, a small boss of granite occurs in the black shales.

Serpentines, diorites, etc.

Further south are the great serpentine areas of Thetford and Coleraine. The country rock is mostly a black or greenish slate with hard schistose quartzite, though at Coleraine station beds of dark red slates with conglomerates similar to those which flank the Stoke Mountain range, and which are described in the Report for 1886, occur, but which differ greatly in character from the crystalline schists of the central axis; while in connection with the chloritic and micaceous schists other areas of serpentine are found, generally of limited extent and frequently associated with talcose minerals, soapstone being often present. These are well seen in the Leeds district, north of Kinnears' mills where the rocks in which the serpentines occur are distinct in character from those seen in the productive asbestus district, as also from those in the township of Broughton. The manifest difference in the character of the strata, together with the fact of the occurrence of a great line of fault between the crystalline schists of the Sutton Mountain anticlinal, and the slates and serpentines to the east, are the chief reasons for the separation of these two series into Pre-Cambrian and Cambrian.

Economic importance of the Cambrian rocks.

The importance of these areas of Cambrian rocks, from an economic standpoint, has already been alluded to in the last Report, 1886, in connection with the gold and asbestus deposits of Eastern Quebec. The remarks then made have been fully sustained by the work of the past season, and it seems to be clearly established that the greater part at least of the gold, is derived from the quartz veins in this series of rocks. That these veins, which occur in great numbers in the slates and quartzites, are not uniformly auriferous, is no more than should reasonably be inferred, since the same feature is common to all gold regions; but it is probable that the greater richness of certain areas is due to the same principle that appears to be established now for the Nova Scotia auriferous leads, viz.: that the most productive veins occur along the axes of the anticlinals. This principle should apply both to the Chaudière and to the Ditton areas, since in the latter the most of the gold yet found is certainly derived from veins which are near the centre of the anticlinal axis in that locality.

It is possible, also, in the Chaudière district, that the frequent outcrops of diorite seen about St. Francis, and for a few miles in either direction, may have had some favourable influence in determining the auriferous characterof this section.

A. B. Pre-Cambrian.

Underlying the series just described are the rocks of the central anticlinal referred to this period, and already alluded to in former reports as constituting the oldest rocks of the Townships. In the report for 1869 by Mr. Richardson, they were described as belonging in part to the Sillery and in part to the Lauzon division of the Quebec group. The view was at that time held that these rocks were the extension of those seen in the Sutton Mountain range, while the structure was supposed to be the same, viz., an overturned synclinal.

Formerly regarded as Lauzon and Sillery.

The axis of the Sutton anticlinal has been traced carefully during the past season and found to extend with great regularity north-east from the townships of Wolfestown and Halifax, through Leeds to the Chaudière River, where it is seen in the cuttings of the railway along the south slope of the river valley, about one mile south of Beauce junction. Northward it is observed in the brook which crosses the road in rear of that place between the concessions of St. Joseph and L'Assomption, though the older rocks are concealed for several miles on either side of the river by the overlapping slates and quartzites of the Cambrian system just described. The ridges of chloritic schists again rise into prominence a short distance further to the north-east in the concession of St. Adolphe and extend thence in an unbroken line for nearly thirty-five miles, forming the high range of hills seen in Frampton, the eastern part of Buckland and the adjoining townships of Standon, Mailloux and Roux, beyond which the prominent elevations gradually sink and the older rocks disappear about midway in the western portion of the township of Rolette. The widest part of this area is in Standon where it has a breadth, north of the Etchemin, of nearly five miles. On the west side it is overlapped by the black, wrinkled slates and quartzites of the Cambrian, which are seen in places to rest upon the older schists in a nearly horizontal attitude, and on the east it is likewise overlapped by the volcanic portion of the same system.

Eastward extension of the crystalline schists.

Further to the north-east, in Patton, Talon, etc., though the anticlinal structure is maintained, none of the rocks of the crystalline schist series have been recognized, as far at least as the Temiscouata road. Between this point and Matapedia Lake the belt of country constituting the height of land, has not yet been fully examined, though prominent ridges occur; but east of that lake the old rocks come into view again and constitute the Shickshock range. This has been shewn on the map of the Gaspé Peninsula. See Geol. Surv. Rep. 1880-81-82.

Their occurrence in Gaspé.

Development south of the Chaudière.

To the south west of the Chaudière the Pre-Cambrian rocks are well seen in continuation of those already described as occurring in Chester and Wolfestown. Within the last few years several new roads have been made which connect the old Craig road with the stations of Black Lake, Thetford and Robinson, on the Quebec Central Railway, and these have afforded good facilities for determining the limit of the schists in this direction. It is probable that several folds occur in the older rocks of this section, some of which include limited areas of the overlying Cambrian, which, under the aspect of purple, black and green slates and quartzites, are seen to lie nearly flat upon the upturned edges of the schists at several points on the Thetford and Broughton roads, the difference in the direction of the strike and dip of the two series being at times well marked.

The area of the older chloritic and micaceous rocks which varies considerably in the townships of Halifax, Ireland, Inverness and Leeds, rapidly diminishes towards the Chaudière by the overlap of the Cambrian strata till it has a breadth of not more than one mile at the southern boundary of the township of Ste. Marie, beyond which point these older rocks are apparently entirely concealed. Areas of chloritic and talcose schists also occur in a ridge extending through the township of Thetford.

Among other lines of traverse crossing the crystalline rocks of this system three may be described as illustrating the anticlinal structure of the area south of the Chaudière. Of these the most southerly is on the road from Ste. Sophie, east of Somerset, to Halifax. On this road, after crossing the flat occupied by the graphitic black shales and limestones, the first rocks seen are green slates, sometimes dark colored and highly schistose, with a great quantity of quartz in irregular veins. They are much twisted, but have generally a high dip to the south-west. In many respects they resemble the Pre-Cambrian rocks of New Brunswick, and represent probably either a portion of that system or the lowest members of the Cambrian series. Thence for two miles the road rises rapidly over greenish schistose slates with an occasional purple-tinged band to near the top of the ridge where green chloritic and micaceous schists come in, the dip of the series for this portion being N.W. Thence alternations of chloritic and micaceous schists are seen along the crest of the ridge and down the eastern slope to the crossing of the brook, nearly two miles west of Halifax Corner, where a band of black mica slates, similar to the rocks in the vicinity of Wolfestown, crosses the road. Green micaceous schists, however, again come in and extend to the road from Halifax to Wolfestown, east of which, towards Black Lake, alternations of green schist and black wrinkled and sometimes micaceous

Lines of section Ste. Sophie to Halifax.

slates, which may represent infolded areas of Cambrian sediments, occur. A series of synclinals is seen in the area east of Halifax, but the structure of the main ridge, east of Ste. Sophie, is undoubtedly an anticlinal one.

The second line of section between Inverness Corners and the Thetford mines crosses the Craig road near Bullet Brook.

Inverness to Thetford Mines.

The beds of green and black striped shales, with limestone conglomerates, seen to the west of Inverness are directly underlaid by green and grey slates, which are cut by quartz veins near Inverness Corner; while two miles east of that place, at the jog in the road near Irving, the black, wrinkled, irony slates appear. None of these slates have the distinctly schistose character of the Pre-Cambrian, but about half a mile further on, where a road runs south to Bullet Brook, green chloritic and micaceous schists come in and form the entire ridge between this point and Craig road, a distance of two miles and a fourth. On the second part of this section, that east of the Craig road, the first rocks near Bullet Brook are twisted green, grey and black slates, containing quartz-veins, which have been opened at this place for copper. Crossing the brook on the road to Thetford, the road ascends rapidly over mica-schists, silvery-grey, green and chloritic. These occupy the entire extent of the ridge nearly to the beginning of the descent to Thetford, a distance of four miles, having a general dip of N. 15°–50° W. < 15°–30°. The axis of the anticlinal is well seen near the eastern summit of the ridge, about four miles and a-half west of the Quebec Central Railway at Thetford station. Near the summit a belt of black, wrinkled and slightly schistose slates crosses the road, with a breadth of nearly two miles, being succeeded by green chloritic and micaceous schists, which thence extend down the road leading to Thetford brook as far as the crossing on the line between lots 23 and 24, three-fourths of a mile west of the Thetford River. Thence the black and grey slates and hard quartzites which accompany the serpentines extend to that stream. In this section also the structure of the second ridge is a true anticlinal one, all the sediments lying to the east of the summit, dipping apparently to the south or south-east, while those to the west dip in the opposite direction. The position of the black, somewhat schistose slates, which are occasionally micaceous, is the same as further to the south about Wolfestown, where we have considered them as infolded areas in the older schists.

St. Sylvester to Broughton.

The third section, between St. Sylvester and Broughton, exhibits a similar succession of rocks. Here the breadth of the crystalline schists is very much reduced. They are first met with at the foot of the steep hill on the road leading from Harvey Hill through the ranges of Handkerchief and St. Frederic, where the ridge of crystalline schists is

the most prominent feature in the country, and has a direct breadth of one mile and a-half. Between this hill and the brook east of St. Sylvester Corner, purple, black and green slates, with hard quartzites, are the principal rocks, and these rest directly upon the schistose series, the dip of both being north-west. The rocks which border the crystalline schists on the east are similar in character to those on the west, and are distinct in character from those of the main ridge.

Areas north of the Chaudière.

North of the Chaudière the section across the central ridge is from the usual series of black, green, grey, and occasionally purple slates, with hard quartz-veined quartzites on either side, across a central area of chloritic and micaceous schists, having a breadth of nearly four miles east of West Frampton, with a distinctly defined anticlinal structure near the summit of the ridge. To the south-west of this ridge, in the vicinity of Les Saintes Anges, the rocks seen on the several roads are micaceous black and grey slates and quartzites, with bands of dark-grey crystalline limestone. Similar rocks are seen in the cuttings on the Quebec Central Railway along the hill south of the Chaudière, and they have been regarded by us as representing possibly the lower portion of the Cambrian, though they may be a portion of the older series. The green chloritic schists appear in a small outcrop at a brook crossing the back-road about one mile north of Beauce junction.

Black and grey slates of Standon.

It will be seen from the several sections here presented that the succession of the strata is tolerably uniform and that the central anticlinal axis in the schists is constant. The distribution to the north-east and the termination of the schists have already been described. There is, however, an apparently overlapping basin of slates of Cambrian aspect, which crosses the Etchemin River in the vicinity of Standon, and can be traced for some four or five miles to the south-west and north-east of that point. It has in no place a greater breadth than one mile, and generally is much narrower, the rocks comprising it being distinct in character from the crystalline series.

From a careful consideration of all the facts presented above, it appears conclusive that, not only on lithological grounds but stratigraphically, the divisions of the Eastern Townships rocks, as now given, can be clearly maintained, many sections having been studied and the relations of the several groups being the same throughout.

The apparent absence of fossils from the beds which are now considered Lower Cambrian is not to be taken as conclusive of their non-existence at some point, since as in the case of the Lower Cambrian of New Brunswick, where diligent search has been prosecuted for more than twenty years and immense collections of primordial fossils made, it is only very lately that organic remains have been detected

in the lowest beds. The metamorphic condition also of a great portion of the strata in the Townships might preclude the discovery of traces of organisms, and even as regards the fossiliferous portion of the Quebec group it is found that the fossils are confined to very limited areas, and that great thicknesses of strata are apparently entirely devoid of any sign of organic life.

CRYSTALLINE AND IGNEOUS ROCKS.

Granites.—The areas of granite found in the limits of the north-east quarter sheet are, so far as now known, confined to two localities, the great masses which form such conspicuous features in the south-eastern portion of the province, not extending so far northward. Of these granites a very limited outcrop is seen about half a mile south of the Chaudière River and about one mile east of the Bras du Sud-Ouest in Beauce. The other is found in connection with large masses of white granulitic rock which form an important feature in the serpentine areas of Coleraine, and Thetford, where the rock, which consists generally of felspar and quartz, at times contains mica. Between Black Lake station and Thetford mines on the Q C. Railway, these white masses are very conspicuous, forming hills from half a mile to two miles east of the railway. In some of the asbestus workings, dykes of this rock, from a few inches to several feet in thickness, are seen to cut the serpentine and, at times, appear to have shattered the rock in contact, thus leading to the belief that the granulite is a newer rock than the serpentine.

Outcrop near the Chaudière

Outcrops in Coleraine and Thetford.

Diorites are somewhat largely developed in this section as well as in that to the south-west. The continuation of the peculiar chain of peaks which extends from the Vermont boundary south of Owl's Head through Orford and Ham mountains into Adstock, is seen in the Broughton Mountain, and again on the north side of the Chaudière in the great mass of the Moose Mountain range and in several peaks to the north-east of it, not designated by special names. These rocks, as stated in Part J, Annual Report, 1886, are closely associated with the serpentine, of portions of which the latter may be and probably is an alteration, and in the serpentine areas of Thetford and Coleraine great masses of diorite rock both massive and concretionary are found. On the Chaudière also, between the Colway and the Gilbert, considerable outcrops of dioritic rocks occur, generally of greenish or greyish shades but, at times, as on the Colway of brownish color. The most extensive of all these is the mass in Cranbourne, known as Moose Mountain, which has been outlined over an area ten miles in length and two miles and a-half in breadth but its northern boundary has not been reached, owing to the densely

Chain of diorite hills.

Outcrops on the Chaudière.

Moose Mountains.

wooded character of the country in this direction, but it probably extends for several miles further. The areas on the Chaudière are generally of small extent, and often occur in connection with hard quartzose sandstone and black slates which are cut by quartz veins. At times these diorites are highly serpentinous, and form a serpentino-dioritic agglomerate. All these rocks belong to what is now regarded as a portion of the Cambrian system.

Diabase associated with the Sillery rocks.

Other masses of trap rock, mostly diabases, are found associated with the Sillery formation. These are greenish and brownish, and are, at times, amygdaloidal While they are quite numerous, probably the largest and most important are, 1st, near St. Apollinaire, five miles east of St. Antoine de Tilly, and not far from the line of fault between the Sillery and the Hudson River formations; 2nd, an area of considerable size whose southern limit is seen on the road from St. Gervais to St. Lazare, whence it extends to the north in a series of outcrops some of which are of large extent, for four miles to the vicinity of and beyond St. Nerée, and 3rd, a prominent hill on the road leading from the St. Henry and Anselme road to St. Gervais. These traps have exercised an apparent metamorphic action on the slates with which they are in contact, and in all the three localities, bands of slate and sandstone are intimately mixed with the trappean rocks. Small areas of similar rocks also occur with the black graphitic limestones and slates near Somerset and Ste. Julie.

Their principal development.

Serpentines.—The areas of these rocks are often of considerable size and great economic value. The largest extends from the road leading from Coleraine to Wolfestown, through Coleraine into Thetford, and is the continuation of the belt described in Part J, Annual Report, 1886, as occurring in Ham and Wolfestown. The largest development is in the northern part of Coleraine about Black Lake and in the portion of Ireland adjoining, and it is in its northern prolongation into Thetford, where it forms a belt east of the Thetford River, that the valuable deposits of asbestus occur which are known as the Thetford mines. The economic importance of this belt was discussed in the last Report, but during the past two years a great amount of exploratory work has been done by various parties to determine the existence of workable veins of asbestus, and many new outcrops have been found, which may be briefly mentioned.

Economic importance.

Observations by Mr. Obalski.

The main ridge which extends north-east from Coleraine forms a very prominent mass along the west side of the Q. C. Railway as far as Black Lake where the most northern peak, known as Silver Mountain, rises on the south-west side of that sheet of water to a height by aneroid of about 500 feet above its surface. The belt has a breadth of two miles and a-half with its western limit in lot 24, ranges I to IV Ire-

land. The elevations of this ridge were not taken by us, but on a plan by Mr. Obalski, mining engineer for the province of Quebec, several prominent peaks are noted as rising from 600 to 650 feet above the lake. In this great mass of serpentine but two deposits of asbestus of sufficient importance to warrant mining, are yet known, viz., that owned by Fenwick and Sclater of Montreal, which is on the extreme south-east corner of the mass at a distance by road of one mile and a-half from Coleraine station, and the other, owned by King Bros., of Quebec, on lots 24 and 25, range III, Ireland. On Silver mountain, however, a number of small veins of asbestus have been observed, but no attempt has yet been made to develop them.

Coleraine and Ireland.

Black Lake.

This area of serpentine is bounded on the east by a ridge of diorite which extends to the small lake above Black Lake, opposite which the serpentine of the main mass crosses the stream flowing into that lake and shews in small cuttings on the railway as far as Black Lake station. The country along the Q. C. Railway for several miles north of Coleraine station is thickly strewed with serpentine boulders, but ledges rarely appear.

Black Lake to Thetford Mines

The main mass of serpentine is cut off at the shore of Black Lake, but re-appears on the north side and between the lake and the railway. West of the Thetford River it has not been seen except at one point on the road a short distance beyond that stream, where a mass of the rock occurs, but has the appearance rather of a large boulder than of a ledge. The northern line of the main belt crosses the railway a short distance north of Black Lake station and continues north-eastward with some breaks, showing diorite and granulite to the Poudrier road, which is now, for the most part of its length, merely a track largely overgrown. This road is nearly midway between Black Lake and Thetford stations. In the area lying between the railway and the Thetford River, towards the Thetford mines, diorites are occasionally seen, and several cuttings are made in the serpentine along the line of the track in this direction, but the great mass of asbestus bearing rocks keeps to the south-east of the railway towards Caribou Lake.

Thetford Mines

Near the boundary of the township of Thetford, serpentine comes in again to the west of the railway, and some rich ground is seen between it and the river, and passing into Thetford, it occupies the entire space between the river and the mines for a distance of half a mile or more, much of the surface being covered with drift so that the character of the underlying rock can only be determined by excavation.

Thetford and Black Lake road.

A waggon road has lately been made between Black Lake and Thetford, and thence alongside the railway to Robertson station. Between the two former places it rises steeply over serpentine for a mile to near the foot of a lofty ridge, on which Reid's, now Wertheim's,

Old Poudrier road.

mine is situated, whence it keeps more northerly and crosses the old Poudrier road, about one mile south-east of the railway. On this latter track the serpentine shews for several miles, the lots having been taken up by different parties as far back as lot 17, range A and B, two miles from the crossing of the Thetford road, beyond which the country is said to be swampy, and rock exposures rare. In this direction the masses of white granulite form very conspicuous features and occupy a very considerable area. At Thetford the largest of these is seen near the road leading from the Thetford mines to Ireland; west of the Thetford River no traces of serpentine were observed; slates and hard sandstones being the principal rocks till the schists of the mountain ridge are reached.

Granulite.

Area of serpentine noted by Mr. Obalski.

The principal area of serpentine extends north-eastward from Thetford station on the east side of the railway for about one mile, beyond which it disappears; but from the notes which Mr. Obalski has kindly furnished us of his exploration, it comes in again farther to the east. Mr. Obalski says:—"In Thetford township I found serpentine on lots 10, 11, range VII; lots 14, 15, 16, range VIII; 14, 15, range IX; 5, 7, 9, 10, range X; as also in Adstock on the Coldstream River, at the end of the Poudrier road."

Little Lake St. Francis.

Mr. Obalski also spent some days exploring the country in the vicinity of Little Lake St. Francis. He says:—"On the north-east side of this lake I noticed a belt of serpentine, three-fourths of a mile wide, running north-easterly; as also near a lake without a name, near the Poudrier road. Much of this resembles the Wolfestown serpentine, but other portions were light-colored and siliceous."

Thetford to Broughton.

On the north side of the railway, in the township of Thetford, serpentine occurs in lots 16, 17, 18, range IV, containing chromic iron; and small mounds of the rock occur also on lot 13, range V; and in range XI, Broughton, along the south side of the road from Broughton station to Harvey Hill, frequent outcrops of serpentine and soapstone are seen. These were mapped some years ago by Mr. H. Y. L. Brown, but no asbestus of economic importance has yet been reported from these latter areas. Further to the north-east, serpentine and soapstone occur on lot 14, range VII, on which the Broughton mine is situated. This is the most easterly outcrop of the belt known on the north side of the railway.

Broughton.

Chaudière district.

In the Chaudière district, serpentine occurs in three bands, separated by hard quartzites and black and grey slates on lot 13, range I, Tring, in which several small veins of asbestus were seen. Also on the Bras du Sud-Ouest, at the falls, three miles from the mouth, and in small knolls on the hill side east of that stream, and half a mile south of the Chaudière. On the Des Plantes it is seen in a hill and in the stream,

with slates and sandstones, just above the road across the mouth of the river, and further up at the Falls from one to two miles above. The outcrops at both these places are not large, but small veins of asbestus were observed. Small openings have been made to test them, although not much work has yet been done.

Beyond this, to the north-east, a small outcrop of serpentine is found in the east flank of Moose Mountain, on lot 23, range V, Cranbourne, on the west bank of the Etchemin, owned by Mr. Mangan. Here veins of asbestus up to five-eighths of an inch were seen. No serpentine was observed by us to the north of this point, but Mr. McOuat reports three small outcrops of serpentine rock on the old track, now entirely grown up, leading past Lac au Crapaud; one in range IV, Rolette, the others on range VI, Talon. The country in this direction is a densely wooded wilderness. Cranbourne.

Among other localities observed by us may be mentioned an outcrop on the concession of Ste. Catherine, near the road, four miles east of St. Sylvester Corner, owned by Mr. Fahey, of that place, near the contact of schists and crystalline dolomites, with black and grey slates. This, in so far as we could see, contained but slight traces of asbestus. To the south-west in the township of Leeds, on the road north from Kinnear's Mills, and on lots 1, 2 and 3, range X, several small areas occur; but from none of these has workable asbestus been reported, though good chromic iron was found there, and several beds of very rich magnetic iron ore occur in the vicinity. Also on range XV, of Leeds, about two miles south-west of Harvey Hill, Mr. Richardson reports several small areas of serpentine and soapstone. These, also, have not yet produced asbestus in workable quantity. Ste. Catherine. Fahey's mine. Leeds.

The character of the serpentine in these small detached areas outside of the main mass of Thetford and Coleraine is generally uniform, but differs somewhat from that in the mining districts. It is often softer and has a peculiar talcose shade and unctuous aspect, and is frequently associated with soapstone, a mixture not found at any of the quarries now worked, with the exception of the mine at East Broughton, where the workable asbestus, in so far as yet known, is confined to a single vein at the contact of the slates and quartzite with the serpentine, and which has now been worked to a depth of over 60 feet. In the lower portion of this working, soapstone of fine quality was met with, which in places forms the hanging wall of the main vein of asbestus. Difference in character of the serpentine.

Surface Geology.

The features of the surface geology to which attention was specially directed during the past two years had reference to the course of the ice-flow and the distribution of boulders and other drift. The great valley of the St. Lawrence, which in pre-glacial times must have extended from twenty-five to forty miles east of its present channel, is clearly defined by the prominent ridge of Cambrian and Pre-Cambrian rocks, and must have been of considerable antiquity. The same was probably true of many of the side streams, such as the Etchemin, the Chaudière, etc., whose pre-glacial character is clearly proved by the finding of old channels flowing into the main river, which have been filled with gravel and sand prior to the deposition of the boulder-clay.

Pre-glacial valley of the St. Lawrence.

Character of surface.

Throughout the entire area great deposits of clay and sand are found. These are especially noted in the broad, flat country lying to the east of the St. Lawrence, over which the line of the Grand Trunk Railway passes, and where large areas of peat bogs occur. In some of the river sections thick deposits of clay are found, which have a depth of many feet, but most of these are devoid, in so far as could be seen, of marine shells, which were observed at but very few points, though this area must have been submerged for several hundred feet.

Throughout this great area exposures of rock are comparatively few. Occasionally a low ridge of hard sandstone and slate appears above the surface. The river channels sometimes show fair rock sections, as on the Becancour and elsewhere, but the smaller streams do not appear to have cut through the drift in many places to the underlying rock. The surface of the country rises very gradually, after reaching the crest of the cliffs which overlook the St. Lawrence, the elevation of Fort No. 2, in rear of Lévis, being, by aneroid, 350 feet above the river, while at Beauce Junction the elevation is only about 100 feet higher. The Pre-Cambrian ridges rise abruptly, and at Harvey Hill have elevations of 1400 to 1600 feet, while the ranges of the Buckland hills have probably not far from the same height. On the east side of these ridges the country slopes gradually to the great basin of the St. John River waters, which is near the eastern limit of the province, and which, when seen from the highlands to the west, looks like a great flat or slightly undulating and thickly wooded plain, analogous to the St. Lawrence basin.

Surface elevation.

The theory proposed several years ago of local glaciers, instead of a great ice-cap, seems to be sustained by the observations of the past two years in the country lying to the south of the St. Lawrence. Striæ are not numerous, but where seen have a generally westerly course on

the west side of the main ridge, trending on the low lands towards a south-westerly or north-easterly direction along the valley of the St. Lawrence, while on the east side of the ridge the course of the striæ indicates a motion to the north-east into the upper branches of the St. John River. As a general rule, the markings, where river-valleys exist, follow the course of these. The following list from places pretty wide apart may be given :—

Striæ.

S. 55° W. on second Con. road, between St. Gervais and St. Raphael midway.
N. 80° W. on second Con. road, one mile east of St. Raphael.
N. 85° W. on fourth Con. road, near St. Nerée Church.
N. 85° W. on road to Armagh, 2½ m. N.-E. of St. Lazare.
N. 75° W. on road ¾ mile south of Armagh Church.
N. 50° W. on road 2½ m. S.-E. of Ste. Agathe.
N. 40° W. on same road, one mile west of Craig Road.
N. 35° W. cor. of road, five miles west of Tring.
S., on east side of West Frampton Ridge, also on top of ridge.
N. 60° W. on road from Frampton to Ste. Henedine.
S. 35° E. on ridge S.-E. of Frampton.
N. 60° W. near Ste. Sylvester.
S., at cor. of road near Lake Etchemin.
N. 65° E. St. Justin Church.
N. 20° E. crossing of Becancour River, one mile east of Campbell's corner, Inverness.
S. 55° W. road St. Anselme to St. Gervais.
S. 35° W. road from St. Gervais to Ste. Claire, R. VIII, Martinière.

Kames.

In many of these cases the connection between the course of the striæ and the old river valley is very plain. Though areas of sand, gravel, and clay are numerous, well defined kames are rare, the most conspicuous seen by us being on the road from Leeds village to Kinnear's mills, about a fourth of a mile north of the Osgoode River; the direction of this kame is generally parallel to the course of the stream or N. 5° E. It has a length well defined of over half a mile, with an elevation of thirty feet.

Drift Laurentian boulders inland.

Among the most interesting surface features in this section is the presence of scattered boulders of Laurentian rocks, gneiss, labradorite, limestones, etc. These in the valley and along the hill-sides of the Chaudière are so abundant that they have been used for building the church at St. Joseph, and the great variety of Laurentian rocks in this structure is an interesting geological study in itself. The elevation of the locality from which these boulders were obtained is from 450 to 600 feet above the St. Lawrence. But further inland similar boulders occur, not only in the approximately level country of the Cambrian to the east of the central axis along the line of the Quebec Central Railway, but even on the most elevated ground, as at

Harvey Hill, which is calculated, by barometer, to have an elevation of about 1,500 feet. Along the slopes of the hills in this vicinity scattered pieces, both large and small, of well rounded true Laurentian gneiss occur, the source of which could have been no other than the rocks along the north side of the St. Lawrence. It is difficult to conceive, either on the theory of local glaciers or on that of a great ice sheet, how these scattered boulders could have been deposited on the high lands of the interior, since on the former hypothesis the local glacier could have had no connection with the source of the boulders and on the latter the ice markings indicate that the course of the glacier could not have carried boulders from the hills along the north side of the St. Lawrence, across the great valley of that river, to the crest of the opposite ridges 1,500 feet or more above sea level.

Theory of their distribution.

The alternative theory to account for their present position must be one of submergence and floating ice, just as we see at the present day, the transportaion of loose stones going on from the north to the south side of the St. Lawrence by the agency of great ice-pans, which, freezing along the shore and around the beach stones, are borne away by the tide and subsequently stranded often at distances far remote. A beautiful illustration of this is seen along the shore between Cape Rouge and Point au Platon. Along this portion of the river, more particularly on the north side, but also on the south side above St. Croix, there is a series of shallow bays with great flats, bare at low tide and extending out for nearly a mile from the shore. These flats are thickly strewn with boulders of Laurentian rock, while the points which divide the bays are in nearly every case entirely composed of boulders. These have been undoubtedly left in their present position by the action of floating ice carried along by tide and wind, and stranded in these coves precisely in the same way as timber rafts, when descending the river, if they meet a strong north-east wind below Point au Platon, are driven on shore and frequently broken up. It is, therefore, quite conceivable on the supposition of a submergence sufficient to nearly cover the hill ranges of the interior, that the scattered boulders there observed were deposited by the same agency.

The distribution of the gold in the drift, for the country south of the Chaudière, was given in last report. In connection with the question of submergence the observations of Mr. A. Webster may be noted. He says "the drift appears to come from the north-east, and is found overlying a bluish-grey boulder clay, in which no gold has been observed. The gold drift contains fragments of local rocks and foreign boulders of Laurentian and newer formations;" and again, "The altitude of the gold-bearing drift appears nowhere to exceed 2,000 feet above the sea. Below this height colors of gold may be said to occur anywhere to the

Remarks of Mr. A. Webster

south-east of the great Quebec anticlinal and most abundantly on the upper waters of the Chaudière and St. Francis rivers. It has also been found on the Maine water-shed." Mr. Webster also remarks that "On the St. John and Daaquam rivers, to the north east, no gold was found, though carefully looked for. This may be owing to the swampy nature of the country and the few exposures of bed rock."*

It is, however, probable that the gold-bearing rocks of the southern area are concealed in this direction by the overlap of the Cambro-Silurian sediments already described. From the remarks in Geol. Can., 1863, p. 929, as to the phenomena observed about Lake Memphremagog and on the sides of the mountains in northern Vermont and New Hampshire, the theory of a submergence of this portion of Quebec to a very considerable depth is clearly stated. The occurrence of clay terraces at the upper end of that lake, 778 feet above sea level, with successive terraces of sand and gravel, to a further height of 579 feet, is noted, while it is further stated, *op. cit.*, "similar stratified deposits form a regular terrace-like beach in Ripton on the Green Mountains at a height of 2,196 feet. Ancient beaches are described by Dr. Hitchcock as existing in the White Mountains at elevations of 2,449 and 2,665 feet above the sea."

Evidences of submergence, Geol. Can. 1863.

Economic Minerals.

Gold.—The history of the gold industry in the Chaudière district was given in the last report, and but little further can be said on the subject. During the last two years work has been carried on by four companies, with, so far as could be learned, satisfactory results. Part of this work was largely of an exploratory character. Of these companies, the works of McArthur, Copal & Co. operating near the village of St. Francis, Beauce, arethe most extensive. They are situated at Meul Brook, a branch of Mill Creek, about half a-mile from the mouth and to the south of the village. Prospecting for an old river-channel has been going on at this place for several years, but two years ago the ancient bed of the Meul stream was struck, and had been tunnelled by the end of 1888 to a distance of over 600 feet, openings being made for ventilation and the easier working of the mine. At the time of my visit, in September of that year, the end of the tunnel at 400 feet, was thirty feet lower than the present bed of the stream, which was about sixty yards to the east. Great difficulty was encountered in sinking, owing to the quantity of quicksand encountered. The bottom of the old channel contained a good deposit of well-rounded, worn gravel, cemented with sand and clay, from which nuggets of gold from $10 to $153 in

Gold mining on the Chaudière River.

St. Francis. McArthur, Copal & Co.

* Rep. Prog., 1880-81-82, p. 4 A.

value had been reported. Difficulty in washing the gravel in order to save the fine gold was experienced, the system of sluicing not being properly arranged as regards fall and other appliances necessary for obtaining the best results. The returns of the quantity of gold produced from this mine are unfortunately not to hand for publication.

Des Plantes River. H. Sewell.

At the Des Plantes, Mr. Horace Sewell, in connection with Montreal parties, has been engaged during the last two years in locating the old river-channel of that stream. During the last year a shaft was sunk on the east side of the river, about half a-mile above the road and a short distance below the old workings of Mr. Mackenzie. The bed rock was reached at a depth of thirty feet, and consisted of sandstones, slates and diorites, overlaid by about four feet of well-worn river gravel, cemented with clay and sand. This is now being followed, and coarse gold in paying quantity is reported. The Des Plantes, in the earlier days of gold mining in this section, produced a large amount of coarse gold.

Cumberland stream, Capt. Richards.

On the Cumberland stream Capt. Richards has continued his exploratory work, but when the last returns were received at the close of the season, had not apparently succeeded in striking the old channel in that quarter. No returns of output are available, but, in so far as could be learned, very little coarse gold was obtained.

Famine River. St. Onge Bros.

The fourth company was working on the east bank of the Famine River, about one mile above the bridge across the mouth of the stream. The former workings of the St. Onge Company having proved unprofitable from several causes, a drift was started in the bank of the Famine by two of the St. Onge brothers, which has penetrated what the miners regarded as another channel in gravel carrying gold, the richness of which has not yet been learned. No attempt has yet been made to work the quartz reefs of the Chaudière district. An analysis of a piece of quartz from lot 12, range I, north-east St. Francis, was made last year by Mr. Hoffmann, who obtained .117 of an ounce to the ton of 2000 lbs., showing the auriferous character of the vein. It is doubtful if the Cambrian gold-bearing rocks appear very far to the north-east beyond Cranbourne, being probably concealed by the over-lapping Cambro-Silurian; but quartz-veins, which look well and which, from analyses made by assayers at various places in the United States, have shown a good amount of gold, occur near the road leading from St. Francis village to Cranbourne, about four miles from the former place.

Harvey Hill Mines.

Copper.—The indications of copper are quite numerous in the section south of the Chaudière, but north of that stream are very slight. The most important of these, from a historic and commercial standpoint, are the celebrated mines of Harvey Hill, which were worked very

extensively some twenty years ago, but have been idle during the last ten or twelve years. Lately, however, the property has changed hands, and a company has been organized, which has begun a thorough exploration of the mines, old levels are being extended and new ones driven. A considerable quantity of good ore, much of which is of high grade, has been shipped during the last three months, but no facts which have not already been mentioned in the reports of the Geological Survey have come to light. As much attention has of late been directed to the occurrence of copper in this portion of the townships, the following list of localities, published by Mr. Richardson in the Report for 1866, but which is not generally available, may be reproduced here :—

List of copper localities—Halifax.

Halifax.

Range.	*Lot.*	
1	10	Green carbonate in dolomite and yellow sulphuret; in white quartz in chloritic slate in another place on the list.
3	10	Yellow, variegated and vitreous sulphurets, with green carbonate and black and red oxyds in a gangue of quartz calcspar and brown spar of from eight inches to three feet, running with the stratification in chloritic slate, which holds specular and titaniferous iron ore. This is the *Halifax Mine* (Geology of Canada, 1863, p. 724), in which considerable work has been done by adits and shafts. In a quartz-vein cut by an adit a small quantity of gold was obtained. Land belongs to *Celeste Dubois.*
3	16	Yellow and variegated sulphurets in nacreous slates.
3	18	Green carbonate in black slate.
5	6	Green carbonate in white quartz, with calcspar in nacreous slate.
6	6	Green carbonate in chloritic and nacreous slate.
7	5	Yellow and variegated sulphurets in white quartz, with chloritic in chloritic slate. *Théophile Girouard.*
7	6	Yellow sulphuret in a quartz-vein in dolomitic limestone. *Megantic Mining Company.*
7	9	Green carbonate in white quartz in chloritic and epidotic slate, with granular magnetite.
8	9	Yellow and variegated sulphurets in dolomite. *Black Lake Mine.* (See range 9, lot 9.)
10	5	Yellow, variegated and vitreous sulphurets.
10	10	Yellow, variegated and vitreous sulphuret.
10	11	Yellow, variegated and vitreous sulphuret.
11	5	Yellow sulphuret.
11	6	Yellow sulphuret.
11	11	Yellow, variegated and vitreous sulphuret.
11	12	Yellow, variegated and vitreous sulphuret.
11	12	Variegated sulphuret in a two-foot vein of quartz.
11	13	Yellow, variegated and vitreous sulphuret.

11	20	Yellow, variegated and vitreous sulphuret. *Canada Mining Co.*
12	10	Yellow, variegated and vitreous sulphuret.
12	11	Yellow, variegated and vitreous sulphuret.
12	13	Yellow, variegated and vitreous sulphuret.
12	18	Vitreous and variegated sulphuret and green carbonate in quartz courses in nacreous slates. — *Ryan.*
13	16	Yellow, variegated and vitreous sulphuret in nacreous slates. *English and Canadian Mining Company.*
13	17	Yellow, variegated and vitreous sulphuret in nacreous slates. *English and Canadian Mining Company.*
14	13	Yellow, variegated and vitreous sulphuret.
14	14	Yellow, variegated and vitreous sulphuret.
14	15	Yellow, variegated and vitreous sulphuret.
	16	Yellow, variegated and vitreous sulphuret and green carbonates, in a vein with quartz, bitter spar, chlorite, steatite, specular iron, and a little native gold. (Geology of Canada, p. 730.) *English and Canadian Mining Company;* land to — *Nutbrown.*
15	16	Yellow, variegated and vitreous sulphuret in nacreous slates. *English and Canadian Mining Company.*
	17	Yellow, variegated and vitreous sulphuret in nine quartz courses and three beds of nacreous slates. *Harvey Hill Mine. English and Canadian Mining Company.* (Geology of Canada, 1863, pp. 724-729.)
	18	Yellow, variegated and vitreous sulphurets. *English and Canadian Mining Company.*
20	19	Yellow, variegated and vitreous sulphurets. *Canada Mining Company.*
9	4	Variegated sulphurets.
	6	Variegated sulphurets.
	9	Yellow and variegated sulphurets in dolomite and slate. On this and on the same numbered lot in range 8 is situated the *Black Lake Mine,* in which considerable exploratory work has been done. *Dr. James Reid and others.*
11	6	Variegated and vitreous sulphurets in nacreous slate. *W. W. Stuart.*
	7	Variegated sulphuret in dolomitic limestone. *A. G. Woodward.*
	12	Green carbonate in white quartz in chloritic slate.

Ireland.

Ireland.

1	3	Green carbonate in white quartz in chloritic slate, associated with dolomite.
9	9	Green sulphuret in dolomitic limestone.
11	4	Variegated sulphuret. — *Bailey.*

Inverness.

Inverness.

1	7	Variegated and vitreous sulphuret in nacreous slate. *W. W. Stewart.*
2	4	Variegated sulphuret in a two-foot vein of quartz in nacreous slate. *Megantic Mining Company.*

	19	Green carbonate in flakes in strings of quartz cutting micaceo-chloritic slate.
3	22	Green carbonate in flakes in strings of quartz cutting chloritic slate.
4	2	Yellow sulphuret in dolomitic limestone.
	4	Variegated and vitreous sulphurets in nacreous slate. *Angus McKillop.*
6	9	Variegated and vitreous sulphurets in nacreous slate. *Jas. Steele.*
	14.	Yellow and variegated sulphuret disseminated in three quartz-veins of from one to two feet thick, running with the stratification in nacreous slate.
11	23	Green carbonates in dioritic slates on the River Becancour.

Leeds. Leeds.

2	6	Variegated sulphuret. — *Harris.*
4	4	Yellow sulphuret in dolomitic limestone. — *Ewart.*
9	8	Green carbonate in flakes in green chloritic sandstone.
10	8	Yellow, variegated and vitreous sulphurets.

Copper is also reported by Dr. Reid as occurring in Leeds, range 15, lot 14; also on lot 5, range 5, and lot 4, range 9. These localities have not yet been examined by us, as the report came to hand after our return from field work.

Thetford. Thetford.

Range.	*Lot.*	
1	6	Green carbonate in green slate, resting on black slates, with cubes of iron pyrites.

Nelson. Nelson.

11	8	Yellow and variegated sulphurets and green carbonate disseminated in diorite to a breadth of thirteen feet.

Broughton. Broughton.

5	10	Variegated and vitreous sulphurets.
	12	Variegated and vitreous sulphurets.
4	13	Variegated and vitreous sulphurets.

Frampton. Frampton.

2	14	Green carbonate in grey limestone.

St. Giles Seigniory. St. Giles.

Ste. Marguerite, 1, 2, 3. Variegated and vitreous sulphurets and green carbonates in quartz courses in nacreous slates. — *Cromwell.*

Several other localities exist in the seigniories of St. Mary, Gaspé, Lauzon and Sillery, where indications of copper are found, sometimes in diorite, at others in limestone, sandstone, etc., which are described in the report of Mr. Richardson, quoted above. None of these appear, however, to be of any economic value, and the same may be said of most of those noted in the preceding list. The above are all the localities at present known to us where copper ore has been observed within the limits of the north-east quarter-sheet of the Quebec map.

Titanic ore of Colway River.

Iron Ore.—The beds of iron ore which occur in Leeds, near Kinnear's mills, have already been described in the previous report. In a former report a bed of titanic iron ore is described by Dr. Hunt as occurring on the Colway, with a breadth of between forty and fifty feet, but of late years no attention seems to have been paid to it, presumably on account of the high percentage of titanic acid.

Chromic iron.—Local deposits of this mineral occur in connection with the serpentines at several points. From the area in Leeds, near Kinnear's mills, about fifty tons were removed two years ago by Dr. Reed and found a ready sale at a fair price. Another deposit in Thetford, range IV, lots 16, 17, seems to have a considerable extent, but is probably of too low a grade to be suitable for the foreign market, though no analysis of it has yet been made.

Thetford.

Asbestus.—The Asbestus industry continues to be one of the most important in the province, and as the work of the last two years has, to a certain extent, embraced the leading areas where mining has been prosecuted, a brief *resumé* of its progress and development has been deemed advisable as a supplement to that which appeared in the last report.

First reference to asbestus.

Prior to 1862 the presence of asbestus was known in connection with the serpentines of the Eastern Townships, since at the London International Exhibition of that year a specimen of a vein from the Seigniory of St. Joseph was placed in the collections forwarded by the Geological Survey. (See Cat. 1862). Reference to its occurrence with chromic iron in various parts of the Eastern Townships and Gaspé is found in the Can. Nat. 1862, vol. vii. It was not, however, for some years, or till 1878, that its importance, from an economic standpoint, was discovered. Since then the growth of the industry has been very rapid. Within the last two years attempts have been made to unite under one management the mines of Thetford and Black Lake, but this scheme has been only partially successful. During the past year a company was organized in London by Mr. John Bell, which now owns the Thetford property, formerly known as the Boston Asbestus Company; the Bellmina area, worked for several years by Mr. Grey for Mr. John Bell, and the Hayden lot in north half of lots

27 and 28, Range B, Coleraine, now under the management of Mr. Carter, while Mr. Thos. Sheridan remains in charge of the Thetford area, and it is but fair to say that much of the success which has attended the operations of this company is due to the economy and skill with which he has developed the property at that place. In addition to the other mines operated at Thetford in 1886 or the date of the last report on this subject, viz.: King Bros., Johnston, Irving & Co., and Ross, Ward & Co., several new openings have been commenced. The Ward Bros. have located a new quarry to the west of the Quebec Central Railway, which has struck rich ground. Mr. A. H. Murphy, in lot 28, range V., uncovered a considerable space and disclosed some fine veins, while further west, or towards the river, King Bros. and Johnston have started several prospecting pits, in all of which the asbestus is visible, and the surface indications are very satisfactory. These several trials have proved very fairly the value of the serpentines lying between the railway and the river, and shew that the productive ground of Thetford is not confined to the mound in which the mines were all at first located. On the adjoining property of Lucke & Mitchell, lot 32, range C, Coleraine, although the excavations made several years ago disclosed good workable veins, nothing further has been done to develop it. It may be said that the operations of all the companies engaged at Thetford during the past two years have been eminently satisfactory, and although the bad weather of last season interfered to some extent with the output, yet the amount of asbestus mined was greater than in any previous year. An attempt was made at the Boston Company's mine by Mr. Sheridan to prove the rock at a lower depth, which was completely successful, and veins of beautiful silky mineral, up to three inches in length, were obtained from a further depth of thirty feet, the expenses of the shaft being much more than repaid by the quantity of asbestus removed. This trial shaft is satisfactory inasmuch as it probably proves the productiveness at deeper levels of all the adjacent mines. At King Bros.' mine, which had encountered a mass of comparatively poor rock, necessitating expensive cutting, the trouble has been overcome and very rich ground again found. The returns from the Johnston mine are not yet in, but it is known that work has also been satisfactory. At the Ward mine much delay arose towards the close of last season from the quantity of water in the quarry, due to springs and wet weather, which necessitated the placing of a pump, an expense from which the other mines are as yet apparently free; but though this latter mine is situated at a lower level than the others, the size and quality of the veins is in no way inferior. The output for the Bell Company's mine at Thetford for the past season to the 21st December

Thetford Mines

Output at Bell's Mine, Thetford.

was 1,350 tons, of which there were: Firsts, 930 tons; seconds, 105 tons; while the balance was thirds, or what is there called waste, in addition to a considerable quantity in stock and undressed. This mine has, during the past year, been fitted with air compressor and drills, while hoisting engines will probably be added during the coming season.

King Bros.' mine.

From King Bros.' mine the output for the season of 1888 was 580 tons as follows: Firsts, 170 tons; seconds, 165 tons; thirds, 245 tons. In the township of Coleraine several new mines have been started, among which may be mentioned that of the Bell Company on north half lots 27-28, range B (formerly Hayden); lot 32, range B by Capt. Williams; and on the Quebec Central Railway, about one mile south of Black Lake station, by Loomis & Johnstone. From the first of these no returns are to hand, the work having been started late in the season, but an examination of the locality shewed a great number of small veins on the surface at several points, while in the cut near the foot of one of the mounds fibre of fine quality in lengths from one and a half to two inches was disclosed. Several large masses of white granulite occur in this vicinity.

Black Lake mines.

From Capt. Williams' mine, lot 32, range B, the output to 1st of October was twenty-nine tons, of which four and a half were classed as *firsts*, and the rest about equally divided between *seconds* and *thirds*. Good veins were also seen on the surface on this property.

Reed's mines now Wertheims

The south half of lots 27-28, formerly belonging to Dr. Reed, but lately sold to the Wertheims, of Frankfort, Germany, is now being opened up, it being the intention of the new company to put in improved machinery with a view to economy of production. This property is the most elevated in the district, being not far from 600 feet above Black Lake station, and the surface indications are very favorable, veins up to two inches and a half being found in a series of cuttings along the crest of the hill. The fibre of much of the veins is soft and silky, shewing that the greater elevation of the area is not the cause of the stiffness or harshness seen at some localities. Dr. Reed states that prior to the sale about twelve tons were taken from this place, of which two tons were *firsts* four *seconds* and six *thirds*. This mine is now being worked by contract at $25 per ton, made ready for the market. On the north side of the Poudrier road in lots 27, 28, 29, Range A, Coleraine, several openings have been made in which good indications were found, veins up to one inch and a half, with many small ones being observed. Also on lot 26 an opening well up on the hill shewed small veins of asbestus, and on Lot 23 the surface indications are very fair, though but little has been done in any of these lots to determine their real value.

Further to the east, about Little Lake St. Francis, though small veins occur, those seen, if fair samples, were of poor quality; the fibre being short and harsh. The present comparative inaccessibility of these more remote localities will seriously affect their value. In the southern part of Coleraine and in the south-east corner of the great ridge of serpentine which extends from Wolfestown road to Black Lake, work was begun or rather resumed by the Megantic Mining Co. Mining in this locality was started in 1886, and was noted in previous report as having disclosed a large vein of asbestus with fibre of four inches in length. This vein was not apparently persistent to any depth, the rock being greatly shattered near the surface and for some fifteen feet down, and though quite a number of veins, some of which, in the more solid rock, shewed fibre of one inch and a-half in length, much of the asbestus is greatly discolored, owing to the broken character of the rock. A peculiar feature not noticed in any other place in this district is the presence of irregular veins of mica, in scales of half an inch or more in diameter, in a paste of decomposed serpentine or soapstone. It is probable that after passing the shattered ground good mineral will be found. The output for the four months of last season to Oct. with an average of twelve men was thirty-nine tons, of which one-third would rank as *second* and two-thirds as *third* quality. On the same ridge, but on the extreme west limit, on lots 24 and 25, range III, Ireland, King Bros. have started two openings. The elevation of these by aneroid above the surface of Black Lake is 500 feet or about 300 to 350 feet above the mines at Thetford. The two knolls in which the asbestus is found at this place are about one-fourth of a mile apart, and the fibre occurs in a series of thin veins from one-eighth of an inch to over an inch in size in places, as many as twenty being found in the space of six inches. Many of these veins shew a selvage of whitish weathering serpentine on either side, separated by a thin vein of asbestus from one-fourth to three-fourths of an inch thick. Other veins of good size, ranging in thickness to one inch and three-fourths, are numerous, the general aspect of the serpentine and contained veins being much like that of the great ridge in Wolfestown. The surface indications are excellent, but the property has not been sufficiently developed to form an estimate of its production, only two months work of a few men having been spent upon it.

Little Lake St. Francis.

Megantic Mining Co., Coleraine.

King Bros., Ireland.

In the Black Lake district proper the three established mines, viz., the Scottish-Canadian, the Anglo-Canadian and the D'Auville, have all been steadily at work. Mr. Penhale, the Manager of the Scottish-Canadian, states that in the eight months ending 10th Nov., 400 tons were shipped from that mine, of which 40 tons were *firsts*, 110 tons *seconds*, and 250 tons *thirds*, but operations were hindered by scarcity

Scottish Canadian mine.

Black Lake.

of men and bad weather so that the projected new workings could not be carried on. This mine is equipped with improved machinery, air compresser, rock drills, hoisting engines, and dumping skips, and has a new set of appliances for crushing the rock, and separating the asbestus, more particularly in regard to the lower grades, to avoid the great expense of cobbing by hand. Although this machine was in operation but a short time, it is claimed by the manager to be a great success. Should this be the case and the asbestus of short fibre be easily separated, the profits of the industry will be largely increased; since many of the dumps, most of which now cover very valuable ground, can be profitably worked over, and the refuse disposed of for ballasting or other purposes while under the present system of hand cobbing, the shorter veins do not warrant the expense necessary for their separation. In this connection it may be remarked that the question of dumps is beginning to assume a somewhat serious aspect which will be aggravated as the production of the mines increases; since many of them will ultimately have to be removed, as the necessity for extending the present workings will require the space now covered up.

Anglo-Canadian mine.

Of the three Black Lake mines, the output from the Anglo-Canadian for the six months ending Nov. 15th, was, according to Mr. Hopper, about 210 tons, the average number of hands employed being 30 to 35. The principal pit at this mine has now been sunk to a considerable depth, and Mr. Hopper reports veins of asbestus from the lowest branch of very superior quality ranging from three to seven inches in length. These veins have been uncovered since my visit. The percentage of *firsts* has, according to the manager, increased from 10 to nearly 20 per cent. Openings in the face of the knoll of serpentine to the west of the principal pit are now being worked, and the indications here are very good.

Frechette or D'Auville mine

The output of the Frechette or D'Auville mine which lies contiguous to the Scottish Canadian, in the face of the hill, is given by Mr. Hopper for the season ending Dec. 1st, as about 300 tons.

The Anglo-Canadian mine has also a good outfit of improved machinery, air compressor, drills and hoisting gear, the latter being a necessity owing to the present depth of the quarry. The necessity of some machine which will clear the fibre or separate it from the rock cheaply is one which will doubtless be remedied very shortly. Large masses of granulite also occur near or to the south of these openings. In view of the considerable expense of proving areas where the surface veins are numerous but small, it has seemed to me that a few good test holes with a diamond drill would be advisable. The holes could be quickly and easily sunk, and if veins of asbestus were encountered, the core or borings would shew the character of the fibre and to a certain extent the size of the veins.

The elevation of the Anglo-Canadian mine was, by aneroid, found to be 200 feet above Black Lake station which, in turn, was about 100 feet below Thetford mines station. The workings of these mines would therefore be about on the same level as those of Thetford east of the railway. The D'Auville and Scottish-Canadian mines have an elevation of 350 feet above the station, or 150 feet above the Anglo-Canadian, while the upper works of the latter on the face of the ridge are thirty feet lower. Elevations of Black Lake mines.

In Thetford, in the areas north of the Quebec Central Railway, are several outcrops of serpentine. These have only lately been examined for asbestus. Among them may be mentioned lots 16, 17 and 18, range IV, from which veins of good size are reported by Dr. Reid, since my visit. In this belt chromic iron also occurs. Mounds of serpentine are also seen in lot 13, range V, and in range XI, Broughton, from some of which asbestus has been reported, but not in quantity sufficient as yet to be of economic value. These areas might easily be tested with the diamond drill. Serpentine areas of Thetford.

The Broughton Mine, on lot 14, range VII, Broughton, has been worked to some extent during the past two years. I visited it in September 1887, and found it to be somewhat different from the other areas at Thetford and Coleraine. The vein is at the contact of the serpentine, with blackish slates, which in places have a greyish or purple shade, and contain bands of hard bluish-grey quartzite of the Cambrian series thickly veined with quartz. The vein is overlaid in places with soapstone of good quality, from ten to fourteen inches thick, with which the asbestus seems to be intimately associated. The asbestus, of which only one vein could be detected, was eight to ten inches thick in places near the surface, but decreases at the bottom of the workings, which are some 62 feet down, to two or three inches, and becomes irregular, at times splitting into many fine strings disseminated through the serpentine, at others presenting a continuous fibre. Three shafts had been sunk to a depth of 61, 62 and 75 feet, which followed generally the slope of the bed or vein at an angle of about 75°, the rock dipping to S. 40° E. to true meridian; soapstone forms the hanging wall of the vein. The mass of the serpentine which lies to the west was carefully examined at several points, but only in one place, about 150 feet in rear of the openings, were small strings of asbestus of one-fourth to a half an inch seen. Much of the fibre in the north slope appeared to be stiff and harsh and not of good quality, while other portions were beautifully silky. The serpentine of this place resembles in character that near St. Sylvester and along the Chaudière. Broughton mine.

Probable cause of difference in quality of fibre.

The cause of the great difference in quality of the fibre from different points, more especially comparing Black Lake with Thetford, has long been a source of enquiry among the mine owners and managers. By some it is supposed to be due to the level of the different workings, the works of the Scottish-Canadian Company at Black Lake being about 250 feet above those at Thetford, yet this can scarcely be taken as conclusive, since at the Reid mine, now Wertheim's, 300 feet or so higher, much excellent fibre is found; as also in the works of the Scottish-Canadian Company itself, and the D'Auville mine adjoining, where very fine silky fibre is seen. The fibre at the surface, especially where fire has passed, is always harsher than that from lower depths, owing to the loss of a certain percentage of the contained water; and it has been suggested that a more likely reason for the difference in quality may be the dehydration of the asbestus by the action of the intruded diorite or granulite, which at certain points in the Black Lake district occupy a considerable area. If the soft, silky fibre be placed on the fire, it speedily changes its character and becomes harsh and brittle. The serpentine, near the contact with the granite veins or masses, is often very considerably shattered, as though the presence of the granite had exercised a marked influence.

At Thetford the granitic rock in the mines is limited to small and thin dyke-like veins, which have not produced any deleterious effect upon the asbestus. It must, however, be said that the stiff fibred mineral is not in all cases confined to the vicinity of the visible granites, and other causes may in such cases have produced a similar effect.

Map of asbestus areas.

The map of the asbestus region, accompanying this Report, has been compiled principally from our own surveys, using the line of the Quebec Central Railway, which has been kindly furnished us by the Department of Public Works, Quebec, for a base line. All the mines at present in operation in the districts of Thetford, Coleraine and Wolfestown are indicated on it; but in the attempt to place the lines from the Crown Land plans, so many discrepancies were found in the several surveys available, that the designation of these on a plan certified by the office was found impracticable. A thorough re-survey of these areas is of the greatest importance, since lands which now have a comparatively small value may in a very short time be valued at very large sums. In regard to the areas of Belmina, Wolfestown and Danville no late returns are to hand. At Belmina nothing has been done during the past year, the force there employed being transferred under Mr. Carter to the new Bell Company's property, near Black Lake. Exploratory work has been going on during the past year along the great ridge north of Breeches Lake, but

nothing definite as to results has been received, although such information has been promised. The Danville mine has been working with a reduced force, though at last advices from the Manager the output was increasing and the prospects more favourable. During the past season 207 tons were taken out. Danville mine.

Soapstone.—Many deposits of this mineral occur in Broughton, but the quality is in most cases not sufficiently fine to satisfy the market, the shade being dark and the rock too opaque. Considerable quantities have been shipped from the Broughton Mine, where from the lower asbestus workings a very good quality of the soapstone is obtained The quarry at Belmina, formerly Carter's, now Fenwick and Slater's has also been shipping to various points.

Mineral Paints.—The only locality in this section at which mineral paint was observed is that described in the Catalogue of Economic Minerals, Colonial and Indian Exhibition, London, 1886, at Ste. Anne de Montmorenci, where deposits of brownish and brownish-black iron-ochre of considerable extent occur.

Limestones are found at several points, but are not now burned to any extent, and the facility with which the Dudswell lime can be distributed has caused the abandonment of some kilns. Among other places in Broughton where the rock occurs and has been burnt, may be mentioned, top of hill half a mile east of West Broughton church, near the road. Limestone also occurs on lots 3 and 4, range IV, Thetford, on land occupied by Joseph Ouellette, who has burned it. Near St. Victor de Tring, on the road to St. Francis, a bed of limestone conglomerate has also been used for burning lime. Outcrops of grey limestone are also found along the back roads in rear and to the north-east of Beauce Junction, where several kilns have been burned. The rock is a hard, greyish, sub-crystalline limestone, and occurs with hard quartzites and black slates. Further to the north in Mailloux, lots 30-32, range N.W., along the road, there are several exposures of limestone similar to the last, and with the same association of black slates and quartzites. Localities of limestone.

The deposit on the Chaudière, between the Famine River and the village of St. George, has already been referred to under the head of Devonian. These limestones have been burned for many years for local consumption, and were at one time the chief source of supply for the upper Chaudière district. St. George.

Marble.—A considerable outcrop of deep red marble, veined with white calcite, occurs a short distance east of the Colway (formerly Guillaume) River, associated with red slates and sandstones, which resemble the Sillery of Quebec in lithological character, and may represent an overlying area of these rocks in a synclinal basin such as Colway River.

occurs further east beyond St. Francis village. The bed is from ten to forty feet thick, and is exposed at intervals for half a mile on the strike. The rock takes a good polish, and has a handsome appearance. It is not far from the dioritic rocks which show in the bed of the Colway, and which may have been the cause of the alteration.

Building Stones.—The greenish, grey sandstones of the Sillery formation, both above Quebec and at Point Lévis, produce a very durable stone which has been extensively used both in Quebec and Lévis. The rock splits readily, and blocks of almost any required size can be obtained. Hard and more quartzose beds of the same formation occur at various points, and have already been described. The white granulite rock of Black Lake and Thetford should yield a very handsome and durable stone, but no attempt has yet been made to quarry it.

APPENDIX.

SYSTEMATIC LIST OF FOSSILS, WITH LOCALITIES AS REFERRED TO IN THIS REPORT, EXCLUSIVE OF THOSE SPECIES OBTAINED IN THE LIMESTONE CONGLOMERATE BANDS.†

By Henry M. Ami, M.A., F.G.S., Assistant Palæontologist.

GENERA AND SPECIES.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	I. C. R. cutting, 4000 paces below the Lower Levis ferry, Levis, Que., p. 52k.	Road from Levis to St. Joseph, Que., Diplomoceras zone, p. 52k.	150 yards West of last locality, Dalyæ Zone, pp. 52k and 53k.	Cliff facing the foundry, Levis, p. 53k.	Outcrops at City Hall, Levis, Que., p. 53k.	Shales associated with conglomerates near City Hall, Levis, Que., p. 53k.	Mouth of brook 1½ miles N.E. of Marlatt Lake Junction, I. C. R., p. 55k.	One half mile West of last locality, p. 55k.	Snow-shed, cutting West of Marlatt Junction, p. 55k.	Island of Orleans, South-West End, p. 59 K.	Etchemin River, Que., 2½m. below St. Anselme, p. 60k.	Crane Island, St. Lawrence R., Que., p. 61k.	St. Anselme, Que., Weston, 187., p. 61k.	St. Pernard, Que., Chaudière R., p. 61k.	St. Michel de Bellechasse, Que., p. 65k.	St. Paschal, Ruisseau de l'Eglise, I. C. R. crossing, p. 68k.	Notre Dame du Portage, Que., p. 68k.	Two miles above St. Nicholas, Que. pp. 15k and 16k.	Five and a half miles above St. Nicholas, Que., p. 18k.	Ste. Croix, Que., N. of wharf, p. 17k.	Beauceour River, Que., p. 17k.	Pointe-aux-Trembles, Que., p. 18k.	Lorette, Que., pp. 19k and 20k.	Charlesbourg, Que., fifty yards N. of Ch., p. 20k, and 1 mile West of village.	Charlesbg. Que., Templeman's Quarry, p. 21k.	Beauport, Que., Parent's Quarries, Mr. St. Cyr, 1888, pp. 21k and 22k.	Montmorency River, above the bridge, left bank, pp. 22k and 23k.	Montmorency R., Que., Ravine below the Falls, p. 23k.	Montmorency R., Que., mouth of river. Lower point, p. 24k.	Montmorency R., Que., between steps & Lower point, East side of gorge.	Below Victoria Hotel, Point Levis, Que., near Toll-gate, p. 50k.	Below Victoria Hotel, South Que., Que., in black and green shales, p. 54k.	Quebec City, between Grande Allée and New Drill Shed, p. 75k.	Quebec City, between St. John Market and St. Patrick St., pp. 78, 79, and 80k.	Côte d'Abraham, Quebec City, p. 80k.	Chaudière R. R. R. Bridge, Que., p. 57k.
Protospongia fenestrata, Salter																																				*
Hyalostylia sp.																												*								
Solenopora compacta, Billings																											*									
" var. minuta, n. var.																																			*	
? ? (Girvanella ? ?)																																			*	
Leptograptus macilentus, Hall																								*												
Nemagraptus capillaris, Emmons				*																											*					
" sp.																*																				
Didymograptus bifidus, Hall		*			*																															
" consimilis, Hall																																*				
" extensus, Hall		*			*		*																													
" furcillatus, Lapworth		*						?																												
" pennatulus, Hall		*			*																															
" sp.															*																					
Tetragraptus approximatus, Nicholson	*							*																												
" Bigsbyi, Hall				*	*			*																												
" fruticosus, Hall					*																															
" fruticosus, Hall	*	*			*																															
" Decussatus, Hall													*																							
" Ircksæ, Lapworth								*																												
" quadribrachiatus, Hall	*			*				*																								*				
" sedis, Brongniart	*	*	*	*	*		*	*	*	?																										

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Dicho										?																						*				
" octobrachiatus, Hall	*				*																															
? Richardsoni, Hall	*				*					*																										
" ramulus, Hall															?																?					
Loganograptus Logani, Hall										*																										
Clonograptus sp.		*											*																							
" flexilis, Hall	*																																			
" rigidus, Hall										*																					?					
Goniograptus Thureaui, McCoy	*																																			
Dicellograptus Moffatensis, Carruthers																																				
var. divaricatus, Hall											*	*																								
" sextans, Hall											*	*																					*			
" sp											*	*							*																	
? sp.												*																					*			
Dicranograptus cf. D. Nicholsoni, Hopk.																																				
" sp. nov.											*																									
" ramosus, Hall																			*																	
Climacograptus bicornis, Hall											?								*														*			
" var																																				
" var. caudatus, Lapworth																																	*			
" cf. confertus, Lapworth																																	*			
" perexcavatus, Lapworth																																	*			
" scalaris, Hisinger																															?		*			
" " var. normalis, Lap.																																				
" sp.																															*					
" sp.																																				
" sp.																*																				
Diplograptus angustifolius? Hall																								*				*	*	*			?			
" dentatus, Brongniart				*																																
" foliaceus, Murchison																																	?	*		
" cf. folium? Hisinger																															*					
" Hudsonicus, Nicholson																					*															
" latior, N. Sp																		*																		
" mucronatus, Hall											*																						*			
" rugosus, Emmons																																				
" tricornis, Carruthers																															*			*		
" Whitfieldi, Hall																																				
" sp																*																				
" sp											*																				*		*			
" sp																												*	*	*						
Orthograptus quadrimucronatus, Hall																		*						*				*	*	*						
Phyllograptus angustifolius, Hall						*		*						*																						
" Anna, Hall					*									*																						
" typus, Hall	*	*				*			*																							*				
Glossograptus ciliatus, Emmons																															*					
" sp. indt																															*					
Reteograptus Eucharis, Hall																												*								
Trigonograptus ensiformis, Hall																															*					
Ptilograptus plumosus, Hall										*																										
Dictyograptus, N. Sp.																																				
(=D. delicatulum, Dn. preoccupied)		*		*																																
" irregularis, Hall				*																																
" cf. D. Homfrayi			*																																	
" N. Sp				*																																
Dendrograptus sp			*												*																					
Dawsonia acuminata, Nicholson										*																										
" campanulata, Nicholson																																	*			
" sp. indt										*					*																	*			

GENERA AND SPECIES.	1 I.C.R. cutting, 1600 paces below the Lower Levis ferry, Levis, Que., p. 52k.	2 Road from Levis to St. Joseph, Que. Didymograptus Zone, p. 52k.	3 150 yards West of last locality, Didym. Zone, pp. 52k and 52k.	4 Cliff facing the foundry, Levis, p. 53k.	5 Outcrop at City Hall, Levis, Que., 53k.	6 Shales associated with conglomerates near City Hall, Levis, Que., p. 54k.	7 Mouth of brook 1½ miles N.E. of Harlaka Junction, I.C.R., p. 55k.	8 One half mile West of last locality, p. 53k.	9 Snow-shed, cutting West of Harlaka Junction, p. 55k.	10 Island of Orleans, South-West End, p. 69k.	11 Etchemin River, Que., 2½ m. below St. Anselme, p. 60k.	12 Crane Island, St. Lawrence R., Que., p. 61k.	13 St. Anselme, Que., Weston, 1877, p. 61k.	14 St. Bernard, Que., Chaudière R., p. 61k.	15 St. Michel de Bellechasse, Que., p. 66k.	16 St. Paschal, Ruisseau de l'Église, I.C.R. crossing, p. 68k.	17 Notre Dame du portage, Que., p. 68k.	18 Two miles above St. Nicholas, Que., pp. 15k and 16k.	19 Five and a half miles above St. Nicholas, Que., p. 16k.	20 Ste. Croix, Que., N. of wharf, p. 17k.	21 Bécancour River, Que., p. 17k.	22 Pointe-aux-Trembles, Que., p. 18k.	23 Loretto, Que., pp. 19k and 20k.	24 Charlesbourg, Que., fifty yards N. of Ch., p. 20k, and 1 mile West of village.	25 Char esbourg, Q., Templeman's Quarry, p. 21k.	26 Beauport, Que., Parent's Quarries, Mr. St. Cyr, 1888, p. 21k and 22k.	27 Montmorency River, above the bridge, left bank, pp. 22k and 23k.	28 Montmorency R., Que., Ravine below the falls, p. 23k.	29 Montmorency R., Que., mouth of river, Lower point, p. 24k.	30 Montmorency R., Que., between steps & Lower point, East side of gorge.	31 Below Victoria Hotel, Point Levis, Que., near Toll-gate, p. 50k.	32 Below Victoria Hotel, South Que., Que., in black and green shales, p. 50k.	33 Quebec City, between Grande Allée and New Drill Shed, p. 77k.	34 Quebec City, between St. John Market and St. Patrick St., pp. 78, 79, and 80k.	35 Côte d'Abraham, Quebec City, p. 80k.	36 Chaudière R. R. R. Bridge, Que., p. 57 k.
Corynoides calycularis, Nicholson																			?																		
Glyptocystites or Glyptocrinus																		?				*															
Glyptocrinus decadactylus, Hall																											*										
Heterocrinus sp. var. Canadensis, Billings																						*															
Serpulites dissolutus, Billings																											*										
Ptilodictya falciformis, Nicholson																											*										
Pachydictya acuta, Hall																											*	*									
Prasopora lycoperdon, Vanuxem																											*		*	*							
" " var. Selwyni, N. Var																																					
Diplotrypa Quebecensis, N. Sp.																											*										
Batostoma Ottawaense, Foord																																					
Monotrypa incerta, N. Sp																													*								
Amplexopora discoidea, James																														*	*						
Lingula curta, Hall																																					
" Irene, Billings	*	*		*																									*								
" obtusa, Hall																							*														
" Philomela, Billings																																					
" Quebecensis, Billings		*	?	*	*	*			*																												
" riciniformis, Hall																																					
" sp			*																																		
" N. Sp. ?																																					
" N. Sp																																					
" N. Sp				*																																	
Obolella pretiosa, Billings							?						*		*		?																				
" sp							*																														
" sp																																					
Elkania desiderata, Billings															*																						
Linnarssonia sp			*																																		
Leptobolus insignis, Hall																			*																		
" (?) sp																																					
" N. Sp. (?)				*																																	
Acrothele sp																																					
" N. Sp																																					
Schizocrania filosa, Hall																													*								

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Schizocrania or Discina, sp.																									*											
? Siphonotreta micula, McCoy		*																																		
Acrotreta sp.										*					*																					
Discina Pelopea, Billings																							*													
" sp.																				*																
Paterula Sp. Nov.																																		*		
Crania sp.																					*				*											
Orthis emacerata, Hall																				*																
" pectinella, Conrad																											?									
" testudinaria, Dalman																		*		*		*	*		*		*	*							?	
" sp. nov. (?)																							*													
" sp.																															*					
" sp.				*																																
" sp.																	*																			
" sp.																																		*		
Skenidium ? sp.																							*													
Strophomena alternata, Conrad																				*		*	*		*		*									
" deltoidea, Conrad																						*				*										
" sp.																	*																			
Leptæna sericea, Sowerby																		*		*		*			*	*	*	*						?	?	
" N. Sp.																																		*		
Zygospira Headi, Billings																		*		*	*															
" modesta, Say																											?									
" or N. G.																							*	*	*		?	*								
Anazyga recurvirostra, Hall																				*							*									
Stricklandinia ? sp.																																		*		
Camerella hemiplicata, Hall																							*			*										
" n. sp. (?)																							*													
Pterinea Trentonensis, Hall																							*													
Ambonychia radiata, Hall																		*		*	*															
Modiolopsis sp.																							*													
" sp.																		*																		
Vanuxemia sp.																											*									
Ctenodonta dubia, Billings																							*													
Lyrodesma pulchellum, Emmons																										*										
" sp.																				*																
Orthodesma parallelum, Hall																		*		*																
Murchisonia gracilis, Hall																				*							*									
" perangulata, Hall																											*									
Bellerophon bilobatus, Sowerby																				*			*	*			*									
Bucania punctifrons, Emmons																							*				*									
Cyrtolites sp.																																		*		
Conularia Trentonensis, Hall																							*			*	*									
Theca N. Sp.																							*													
Lituites undatus, Emmons																							*													
Endoceras proteiforme, Hall																							*		*	*			*							
Orthoceras anellum, H. or N. Sp.																										*	?									
Turrilepas sp.										*																										
Leperditia cylindrica, Hall																								*												
Primitia Canadensis, J. var. nana, Jones																							*													
" N. Sp.																												*						*		
Beyrichia N. Sp.																							*													
" sp.																	*																			
Shumardia granulosa, Billings			*	*																																
Trinucleus concentricus, Eaton																							*				*									
" N. Sp. (large form)																		*		*																
" sp.																																		*		
Ampyx sp.																																		*		

GENERA AND SPECIES.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	I.C.R. cutting, 16 0 paces below the Lower Levis Ferry, Levis, Que., p. 52k.	Road from Levis to St. Joseph, Que., Didymograptus Zone, p. 52k.	150 yards West of last locality, Didym. Zone, pp. 52k and 53k.	Cliff facing the foundry, Levis, p. 53k.	Outcrop at City Hall, Levis, Que., p. 53k.	Shales associated with conglomerates near City Hall, Levis, Que., p. 54k.	Mouth of brook 1½ miles N. E. of Harlaka Junction, I.C.R., p. 55k.	One half mile West of last locality, p. 53k.	Snow-shed cutting West of Harlaka Junction, p. 55k.	Island of Orleans, South-West End, p. 59k.	Etchemin River, Que. 2½ m. below St. Anselme, p. 60k.	Crane Island, St. Lawrence R., Que., p. 61k.	St. Anselme, Que., Weston, 1877, p. 61k.	St. Bernard, Que., Chaudière R., p. 66k.	St. Michel de Bellechasse, Que., p. 66k.	St. Paschal, Ruisseau de l'Eglise, I.C.R. crossing, p. 68k.	Notre Dame du Portage, Que., p. 68k.	Two miles above St. Nicholas, Que., pp. 15k and 16k.	Five and a half miles above St. Nicholas, Que., p. 16k.	Ste. Croix, Que., N. of wharf, p. 17k.	Bécancour River, Que., p. 17k.	Point-aux-Trembles, Que., p. 17k.	Lorette, Que., pp. 19k and 20k.	Charlesbourg, Que., fifty yards N. of Ch., p. 20k, and 1 mile West of village	Charlesbourg, Que., Templeman's Quarry, p. 21k.	Beauport, Que., Parent's Quarries, Mr. St. Cyr, 1888, p. 21k and 22k.	Montmorency River, above the bridge, left bank, pp. 22k and 23k.	Montmorency R., Que., Ravine below the Falls, p. 23k.	Montmorency R., Que., mouth of river, Lower point, p. 24k.	Montmorency R., Que., between steps & Lower point, East side of gorge, p.	Below Victoria Hotel, Point Levis, Que., near Toll-gate, p. 50k.	Below Victoria Hotel, Point Levis, Que., in black and green shales, p. 50k.	Quebec City, between Grande Allée and New Drill Shed, p. 77k.	Quebec City, between St. John Market and St. Patrick St., pp. 78, 79, and 80k.	Côte d'Abraham, Quebec City, p. 80k.	Chaudière R., Ry Bridge, Que., p. 57k.
Triarthrus Becki, Green																																				
Hydrocephalus sp.																								*				?	*	*						
Bathyurus sp.																																		?		
Calymene senaria, Conrad																																		*		
Asaphus platycephalus, Stokes																				*		*	*		*	*		*								
" Canadensis, Chapman																						*	*			*	*									
" sp.																							*													
Illænus Milleri, Billings																																		*		
" Bouchardi, Barrande																							*				*									
" sp.																																		?		
Æglina rediviva, Barrande																												*								
Dalmanites callicephalus, Green																						*	*											*		
" sp.																				?																
Cheiurus pleurexanthemus, Green																						*	*			*	*									
" sp.																																				
Encrinurus vigilans, Hall																							*				?							*		
" sp.																				?																
Cyphaspis sp.																																		*		
Harpes sp.																											*									

† In the limestone ridges west of the Cemetery, see p. 81K, the rock consists largely of solid limestone which contains fossils of Calciferous age—scattered pebbles and boulders, sometimes of large size are found in the mass—and these contain fossils of Cambrian (Potsdam) age.—R. W. E.