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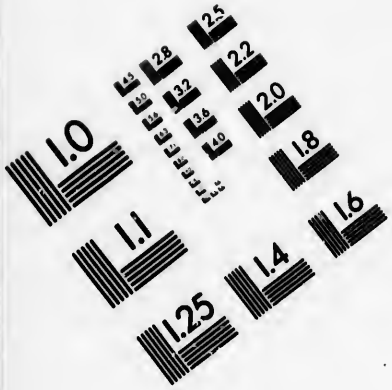

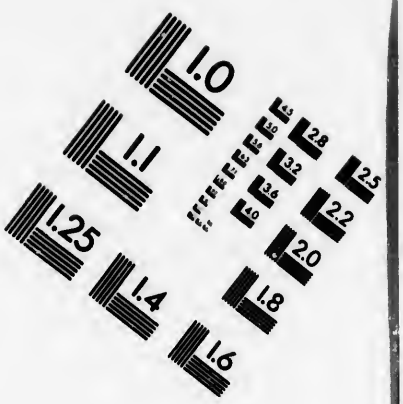

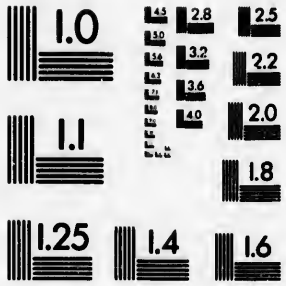

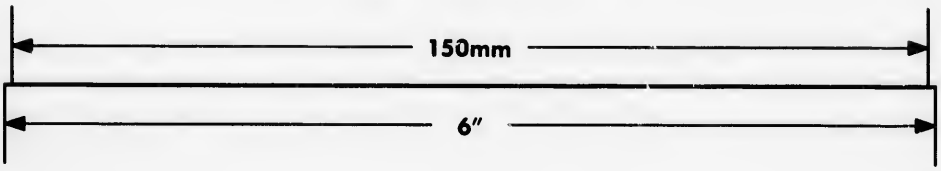

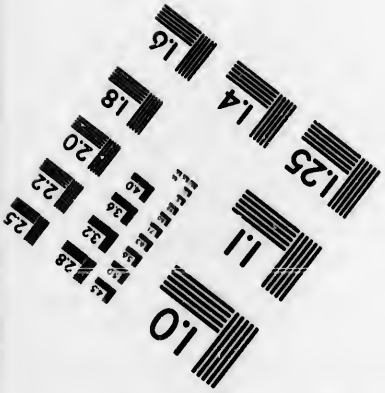

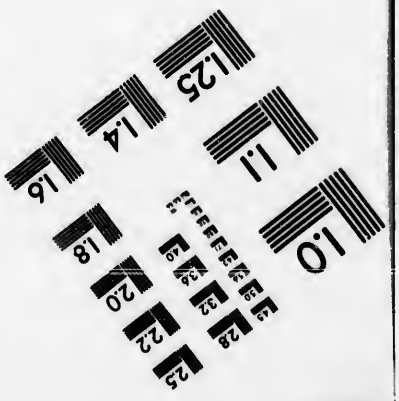

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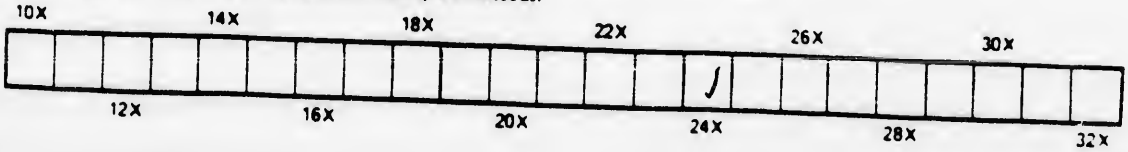

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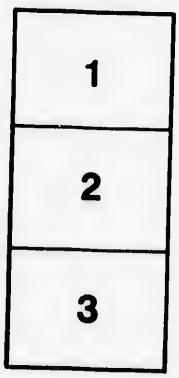

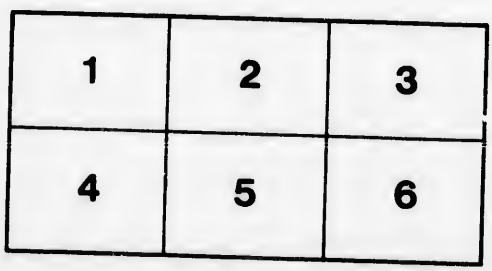

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GEOLOGICAL SURVEY OF CANADA
G. M. DAWSON, C.M.G., LL.D., F.R.S., DIRECTOR

REPORT

ON A PORTION OF THE

PROVINCE OF QUEBEC

COMPRISED IN THE

SOUTH-WEST SHEET OF THE "EASTERN TOWNSHIPS" MAP (MONTREAL SHEET)

BY

R. W. ELLS, LL.D., F.R.S.C.

With a Chapter on the Laurentian North of the St. Lawrence River

BY

FRANK D. ADAMS, M.A.Sc., PH.D.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1896

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1896

Dr. G. M. Dawson, C.M.G., F.R.S., &c.,

Director Geological Survey of Canada.

Sir,—I beg to submit herewith a report on the geology of that portion of Quebec contained in the South-west quarter-sheet map of that province, being the third in the series. It contains the results of observations made chiefly in 1889-90, but which, on account of unavoidable delays in completing the accompanying map, could not sooner appear. The vicinity of the lower Ottawa and the Island of Montreal have been recently re-examined, and the information obtained is incorporated.

A valuable addition to this Report, is the chapter descriptive of the Laurentian rocks of the north-west corner of the sheet, contributed by Dr. F. D. Adams, who has devoted special attention to that part of the region.

Extensive collections of fossils from various points throughout the area have been made by my assistants, Mr. N. J. Giroux and Dr. W. E. Deeks, and also by Mr. Whiteaves, Dr. Ami and myself. These have been examined and named by Dr. H. M. Ami, whose report thereon will be found in the form of an appendix.

I have the honour to be,

Your obedient servant,

R. W. ELLS.

Geological Survey Office,
Ottawa, Nov., 1895.

NOTE.—The strikes and dips in this Report are given with reference to the true meridian, the declination being about 13° west of north.

REPORT

ON A PORTION OF THE

PROVINCE OF QUEBEC

COMPRISED IN THE

SOUTH-WEST SHEET OF THE "EASTERN TOWNSHIPS" MAP (MONTREAL SHEET.)

BY

R. W. ELLS, LL.D., F.R.S.C.

With a Chapter on the Laurentian, North of the St. Lawrence River.

BY

FRANK D. ADAMS, M.A., PH. D.

The present report comprises the results of the observations, made principally during the years 1889 and 1890, in the area included in the south-west quarter-sheet of the "Eastern Townships" series, or that portion adjoining the states of Vermont and New York. The area more particularly described is bounded on the east by Lake Memphremagog and by a line drawn thence north to the vicinity of Richmond, on the St. Francis River; and on the west by Missisquoi Bay and the Richelieu River. Careful examination, however, was also made of much of the flat country lying between this river and the St. Lawrence, but, owing to this area being largely clay-covered and presenting very few outcrops of rock, the geological results obtained are much less satisfactory than for the area further eastward, where rock-exposures are numerous. A re-examination was also made of the country along the lower Ottawa and the Islands of Jésus and Montreal, to obtain any additional details of structure which might be revealed by recent lines of railways or other works, such as quarries and excavations.

Area embraced in the report.

The examinations thus comprise the highly altered series of rocks seen in the Sutton Mountain anticline, which are the northward extension of the rocks of the Green Mountain range in Vermont, as also a very considerable portion of the Lower Palæozoic of the St. Lawrence basin on the west, and of the St. Francis and Memphremagog syncline on the east. The peculiar rocks of Phillipsburg, Stanbridge and Bedford were also carefully examined, in company with

Range of geological formations.

Mr. C. D. Walcott, now Director of the United States Geological Survey, and large collections of fossils were made by Mr. Whiteaves and by my assistant, Dr. Deeks, in order to ascertain, as clearly as possible, the exact position of these beds in the geological scale. These collections have been carefully worked out by Dr. Ami, Assistant Palæontologist, and the results of his examinations appear in the supplementary chapter. The area to the north of the St. Lawrence was more particularly studied by Dr. Frank D. Adams, of McGill University, especially with reference to the distribution of the anorthosites and their relation to the Laurentian rocks of St. Jérôme and the country to the north of that place.

Dr. Frank D. Adams's work.

The St. Lawrence basin.

The flat country between the Richelieu and St. Lawrence rivers, as well as that along the lower Ottawa, to the south and east of the Laurentian escarpment, has already been fully described in the Geology of Canada (1863). It includes the island and city of Montreal, where outcrops of the generally nearly horizontal limestones, shales, &c., of the Cambro-Silurian formations, together with the Potsdam sandstone, are in places well exposed; but over the greater portion of this flat country, rock-outcrops are rare, even in the river-beds; the surface being occupied by a very heavy covering, mostly of marine clays. Out of this, at isolated points, the doleritic mountains of Montreal, Montarville, St. Hilaire, Rougemont, Johnston and Yamaska, protrude abruptly and rise, in some cases, to elevations of 1200 to 1500 feet above the plain. Occasionally, however, ledges of stratified rock are visible, as in the Yamaska River at St. Hyacinthe, where the bed of the stream, for a distance of about a fourth of a mile, shows the presence of highly fossiliferous sediments of Hudson River (Lorraine) age. On the Richelieu also, at Chambly Basin, and in the River des Hurons, a short distance south of St. Hilaire Mountain, nearly horizontal strata, filled in places with fossils, are seen. The examination of the fossils recently collected, shows the age of these rocks to be that of the Lorraine and Utica formations.

Eruptive masses.

Work formerly done in the area.

A large amount of geological exploration has been carried out in this region in former years, in fact, almost since the beginning of the Geological Survey of Canada. The outlines of this work have already been briefly sketched in the earlier reports, and the bibliography of the subject given,* so that it will not be necessary to repeat these here. Since the date of the last official report on this district, however, in 1866, (which had more particular reference to the copper deposits of the area,) and the publication of the general geological map of Canada, of the same

*Annual Reports, Geol. Surv., Can., vol. II. (N.S.), 1886, p. 6 J; vol. III. (N.S.), 1887-88, pp. 25-48 K.

date, the views there expressed as to the structure of the Sutton Mountain region have been very materially changed. This change was due largely to the examinations made by Dr. Sterry Hunt, and later by Dr. Selwyn, and as a consequence the Sutton Mountain anticline, formerly regarded as of Sillery age, is now established as below the lowest fossiliferous sediments. More recent investigations of the formations lying west of the crystalline schists, have shown that the black slates and bituminous limestones of Farnham, instead of constituting a possibly lower portion of the fossiliferous Quebec group, are in reality a newer series; and presumably, from the contained fossils and from their stratigraphical relations to the underlying rocks, the equivalent of the lower part of the Trenton formation. In the stratigraphical sequence assumed in the Geology of Canada, 1863,* these black limestones and slates, of Farnham (when not fossiliferous) were regarded as older than the Lévis division of the Quebec group, and were put at the base, followed, upward, by the Lévis graptolitic series and then by the red and green slates and sandstones of the Sillery formation. This must now be reversed. The true sequence is in ascending order the Sillery, Lévis, (including the Calciferous of Phillipsburg), the Chazy of Stanbridge and the black slates and limestones of Farnham, Abbottsford and St. Dominique, which, at the latter place, graduate directly upward from the fossiliferous Chazy limestone into the Trenton.

Early view as to the structure of the slates and limestones.

Present view of structure of the fossiliferous rocks.

The several geological systems represented in the south-western portion of the province may be stated thus in descending order:—

Superficial deposits.

F. Devonian of Memphremagog Lake.

E. Silurian of the St. Helen's Island, Montreal, Lower Helderberg.
E. " " St. Lawrence Valley, presumably Medina.

D. Cambro-Silurian: Lorraine (Hudson River formation).
" " Utica,
" " Trenton and Black River,
" " Chazy-Trenton east of the Sutton Mountains axis, Farnham, &c.,
" " Chazy,
" " Calciferous,
" " Potsdam sandstone of the Ottawa and St. Lawrence basin.

Sequence of formations.

C. Cambrian: Sillery red and green slates, sandstones and grits.
" Black and gray slates, east and west of the Sutton Mountain anticline.

* Geology of Canada, 1863, p. 240.

C. Cambrian : Georgia series of St. Armand (Lower Potsdam of the Geology of Canada, 1863).
" Lower Cambrian of the Sutton Mountain anticline.
A.B. Pre-Cambrian : Huronian of the Sutton Mountain anticline.
" " Laurentian limestone and gneiss west of the St. Lawrence River.
Crystalline and Igneous rocks, Volcanic and Plutonic.

DEVONIAN.

Devonian of the Eastern Townships.

Areas of Devonian rocks occur at several widely separated points in the area east of the Sutton Mountain anticline and its extension northward. The presence of limited outliers on the Chaudière River at St. George, Beauce County, and in Langevin, to the north-east, was mentioned in my report for 1887.* While detached areas of Silurian (Lower Helderburg) occur at a number of places between the Chaudière and the United States boundary, to the south-west, the only outcrops of strata holding typical Devonian fossils are found on the western shore of Memphremagog Lake. These have been briefly referred to in the Geology of Canada, but few details are there given as to distribution or fossils.

The survey of the shores of Memphremagog Lake, showed the presence of newer strata than those usually assigned to the Lower Helderberg formation, the limestones of which have a considerable development on both shores of the lower half of that sheet of water.

Memphremagog Lake, Sargent's Bay.

Thus at Sargent's Bay, which is a deep indentation on the west side, distant ten miles from the outlet at Magog village, the fossiliferous Silurian is overlain by a series of brownish-gray, somewhat dolomitic flaggy slates and shales. These are well seen at a small brook about one mile west of the wharf at Knowlton Landing, and a careful examination by Dr. Ami, in 1894, showed the presence of Devonian fossils among which were recognized *Spirophyton* (*Taonurus*) *cauda-galli*, Van., *Psilophyton*, sp., and *Bythotrephis*, sp. The containing rocks dip at a high angle and certain bands hold crystals of iron-pyrites, evidently induced in the slates by the action of some of the numerous dykes from the neighbouring Hog's Back Mountain.

Fossils.

Mountain House area.

At the cove by the Mountain House at the Owl's Head landing, about six miles south of this place, plumbaginous limestones occur, and these extend up a gully in rear of the hotel. These limestones contain many well preserved corals, often of large size, of which collec-

*Annual Report, Geol. Surv. Can., vol. III., p. II. (N.S.) 1887-88, p. 10 K, Geology o Canada, 1863, pp. 251 and 436.

tions were made. Earlier collections from this locality had been examined by Billings, who pronounced them to be Devonian in character, and Prof. Dana, in the last, (fourth) edition of his Manual of Geology, describes these rocks as of Devonian age, quoting the authority of Billings and giving a list of fossils from the locality, which includes *Syringopora Hisingeri*, B., *Favosites basaltica*, Goldf., *Diphyphyllum stramineum*, B., and *Zaphrentis gigantea*, Le Sueur. These are presumably of Corniferous age. He also mentions, on the authority of Hitchcock, *Atrypa reticularis*, which, however, may have been derived from the upper Silurian formation in the vicinity. The presence of these Devonian outliers is of special interest, as enabling us to fix, approximately at least, the date of some of the eruptive masses of this area. Thus, at the Owl's Head, the plumbaginous limestone on the beach, is beneath the black slates of the Cambro-Silurian series, which are presumably the lower Trenton, owing to an overturn of the measures, while the intrusive dykes which penetrate the Cambro-Silurian and Silurian slates and limestones, show that the intrusions and crumplings were subsequent in date to the Cauda-galli flags of Sargent's Bay and the Corniferous limestones at Owl's Head.

Fossils.

Overturned strata.

No well defined break between the upper Silurian (Lower Helderberg) and the overlying Devonian has been found, the conditions of deposition, presumably being similar to those in the Beauce district or in the similar beds of the Gaspé peninsula, described under the head of the Gaspé Limestone series in the Geology of Canada, as well as in subsequent reports.* In all these localities there appears to be a mingling of forms of upper Silurian and lower Devonian horizons, insomuch that it has been found very difficult, and in some cases impossible, to define the exact line of separation between the two systems.

Similarity to the Gaspé Devonian.

Silurian.

The areas of Silurian rocks found in this portion of the province are of limited extent. In addition to the basin in which the lower part of Lake Memphremagog is situated and which is probably the largest development of Silurian strata in south-western Quebec, outcrops of very limited extent are found on St. Helen's Island, Montreal, while in the flat country to the east of the St. Lawrence, and to the south-west of Beeancour River, Silurian rocks of an older horizon occur.

*Geology of Canada, 1863, pp. 406-428. Report Prog., Geol. Surv. Can., 1880-81-82, pp. 3-16 D.D.

St. Laurrence River Area.

Silurian of the St. Lawrence Basin.

Of the last mentioned outcrops, it may be remarked that the strata consist for the most part of reddish, soft sandstones and shales which form several areas along the south side of the river,* the exact outlines of which are impossible to define, owing to the great mantle of drift sand and clay which occupies much of this part of the province. Outcrops, however, have been found on a number of streams, and the difference in the character of the soil over those portions underlain by these reddish rocks, as compared with the usually grayish soil formed by the decay of the Lorraine shales, enables their outlines to be at least approximately traced.

St. Francis River.

The most southerly of these areas was re-examined during the past season by Mr. N. J. Giroux, of this Survey, along the St. Francis River and the country on either side adjacent. On this stream the breadth of the reddish outlier was found to be about four miles, and its western edge is about seven miles from the junction of the stream with the St. Lawrence. Two outcrops of the characteristic shales and sandstones were observed on the St. Francis, the upper one on lot thirteen, Augmentation of Wendover, with a breadth on the stream of half a mile, the nearest underlying beds up stream being the fossiliferous grayish sandy shales of the Hudson River (Lorraine) formation. The second is about three miles further down, and is exposed along the river for several miles, the beds in both outcrops being nearly flat. The red beds do not appear on the Yamaska River to the south, the nearest rocks there visible being the gray Lorraine shales, with characteristic fossils, near St. Hugues, about ten miles below St. Hyacinthe.

Medina shales and sandstones.

The age of these beds is supposed to be Medina. No fossils, however, have been found in them, and their determination rests upon their unconformably superior position to the Hudson River beds and to the fact that pieces of the red sandstone are found in the dolomitic breccia which occurs at St. Helen's Island.

Lower Helderberg of St. Helen's Island.

The Silurian outcrop at St. Helen's Island, Montreal, is noticed in the Geology of Canada, pp. 355-56 and a few of the characteristic fossils there found are mentioned. The rocks of the island are described as "prineipally a conglomerate, the inclosed masses in which are sometimes rounded, but chiefly angular. They consist of fragments of Laurentian gneiss; of white quartzose sandstone resembling that of the Potsdam formation; of dark gray limestone, in some cases holding Trenton fossils; of black shale resembling that of

*Geology of Canada, 1863, pp. 205-206.

the Utica formation; and of red sandstone and red shale similar to those of the Medina. With these fragments are associated others of igneous rocks. All of these varying in size from a quarter of an inch to five and six inches in diameter, are inclosed in a paste of light gray dolomite, which weathers to a reddish yellow. * * * About two-thirds of the distance down the east side of the island, there occur two masses of dark gray fossiliferous limestone, weathering to a light gray; which are not magnesian. These are included in a length of about forty yards and are limited on the east side by the water of the river; they have a breadth of scarcely more than ten feet, and appear to run under the dolomitic conglomerate on the west side."*

Character of the strata.

A re-examination was made of the peculiar rocks of this locality during the past season (1895). The supposed conglomerate was found to be rather of the nature of a volcanic breccia, dolomitic, weathering a rusty-brown, but grayish on fresh fracture, and intimately associated with the Utica shales, which show on the south-west end of the island below high-water mark. They are, further, intersected by numerous dykes of grayish trappean rock which are evidently spurs from the mass of Mount Royal. The Utica shale at this place has been greatly altered, the bituminous beds along the contact being sometimes hardened or baked, or occasionally rendered thin and splintery with destruction of the bituminous matter, the rock becoming gray in colour, while the contained fossils are frequently completely pyritized. The Silurian fossils are all obtained from the small patches of limestone found with the breccia at the north-east end of the island. Several collections have been made from these in recent years, in addition to those obtained by Billings many years ago.

Volcanic breccias.

Fossiliferous limestones.

Among these later collections may be mentioned that of Prof. J. T. Donald, of Montreal, in 1880, who published a list† of fossils from the limestone, comprising sixteen genera and thirty-six species, peculiar to the Lower Helderberg formation, but including two species which pass upward into the Oriskany formation of the Devonian. This list has since been very considerably extended by Dr. W. E. Decks, E.A. of Montreal, who made a very comprehensive collection from the limestones of the island in 1890, the results of which were published in the Canadian Record of Science, in that year,‡ in which the number of genera is increased to twenty-four and of species to forty-four. Dr. Deeks remarks: "Of these, thirty-three are common to New York,

St. Helen's Island fossils.

*Geology of Canada 1863, p. 356.
†Can. Nat. 1881, vol. IX., New Series, p. 302.
‡Can. Rec. of Science, 1890, vol. IV., No. 2, pp. 104-109.

sixteen to Gaspé and nineteen to the Nova Scotia series." Several of the species appear to be common to the Oriskany and Lower Helderberg, in which respect they resemble the beds of the Gaspé limestone series, as well as those found on the Chaudière.

Isle Ronde.

Isle Ronde, which is separated from St. Helen's Island by a narrow channel only, is formed of a similar volcanic breccia, and in the extreme north-east corner, below high-water mark, a small outcrop of similar Helderberg limestone occurs, the mass being from one to ten feet wide by thirty feet long. It has the aspect of being inclosed in the breccia which is apparently newer than the limestone with which it is associated. The lists of fossils from this area, prepared by Dr. Ami, will be found in the appendix. The horizon of these limestones, being that of the upper part of the Silurian or the lower portion of the Oriskany parallels them with the beds on the west side of Memphremagog Lake already referred to, where a somewhat similar transition has been recognized.

Utica shales.

The shales of the south-west or upper end of St. Helen's Island have yielded fossils of Utica age among which several species of graptolites have been determined by Dr. Ami, as well as an *Endoceras* and a trilobite, *Triarthrus Becki*.

Volcanic breccias.

Similar breccias to those found on St. Helen's Island, have been observed at several points on the Island of Montreal and on the adjacent islands. Since they have now been demonstrated to be volcanic breccias, of later date than the Helderberg limestone, and not sedimentary conglomerates, they may be removed from the Silurian division of sedimentary rocks.

Eastern or Memphremagog Lake Area.

Silurian of Memphremagog Lake.

East of the Sutton Mountain anticline, the Silurian rocks are confined to the shores of Memphremagog Lake already alluded to, and to a small outlying area extending both to the north-east and south of Sargent's Bay. The formation is here characterized by a considerable thickness of limestone, some of which is graphitic, while other portions are highly dolomitic, and are associated with dolomitic grayish slates.

In several places they contain an abundance of fossils comprising brachiapods and corals. On the east side of the lake, the most southern limit yet recognized is in the cove at Capt. Gully's house, the first outcrop being seen about seventy-five paces west of the wharf at that place. Thence they occupy the entire east shore of the lake to the outlet at Magog village and, crossing the Magog River, extend

to the north into the flat country along the valley of the Cherry River for several miles, occasional outcrops being visible in this direction. At the village of Georgeville, they have a breadth inland of about one mile, and are terminated in this direction by a small brook and a depression, on the south side of which the rocks are black and gray Cambro-Silurian graptolitic slates.

Sargent's Bay and vicinity.

On the west side of the lake, the Silurian rocks occupy the entire shore from the outlet to the extremity of Gibraltar Point, which marks the entrance, on the north side, to Sargent's Bay, and they are here separated from the series of black and gray Cambro-Silurian slates by the small depression known as Austin Cove. On the south side of Sargent's Bay they again come into view, in contact with these slates, about 400 yards south of the wharf at Knowlton Landing; the contact being seen in a small cove at this place, and the Silurian rocks which are here highly fossiliferous and dolomitic are in a nearly vertical position. The breadth here is a little more than a mile, and the rocks can be easily traced almost to the forks of the road turning off across the head of the bay, where they are again in contact with the blackish-gray, pebbly slates and diorites presently to be described. The Silurian rocks along the shore of the upper portion of Sargent's Bay, are in part overlain by the Devonian beds already described, but the calcareous beds are well seen about East Bolton post-office, on the west, and at Pensley's Corners on the east, whence they extend in a narrow band to the north-east, through Millington, crossing the road which runs south from Orford Pond to the lake, at about lots ten to thirteen, range thirteen, Magog, and terminating in the wooded country to the north-east, a short distance beyond the road. The exposures of these rocks south of Knowlton Landing, are confined to a narrow wedge-shaped band. They are seen along the road running south towards Owl's Head Mountain, as far as Perkins Vale where they are in contact with the black and gray slate series, and they extend for about a mile further south in the depression to the west of the road past Owl's Head Mountain, being there apparently cut off by the doleritic rock of that mountain. They are also exposed on the several roads leading across to Mansonville, with a breadth of from a half to three-fourths of a mile. As a rule these Silurian beds have a nearly vertical dip and present the same character of limestone and dolomitic slates throughout.

Area north of Sargent's Bay.

Area south of Sargent's Bay.

Round Island.

South of the Owl's Head Mountain wharf, on Round Island, the same dolomitic slates, in places changed almost to a talcose mica-schist, contain characteristic fossils of Silurian age. They are cut by dykes of green crystalline diorite or dolerite of precisely similar character to the rock of the Owl's Head Mountain. In the long island off the

mouth of Fitch Bay, the contact of the slates and diorites is also well seen.

Capt. Gully's Cove.

The rocks at Capt. Gully's Cove, on the east side of the lake opposite the Owl's Head, also contain corals similar to those found in the beds of Round Island. They are also cut by dykes of considerable size, not only of the greenish crystalline diorite but of a soft, green, talcose rock, which has now a schistose structure. To the south-west of Round Island, a somewhat similar soft, green, talcose rock is seen in connection with the Silurian fossiliferous sediments, on the shore of the lake above the light-house, and forms an exposure several hundred yards in width.

It may be here remarked of these peculiar rocks, that from hand specimens only, they might easily be mistaken for pre-Cambrian schists, and it is by their intimate and undoubted association with the fossiliferous Silurian beds alone, that one is enabled to pronounce definitely upon their age.

Black and gray slates of Fitch Bay, &c.

In addition to the areas of Silurian just described, the great belt of black graphitic limestones with black and gray slates, which is especially well developed along the south-eastern side of Memphremagog Lake, more particularly to the south of and about Fitch Bay, was formerly regarded as of upper Silurian or Devonian age, and the rocks further east, and extending thence northward to the Chaudière River, were also assigned to the same formation.* The reasons for changing the position of these rocks in the geological scale, have already been stated in my report for 1886.† Cambro-Silurian fossils, were in fact found not only in the limestones but in the slates of the same series.

Limestone of Magoon's Point.

The small area of limestone at Magoon's Point which is apparently faulted in between slates of Cambrian age, is of doubtful horizon. The rock is highly crystalline, quite as much so as some of the pre-Cambrian limestones, and the only fossils yet found are crinoid stems. It differs from the limestones of the Silurian in the vicinity, both in character, and also in the fact that the rock does not show the presence of corals, so common in the Silurian beds. It is presumably of earlier date, and may, for the present at least, in the absence of more conclusive evidence, be placed in the Cambro-Silurian series, possibly as an altered portion of the Trenton limestone formation.

Georgeville limestones.

The dolomitic slates and limestones of the Silurian, are particularly well exposed along the east side of Memphremagog Lake, for several miles on either side of Georgeville. They frequently form cliffs

* Geology of Canada, 1863, pp. 432-37.

† Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), pp. 11-17 J.

of considerable height, and their broad, flaggy character is well seen. They are occasionally thrown into abrupt folds, several of which are visible near the Georgeville wharf, but further north, in the vicinity of Oliver's Corner, they are nearly vertical, and large slabs, suitable for pavements or flagging, can be easily removed. To the south of Georgeville, the limestone forms a bold bluff for a couple of miles to the bay north of Allan's wharf, around the shore of which they are also well exposed. Near the head of this bay the strata are in places filled with corals, often of large size, and very good specimens may be obtained from this locality. The slaty portions are frequently schistose and the corals are drawn out and greatly flattened by the pressure through which this schistosity has been induced. Corals flattened in the same way are seen on the shore at Capt. Gully's and at Round Island. Fossils.

The structure of the Silurian in this area is that of a folded basin, resting, on either side of the lake, upon fossiliferous Cambro-Silurian or lower Trenton rocks. That the rocks of the whole series have been subjected to great metamorphic action since their deposition, is evident, not only from the highly inclined and often folded character of the strata, both of the upper Silurian and the underlying Cambro-Silurian beds, but from the presence of numerous dykes, often of large size, which cut the strata of both formations, not only along the lines of bedding but frequently transversely to the bedding or cleavage planes. This is further shown by the alteration of the Silurian fossiliferous beds from their ordinary conditions of calcareous slates and limestones, to that of talcose and micaceous schists in the one case, and highly graphitic and almost crystalline limestones in the other. Fossils were obtained from a number of points in the Silurian, among which may be mentioned, Knowlton Landing, Owl's Head, Round Island, Capt. Gully's Cove, Allan Bay and the road one mile south of Georgeville, at the crossing of the brook near the contact with the graphitic slates. The result of their examination will be found in the appendix to this report. Structure of the Silurian. Fossils

CAMBRO-SILURIAN.

The complicated structure of the Cambro-Silurian rocks of south-western Quebec, furnishes several problems of very great scientific interest. All the members of this system are apparently represented, from the Potsdam sandstone and Calciferous to the Hudson River or Lorraine shales. The physical characters of these where found in the eastern area, however, do not in many cases resemble those which prevail in the characteristic strata of the several formations as developed

Rocks and fossils differ from those of typical areas.

in the St. Lawrence and Ottawa River district, where these rocks can be well studied. In regard to the contained fossils in the former also, it may be remarked of the lower members that, while in general aspect these resemble the typical fossils of the formations further west, there is often a manifest development of forms which cannot readily be compared with those which usually form the basis for palæontological determination, more especially as relating to the Calciferous, Chazy and lower Trenton horizons. The conditions of deposition in the area under consideration, have apparently differed very considerably from those which prevailed in the Ottawa River section.

The elucidation of the structure of this area, throws some light upon the much disputed question as to the age of the rocks of the city of Quebec, as well as of those found on the Island of Orleans and at many points along the Lower St. Lawrence, which have been described in my previous reports on these districts,* as also upon the age and equivalents of the fossiliferous Lévis and Sillery divisions of the Quebec group.

Faults.

The district is traversed by extensive faults, among which may be more particularly mentioned the great St. Lawrence and Champlain fault† described by Sir Wm. Logan in the Geology of Canada,‡ which has been traced from the Vermont boundary, at the foot of Lake Champlain, to the city of Quebec, and thence down the St. Lawrence River along the north side of Gaspé Peninsula.

The Phillipsburg series.

In order that the somewhat complicated structure which prevails in this region may be more clearly understood, it will be necessary, first of all, to explain the structure and stratigraphical relations of what we regard as among the lowest rocks of the system, viz., those above the horizon of the Potsdam sandstone and known as the Phillipsburg series, hitherto described as a portion of the Quebec group; more especially, since it is now very generally admitted by all who have carefully studied this series, both along the Vermont boundary and about Quebec city and Point Lévis, that certain portions at the two extremities of the section can be readily correlated. Very considerable attention has of late years been paid to these rocks by geologists and palæontologists in the United States, among whom Mr. C. D. Walcott has taken a leading part, and their studies of the rocks in the Phillipsburg area as well as of the fossils obtained therefrom, have been extensive. Large collections have also been made by Mr. Whiteaves, Dr. Deeks and myself

Fossils.

*Report of Progress, Geol. Surv. Can., 1880-81-82, pp. 16-31 D.D.
†Annual Report, Geol. Surv. Can., vol. III., (N.S.), part II., 1887-88 pp. 48 K-84 K.
‡Geology of Canada, 1863, p. 234.

from various places in the Phillipsburg and St. Armand section and at Stanbridge, Bedford and Mystic, which have been carefully studied and classified by Dr. Ami (see appendix).

The rocks of this section have been very fully described by Sir Wm. Logan,* and it will therefore be unnecessary to repeat their characters in any detail in this place. At that time, however, it must be borne in mind that the views as to the stratigraphical sequence of the various divisions of the Quebec group were entirely different from those which are now generally received.

Early views as to structure.

Thus, the series of black limestones and slates, in places containing fossils but in others apparently regarded at that time as non-fossiliferous, which appear at several points (notably at Farnham, Melbourne, Danville, etc.,) were, from certain peculiarities of structure, regarded as for the most part of Potsdam age and held to underlie the fossiliferous Quebec group, which was then supposed to comprise the Lévis and Sillery divisions only. The Sillery, moreover, was regarded as probably newer than the Lévis—a point in structure which has since been corrected ; as it is now conclusively established that the Sillery red, green and black slates and grits are older, or stratigraphically beneath the Lévis slates, limestones and conglomerates.†

Farnham limestones.

The Farnham limestone series is now believed, from the evidence of the contained fossils, as well as on stratigraphical grounds, to belong to the horizon of the lower Trenton formation, so that in order to clearly understand the structure of this interesting group, one must completely reverse the stratigraphical sequence as formerly given and read upward from Sillery (upper Potsdam), Lévis and lower Phillipsburg (Calciferous), upper Phillipsburg, Bedford and Mystic (Chazy) and Farnham black slates and limestones (lower Trenton). At Lévis and Quebec, all these formations do not appear, at least not in such perfect development as in the southern part of the province, the Chazy proper being apparently, or for the most part at least, wanting, unless certain beds of the upper Lévis formation may be assigned to that horizon, which appears probable. The lack of uniformity of development may be accounted for by the great faults which affect the areas along the St. Lawrence River.

Stratigraphical sequence.

Area West of the St. Lawrence and Champlain Fault.

The newest rocks of the Cambro-Silurian system found in this area, are situated to the west of the great St. Lawrence and Champlain

* Geology of Canada, 1863, pp. 275-286, and 844-861.

† 1. Geology of Canada, 1863, p. 239-240.

2. Annual Report, Geol. Surv. Can., 1887-88, vol. III. (N.S.), p. 82 K.

Utica-Lorraine.

fault, between it and the River St. Lawrence. They are evidently the south-western extension of the Utica-Lorraine beds which occur along the river on both sides between Quebec and Three Rivers. They are well characterized by fossils, which are found at several places, and of which very considerable collections have been made, as at St. Hyacinthe and St. Hugues, on the Yamaska River, Chambly Basin and St. Jean Baptiste village, (the latter on the River Des Hurons, which joins the Richelieu a short distance above Mount St. Hilaire), and at Chambly. Rock exposures are, however, rare throughout this entire area. Further north, on the lower part of the Becancour, opposite Three Rivers, a small collection of fossils was made in 1888, which showed the presence of the typical Lorraine shale formation at this place, and served to indicate the apparently uniform extension of these rocks throughout this area.

Characters of the Lorraine and Utica.

The rocks of the Lorraine formation differ somewhat in character from those of the Utica. They are more sandy in texture, and are generally of a grayish colour, or have frequent beds of gray, sandy shales, which sometimes pass into sandstone layers. The Utica, on the other hand, is generally characterized by the presence of brown, or brownish-black, bituminous shales, with occasional hard bands of dolomitic limestone, but gray beds like those of the Lorraine are rarely seen.

St. Francis River section.

The most northerly outcrop of the Lorraine shales seen in the present map-sheet, was observed in 1889 by Mr. Giroux in his traverse of the St. Francis River. On this river, from a point three miles above Drummondville, near the falls, beds of the lower Trenton occupy the stream as far down as the fourth lot of the Augmentation of Wendover. From this point to lot sixteen of the same Augmentation, outcrops of gray, sandy shales and sandstones are seen, showing an anticlinal structure at two points in this distance. The dips, as a rule, are low, ranging from five to twenty degrees, and the gray beds, shortly below the sixteenth lot, become covered over by the red shales of the Medina (Silurian) already referred to. The lowest outcrop of Medina on the river is about four and a half miles above the village of Pierreville, below which no rock is seen to its junction with the St. Lawrence, the country being low and the surface consisting of clays.

The Yamaska River.

Ascending the Yamaska, no ledges are visible till within one mile and a half of the mouth of the Chibouet River, near the village of St. Hugues. Here beds of gray sandstone, with blackish and grayish shales, show in the stream. They contain an abundance of fossils, from which a collection was made by Mr. Giroux, as also from the beds on the St. Francis, just mentioned. At St. Hugues, the dip is S. E. $< 30°$, and

the rocks extend thence along the river to opposite the St. Simon church, being exposed for about four miles. The stream flows very nearly along the strike. At St. Simon, where these rocks are blackish, crumbling shales with hard, sandy beds, the dip is S. 60° E. < 70°. Thence up to St. Hyacinthe no rocks are seen.

St. Hyacinthe.

At St. Hyacinthe, the section exposed in the river, opposite the city, extends from just above the middle wooden bridge across the Yamaska to the dam or fall above the upper bridge. The rocks consist of grayish and greenish sandy, flaggy shales, some of which are finely micaceous, and have interstratified thin dolomitic bands.

Dykes of intrusive rock.

The sandy greenish beds contain graptolites, brachiapods and trilobites (see appendix), and are cut by dykes of greenish, moderately coarse doleritic or trappean rock, two of which cross the river and form rapids opposite the tanneries. The shales are much broken and altered along the contact. Several disturbances are seen in these rocks, and one well-defined anticline which occurs in contact with a dyke, soon becomes overturned. The general dip of the beds in this section is S. 60° to 70° E. < 20°. Associated with the gray marly shales are occasional bands of hard flinty or cherty limestone, both blackish and brownish in colour. In the blackish beds Orthoceratites were found. Between St. Hyacinthe and St. Pie, which is on the East Branch of the Yamaska, ten miles distant, no ledges are seen; the water in the stream has no current, and the banks on both sides are mostly of clay.

St. Pie.

At St. Pie, a short distance below the road-bridge, ledges of black and bluish-gray limestone, with thin veins of calcite, cross the stream. These rocks are generally slaty and are cut by dykes of diorite, some of which are almost a pure crystalline hornblende-rock. One of them has a breadth of ten feet or more, and it has altered the limestone in contact by shattering and breaking the adjacent strata. In a band of slaty limestone, between the Canadian Pacific railway-bridge and the road-bridge, graptolites were found, with long, straight, single forms. No other fossils were observed by us, but from a collection made in 1879 by Mr. T. C. Weston, ten species were determined by Dr. Ami, which showed their horizon to be Trenton. (See appendix).

Fossils.

St. Pie and Abbottsford

Between St. Pie and Abbottsford, these black limestones frequently appear along the roads and in ledges through the fields. They are all highly cleaved, and though carefully examined for fossils, none other than those just mentioned were observed. These rocks continue eastward to the foot of Yamaska Mountain, where, at the west flank, they are found in contact with the eruptive rock of the

mountain mass, by which they have been greatly altered, the slaty limestone becoming very hard and cherty at the contact. Near the base of the mountain, certain beds of this limestone series have a conglomeritic character, with pebbles of limestone in a slaty calcareous paste. They are thrown into a series of folds, and are all highly cleaved. West of the mountain, they are exposed for nearly two miles, or to the level country, which continues thence to the Yamaska River. Diabase dykes are observed, sometimes nearly black in colour and generally fine-grained; and these usually occur along the bedding planes, but sometimes cut directly across the strata.

River des Hurons. The country between St. Hyacinthe and the Richelieu River at Beloeil, is flat, and no rocks are exposed till the rock of the mountain is reached. At several places along its base, ledges of sandy shales and limestones of Lorraine aspect are seen, and at the village of St. Jean Baptiste, on the River des Hurons, sandy and calcareous beds

Fossils. contain a great abundance of fossils. The locality was noted in the Geology of Canada (1863), p. 209, but large collections of fossils have since been made from this place, which present the usual Hudson River or Lorraine aspect. (See appendix). About St. Johns city,

Mt. Johnston. no rock-exposures are seen, but on the south-west flank of Mt. Johnston or Monnoir, about six miles north-east, blackish-gray limestone and slates were observed along the road in contact with the granite of the mountain mass, in which a layer containing fossils of Hudson River age occurs. These rocks are all highly altered along the contact.

Chambly Basin. About Chambly Basin also, the Lorraine shales and sandstones are well exposed. These have yielded fossils, a good collection having been made from this locality in 1890 by Dr. Deeks, my assistant in that year.

Utica shale near Montreal. The Utica formation appears occasionally in the district east of the St. Lawrence, as well as about the Island of Montreal. Good exposures are found at Point St. Charles,* near the northern extremity of the Victoria Bridge, and vicinity, as well as at St. Helen's Island, already alluded to, and the characteristic shales of the formation appear again on the east side of the river above Longueuil, and thence toward Laprairie, beyond which place, to the south-east, this formation is concealed by the great mantle of clay and sand. At the

Joliette. village of Industry, or Joliette, on the west side of the St. Lawrence, the Chazy and Trenton beds are well exposed, but a small collection of Utica fossils in the Museum, made by Sir Wm. Logan in 1852, at this place, has been examined by Dr. Ami, and indicates the occurrence of an outcrop of this formation in the vicinity.†

*Geology of Canada, 1863, p. 207.

†Can. Rec. of Science, Oct., 1892, p. 21.—The Utica Terrain in Canada (H. M. Ami).

To the south and east of Montreal the Utica appears but rarely. Black shales with characteristic fossils show in the bed of the Little Montreal River at L'Acadie, west of St. Johns, and, further south, they are well exposed in the Lacolle River, half a mile east of Lacolle village. On the east side of the Richelieu, west of Clarenceville, on the road from Lacolle, black graphitic shales are exposed which contain graptolites and other fossils of a lower horizon. These are probably the equivalents of the Quebec city rocks, overlain by the Utica on either side. The typical Utica occurs again at Clarenceville and for some distance east towards Missisquoi Bay. The eastern area of the Memphremagog basin has yet shown no rocks of Utica age, the graptolitic shales there found belonging to a lower horizon, presumably the lower Trenton.

L'Acadie. Lacolle. Clarenceville.

The valley of the St. Lawrence, from Lake St. Louis almost to Quebec city, and for some miles on either side of the river, is occupied by strata of the Utica and Lorraine formations, between which, the line of separation at most points, is difficult to ascertain, owing to the great mantle of clay so widely distributed throughout this area. This region was one of the first studied by the Geological Survey. The strata exposed are nearly horizontal, disturbances being few and due to intrusive masses of doleritic matter. The rocks where exposed, abound in fossils, and their true horizons can therefore be readily determined. The doloritic rocks which intersect these strata, form mountain masses, sometimes of large extent, which present conspicuous features in the otherwise monotonously level landscape.

St. Lawrence River area.

These rocks, both the fossiliferous sediments and the intrusive masses, have been well described in the earlier reports of the Survey.* In the first of these, viz., that for 1847, the characters of the rocks visible on the line of section between Montreal and Lake Memphremagog are so clearly stated that but little remains to be said on that subject.

Intrusive mountains.

As, however, the relations of certain groups, more particularly the crystalline schists and the red and green slates and sandstones of the upper Cambrian (Sillery) were not at that time clearly understood, these will call for some remarks on a subsequent page. The general horizontality of the measures, except where this is disturbed by the presence of the intrusive masses or dykes, is maintained almost to the vicinity of the great St. Lawrence and Champlain fault, which, as already described in a former report, extends from the city of Quebec to the foot of Missisquoi Bay. The fault brings beds of the Trenton formation

St. Lawrence and Champlain fault.

*Report of Progress, Geol. Surv. Can., 1847-48, pp. 10-22. Report of Progress, Geol. Surv. Can., 1858, pp. 171-178, and Geology of Canada, 1863, pp. 205-210.

against the Calciferous and Chazy at Phillipsburg and Stanbridge, and its existence is very evident wherever rock-exposures are visible along its line; but as there is a heavy covering of drift over a considerable portion of the country which it traverses, its delineation on a map, between exposed points, must of necessity be largely conjectural.

Disturbances of strata.

This great fault marks one of the important geological features of the district under discussion, but the amount of displacement occasioned thereby is presumably no greater than that caused by other heavy faults, which traverse the country in a north-east to south-west direction, and which are seen as far east as Lake Memphremagog. Not only is this entire area greatly affected by these faults, but extensive crumplings of strata have occurred, which have closely involved the rocks of the older or crystalline-schist series, with the most recent sediments of the district. Narrow areas of the Cambro-Silurian are seen, which contain fossils, but are apparently interstratified with the schists; while in some places the formations are so completely overturned that the fossiliferous Devonian now underlies the Cambro-Silurian.

Trenton formation.

The rocks of the Trenton formation, which underlie the Utica and Hudson River (Lorraine) just described, have also a wide distribution. In the earlier reports of the Geological Survey * certain portions of these rocks were included in the Upper Silurian; these comprise both the black graphitic limestones and associated clay-slates which have already been described,† and which will be more particularly discussed later.

St. Francis River, Drummondville.

The eastern limit of the most westerly area of these Trenton rocks, is seen on the St. Francis River about three miles above the village of Drummondville. They are here separated from another area of similar-looking rocks, presumbly of the same age, by a belt of greenish sandstones, with red and green slates of Sillery aspect. At Drummondville, the black slates and limestones contain graptolites, in character like those from the vicinity of Memphremagog Lake, and the rocks themselves are much broken up by intrusive masses of dioritic or trappean material.‡ From this locality a collection of fossils was made in 1863 by Mr. T. C. Weston which have been described by Dr. Ami (see appendix). Just below the rapids caused by the trap masses at Drummondville, the black slates dip nearly south $< 50°$, and in places are pebbly, some of the bands constituting a slate conglomerate. These

Fossils.

*Geology of Canada, 1863, p. 434.

†Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 16J.

‡Geology of Canada, 1863, p. 718.

black slates are said by Mr. N. J. Giroux to extend for half a mile below the bridge at the town, and are generally much broken and jointed. On lot sixteen, range three, of Wendover, the black lime- Wendover.
stones, often slaty and occasionally sandy, are interstratified with brownish calcareous slates, and dip S. $< 40^\circ$; and a few miles below, or near the line between the townships of Upton and Grantham, a cliff about forty-five feet high, presents a good section of thin grayish or brownish-gray crumbling shales, which dip S. 25° E. $< 60^\circ$. These contain thick bands of grayish-brown sandstone, the whole having the aspect of the Utica formation as seen at Montmorency Falls. These beds are somewhat disturbed, dipping generally at a high angle, both Faults.
to the north and south, and they are probably affected by faults, indications of which are apparent at several points. They presumably represent a higher portion of the series than the blackish slate of Drummondville.

To the north of this area, exposures of the fossiliferous rocks are Becancour River.
next seen on the Becancour River, where, however, they are mostly confined to the Lorraine shales, and greenish-gray, sandy beds occupy the lower part of that stream for some miles, or to within a short distance of the road which crosses between ranges seven and eight of the township of Maddington. The lower exposures of these shales are nearly flat, but the dip suddenly rises to an angle of 60° to 70°, owing to sharp folding and faults. These grayish sandy beds, extend up the stream almost to the contact with the red and green slates of the Sillery, and the Trenton black limestones, if they occur at all, are reduced to a very limited area.

Returning to the St. Francis River, a second area of the black St. Francis River Drummondville and Richmond.
limestones, and associated blackish-gray calcareous slates, is seen in the stretch between the falls three miles above Drummondville and Richmond. The red slates and green sandstone of the Sillery, at the falls, are confined to a narrow band not more than one mile in width, and indications of faults are seen on either side. On the upper or southern side, the rocks in contact are a series of black limestones of lower Trenton aspect, resembling those of St. Dominique, which form the bed of the river for some distance. Thence up stream, outcrops of the same limestones are seen at several points, as far as lot eight, range one, L'Avenir, where these are underlain by the Cambrian slates of the area west of Richmond.

The northern portion of the eastern area of these rocks, viz., that Kingsey.
part north of the St. Francis River, has a very considerable development in the townships of Kingsey, Simpson and Warwick. The slates

and limestones can be traced continuously into the Warwick and Arthabaska district, described in a preceding report.* About French Village or Kingsey, the black limestones of this series are well developed, and the associated rocks are bluish-gray, often calcareous, and blackish-gray slates, the latter frequently containing pebbles of hard grayish-brown limestone or fine-grained sandstone. This pebbly character is well marked throughout certain portions of this entire formation and has served to distinguish the slates of this age, not only in the Wotton area, north of the St. Francis, but also about the shores of Memphremagog Lake, where also certain bands hold a great abundance of graptolites of presumably lower Trenton age.† The rocks of the Kingsey area are bounded on the west, at several points, by red slates and hard green sandstones of upper Sillery (Cambrian) aspect, although owing to the great covering of drift which prevails at many places, the continuous contact cannot be observed. In some places this is doubtless of the nature of an overlap, while at others the structure is complicated by faults.

Fossils.

Richmond.

On the line of the Grand Trunk railway, between Richmond and Actonvale, these rocks were also seen at several points. At Richmond, another basin which extends along the line of the Grand Trunk to Danville, has been already described in my report of 1886.‡ This crosses the St. Francis into Melbourne and thence continues south in a rapidly narrowing valley, extending up the stream which flows from Brompton Lake past the village of Kingsbury, near which place is the celebrated New Rockland slate quarry. To the south of Kingsbury, the peculiar graphitic limestone and shales, by which the formation is easily recognized, can be traced in a very narrow outcrop for several miles along the road to Melbourne Ridge, in which direction it separates the crystalline pre-Cambrian schists from the red and green or bluish-gray slates and quartzites of the Cambrian. On the Grand Trunk section, after passing the green chloritic rocks, (which are, to some extent at least, schistose diorites, and which form an almost continuous band from the Vermont boundary all along the flank of the mica-schist series of the central anticline), a series of black and gray wrinkled, often woody fibred slates, is found, cut by quartzose veins and containing, in their upper parts, beds of hard quartzose sandstone. These are well exposed about South Durham and Lisgar stations, where they rest directly upon the green chloritic rocks just mentioned. Several purple bands occur in the lower part, and these are well seen along the St.

Grand Trunk railway, Richmond to Acton.

* Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 19-20 A.
† Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 16 A.
‡ Annual Report, Geol. Surv. Can., 1886, vol. II. (N. S.), p. 18 A.

Francis River, where they have been opened for a slate quarry, which was subsequently abandoned. About two miles west of the station of South Durham, ledges of hard sandstones resembling the Sillery, are overlain by black and bluish-gray calcareous slates, with beds of black limestone, like the rocks seen in the St. Francis River section. The latter show the presence of foldings, but generally they dip at moderately low angles of from twenty to forty degrees. These are seen in cuttings between Durham and Danby, but beyond the latter station the surface falls easily to the crossing of the Moose River, beyond which, towards Actonvale, the red slates and sandstones of the Sillery are again exposed. Sillery red slates, &c. Black slates and limestone.

Tracing the black calcareous slates and limestones southward, their western limit in this direction is seen at the crossing of the Moose River on lot thirteen, on the road between ranges three and four, Acton, where bluish-gray, calcareous slates dip S. 70° E. < 75°. Thence they are exposed along the road to South Durham for about three miles, to the point where this road meets the railway, two miles west of Durham station, being here terminated by the underlying sandstones of the Sillery. Further to the south, they are found near Bethel, or North Ely village, at which place also fossils have been found in the limestones, associated with these slates, precisely similar to those obtained from the beds of Danville and Richmond. Further to the south-west, these rocks apparently abut against the mass of Shefford Mountain, on the north side of which dark limestone and bluish-gray calcareous slates are seen; and, in the valley lying between the Granby ridge and West Shefford, there is a second development of the bluish-gray, pebbly slates, with which, on range three, lots five and six, Granby, small outcrops of the black graphitic limestone are found. Acton. Durham. North Ely. Fossils. Shefford.

In the townships of East and West Farnham, these rocks assume a greater breadth. They rest unconformably upon the series of red and green shales and green sandstones of the Granby ridge, which terminates in this direction before reaching the north branch of the Yamaska. About the village of Adamsville, the black and bluish-gray pebbly slates are well exposed, but are too highly cleaved to disclose the presence of fossils. A short distance to the south-west, on the south branch of the Yamaska at Brigham post-office, a considerable exposure of black limestone is seen on lots twenty-four and twenty-five, range two, East Farnham. The limestones are generally slaty and cleaved, but in some places there is a dip S. 85° E. < 20°. They strongly resemble the beds of St. Dominique, East Farnham and Danville in aspect, and are exposed in the stream for about 500 paces Farnham. Adamsville. Fossils.

below the road. They contain traces of graptolites and are cut by quartz-veins. No other fossils were observed at this place, but, in the river below or near West Farnham, blocks of considerable size were seen, probably from the same series of beds, which contained a great number of fossil forms, all of which appear to belong to the Trenton formation. The position of these calcareous slates and slaty limestones, is apparently below the bluish-gray pebbly slates, and, if we take a line of section from the fault at Farnham, south-east to Cowansville and Sweetsburg, the structure of these rocks, which have been the subject of dispute for some years, will be made clear.

Farnham to Cowansville.

At Farnham, in the bed of the Yamaska River, there is a very considerable exposure of calcareous rocks, including slates and limestones. Beginning with the lowest of these, about three-eighths of a mile below the road-bridge, grayish-brown, somewhat micaceous, sandy slates are seen, dip N. 85° E. < 20°. Below this the river is filled with large boulders, the country is flat, and no ledges were observed. These slates are cut by dykes of coarse hornblendic diorite, in places made up almost entirely of hornblende crystals, the dykes ranging in width from one to ten feet or more. While these generally follow the lines of bedding they sometimes cut directly across them. Approaching the highway-bridge in the centre of the town, the rocks become darker and more calcareous, with beds of dark grey or black limestone, which are rusty on weathered surface and are evidently dolomitic. These bands are associated with slates, which are much twisted and cleaved across the bedding. Between the two railway bridges, traces of graptolites are seen, and in certain black slaty beds a hundred yards above the upper railway-bridge, interstratified with the black limestone, an *Orthoceras* and several other fossils were obtained. In the extension of these beds on the south side of the river, graptolites were found, all straight forms, the rock breaking out in broad flaggy pieces which are cut by diorite dykes as at St. Pie. Most of these beds are also cleaved across the bedding and the fossils are hard to obtain. In a thin band which accompanies the graptolitic slates, *Ptilodictya* and crinoid stems were seen, with several other forms not determinable. Thence up stream for nearly two miles, the black slates and limestones were observed, in the upper part becoming greatly broken and altered, some of the beds being cherty and hard like those at the Marsouin River on the St. Lawrence, traces of graptolites being also seen in these. This is presumably not far from the line of fault between the Trenton beds and the Sillery of the Abbottsford and Granby area; the actual contact here being concealed by drift, though pieces of the green and red slates are plentiful in the stream.

Intrusive dykes at Farnham.

Fossils.

Cherty beds.

On the road from Farnham to Cowansville, which follows the river-flat for some distance, rock-exposures are few for the first four miles, only one ledge of the black cherty slates being visible, about one and a half mile east of the first-named town. Red and green slates occur in the river on lot thirty-three, range three; while a knoll of hard grayish-green sandstone on lots thirty-one and thirty-two, range three, of West Farnham, probably marks the southern extension of the Sillery ridge, south-west from the town of Granby. These rocks do not come quite to the railway-crossing on the road, and on the east side, on lot thirty, range three, they are succeeded by the series of blackish and grayish pebbly slates, which occupy the valley south-east of Granby, already described. These are seen at intervals along the road to Farnham Centre, near which place, on lot twenty-six, range one, Farnham, the ledge of black slates and limestone occurs as described in the Geology of Canada, 1863 (p. 239). The fossils from this place as there described have a manifestly lower Trenton aspect. (See appendix). Road east of Farnham. Farnham Centre fossils.

The exposure already referred to, on the branch of the Yamaska, is to the north-east of this locality and on the strike of the beds just mentioned. On the road leading to Brigham from Farnham Centre, ledges of the thin bluish-gray slates of the Adamsville area occur. A list of fossils from this locality is given in the appendix. Brigham.

From Brigham post-office to Allan's Corners, the country is generally level and covered by sandy drift; but on the roads to the north and south occasional outcrops of the bluish-grey pebbly slates are exposed. These are highly cleaved and the dip is doubtful, but they appear to be thrown into a series of folds. Just south of Allan's Corners or East Farnham, on the road to Cowansville, bluish-gray dolomitic slates, with small masses of limestone, occur, which contain fossils. These rocks are precisely similar in character to the Chazy slates seen at Mystic, from which large collections of fossils were made in previous seasons, and the contained masses of limestone near Allan's Corners are also fossiliferous in the same way as those in the strata at Mystic. These dolomitic brownish-weathering slates extend through Cowansville, and are exposed on the road east from East Farnham, to the intrusive mass of Brome Mountain. At several points they contain limestone bands which yield fossils, such as to show them to be the equivalents of the Mystic limestone and slates. Allan's Corners fossils.

It would therefore appear that the black limestones and slates of Farnham Centre, occupy the centre of a synclinal in Chazy rocks, the western outcrops of which are seen along the road from Farnham south to Mystic, while the eastern is seen on the roads west of Cowansville; Syncline in Chazy.

and as the contained fossils are of lower Trenton aspect, the apparent stratigraphical position is clearly supported by the palæontology of the section.

L'Ange Gardien.

To the north of Farnham, (Farnham station) the road to L'Ange Gardien and Abbottsford shows ledges of blackish-gray slates and limestones similar to those just described as occurring about the former place. On the road east from L'Ange Gardien, these black limestones are exposed for nearly one mile and three-fourths, the probable contact with the red and green shales of the Sillery being 1140 paces beyond the angle of the road, east of the village. This is on the St. George range road. The actual contact is here concealed by a low swampy flat. Dykes of diabase rock, apparently from Yamaska Mountain, cut the red and green slates of L'Ange Gardien as well as the black limestones of that locality.

Papineau range road fossils.

On the Papineau range road, two miles south of Abbottsford, the line between the Trenton and the red slates crosses about one mile and a half east of the Farnham road, in a valley near a small brook, the red slates showing on the east of the brook, and the black limestones on the west, just beyond the line of the Canadian Pacific railway. At this locality, the most extensive outcrops are about one-eighth of a mile west of the railway and about the same distance north of the Papineau road. They consist for the most part of dark, grayish-black, or black, slaty limestone, which in places contain graphitic layers. Crinoid stems were seen in some of the beds, and loose pieces contained a great abundance of Trenton forms; but these were not found in place. Bands of limestone conglomerate, with partings of dark or blackish-gray shale occur as a part of the series, and contain large pebbles of grayish (dove-gray) limestone, which hold whorled shells; both the pebbles and the contained shells being precisely similar to what are found in the eastern portion of the Phillipsburg section where the rocks are of Chazy age. The rock, as a whole, resembles somewhat the Stanbridge conglomerate, but the pebbles are not so numerous. These limestones have been burned quite extensively for lime, but the quality is not considered so good as that produced from the stone of St. Dominique. East of the main area of the dark limestones, which are all highly cleaved, on t'.e Papineau range road, there is a considerable thickness of grayish and bluish-gray slates, in places somewhat dolomitic, which extend nearly to the railway. These rocks resemble very strongly those on the Grand Trunk railway between Durham and Danby. They do not at all resemble the rocks of the Utica or Lorraine in character, and are, in so far as examined, devoid of fossil remains.

Contact of Trenton and Sillery.

Between L'Ange Gardien and the Papineau range road, on the road from Farnham to Abbottsford, black limestones show for several miles south of the latter place; but approaching L'Ange Gardien, splintery grayish clay-slates, like those of St. Liboire, on the Grand Trunk railway, east of St. Hyacinthe, occur at several places. These are apparently an upper portion of the black limestone series, and probably the equivalent of those seen at Farnham, in the lower part of the section on the Yamaska River. They also show along the road south of L'Ange Gardien, with pebbles in places, and resemble both the rocks east of Granby, and those near Memphremagog Lake, presently to be described.

West of Yamaska Mountain, at Abbottsford, the strata are mostly black calcareous slates and blackish limestones which weather in places to a shade of brown. They extend to the flank of the mountain, where their contact with the eruptive rocks has already been described. Abbottsford.

Although well exposed for two miles or more west of the mountain, in the fields and on the several roads, a search for fossils in these beds was unsuccessful. They have generally a dip to the south-east at angles of 20° to 40°, but are highly cleaved. That they are the extension of the beds seen at St. Pie and St. Dominique is apparent from their position and general aspect; and probably a more exhaustive search in beds unaffected by cleavage, if such can be found, would result in finding fossils similar to those obtained at those places.

The section at St. Dominique, further north, has already been described in the Geology of Canada.* The exposures here rise quite abruptly from the generally level country which extends thence to St. Hyacinthe, and the lowest beds seen are grayish nodular limestones, which are extensively quarried for building stone. The limestone beds have thin partings of black shale, and both contain fossils which show them to belong to the upper part of the Chazy formation. Ascending the hill, which is about fifty feet high, these Chazy beds gradually pass into the series of blackish limestones and calcareous slates, which we have just been describing, and which should therefore represent the Black River formation. Certain bands in these are highly fossiliferous, but, as a rule, all the beds of this series are affected by cleavage planes and the fossils are difficult of extraction. The beds at the lower quarry, dip S. 80° E. < 20° to 30°, and at the quarry at the top of the hill, S. 70° E. < 20°. The colour of the limestone at the top of the rise, is a dark lead-blue, and the beds are frequently cut by veins of calcite. These strata contain fossils of lower St. Dominique. Fossils.

*Report of Progress, Geol. Surv. Can., 1847-48, p. 18; Geology of Canada, 1863, p. 205.

Trenton age. To the east of these exposures the limestone becomes more slaty, and is frequently black and highly cleaved in the direction of the dip, at an angle of 70°. Certain beds hold *Triuucleus* in abundance, but, owing to the cleavage planes, it is difficult here also to break out good specimens. These beds become more shaly in the direction o the St. Dominique church, and contain bands of hard dolomitic limestone, resembling in general aspect, the rocks of the city of Quebec. Fossils were not found in the upper part of the section, which terminates just before reaching the church, but this probably represents some portion of the Trenton series.

Fault.

Going east from St. Dominique, the road descends very gradually to the low plain of the Black River, and shows no ledges in so far as examined; but on the roads to the south, towards St. Pie, brownish-weathering black slates like those of that village, are seen at intervals. These are terminated about one mile and a half before reaching the Black River, by ridges of hard greenish-gray Sillery sandstone, the fault between the two series evidently extending from about midway on the north side of Yamaska Mountain and keeping to the west of the stream mentioned. North of the village of Upton, this fault crosses the road about three miles north of the Grand Trunk railway, just to the west of the knoll on which the Upton copper mines are situated, whence it apparently extends to the falls of the St. Francis, three miles above Drummondville, where the contact with the red Sillery slates has already been described.

Phillipsburg and vicinity.

The section of these rocks, south of Farnham, is a very important one, and throws much light upon some intricate points of structure in connection with the fossiliferous Quebec group, as stated in the Geology of Canada, more particularly as regards the peculiar rocks of Phillipsburg, Bedford and North Stanbridge. This area, beginning at Phillipsburg and extending eastward through St. Armand, and south to Highgate Springs, Swanton and St. Albans, has long been historic. The structure is complicated by faults, some of which are apparently of considerable extent and in places the beds are overturned. The opinions of various geologists concerning the age of these rocks have been already very fully given by several writers in the United States, in connection with the discussions of the Taconic controversy, which presents some features closely resembling those which pertain to the Quebec group question in Canada. The bibliography of the subject will be found in the "American Geologist," for February, 1889, in a paper by Prof. Jules Marcou, entitled "Barrande and the Taconic System," as well as in papers by Mr. C. D. Walcott.

The description of the rocks of this area, and the early views as to their structure, are well given in preceding reports on the part of the Geological Survey.* Further data bearing on the subject, as well as a brief abstract of the discussion on this question, were given in the Annual report for 1887-88, pp. 39 K-40 K, so that it is necessary, in the present Report, to state merely the final conclusions arrived at as regards their actual structure, in so far as this has now been ascertained.

Peculiar character of rocks and fossils of the Phillipsburg series.

Before discussing the problem of the Phillipsburg rocks, it may be well to state that, while strata containing fossils of Calciferous and Chazy aspect are found at several points along the road section between Phillipsburg village and St. Armand station on the Central Vermont railway, the character of the beds is different from what is found in the regularly stratified series of the typical Calciferous and Chazy of the Ottawa valley. The fossils also, while presenting characters seen in these formations, can not, in most cases, be identified with those found so abundantly in the typical Calciferous and Chazy areas. Thus, in the Ottawa section, where the strata are undisturbed and nearly flat, the lowest beds of the Chazy, directly overlying the dolomitic beds of the Calciferous, are greenish grits and sandstones, which gradually become shaly and calcareous, so that there is a very considerable development of the sandy beds in the lower part of the Chazy before the Chazy limestone is reached. Certain shaly beds of the lower Chazy contain fossils, but the greatest development of fossiliferous rocks is in the upper, or limestone portion. In the Phillipsburg section, there is no trace of the sandy or shaly greenish-gray lower portion of the Chazy formation as developed further west; the limestone, regarded as Chazy, succeeding directly upon those beds which have been referred to the Calciferous, from the evidence of the fossils. This difference may be explained either on the assumption that a fault has cut out the lower or slaty portion of the Chazy, (of which however there does not appear to be any very clear evidence), or, on the ground that the conditions of deposition in this section, east of the St. Lawrence, have been entirely different from those which prevailed to the west of that river; so that, instead of littoral deposits, resulting in shales, grits and sandstones, as found in the typical Chazy of the Ottawa district, the deposition was for the most part in deep water, and the sediments laid down were almost entirely calcareous. In the latter event it would be exceedingly difficult, as is indeed the case, to draw any sharp line of division between the Calciferous and Chazy formations for the eastern area.

*Geology of Canada, 1863, pp. 273-287 and 844-862.

Fossils.

The rocks on the shore of Missisquoi Bay, at Phillipsburg, west of the fault, are blackish-gray and black slates with bands and lumps of dolomite, in certain beds of which, graptolites are found. The exact horizon of these can scarcely be determined from the fossils obtained, but from their general appearance they would seem to belong to the Trenton (probably lower) series, and they have been so described. They would

Trenton west of fault.

therefore probably represent the extension southward of the beds described as occurring at St. Pie and Abbottsford, which are separated, by the great St. Lawrence and Champlain fault from the Sillery rocks of Abbottsford, from the Chazy of Stanbridge and the Calciferous of Phillipsburg, a short distance further south. These beds are also continuous across the boundary into Vermont, and their extension into that state has been described under the head of Trenton-Utica, at Highgate Springs.*

Area East of the St. Lawrence and Champlain Fault.

Fault at Phillipsburg

At Phillipsburg village, where the contact between these rocks and those of the Phillipsburg series proper is well seen, the fault is clearly defined, the slates along the contact being broken up, and clearly showing the effects of the dislocation. Eastward of the fault, the grayish, calcareous beds described on page 844 of the Geology of Canada (under Division A) come in. These extend to the valley in which Strites' Pond is situated, and, according to the measurement of Sir Wm. Logan, this portion has a thickness of 700 feet. In the section just quoted† the rocks of Division B, aggregating 1040 feet, represent the middle and upper portion of the Calciferous, and shade gradually into the Chazy in the upper part, so that the point at which the exact line of division between the two formations occurs is scarcely indicated.

Thickness of the Calciferous.

Chazy syncline near St. Armand Station.

The Chazy, or upper portion, occupies a well defined syncline in the eastern part of the section, the centre of which is seen on the road from Phillipsburg to St. Armand station, on the Central Vermont railway, near the beginning of the steep descent to the valley of Rock River, and fifteen chains west of the railway itself. Looking south-west from this point, the extension of this syncline is seen about three-fourths of a mile distant, the north-west dip being well exposed on the road in lot twelve, west St. Armand, and in outcrops along the west side of the railway, about half a mile south-west of the St. Armand station. These rocks carry an abundance of fossils, of which large collections were made during the season of 1890.

*Geology of Canada, 1863, pp. 854, 855.
†Geology of Canada, 1863, p. 844.

They resemble in characters those of the Calciferous and Chazy formations. Many very perfect specimens were also obtained from this section some thirty years ago by Logan, Billings, Whiteaves and others.

St. Armand north.

On the road going north from St. Armand station, this synclinal structure is also well seen, and the apparent line between the Calciferous and Chazy in this direction is about sixty chains south of Blood's Corners, which is the old name of the cross-roads in lot one, range nine of Stanbridge. As nearly as can be ascertained, the line between the two formations, the Calciferous and Chazy, as seen on the road from Phillipsburg, may be placed near the sharp bend seventy chains west of the cross-road at St. Armand station, (formerly Moore's Corners). The rocks of the Calciferous formation between this point and the village of Phillipsburg extend in several ridges to the north-east and south-west. In the former direction they appear to end, through faulting and by the overlap of the Chazy beds, about three-fourths of a mile north-east from Blood's Corners. In this direction they keep close alongside the road going from Blood's Corners to Stanbridge station, as far as the sharp bend in the road on lot two, range nine, Stanbridge, the blackish slates of the Trenton being in contact on the west side all the way. On the road east from Blood's Corners they are apparently overlapped by the Chazy, twenty chains west of the crossing of the Central Vermont railway, the Chazy at this place being affected by slight undulations in the centre of a somewhat broad synclinal basin which occurs in these rocks in this direction. Beyond this, to the north, the Calciferous beds are not seen, while those of the Chazy, comprising limestone, limestone-conglomerate and slates, are well developed, and the strata are in places very rich in fossils, more particularly in the more northerly portion of the belt, about two miles north of Mystic (formerly Stanbridge Centre). From these beds also large collections have been obtained. (See appendix.)

St. Armand south.

To the south-west of Phillipsburg, the Calciferous rocks extend along the shore of the bay, separated from it for nearly a mile by a very thin margin of the black, calcareous slates of the Trenton. On the boundary-line between Quebec and Vermont, the centre of the Chazy syncline is seen about one mile and a quarter from the shore of the bay and the rocks of this series have been traced but a short distance south of the line in this direction.

Two synclines.

The structure of the two principal synclines which occur along the Vermont boundary between the Sutton Mountain axis and the shore

of Missisquoi Bay (more particularly seen between Phillipsburg and St. Armand, and further east between that point and Frelighsburg) is basin-shaped to the south, so that the lower rocks converge towards the boundary. The newest rocks of the section do not, therefore, extend so far south, the centre of the syncline having a declination north-east at a low angle.

Stanbridge and Bedford.

The Chazy fossiliferous rocks which occupy the syncline in the Calciferous of Phillipsburg extend continuously from the Vermont boundary in a north-east direction to lot twenty-two, range six, Stanbridge. They consist, as just stated, of limestones, limestone-conglomerates and slates, bluish-gray and frequently dolomitic as evidenced by their rusty-brown weathering. They are affected by folds, several anticlines being visible. Their most westerly observed outcrop is on the road from Stanbridge station to Bedford, and on the road parallel to this on lot six, range eight, Stanbridge. On the former road, ridges of conglomerate cross the highway and extend nearly to the bank of the Pike River. This is one mile west of Bedford Corners. The rocks here dip about S. 75° E., at a moderately low angle; but on the road south of this, at what is marked on the map in the atlas of 1866 "Mr. Carey's place," the first outcrops near the line of railway, dip N. 55° E. < 55°, which dip, however, rapidly changes in going east, to N. 15° E. < 2° to 5°, and on the road thence north to Bedford, on range seven, is reversed to north-west, showing the presence of a low and broad sycline in this direction. The south-easterly dip of the western line of outcrop, is maintained to the extreme northerly exposure. Thus near Wallbridge's mill, at Mystic station, the dip of the conglomerates and associated dolomitic slates is S. 50° E. < 30°, while at the most northerly outcrop on lot twenty-two, range six, it is S. 40° E. < 25°.

Mystic Station.

Thickness of the Chazy at Stanbridge.

The most easterly outcrop of the Chazy conglomerates, is on lot twenty-two, range five, where the dip also is S. 40° E. < 60, and the entire breadth across the measures at this place is eighty chains, which, if there were no folding of the strata, and assuming the dip to be 25°, (apparently to be the average from most of the outcrops in this section,) would give a thickness of something over 2000 feet for this portion of the Chazy. It is possible, however, that this area may be affected by foldings which do not appear at the surface, but the apparent structure at this place is, as stated, that of a broad syncline. Throughout these outcrops, fossils are abundant, and can be obtained both from the pebbles and the paste. Many of the pebbles show that they are derived from the Calciferous beds of the Phillipsburg and St. Armand section, while the fossils from the paste indicate that the rocks themselves are probably the equivalents of the Chazy. An inter-

esting discovery during the past season, was the finding of graptolites in bands of dark gray limestone with dolomitic slates on lot nineteen, range six, Stanbridge, in a small outcropping ledge about twenty chains north of the road leading to North Stanbridge.

Lower Cambrian of St. Armand.

The Chazy rocks of Bedford and vicinity have been very fully described in the Geology of Canada (pp. 849-850.) East of St. Armand station, the area is divided by the prominent ridge of the Georgia sandrock, described in the report just quoted under the heading of Potsdam, but which the recent observations of Mr. C. D. Walcott have shown to be much lower in the scale than the Potsdam sandstone of Canada. There is no error, however, in the determination of Billings and Logan as given in the Geology of Canada, since at that time (1863) the term Potsdam, in Canadian geology, was employed to include all between the Calciferous and the Huronian.

Mr. Walcott has, however, succeeded in finding a very considerable fauna, of trilobites particularly, in the extension of these rocks southwards, which enables them to be more accurately placed and they appear now to be assignable to a horizon lower than Potsdam and probably in a great part to the Lower Cambrian.

Georgia sand rock.

The area of these rocks to the north of Vermont is small They extend north in a band of about a mile in width as far as the forks of the road, on lot 131, West St. Armand. They are directly overlain on the west by the limestone-conglomerate just described, which dips near the contact south-easterly at angles of 5° to 10° and this apparently folds over the low ridge of the older rock. At the direct contact on the north-east extremity, however, there are indications of a fault, in the broken character and highly tilted position of the Chazy limestones and slates, the dip being both to the north-west and south-east < 90° to 75°, but diminishing in a short distance from the contact itself to 20°.

Fault.

On the road going north from the terminus of this Cambrian outcrop on ranges six and seven, ledges of limestone-conglomerate occur at intervals, with the usual dolomitic slates. By their change of dip, they show the presence of foldings at several places, so that it is impossible to ascertain the thickness of the measures in this direction. The areas of limestone-conglomerate are, however, not numerous, and they do not, in so far as yet known, appear east of the branch of Pike River in range six.

Pebbly Trenton slates.

The eastern limit of the Cambrian (Georgia sand-rock), is seen on the road east from St. Armand to Frelighsburg, at the cross-road on lot 126. Beyond this, to St. Armand Centre, a series of outcrops of bluish-

gray slates occurs, which are calcareous in places and dolomitic-weathering. At times these contain pebbles like the strata seen east of Granby and on the west side of Sargent's Bay on Memphremagog Lake, as well as at other points already referred to. While several low undulations are apparent, their general structure is that of a syncline sloping towards the north-east. The beds of black limestone and slate of Farnham, which there come in upon the dolomitic slates, do not anywhere appear in the vicinity of the Vermont boundary, at least in so far as yet observed by us.

Northern Vermont.

The extension of this area into Vermont, can be traced on the road leading from Highgate Springs to Highgate Falls. After crossing the ridge of the Cambrian, or red sand-rock, to the east, the rocks first seen are the bluish-gray, dolomitic slates, precisely like those observed on the road from St. Armand to Pigeon Hill and in the vicinity of Mystic. Their contact with the Cambrian is a short distance west of the village of Highgate Falls, and these slates have, in Vermont, yielded, to Mr. Walcott, fossils of Chazy age. Just at the bridge at Highgate Falls, they are apparently cut off by a great overthrust fault, which brings up the Cambrian again upon the Chazy. Going south from this place about half a mile, at Hungerford Brook, ledges of

Limestone conglomerate.

blackish slates, calcareous in places, form an anticline at the bridge over the highway. These slates have yielded fossils of Cambrian age. A fourth of a mile south of this brook, ledges of limestone and limestone-conglomerate, in places a breccia, occur along the road, associated with great exposures of brown-weathering dolomite which are cut by small veins of quartz. The conglomerates or breccias contain masses

Fossils.

of limestone which hold fossils of Upper Cambrian age, such as *Agnostus Orion*, &c., so that the horizon of the dolomites themselves is apparently the same as that of the associated fossiliferous slates, and they here form the western side of the Chazy syncline.

Sweetsburg.

The position and age of the prominent dolomite bands of this locality are important questions, as they assist in the mapping out of the structure north of the Vermont boundary. They are the precise equivalents, in aspect and associated strata, of the heavy dolomitic bands which cross into Canada about two miles south west of St. Armand Centre, near West Franklin. They cross the Boundary on the east side of the syncline, near the line between lots fifty-six and sixty-seven, west St. Armand. Here they directly underlie, on the east, the series of Chazy slates (dolomitic) already described, and extend thence in a north-east direction past the village of St. Armand Centre to Lagrange's Mill. Thence northwardly they skirt the west side of the village of Dunham. Further to the north-east they form a

prominent ridge, south of Sweetsburg, whence they continue to the south-west corner of the Brome Mountain. The dolomite bands are well exposed on the road leading north of Sweetsburg, and the associated slates are well-banded and very greatly disturbed.

Dolomite bands.

These bands of dolomite, which are a prominent feature in this district, serve to define very clearly the eastern limit of the Chazy or Cambro-Silurian strata in this direction.

Memphremagog Lake Area.

Memphremagog Lake area.

The most easterly area of the Cambro-Silurian rocks included in the south-west quarter-sheet map, is that about Memphremagog Lake. They here form the extension to the south-west of the great series of south-eastern Quebec described in the Annual Report of 1886.* They are there said to occur in two distinct areas, of which the western is situated to the west of the Sherbrooke anticline, and occupies the townships of Wotton, Brompton, &c., while the eastern occupies the great portion of the country east of the Sherbrooke anticline, and has in part been styled by Hitchcock, in his report on the geology of New Hampshire, the Calciferous mica-schist series. The rocks of the two areas differ somewhat, more particularly in the development of limestone, the eastern area, in certain portions, being largely a calcareous formation, while in the St. Francis River area, the limestones are comparatively rare, and the slates are the prevailing rock.

Fossils.

Lower Trenton.

The age of these limestones, was ascertained not only by the presence of fossils at a number of points in the limestone itself, but by the occurrence of graptolites in the slates with which they are in some places associated, and which stratigraphically appear to form the lower part of the series.

Black slates and limestone.

While these slates and limestones are presumably of the same age as those already described as occurring in the Granby and Farnham section, and their extension north to Kingsey, the character or aspect of the calcareous portion of the series is somewhat different, owing presumably to the great alteration which has affected the rocks of the central and eastern areas. Thus they have frequently become graphitic, and in places, more particularly near the granitic areas, have had a schistose structure imparted to them, with the addition of mica and staurolite crystals.

The two areas about Memphremagog Lake, are separated by the Cambrian and pre-Cambrian ridges which extend south-west from Massawippi Lake to Memphremagog Lake. The rocks of the more

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), pp. 15 J, 21 J.

Pebbly black and gray slates.

northern portion, consist of blackish-gray and bluish-gray slates, frequently thickly studded with ochreous spots, which are principally caused by the decomposition of crystals of dolomite. These slates often become almost a conglomerate, through the presence of scattered pebbles of hard sandstone or even of limestone, and have been elsewhere referred to under the name of pebbly slates. This pebbly character is well seen on the south-west side of Memphremagog Lake, both near the contact with the Silurian, where the graptolitic bands are developed, and further west, about the flanks of Orford Mountain; also along the roads leading south through Bolton and Potton townships, at a number of points east of the Cambrian of the Missisquoi Valley. These rocks are precisely similar in character to those noted in 1886 in Wotton township, to the north of St. Francis River, which were formerly regarded as Silurian.

Graptolites of Castle Brook.

The graptolites obtained in 1886 have already been described,* and clearly show the horizon of these rocks. Since then a new locality on Castle Brook, lot five, range fifteen, Magog, has been discovered, which is probably the most productive in graptolites of any yet found in Canada, and from which large collections have been made, both by ourselves and by Mr. Walcott of the United States Geological Survey. The graptolitic slates are best seen at Willard's mill, where their surfaces are completely covered with beautifully preserved forms. About ten species of graptolites have been recognized by Dr. Ami from collections made at this place. The rocks of this division, which occur east of Memphremagog Lake and west of the Cambrian of the Fitch Bay ridge, do not show limestone in any quantity. They consist for the most part of slates, often with scattered pebbles and frequently with ochre-spotted beds, while certain bands are highly graphitized, and contain graptolites, which, although poorly preserved, are similar in character to those from the west side of the lake. Thsee are on lot nineteen, range two, Stanstead. The same graphitic band of slates, is seen in its extension to the north-east on the road crossing lot twenty-three, range three of the same township. Near the line between lots sixteen and seventeen, range two, a band of conglomerate, with pebbles of slate, sandstone and qufartz, crosses the road just beyond the brook, and probably marks the lower part of the Cambro-Silurian in this direction, since, on the ascent of the hill to the south, black and green slates and hard sandstones of Cambrian aspect occur.

Conglomerates.

Graptolitic slates.

In many places around the shore of the lake and at points inland, traces of these graptolites are found, though their perfect preservation

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 16 J.

is rare, owing apparently to the very considerable degree of metamorphism which has affected all the strata in the vicinity. The strata are often broken up and are cut by intrusions of different kinds of trappean or volcanic rock, some of which are white and felspathic, while others are a green diabase. These vary in thickness from dykes of two feet or so, to great masses, and it is clear that the smaller dykes seen about the shores of the lake are, in some cases at least, spurs from some one of the larger masses forming hills; precisely as the dykes which cut the strata about Yamaska and the other mountains of that district are connected with and can be traced into the intrusive masses there. That the mountain masses of Orford, Hog's Back, Sugar Loaf and Owl's Head, with, a number of lesser hills to the west of Memphremagog Lake, are intrusive in the slates of that area, is shown by the broken character of the slates in contact, in their great alteration near these contacts, evidenced both by a porcellanizing or other hardening of the strata, in some places, and by the formation of crystals through the mass of the slates at many points. Intrusive masses of Memphremagog Lake.

The intrusive character of the dioritic matter, is also seen in the fact that many of the dykes cut directly across the stratification of the slates themselves. That the whole series has been profoundly disturbed since the deposition of the Silurian, is very clear, since all the strata (viz., the Cambro-Silurian, Silurian and Lower Devonian) are inclined at high angles and in some places inverted, as in the case of the Devonian limestone at Owl's Head which dips directly beneath the Cambro-Silurian slates, only a short distance from where the latter are seen to be acted upon and penetrated by the great mass of the Owl's Head Mountain. The fossiliferous Silurian beds of Round Island, a short distance south of Owl's Head, are moreover penetrated by great dykes of green diabase similar in character to the rock of the mountain, and on the east side of the lake at Capt. Gully's Cove, the presence of large dykes, both of green diabase and green, soft, talcose-looking matter, which have broken directly through the fossiliferous sediments and altered them along the contacts, is readily observed. Their action upon the slates.

The Cambro-Silurian rocks south and east of Fitch Bay, which is an arm of Memphremagog Lake on the east, differ, as already stated, in some respects from the slates of the lake itself. These slates are largely calcareous near their western outcrop, which closely follows the east shore of the lake south of Fitch Bay and the south shore of the bay itself to its head, running thence along a depression to the northeast to Massawippi Lake, where, about the south end, they are well seen in large cliffs along the highroad and on the east side of the lake Fitch Bay Massawippi Lake.

in the numerous cuttings of the Boston and Maine railway (formerly the Passumpsic railway), from Sherbrooke to Newport.

Black slates and limestones of Stanstead.

On the section going south-east from Fitch Bay Narrows, through Smith's Mills to Stanstead, the relations of the limestones and the black pebbly and ochre-spotted slates are well seen. The first rocks, after passing the bridge and ascending the hill to the south, are bluish-gray and blackish graphitic limestones with slates, which dip N. 50° W. < 45°. These are the same in character with the rocks of Massawippi and North Hatley. Going south, similar rocks were seen to the line between lots five and six, range five, where the granite is met. This forms a knoll on the west side of the road, and is generally gray in colour, composed of white felspar, black mica and gray quartz, the rock being generally coarse in texture.

Action of the granite on the slates and limestones.

The granite extends from this place to the Vermont boundary, and on the east shore of the lake, its contact with the limestone is observed near the line between lots three and four, range three. Near Beebe Plain or Stanstead Junction, the contact of the granite and limestone is seen in large exposures seventy-five yards west of the station, the stratified beds being altered to a schist holding mica, and the granite being in the shape of a huge dyke-like mass, which is brownish-gray and felspathic; the main body of the granite terminating about a fourth of a mile west of this point. On the road thence to Smith's Mills, slates and limestones show at intervals, with occasional dykes of the granite, which do not appear to have greatly broken up the rock in contact with them. The main granite area apparently terminates on this road near its junction with the road to Griffin's Corners, on lot four, range seven. In this direction the limestones and slates are both highly altered and micaceous; but as we approach Smith's Mills the micaceous aspect generally disappears, and the rocks resemble those along the south side of Fitch Bay. The limestone of Smith's Mills is bluish- and blackish-gray and the associated slates contain cubes of iron-pyrites, thickly disseminated. The rocks sparkle in the sun, probably from the presence of quartz, since no mica is discernible, and veins of calcite and quartz are seen. Under the railway bridge at this place, the rocks in the cutting are much distorted and are traversed by quartz-veins of large size, which are twisted in all directions.

Smith's Mills.

Pyrites appear to be a constituent of these rocks over very large areas, being found throughout the entire Cambro-Silurian series between Lake Memphremagog and the Cambrian near Lake Megantic. Between Smith's Mills and Stanstead, the proportion of calcareous

beds perceptibly diminishes and the rocks become more slaty. Beds of this peculiar black and gray pyritous slate, precisely like that seen about the shore of Memphremagog Lake near Sargent's Bay, and in which the graptolites are found on the east side of the lake, become interstratified to a considerable extent with the limestone beds, proving the unity of the two series and showing that the limestones are probably of slightly later date than the slates. The predominance of the slates over the limestones increases as we go further east into Barnston and Barford, but the distribution of the rocks in this direction has already been given.

Area east of Memphremagog Lake.

Reference has been made in the report for 1886, to certain dark-gray limestones which occur west of Memphremagog Lake, in the vicinity of Peasley's Corners, and at the head of Sargent's Bay; and it was then thought that these might be a part of the graphitic limestone and slate series which carries graptolites of the Cambro-Silurian. At that time fossils had not been found in these limestones, but since that date a few corals have been collected which tend to show that these calcareous beds, though very like in character to those of Cambro-Silurian age in many respects, should, for the area mentioned, be connected with the fossiliferous Silurian strata. The excessively disturbed and intimately infolded character of all the beds in this section, very frequently makes the exact determination of horizons, unless fixed by the presence of characteristic fossils, exceedingly difficult.

Upper Silurian of area north of Sargent's Bay.

Another area of limestone on Memphremagog Lake, viz., that at Magoon's Point, on lot twelve, range two, Stanstead, also presents difficulties in assigning it to any particular horizon. The rock is apparently devoid of fossils, with the exception of a few fragments of crinoid stems, and is highly crystalline, being in places a true marble. It is associated with certain black slates which may be Cambrian or lower Cambro-Silurian. The cause of the great metamorphism is difficult to ascertain, unless it be found in the granitic mass of the point near by, which may here lie at no great depth. In its crystalline character, it resembles the marble of Dudswell, but the rock differs from the Dudswell marble in not carrying fossils of Silurian age. We have therefore regarded it rather as a portion of the Cambro-Silurian graphitic limestone series of the south side of Fitch Bay, which is also seen in Whetstone Island, lying off the point itself.

Magoon's Point limestone.

This island presents peculiar features. The south-west end consists of a considerable dyke of eruptive diorite, altered and sheared till

Whetstone Island.

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 21 J.

it now presents in places the aspect of a talc-schist. This is greenish, or brownish, where in contact with the black and gray limestones, which are the rocks in the immediate vicinity. At the contact itself, the limestone has the appearance of being altered by heat, having a reddish aspect, while the dyke has become soft and schistose. This dyke extends for a considerable distance along the east side of the island, in places weathering rusty like a dolomite; in others through pressure and shearing, resembling a chlorite-schist. Towards the north end of the island, the rocks are black pyritous slates, and these are cut, on the outer or north-west side, by a second dyke, which crosses from the mainland to the north. South of this, the black pyritous slates occupy the west side of the island for nearly three-fourths of its length, where a dyke of talcose-looking rock comes to the shore, beyond which the black slates gradually shade into the graphitic calcareous beds first noted at the south-west end. These limestones, both on the island and on the mainland, contain numerous quartz-veins, and the rocks themselves are much disturbed and often show a very intricate series of crumplings. From the position of the limestone on the west side of Whetstone Island, it is probable that the outcrop seen at Magoon's Point is a part of this series, as already suggested. Certain bands of slaty rocks on the island, furnish excellent whetstones, which were at one time extensively worked, whence the name of the island.

Whetstone rock.

There is yet another well defined area of these graphitic limestones and slates, viz., that found in the southern part of the township of Melbourne, whence it extends across Ely into North Stukely. This occupies a well-defined depression to the west of the Melbourne ridge, and appears to be folded in amongst green chloritic and micaceous schists of pre-Cambrian age.

Ely and Stukely band.

The northern limit of this basin is seen a short distance to the north of the road, traversing range three of Melbourne, whence, to the south-west, the peculiar black graphitic limestone and slates are easily recognized on several roads in the northern part of the township of Ely, between South Ely and Valcourt, just west of the village of Lawrenceville and on the road from North Stukely to Ste. Anne de Rochelle. The breadth of this belt is rarely a mile at any place, and the strata appear to be all highly inclined. In South Ely, they are bounded on the south by black slates, often graphitic, but in which no determinable fossils could be found. These, as seen in a small brook at this place, rest directly against crystalline limestone and mica-schists of pre-Cambrian age.

South Ely.

*Geology of Canada, 1863, p. 809.

South Stukely and Frost Village.

To the south of the North Stukely road, in a valley, many large pieces of red and green Sillery slates are seen, which from their general aspect would indicate that outcrops of these rocks exist in the immediate vicinity. They were not, however, found in place, though the presence of blackish wrinkled slates believed to be of Cambrian age, was noted still further to the south on the road from South Stukely to Frost Village. These probably form the lower part of the Cambrian and Cambro-Silurian basin just described.

Area north of Memphremagog Lake.

To the north of Memphremagog Lake, the road from Magog to the Montreal road, which leads from Sherbrooke to North Stukely, shows frequent outcrops of blackish and grayish, sometimes thickly ochre-spotted slates, like those which contain the graptolites near the lake shore. Similar slates extend west on the Montreal road to the crossing of the brook near the inlet to Brompton Lake. They are well characterized by the presence of pebbles of slate and sandstone, and a short distance beyond this brook are underlain by black, green and purple slates with beds of quartzose sandstone of Cambrian aspect. This brook, flowing into Brompton Lake, may be regarded as constituting the western limits of the Cambro-Silurian in this direction.

Webster Lake.

On the road leading north to Key Pond or Webster Lake, similar slates are exposed to the western shore of the pond. They are of the series which is described in the Report for 1886, as occupying the valley of the St. Francis in the township of Brompton, and, on Webster Lake, they are in contact with serpentines and diorites, which appear to come to the surface along the line of contact between the Cambro-Silurian and Cambrian rocks. West of this, to Brompton Lake, serpentines and diorites, with occasional ledges of greenish, grayish and purplish slates, are the prevailing rocks, and these latter may be classed with the Cambrian system.

Brompton Lake.

It will be observed, that in the areas east of the St. Lawrence and Champlain fault, the characteristic limestones and shales of the Calciferous, Chazy and Trenton do not appear. No beds resembling those of the Ottawa and St. Lawrence basin, marked by the typical fauna of these formations there (with the exception of those at St. Dominique) have been recognized, though the stratigraphical sequence of formations and the similarity of the fauna obtained from the beds of the eastern area, in many respects, to those found in the typical Cambro-Silurian formations of the western area, enables us to determine pretty closely the several divisions of strata which we have just described.

Rocks of Montreal Island and vicinity.

The various formations found along the lower Ottawa and on the Islands of Montreal and Jésus, have been described in the earlier reports of the Geological Survey, more particularly in the Geology of Canada*; but, as the volumes containing the descriptions of these localities are now with difficulty accessible, it may be useful to repeat here some of the principal geological features pertaining to the several Cambro-Silurian formations as there developed.

The lowest of these, viz., the Calciferous, with its gradual passage downward into the Potsdam sandstone, has a somewhat extensive development along the lower Ottawa and that portion of the St. Lawrence from the junction of the Ottawa at the village of Ste. Anne's upward for some miles. A small outcrop of the characteristic Calciferous sandy limestone shows at the south-western extremity of the Island of Montreal, at the north end of the railway bridge and in cuttings on the Canadian Pacific railway at Ste. Anne's station. The beds are flat-lying, or nearly so, and the Potsdam sandstone appears on Isle Perrot, on the other side of the Ottawa River. East of Ste. Anne's, towards Pointe Claire, the country is largely drift-covered, and outcrops are very rare, so that the eastern limit of this formation cannot be definitely fixed in this direction. The western side of the island affords few exposures, but at the first rapid in the Rivière des Mille Isles, about two miles above the village of St. Eustache, Calciferous beds appear on either side of the stream. A small outcrop also appears on the northern side of Isle Bizard, but these outcrops are soon covered by drift or by beds of the overlying Chazy limestone. Similar outcrops of the Calciferous show on the Rivière à la Graisse, in the village of Rigaud, but the drift deposits along the lower Ottawa are so continuous that the rock is very rarely seen.

West end of Montreal Island.

St. Eustache.

Rigaud.

The succeeding formation, the Chazy, is imperfectly developed in this direction. An outcrop of limestone appears on the west side of Isle Bizard overlying the Calciferous, containing an abundance of fossils, but the sandy and shaly beds of the Ottawa River area are absent from this locality. In fact, this portion of the Chazy formation was observed at only one point in this locality, viz., in a quarry at the east end of the Canadian Pacific railway bridge near Sault au Récollet station; though in the development of this formation along the Ottawa River, between Grenville and Carillon, the sandy and shaly beds form

Isle Bizard.

Sault au Récollet.

*Geology of Canada, 1863, pp. 114-116, 131-133, 136, 141-145.

a very considerable thickness, underlying the fossiliferous limestone which constitutes its upper part.

The limestones have, however, a very considerable extent on Isle Jésus, and a number of fine quarries have been opened in the beds in the vicinity of St. Martin Junction, where the strata lie nearly flat. Chazy limestones also appear on the River St. Lawrence at Pointe Claire, but are overlain by the beds of the Black River formation a short distance inland. Chazy limestones also show on the western side of Montreal Island near the village of Cartierville, opposite Bord-à-Plouffe, but the greater part of the island is so uniformly covered with deposits of clay and sand that rock outcrops are rarely seen. St. Martin Junction.

The overlying Black River formation, is seen at widely separated points on the island of Montreal and the adjacent Isle Jésus, but it was found impossible to trace this formation with any degree of exactness. The only definitely recognized outcrop on the first-mentioned island, occurs at Pointe Claire, where, in an escarpment between the line of the Grand Trunk railway and the village, about fifty feet of the Black River limestones are exposed. The outcrop is the site of very extensive quarries, from which much of the stone for the piers of the Victoria Bridge at Montreal was obtained. It is underlain by the Chazy limestone on the shore of the St. Lawrence, in the village, but does not extend to any great distance in either direction. The beds are nearly flat, or dip to the south-east at an angle of 1° to 3° and certain strata are almost entirely composed of *Tetradium fibratum*, a characteristic fossil of the Black River formation. Black River at Pointe Claire. Fossils.

To the south-west and west of Montreal Mountain, the island is mostly clay-covered, and the next outcrop of these strata recognized by us was at St. Vincent de Paul on the west bank of the Back River about four miles below Sault au Récollet. The west bank of the stream at this place is a cliff chiefly composed of Trenton limestone, but on the shore several feet of the rock have an abundance of Black River forms, among which were recognized *Gonioceras anceps, Actinoceras Bigsbyi, Columnaria Halli, Streptlasma corniculum, Tetradium fibratum, Cyrtodonta Huronensis, Murchisonia gracilis, Glyptocrinus, Stromatocerium rugosum, Strophomena incurrata, Licrophycus* like *L. Ottawaensis, Pachydictya acuta, Orthoceras, Cyrtoceras*, etc. This band does not show at the upper part of the cliff. St. Vincent de Paul. Fossils.

The limestones of the Trenton formation have by far the widest distribution of any of the Palæozoic rocks in this vicinity. They are well developed about the city of Montreal, and the quarries about Mile End and at Côte St. Michel are situated in this formation; while a some- Island of Montreal.

what broad ridge of the same rock extends lengthways of the island and is crossed by the roads north-west from Longue Pointe and Pointe aux Trembles towards the village of Rivière des Prairies. These beds show also on the east side of the Back River opposite St. Vincent de Paul, on Isle Jésus, and on the road from that place to the Pont Viau or Sault au Récollet bridge. They are penetrated by the intrusive rock of the Montreal Mountain, excellent illustrations of the alteration produced being seen on the several roads which lead from the city of Montreal to the Mountain Park.

Lachine.

Trenton limestones also show on the beach of the St. Lawrence at Lachine and for a short distance west, but do not appear inland till the vicinity of the mountain is reached.

Joliette.

On the mainland, north of the St. Lawrence, at Joliette, Chazy and Trenton rocks are both well exposed, as well as on the road leading north-east to Ste. Elizabeth. This locality is referred to by Sir William Logan,* and the presence of the characteristic Black River fossils is there noted. More recently (1881) extensive collections of fossils have been made from this locality, by Dr. Ami, and by Mr. Giroux in 1891 and 1892, and lists of these have been given by Dr. Ami in the "Canadian Record of Science" for April, 1892, pp. 104-108; the whole subject of the Trenton has, however, been so thoroughly discussed in the Geology of Canada, that but little further remains to be said on the subject.

Fossils.

Borings at Montreal.

Some new developments have, however, recently been made in and about the city of Montreal by means of bore holes, that have been sunk for a water-supply for special purposes. Of these, the deepest has penetrated the calcareous formations for over 2000 feet, the lowest beds reached being of a sandy nature, probably the underlying Potsdam sandstone. As the bore apparently started near the contact between the Utica and Trenton, the thickness of the three underlying formations can not be far from the amount just mentioned. In none of the bores made in the city or its vicinity does the underlying Laurentian appear to have been reached.

Trenton limestone of Montreal.

The exposures of the several formations as seen on the island of Montreal, are too widely separated to afford any conclusive data for determining their thickness, even in the case of the Trenton, which is the most commonly exposed. In this case, the limestones of the formation are found at the very summit of Westmount and nearly to the summit of Mount Royal. This fact, taken together with the occurrence of the Utica shales on the low ground near Point St. Charles

*Geology of Canada, 1863, pp. 148-49.

and on the river opposite the city, as well as the horizontal character of the Trenton ridge to the north-east, tend to establish the existence of a fault of considerable extent on the south-east side of the mountain itself; while the super position of upper Chazy or Black River limestone upon the Calciferous at the lower end of Isle Bizard, indicate a fault also in this vicinity. It is probable that several such faults occur at various places on the island, consequent on the intrusion of the mountain mass itself, or of some of the many trappean dykes, which extend to Ste. Anne's on the south-west, and to the north and north-east as far as Rivière des Prairies. These will, however, be noticed on a subsequent page. Probable fault.

The characteristics of the Trenton and Black River rocks as developed in the St. Lawrence and Ottawa basins, will be found stated in detail, in the Geology of Canada, pages 136-176.

The area east and south of Montreal, between the St. Lawrence and Richelieu rivers, was thoroughly traversed in order to obtain any additional facts relative to the distribution of the several formations which occur there, viz., the Trenton, Chazy, Calciferous, and Potsdam sandstone. The outcrops noted were, however, in most cases widely separated, while the general horizontality of the strata, and the usually level character of much of the surface, largely covered by drift clays in this direction, make the actual determination of geological boundaries impossible. Area east of Montreal.

The Calciferous formation is largely developed in the county of Beauharnois, east of the St. Lawrence, and is well exposed near Valleyfield in a quarry on Grande Isle. The beds are here nearly flat, and the formation extends south-eastward to the Chateauguay River at Ormstown, quarries of the characteristic limestone, which is here fossiliferous, being found near the road a short distance west of that place. The formation is also well seen at the village of Huntingdon, in the bed of the stream, though the country between Ormstown and that place shows no ledges in the vicinity of the Chateauguay River. Potsdam sandstone blocks, however, occur in this direction and form ridges fifteen to twenty feet in height and an eighth of a mile or more in length, as at Dewittville. The horizontal beds of the Calciferous also show on the river above Huntingdon, south of which, to the boundary of the state of New York, the surface is occupied with sandy drift, although blocks of the Potsdam sandstone occur. On the road going east, about two to three miles north of the International boundary, the surface, for the first four miles, is occupied with drift sand, in which occur great quantities of sandstone blocks; but at the village of Manningville, in Franklin, the Valleyfield. Huntingdon. Huntingdon to Hemmingford.

typical Potsdam sandstone appears in flat-lying beds, and these are exposed at intervals, nearly to the Grand Trunk railway at Hemmingford. Loose pieces of the Calciferous formation come in on this road about one mile west of Hemmingford station. East from this, towards Lacolle, by way of Bogtown, the Calciferous appears at intervals to within about two miles of Lacolle village, where the limestone of the Chazy formation is found, and this extends eastward for about three-eighths of a mile beyond the village to the contact with the Utica shale at the fault.

Lacolle to Grande Ligne.

The Chazy limestone is well exposed in a quarry (Legault's) about four miles north of Lacolle, and on the road to Stottsville, the rock being grayish in colour and containing numerous characteristic fossils. Thence it can be traced northward by a somewhat well-defined escarpment to the vicinity of Grande Ligne. The contact here between the Chazy and the Utica of the Richelieu plain, is well marked by a ridge, which is about one mile north-west of the Grande Ligne station. Here some quarries occur in the Chazy limestone about one mile west of the contact. In these, the rocks dip from N. to N. 40° W. < 15°–20°. A short distance north of this road, the Chazy ridge sinks again to the level of the plain and the country is presumably occupied by the Trenton and more recent formations. From the Grande Ligne quarries, good collections of fossils were obtained by Dr. Deeks. (See appendix.)

Fossils.

The country thence westward, throughout the counties of Napierville and Chateauguay, is level, with occasional ridges of boulders mixed with sand and gravel or clay. No outcrops could be found, but pieces of Chazy limestone, with Calciferous and Laurentian blocks, are scattered about, and no accurate boundaries could be determined. On the road from St. Johns to Napierville, by way of L'Acadie and the Montreal River road, the Trenton limestone was seen in low exposures near the cross-roads about four miles west of St. Johns; and in the crossing of the Little Montreal River, near L'Acadie, the Utica shales were observed, but these were the only outcrops seen in this direction.

Area east of Montreal.

The area east of Montreal, in Beauharnois, Chateauguay and Napierville counties, was mapped by Sir William Logan and published in the large map of Canada (1866), and in default of any more definite information, the lines as thus laid down have been, for the most part, retained in the accompanying map. As thus indicated, it may be said that the Potsdam sandstone, which in this section is evidently the lower part of the Calciferous formation,* extends from the boundary

*The Potsdam and Calciferous formations of Quebec and Ontario. R. W. Ells. Trans. Royal Soc., Can., vol. XII., sec. IV., 1894.

between New York and Quebec, in a gradually narrowing area, of which the western limit is outlined from the vicinity of lot eighteen, range one, Hinchinbrooke, to the Chateauguay River near Ormstown, whence it follows closely the course of the stream for nearly ten miles, turning then westward towards the St. Lawrence and crossing that river about midway between Valleyfield and Beauharnois. Westward it occupies a large part of the seigniories of Vaudreuil and Soulanges, to the shore of the Ottawa River, as far west as Rigaud Mountain. Its eastern and northern margin leaves the St. Lawrence at Beauharnois village. Thence it keeps to the east, and crosses the Chateauguay River about seven miles from its mouth, after which the eastern outline of the formation turns southward and in an irregularly curving line continues east of the Chateauguay and English rivers to the International boundary south of Hemmingford, as already noted. Limits of Potsdam and Calciferous.

The Calciferous limestones occur in two areas separated by the Potsdam sandstone just described. The western area comprises the greater part of the county of Beauharnois to the St. Lawrence River, west of the Potsdam outline. The eastern area, as far as we can ascertain, occupies the southern and western parts of the counties of Napierville and St. John with the northern part of Chateauguay, and the western portion of Laprairie. It reaches the St. Lawrence between Beauharnois and Chateauguay Basin, where the overlap of the Chazy formation occurs, the line between the eastern limit of this formation and the Chazy being largely conjectural. The northern limit of the Chazy reaches the St. Lawrence about two miles below Caughnawaga village, being succeeded in regular order by the Trenton formation, which, in its eastern extension, can be seen near St. Johns', as already noted; while the Utica shales, seen near L'Acadie, extend thence northward and westward to the St. Lawrence, and, with the Lorraine, occupy most of the St. Lawrence basin east of that river for some miles. Areas of Calciferous. Chazy boundary.

Concerning the Potsdam sandstone, which has been generally considered to form the upper member of the Cambrian system, the following remarks may be made. It is described in the Geology of Canada† as "traceable from St. Lawrence County, New York, into Canada, where it has its greatest development in the county of Beauharnois." * * * "The formation fills up the inequalities of the underlying Laurentian series: and in New York the lowest part is described as a coarse conglomerate, deriving its material from the subjacent gneiss, and containing rounded masses of quartz, some of which are eight inches in diameter, held in The Potsdam sandstone.

*Annual Report, Geol. Surv., Can., 1887-88, vol. III. (N.S.), p. 83 K *et al.*
†Geology of Canada, 1863, pp. 87-90.

a fine-grained matrix of silicious sand. At Potsdam (N. Y.) the rock appears to be a fine-grained yellowish-brown, very evenly bedded sandstone, affected by a multitude of parallel vertical joints."

Base of the Calciferous formation.

As no work has been done in this region by which additional facts have been obtained beyond those mentioned in the report just quoted, it is here deemed unnecessary to give further details of this area, which is fully described on the pages already referred to. It may, however, be said that, in view of all the evidence, both palæontological and stratigraphical, it has been considered most in accordance with the facts, to regard the Potsdam sandstone formation, as developed in the St. Lawrence and lower Ottawa areas, as the continuation downward of the Calciferous, and to consider these two members as constituting the basal portion of the Cambro-Silurian system. No defined break between the Calciferous limestone and the Potsdam sandstone has yet been observed in Canada.

Cambrian.

The classification of certain areas as Cambrian, in the south-western portion of the province rests, to a large extent, upon stratigraphical position and lithological characters. In regard to most of these rocks, however, there can be no doubt as to their position, since from the conclusions already published for the areas south and east of Point Lévis,* it is plain that the lower portion of the fossiliferous Quebec group, by which we mean a large part at least of the division commonly styled "Sillery," and the portion intermediate between this and the crystalline schists of the pre-Cambrian anticlinals, must be assigned to this system.

Sillery division of the Cambrian.

In the portion of the province more directly under discussion, areas of rocks which have been regarded as of upper Cambrian age occur, not previously pointed out and which call for a somewhat fuller explanation. Of these the most westerly is that which, in its northern portion, viz., that south-west of Point Lévis has been described at some length in the previous report.* In this, the red and green shales and hard sandstones of the Sillery formation are stated to occur along the line of the Grand Trunk railway between Lyster and Stanfold and on the Becancour River, to the fault separating them from the Trenton-Utica and Hudson River rocks already described; and in this area they "form the western side of a synclinal basin, the eastern edge of which appears at Inverness and Ste. Sophie."*

*Report, Geol. Surv. Can., 1887-88, vol. III. (N. S.), p. 62 K.

Further to the south-west, these rocks are traceable in occasional outcrops, the surface being largely drift-covered, though Balstrode and Horton, in a gradually narrowing belt to the St. Francis River, where, at the falls, about three miles south east of Drummondville, they appear in a band about a mile in width, overlapped by black limestones of Trenton aspect on the east, and in the vicinity of Drummondville, by the black slates holding graptolites, already referred to. Between the south-west branch of the Nicolet, a short distance below Ste. Clothilde, and the St. Francis, the surface is largely drift-covered, with coarse sand and gravel and no rock is seen; so that for this portion the outline of the Sillery must be conjectural. St. Francis River belt.

South of the St. Francis, in Wickham and Acton, and north of the Grand Trunk railway, the outcrops of these rocks are also limited, but are seen at intervals, and no other rocks of the overlying series appear. It is probable, therefore, that the Sillery formation extends in a gradually widening area to the line of the railway mentioned, having its eastern limit near the crossing of the Moose River about five miles east of Actonvale station and its western limit a short distance, probably about one mile, west of Upton station. Between these two points, outcrops are quite frequent of the peculiar greenish-gray sandstone of the Sillery, with red and green slates. Further south, in Roxton and Milton, the Cambrian area assumes much larger dimensions, having a breadth, from east to west, of about seventeen miles. In the vicinity of Roxton Falls, the sandstone portion of the formation is well displayed and thence to the south-west through Roxton Pond village and further through the town of Granby, these rocks form a prominent ridge which is a marked feature in the landscape. This sandstone ridge extends into the township of East Farnham, and its most southerly recognized outcrop is on the third range of West Farnham, near the township line of East Farnham. The sandstones are here associated with red and green slates and are most abundantly developed along the eastern portion of the Sillery area. Grand Trunk railway west of Richmond. Granby ridge.

West of Roxton Falls, on the road to Milton, the sandstones become less prominent, and frequent outcrops of red and blackish-gray slates are seen. Near the line of Milton township, several small knolls of diorite appear, but along the roads through St. Valerien, and thence to Milton Corners, the red slates of the formation have a very extensive development, outcrops of the sandstone appearing at intervals. These rocks continue across Black River to the adjacent township of Granby to Abbottsford.

St. Hyacinthe, where also ridges of the sandstone are seen which extend, to the south-east, to about the centre of the mass of Yamaska Mountain, and are there in contact with the Trenton slates and limestones which occur east of St. Pie and St. Dominique, though the country in the vicinity is largely drift-covered, and the actual contact is concealed.

In the township of Granby, the red slates of this formation are well exposed on the road from Abbottsford to Granby village. About Mawcook to the north, and to the south-west on ranges of Papineau, Ste. Seraphine and St. George, they crop out in frequent ledges, with occasional locally-developed masses of sandstone. On lot fifteen, range nine, Granby, a quarry was opened in red and green slates, and a large quantity of rock extracted, about twenty years ago. The beds cleave to the south-east, but the cleavage is not sufficiently well defined to make good merchantable slate, possibly because the excavations had not reached a sufficient depth. In some of the lower beds, the cleavage appears to be curved, and in places is transverse to the bedding, while in others the rock itself seems to dip to the south-east at a high angle. A second quarry was opened about one-eighth of a mile west of the large one, but not much rock was removed. From that extracted, the slates appear very similar in character and colour to the stone from the Rankin Hill quarry, Acton, being a dark red.

Slate quarries.

The slates of Mawcook are in places traversed by irregular small quartz veins, and slight traces of copper appear in some of the harder quartzose bands, but this is of no economic value. A small quarry for local flagging, has been opened in the western edge of the red slate belt, about one mile and a half east of the village of L'Ange Gardien, but the slate is of inferior quality and is, moreover, cut by dolerite, presumably from the Yamaska Mountain. In the township of Acton, quarries have been opened in the red slate portion of these rocks on lot twenty-eight, range one, and on lot twenty-six, range five, the latter, known as the Rankin Hill quarry has been described in the Report on "the Mineral Resources of Quebec."* Of the former, we have no details of the operations, but no great amount of work appears to have been done.

Disturbance.

The rocks of this area appear to have been thrown into a series of folds, and probably some of the synclines are overturned, as is the case with similar rocks about Lévis and along the lower St. Lawrence. The description of the Sillery rocks given for that region in the report for

*Annual Report, Geol. Surv. Can., 1888-89, vol. IV. (N.S.), p. 129 K.

1887-88, p. 64 K, answer equally well for the areas now under discussion.

The sandstone ridges are local in their development, and the red shade of the slate frequently passes into green. From the relations of the overlying Trenton limestones on either side, the contact on the west appears to be due principally to faulting, while in the south and east it is more of the nature of unconformable overlapping. Contacts with the Trenton.

The third area east of the St. Lawrence is that found in West St. Armand. This consists of a narrow tongue of Cambrian rocks extending from the state of Vermont for about three miles and a half north of the boundary, where it has a breadth of not more than a mile and a quarter. It is separated from the Chazy of the Phillipsburg section by a line of fault, and it bounds, on the west, the Chazy basin of Stanbridge in its extension south-west from Farnham Centre. Third or St. Armand area.

This area has been described in former reports,* and is well outlined in the atlas accompanying the Geology of Canada. The rocks are there stated to belong to the Potsdam group and to very possibly represent its lowest member. This would appear to be confirmed by the more recent observations of Mr. C. D. Walcott on this series of rocks, by whom large collections of fossils have been obtained on the Vermont side of the boundary, from which he considers these rocks to be very low down in the Cambrian system. † Lower Cambrian.

The thickness of this old series as given by Sir William Logan in 1863, is about 2200 feet. It represents what is known as the Red sandrock of Vermont, and consists largely of dolomitic strata often highly siliceous, white and reddish in colour and with bands of dark-gray and bluish-black slate. Details are given in the report just cited. The northern outcrop of the series terminates in low land on lot 131, west St. Armand, just beyond, and to the west of the forks of the road at that place, where a sharply defined fault is seen between it and the Chazy limestone. The strike of the rocks is a few degrees east of north, and if prolonged this would meet the southern extremity of the Cambrian area of Granby, part of which may represent higher beds in the same series, in this respect following what appears to be a recognized fact in several of these formations, that as we go northward we pass from lower to higher beds. Thickness of the Georgia series (Lower Potsdam).

The eastern limit of this area of dolomitic Cambrian rocks in the state of Vermont, is a short distance south of the village of Highgate Falls, and it is there marked by the presence of beds of limestone con- Northern Vermont.

*Geology of Canada, 1863, pp. 281-286, and 851-52.

†Correlation papers, Cambrian, Bulletin U. S. Geol. Survey, No. 81, pp. 91-117 and p. 360.

glomerate or breccia, along with black slate, having heavy beds of rusty, weathering hard dolomite, cut by small strings of quartz, which, having resisted the weathering better than the containing rock, stand out prominently from the surface, and at times appear as a network of veins. The black slates, according to Mr. Walcott, contain fossils of upper Cambrian age; and from the brecciated masses also other Cambrian fossils were obtained. This band therefore clearly marks the upper line of the Cambrian rocks in this direction, and they are distinctly higher in the scale than the Red sand-rock of the St. Armand outcrop.

Fourth area o Cambrian.

A fourth area of Cambrian age, forms an important belt further to the east and extends from the Vermont boundary in a north-east direction, continuously to Kingsey, on the north side of the St. Francis River, where it is prolonged still further in the same direction and has already been described in a previous report as constituting the Cambrian of Stanfold, Lyster, &c.,* in the counties of Richmond and Wolfe. Its extension to the south-west is depicted on the map of Vermont by Prof. Hitchcock, where it forms the eastern boundary of the Chazy belt already described as extending to the east of Highgate Falls. It crosses from Vermont into the province of Quebec near the line between lots fifty-six and sixty-seven, St. Armand. At this place, about a fourth of a mile east of a cross-road which is one mile south of the Boundary, a considerable hill rises to the left of the road going east, the rock of which is a black slate with large bands of dolomite, cut by quartz-veins, which constitute, in some places, nearly half the mass of the dolomitic portion. Occasionally the rock becomes a conglomerate or breccia, mixed with the dolomite, and some of the limestone masses contain obscure fossils. The general aspect of these rocks is very similar to that noted as occurring in the upper Cambrian, south of Highgate Falls, Vermont. On the road leading south-west from St. Armand Centre, which crosses the Boundary on lot fifty-six, the dolomite bands come in about three-eighths of a mile south of the cross road at that place, with hard grayish sandy slates and quartzites. These are thence traceable to the Boundary, where, just to the west of the road, a prominent ridge composed of similar slates, dolomite and quartzite occurs. Fucoidal markings were observed in the slaty beds. A hill of similar rock rises on the east side of the road leading to Franklin Centre; and, on the road going east, just south of the Boundary, the series of grayish, hard, sandy and occasionally dolomitic slates, like those seen at Frelighsburg, is crossed, and these extend to the village of East Franklin, Vt., which is about three miles and a half

Distribution in St. Armand.

Fucoids.

*Annual Report, Geo. Surv. Can., 1886, vol. II. (N.S.), p. 27 J.

south of Frelighsburg village, on the road to which place, similar slaty rocks are frequently exposed.

Dolomitic bands in Upper Cambrian.

The bands of dolomite just described, may be taken as determining the upper part of the Cambrian for this area, and these can be traced very continuously for a considerable distance to the north-east. They cross the Pike River at Lagrange's mill, one mile and a half north-west of Frelighsburg, a short distance to the west of which place, and in the hills north of the road, great ledges of the quartz-veined dolomite present a folded structure and are underlain by black and rusty slates; the aspect of the rock being precisely similar to that south of Highgate Falls, except that the brecciated-conglomerate does not appear in this direction. These are in turn overlain by the Cambro-Silurian dolomitic slates, a short distance to the west. Further to the north, this contact is seen in the road between East Stanbridge and Dunham, near the forks of the road, on lot eight, range eight, Dunham, and still further north at Sweetsburg village, where, on the road to Brome Mountain, these peculiar dolomitic bands, in twisted blackish gray slates, are well exposed The strata all along this contact of the Cambrian and Cambro-Silurian, are very greatly disturbed, being twisted in every direction and highly cleaved. No rocks with Calciferous fossils appear anywhere in this direction, and it is probable that the Chazy is separated from the Cambrian by a line of faulting along which the doleritic mountains of Brome, Gale and Shefford have been erupted.

Character of the Cambrian of the Sutton anticline.

The breadth of this Cambrian belt, on the Vermont boundary, appears to be nearly four miles and a half, to where it is limited on the east by the series of underlying green chloritic, mostly schistose, but occasionally massive dioritic rocks. The strata which compose this belt, differ somewhat from those which make up the areas already described. The rocks are largely slates, greenish, grayish or black in colour, with occasionally bands of dark purple. With these are local developments of hard, generally bluish-gray quartzite or quartzose sandstone, veined with quartz and frequently with small blebs of clear quartz. These rocks appear on both sides of the central axis of Sutton Mountain, having a general dip to the north-west on the west flank of that axis, and to the south-east on the east side.

Dunham to Frelighsburg.

About Dunham and on the road to Frelighsburg the characteristic Cambrian rocks of this area are well seen. On the road from Dunham to East Stanbridge, after crossing the series of bluish-gray and black slates and limestone of the Chazy, the conspicuous band of quartz-veined dolomite, already described, is exposed in lots nine and ten, range

seven of Dunham; with these are associated local bands of generally hard and fine-grained sandstones. Approaching Dunham village at one fourth of a mile west of that place, bluish-gray, gray and occasionally brownish-gray slates occupy the hill, with hard, sandy bands from half an inch to three inches or more in thickness. These were carefully examined for fossils, but as the different beds are much disturbed, no trace of them could be found. The general dip, however, is to the north-west. Occasional dolomite bands are seen in these slates, which probably represent the upper portion of the Cambrian, though they do not lithologically resemble the rocks of the Sillery formation.

Frelighsburg and vicinity.

On the road south to Frelighsburg from Dunham, after crossing these slates in the first half mile, the strata become grayer, and more sandy, are slightly micaceous and similar to those seen in the river at Frelighsburg village, where impressions of fucoids were recognized. It is, apparently, in the upper portion of this series that the dolomite bands occur which are seen at Lagrange's mills and on the road to St. Armand Centre about half a mile east of the latter place, whence they are traceable to the boundary of Vermont, where they have been already described. East of Frelighsburg, on the road to Abercorn, these sandy, gray, micaceous slates extend for about one mile and a half, and about one mile west of Abbott's Corners they are in contact with green chloritic schists, slightly micaceous in places, which thence extend easterly to the valley of the North Branch of the Missisquoi River near the village of Abercorn.

West of Dunham, on the straight road towards Riceburg, the band of hard dolomite is seen a short distance beyond the crossing of Gear Brook, about half a mile west from the village corner; while north-east, towards Sweetsburg, these upper Cambrian rocks keep just to the west of the road as far as the forks on lot seventeen, range four, Dunham. They are also well seen on a road going east, for a mile or so between lots thirteen and fourteen. On a cross-road on lot fifteen, a tongue of calcareous and slaty rock comes in on the line between ranges four and five of the same township. The hard, cleaved Cambrian slates here form an abrupt slope on the east, and this

Sweetsburg.

ridge keeps a short distance to the east of the main Sweetsburg road as far as the cross-road on lot seventeen, range four. This cross-road passes over a steep ridge of hard dolomitic rock, which is sometimes highly quartzose and slaty, often rusty-weathering, and this can be traced southward to the road from North Sutton to Dunham. It forms a prominent ridge to the south of Sweetsburg. On the road going back to Sweetsburg, along ranges two and three, the rocks are all slates, brownish-gray and grayish, hard, sandy or quartzose,

cleaved to the south-east, but the dip of the banding is generally to the north-west. Near the top of a high hill on lot nineteen, range one, beds of hard gray quartzite and slate dip N. 55° W. < 75°, the rocks being well-bedded. This point is 350 feet above the river at Sweetsburg, and between this outcrop on the north slope of the hill, and the forks of the road from West Brome, the hard quartz-veined dolomite band again shows in the fields and along the road. North of Sweetsburg, this again appears and extends to the mountain near the forks of the road between lots three and four, range one, East Farnham. It is here overlain to the west by the calcareous slates of Cowansville, which thence continue along the west side of Brome Mountain to West Shefford. This band of dolomite, with the associated black and gray slates, may therefore, in this direction, be taken as limiting the Cambrian on the west, as far as the Brome Mountain.

Waterloo.

To the north of this mountain, about Waterloo, the rocks, classed as Cambrian, are believed to be such because of their stratigraphical position between the green chloritic schists and the Trenton-Chazy limestone, and from their general resemblance to those just described. They consist for the most part of grayish and greenish-gray sandy slates, with occasional hard quartzose bands. The same hard, green, slaty rock, with bands of black and gray and occasionally hard, greenish-gray quartzite, are seen as far as Boscobel Corner, and also on the road between that place and Knowlton Falls. At Bethel or North Ely, hard sandstones with gray and black slates occur, the whole resembling the lower Sillery, and going eastward from this place, great ledges of green and gray hard sandy slates with quartz-veins, dip N. 50° W. < 70°; this is on lot twenty-four, range four, Ely. The probable base of the Cambrian in this direction, is seen near lot one, range one, Melbourne, on the road where it crosses into the township of Ely. At this place, there is a hill of conglomerate rock, containing pebbles of white quartz and pieces of slate, which resemble the schistose-conglomerate beds described in the report for 1886, (p. 26 J) as occurring at Stoke Mountain, Sherbrooke, &c., and which there form the base of the Cambrian rocks. Like them also, the rocks at this place are somewhat schistose and are associated with bands of hard sandstone and greenish slate. These conglomerates appear to be local developments, but the characteristic green slates and quartzites of this series can be traced for miles.

North Ely.

Conglomerates.

Along the line of the Grand Trunk railway, after passing the green schistose rocks which extend from Richmond westward to within two miles of Lisgar station, Cambrian rocks are again seen. The first exposure of these is half a mile east of the 71st mile-post, where there

Grand Trunk railway west of Richmond.

is a cutting in hard greenish quartzose, and quartz-veined rocks, which may represent the lowest member of this system. A quarter of a mile west of the same mile-post, ledges of greenish-gray, somewhat sandy slates, like those already described, dip N. 60° W. < 60°. These are also veined with quartz. At Lisgar station, which is one-eighth of a mile west of the 69th mile-post, ledges of black and gray slates, hard and sandy, have the same dip. A mile and a half further west, black wrinkled woody-fibred slates, quartz-veined and crumpled, and containing scattered pebbles of large size of slaty sandstone and of dolomitic limestone, seem to indicate the presence of an overlap of Cambro-Silurian slates. Beyond this, several cuttings are seen in blackish and bluish-gray, sometimes calcareous, slates with pebbles of sandstone and slates, the age of which cannot be determined by fossils, but which also appear to be more nearly allied in character to the Chazy-Trenton than to the Cambrian rocks.

Lisgar.

Further north, on the St. Francis River, the Cambrian rocks are well exposed. After passing the green chloriti schists, which we may remark are similar in character to those seen at St. Armand Pinnacle, near the Vermont boundary, altered gray slates, occasionally of a bluish tinge, occur. These are followed by reddish-brown or purple slates, which, a little lower down the river, have been quarried.

Kingsey.

About lot five, range one, Kingsey, heavy beds of grayish quartzite dip N. 70° W. < 75°. These are sometimes coarse and full of grains of quartz and have interstratified beds of greenish slaty rock carrying large veins of quartz. These are again succeeded, a little lower down, by reddish-brown and purple slates, and these again by bluish-gray, greenish-weathering slates, which dip N. 80° W. < 70° and which extend to about lot eight, range two, Kingsey. These slates produce a series of rapids in the river. They are all much twisted and quartz-veined, and resemble the greenish slates which we have classed as Cambrian and which overlie the crystalline schists in Inverness and elsewhere to the north of Richmond. Below this place no rocks occur along the river, till the black Trenton limestones of L'Avenir are met with on lot six, range two, Kingsey township.

L'Avenir.

Precisely similar rocks extend to the north-east and have already been described and mapped for the area north of Richmond, in the Report and map for 1886. An area in the township of Kingsey composed of dark red or purple and green slates, with bands of quartzite and hard grit, begins near French village, where it is unconformably overlapped by the black graphitic limestones and slates of the Trenton, and this extends north-eastward into Shipton and Tingwick.*

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), pp. 27-28 J.

Another important area of these Cambrian rocks, is that seen on the east side of the Sutton Mountain anticline. These rocks are presumably, in part at least, the equivalents of the prolonged belt along the west side just described. The rocks of this area, however, differ in some respects from those of the west side of the anticline, more particularly in the presence, at various points, of eruptive rocks, such as diorites, .&c., which in places are associated with serpentine and soapstone. Area east of Sutton Mountain.

In some respects the Cambrian of the eastern or Missisquoi Valley area, is easily confounded with the rocks of the Cambro-Silurian of the same section. Careful examination, however, enables us to clearly distinguish between the two series, though both are affected by the eruptive masses which form so important a feature in this part of the province.

The principal stratified rocks in this area consist of slates and quartzites. The former are grayish, black, green and purple in colour. The quartzite is generally hard bluish-gray, veined with quartz, but sometimes is a true gritty sandstone, and the slates not infrequently contain interstratified hard sandy layers. Character of the Cambrian in Sutton and Potton.

The contact between the Cambrian slates and pre-Cambrian schists near the Vermont boundary, is visible a short distance west of Mansonville station on the Canadian Pacific railway. To the east of this place, the rocks are generally black stained slates, much twisted and quartz-veined, and with occasional bands of quartzite. Just west of the station, the crystalline micaceous schists of the Sutton anticline come in, and thence extend westward to West Potton, and along the mountain road to Abercorn. Similar slates and quartzites are seen further north at the eastern extremity of the Bolton Pass road and in the valley of the Missisquoi River. North of Bolton Centre, these slates become much disturbed, and masses of diorite and serpentine are exposed between this place and the line of the Canadian Pacific railway at Eastman. Between Eastman and Orford Mountain, the rocks are both slaty and quartzose, and purple-coloured beds are seen just to the west of the Orford Pond on the road to Bolton Forest. While these rocks are of necessity much altered by the action of the dioritic masses, as is seen in the presence of the serpentines and in the schistose character of some of the beds, they do not, as a series, resemble the crystalline rocks of the central anticline. The construction of the Canadian Pacific railway through this district has furnished excellent opportunities for their study, and a paced section along the portion between Eastman station and Magog may here be described. Bolton.

Section on the Canadian Pacific railway between Magog and Eastman.

On this section the rocks of the different series, from the Silurian to the pre-Cambrian, both inclusive, are represented. The Silurian dolomitic slates and limestones extend nearly to the line between ranges sixteen and seventeen, Magog, where they are underlain by the black and bluish-gray slates, with beds of sandstone of the fossiliferous (graptolitic) series already described.* These graptolites and associated slates continue westward to the outcrops of the dioritic mountains of the Orford range, which appear to have come through along the great line of fracture near the contact of the Cambro-Silurian and Cambrian systems, the contact with the slates of the former being seen in the cuttings at Miletta station on the Canadian Pacific railway. The dioritic rocks of the mountain thence extend to the middle of Orford Pond, and form a very prominent ridge for some miles both to the north and south.

Graptolitic black slates.

Contact with Orford Mountain diorites.

For some years, the rocks east of this cutting were supposed to be of Cambrian age, but the finding of the lower Trenton graptolites in portions of the black slates, and the general aspect of the strata where not too highly altered to ascertain the original characters of the rocks, have now made it clear that they should be assigned to the Cambro-Silurian system.

Altered character at the contact.

In this cutting, the action of the diorites upon the slates, is well seen. It may be stated that, for forty yards, the rock is mostly a black slate of the pebbly series, highly cleaved; the cleavage planes, where not too much broken, being N. 85° E. < 85°. Then, for twenty-four yards, the colour of the slates gradually changes to a grayish-green tint, and the rock is much more jointed and broken up, the slates having a burnt or baked aspect as we approach the end of this distance, to the contact with a dyke of the diorite. This diorite is also much altered at the contact, being shattered or broken, and slightly scoriaceous near its junction with the sedimentary beds. The dyke has a width of about six feet when the slates again come in, much broken, in a band of ten feet, to the main mass of the diorite, which soon becomes greenish-gray in colour and concretionary in structure. It apparently contains a small quantity of serpentinous matter throughout its mass, and at the end of seventeen yards holds another band of the slate, about two feet in thickness, which appears to have been caught in the outflow. The cuttings extend for eighty yards further, chiefly in concretionary diorite, along the joints of which thin coatings of calcite occur.

* It may here be remarked, that the finding of the graptolites was due to a paragraph in Sir Wm. Logan's note book for 1847, where the presence of these fossils in loose pieces of the black slates on the fifth lot of the fourteenth range of Magog was mentioned. This was noted in the Report for 1866 (p. 31), by Mr. Richardson, but no further attention was paid to their occurrence till our investigation in 1886.

The diorites of Orford Mountain then extend continuously to Orford Pond, the rock varying in character, being in places a hard fine-grained diorite, in others a moderately coarse diabase with crystals of hornblende or pyroxene, and in others a coarse almost syenitic rock, like portions of Brome Mountain. At the east end of Orford Pond, a cutting in serpentine marks the presence of a somewhat narrow band of this rock, which appears to extend for some distance along the western portion of the Orford Mountain chain, sometimes as a pure serpentine, but elsewhere as a serpentinous diorite. In the centre of the cut is a band of black slaty rock, which on examination is seen also to be a serpentine, and the west end of the cutting is in a soft dirty-green similar rock, with what appears to be soft yellowish-green talcose matter, and with the appearance of an altered concretionary diorite. Orford Mountain diorite. Serpentine.

The second cutting, which is a short distance west of that just described, begins in a rubbly or concretionary serpentine, light yellowish-green on jointage planes, with an apparently bedded structure in places. This is followed by a band of grayish-green slates, highly altered, about three feet thick, the slaty cleavage well developed in the lower part and looking like a slaty dolomite. This again is underlain by hard generally fine-grained grayish dioritic-like rock which may, however, be a hard altered quartzose sandstone holding clear grains of disseminated quartz, it being almost impossible to determine these sandstones in hand specimens, when highly altered, from the diorites, the latter often having a bedded structure. Second cutting.

The slates are brownish-gray on fresh surfaces and weather to a reddish-brown. The band of dioritic rock extends for thirty-two yards when serpentine again appears with a breadth of twenty yards. This is generally much shattered, at the end passing into the black slaty variety, which extends for sixty yards, to end of cutting, the rock being a soft talcose-looking slaty serpentine with lumps of harder consisteney. Slates, diorites and serpentine.

The next cut is on the west side of Orford Pond and begins with crushed slaty serpentine for fifteen paces. Then a three foot band of dolomitic rock occurs, extending up the face of the cut, and serpentine again for thirty paces, to a dyke of hard fine-grained dark-gray quartz-diorite, ten paces wide; then serpentine again much crushed and slaty for fifty-three paces to a second band of doloritic-rock seven paces wide; lastly serpentine to end of the cut, for forty paces more. On the road, a short distance to the north, grayish-brown slates occur, cut by diorite, and on the road to the south are purple slates, with hard quartzose grits or sandstones. These are characteristic Cambrian strata. Cutting at Orford Pond.

Cutting west of the pond.

The next cutting, going west, a short distance beyond the pond, begins with serpentine for sixty paces, then a gap for twenty paces to hard gray quartzose rock, pyritous and rusty-weathering, massive but intersected by joint planes. This extends for forty paces, then a gap to hard bluish-gray dioritic rock for seven paces, to a band of soapstone, rusty and impure. This has a breadth of sixteen paces, and on the right the rock is serpentine, while to the left, hard green diorite extends for one hundred paces to green schistose slates. A short distance beyond, the cutting passes through a band of porphyry, blackish-gray, generally fine-grained, with crystals of black hornblende and an occasional pebble of black slaty rock. This is cut by a dyke of granite, grayish in colour, composed of hornblende, felspar and mica which is in turn cut by small dykes of reddish spotted rock.

Soapstone.

Purple and green slates east of Eastman.

Between this and Eastman, the rocks are slaty and schistose. Some of the beds contain talc and mica, but these are apparently due to local alteration, since these bands are intimately associated with green, gray, black and purple slates of Cambrian aspect. In places these rocks are dolomitic, and the dolomitic slates on the road south from Eastman contain bands of serpentine at several places. On the main road past Orford Pond to Bolton Forest, the several kinds of slates are well seen, the serpentine being intimately associated with the purple and green variety, some of which near the Bolton Forest post-office are quite schistose. After crossing the high trestle at Eastman village, the chloritic and micaceous schists of the central axis are seen in the cuttings to the west, and these extend with a south-east dip to a distance of nearly a mile beyond Eastman station, where the axis of the Sutton Mountain anticline is visible in a small cutting in blackish mica-schist. On the road leading south from Eastman village to the Huntingdon mine, the rocks are principally slates. These are bright green, black and gray, and dark indian-red or purple. They have beds of green and dark-gray grits interstratified with numerous outcrops of serpentinous and dioritic rock. These are exposed at intervals to Bolton Centre, five-eighths of a mile west of which place, their contact with the crystalline schist series is well seen, as well as on the road from that village to Grass Pond, about two miles north.

Road south from Eastman.

Brompton.

To the north of Orford Mountain and in the township of Brompton, the Cambrian rocks seem to have a wider development. Purple and dark red slates are a part of the series at several points, among which may be mentioned the old Montreal road through North Stukely, a short distance west of Fraser Lake, and an area to the west of Brompton Lake, where a quarry has been opened in a fine purple slate of this series, on lot eighteen, range ten, Brompton Gore, apparently in the

extension of the slate belt of Rockland, but further to the east; while on the extension of the same belt to the north-east of the St. Francis River, in the township of Cleveland, similar purple beds are also found. The area about Brompton Lake is broken up by intrusions of diorite and by masses of serpentine, some of which, near the foot of the lake, are of considerable extent. The bluish-gray slates of the Rockland quarries have already been described, and it need only be said of this belt that it is the extension to the south-west of that depicted on the map of the south-east quarter-sheet, (1886), as extending from the St. Francis River between Windsor Mills and the slate quarries of Melbourne and Cleveland, where these rocks have a breadth of between eight and nine miles. The serpentine outcrops appear in this belt almost as far north as Windsor Mills, but these will be described later.

Serpentine of Brompton Lake.

There are two other areas of Cambrian rocks to be described in this section, both of which are limited in extent. The most easterly is an infolded basin in crystalline schist in the townships of Stukely and Bolton, where certain black wrinkled slates, with frequent pieces of purple slates occur to the south of the road from North Stukely to Ste. Anne de Rochelle, underlying the Cambro-Silurian area of slates and limestones. The second area is east of Memphremagog Lake, lying to the north of Fitch Bay, and extending thence to Massawippi Lake. The rocks of this latter area underlie the Cambro-Silurian of the east side of the lake, and rest upon a series of crystalline schists which are held to mark the extension to the south-west of the Sherbrooke anticline in which the copper deposits of Ascot occur. They consist of green, black and gray slates, with occasional bands of conglomerate which are sometimes schistose and which have already been described.* The breadth of this belt of Cambrian slates, sandstones and conglomerate on the road from the upper end of Massawippi Lake to Magog is about two miles in its broadest part near the head of the lake, and similar rocks appear on both sides of the ridge of crystalline schists. They extend south-west past the lower end of Lovering Pond and apparently terminate at Magoon's Point, on the north side of the entrance to Fitch Bay.

Cambrian of North Stukely.

Area east of Memphremagog Lake.

Schistose rocks appear on the road, crossing into Vermont, east of Bear Mountain, about half a mile south of the boundary. These are overlain to the north by the bluish-gray and black pebbly slates of Sargent's Bay, and with them are two small outcrops of black graphitic limestone similar in character to the rock of Melbourne and Richmond. The schistose rocks in this direction look like altered

Vermont, west of lake.

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 27 J.

slaty beds and contain quartz-veins which have been mined apparently for galena, of which slight traces were observed in some pieces of the quartz. They do not resemble the pre-Cambrian schists so much as the altered Cambrian rocks, such as are seen on the Canadian Pacific railway west of Orford Mountain.

Potsdam sandstone referred to the Calciferous.

The areas of Potsdam sandstone north and west of the St. Lawrence, have already been described and mapped. Although a re-examination of this section was recently made, nothing further of importance concerning the distribution of the Potsdam was ascertained, the area being largely drift-covered, and no details can be added to those given in the Geology of Canada of this region.* The Potsdam sandstone is now held to form the lower and sandy portion of the Calciferous formation, constituting, with that formation, the lowest member of the Cambro-Silurian system.

Pre-Cambrian.

Rocks west of St. Lawrence described separately.

In this report the pre-Cambrian areas east of the St. Lawrence only will be discussed. The Laurentian rocks west of that river, more especially in the country north and east of St. Jérome, form a division distinct in character from the crystalline schists of the Eastern Townships. They have been very thoroughly studied by Dr. F. D. Adams both in the field and in the laboratory, and his remarks upon the area will be found in a supplementary chapter.

The crystalline rocks of that part of the "Eastern Townships," comprised in the area here described, have been already indirectly referred to in previous reports, as constituting the most westerly of the three anticlines which are found in south-eastern Quebec.†

The early views as to the structure of this series of rocks have been already given in the report just referred to, as well as their relations to the overlying Cambrian and other systems, and need no further reference in this place. It may, however, be mentioned that the early views of the structure of the Sutton Mountain rocks, according to which they were regarded as a metamorphic portion of the fossiliferous Quebec group, were first publicly challenged by Dr. T. S. Hunt in 1871,§ and subsequently and officially by Dr. Selwyn in 1877. In the Report of Progress for 1847-48 (p. 52), the anticlinal structure of the Sutton Mountain ridge is indicated, but at that date these rocks were

Early views as to structure of Sutton Mountain rocks.

*Geology of Canada, 1863, p. 95.

†Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.) p. 30 and 33, J.

§American Geologist, vol. V. April, 1890, Dr. T. Sterry Hunt, "The History of the Quebec group."

supposed to belong to a much more recent period, viz., to the Hudson River formation. This opinion was subsequently changed, owing to the discovery of fossils in the strata at Point Lévis, by which the rocks of the Quebec group were, in 1860, assigned to the base of the Lower Silurian instead of to its upper portion, although the view that the crystalline schists were the equivalent of the fossiliferous Quebec group was still maintained.

Prominent hill features.

The Sutton Mountain range is the extension into Quebec of the Green Mountains of Vermont. It consists of a prominent ridge, the elevation of the highest point, Sutton Mountain, being stated in the earlier report to be about 4000 feet above the sea.* This elevation does not appear to have been carefully ascertained, however, and is presumably exaggerated, as in the case of the other prominent detached hills, such as Orford Mountain and the Owl's Head, of which the first-named was for many years considered the highest land in eastern Canada, with an elevation of over 4000 feet. Within the past three years the height of Orford Mountain has, however, been carefully measured by aneroid, not only by Mr. Giroux, my assistant, and by myself, but by another gentleman, the three separate observations giving, for the height of the mountain above the railway at its base, only 1930 feet, or about 2860 feet above sea-level. From this we infer that the highest point of the Sutton Mountain range is something under 4000 feet.

Orford Mountain.

Characters of the Sutton Mountain rocks.

Excellent sections are presented along the road from Abercorn to Mansonville which crosses the southern portion of the range, as well as through the Bolton Pass which traverses it between Knowlton village and East Bolton, about ten miles further north, and the anticlinal structure can be well seen on both these lines of section. The crystalline schists of this range may be divided into two principal portions, viz., the gneissic, micaceous, quartzose and talcose schists of the central portions or that in which the axis of the anticline is situated, and a series of green, chloritic, schistose rocks, which constitute an easily separable portion, flanking the central area of schists to the west and extending from the Vermont boundary to the St. Francis in the vicinity of Richmond. This second or chloritic division is recognized also at various points on the eastern slope of the range, but it does not there present so marked a development, and it is possible that its area may be here reduced by the agency of extensive faults which traverse the valley of the upper part of the Missisquoi River.

The line of the anticlinal axis of the central area is easily recognizable, and has been determined on all the roads which furnish sections

*Geology of Canada, 1863, p. 251.

Anticlinal axis of the Sutton Mountain range.

across the range. At the south-west extremity it crosses the road west of Mansonville, in the vicinity, or just to the west, of West Potton post-office, the dip of the crystalline schists thence to Abercorn being north-westerly, while towards Mansonville station the dip is to the south-east. The strata are affected by local crumplings, but these do not disturb the general direction of the dips.

Its position.

On the road through the Bolton Pass, the axis of the anticline passes a short distance west of the fork of the road on lot twenty-eight, range three, Bolton, the same regular divergence of dips being seen to the east and west of this place. On the line of the Canadian Pacific railway, this axis is seen in a small cutting one mile west of Eastman station. Further north, it passes just west of the village of North Stukely, and still further in this direction it is recognized in close proximity to the road through Melbourne Ridge about lot fifteen, range three, Melbourne, whence it continues across the St. Francis River into the township of Cleveland. In all these places the reverse dips from the central axis are easily recognizable for some miles in either direction. This anticlinal structure of the range was discussed and pointed out by Dr. Selwyn in a paper read before the Royal Society of Canada in 1882.*

Chloritic schists.

The distribution of the chloritic schistose portion is somewhat important from the economic standpoint. In character it presents the features of a dioritic rock which has undergone very considerable metamorphism, by which the mass has assumed a schistose structure. The presence in certain portions of amygdules, which have also been drawn out or elongated in the shearing process, is evidence of its originally eruptive origin. The colour varies from dark green to purple.

Copper ore of Pinnacle Mountain.

In their most southerly extension, these rocks are well seen on the road from Frelighsburg to Abercorn. They come to the surface about one mile west of Abbott's Corners, where they have a cleavage to the south-east, though the dip of the bedding-planes is doubtful. Thence to the Pinnacle Mountain, these rocks present good exposures, and are sometimes schistose and at others massive. They are precisely similar in character to the rocks seen at St. Armand and Rochelle in Stukely, and on the hill to the east of Waterloo. On the south side of the Pinnacle Mountain, a deposit of copper ore was worked for several years, but finally abandoned. Similar rocks extend to the valley of the North Branch of the Missisquoi River at the village of Abercorn, on the east side of which the mica-schists appear, as well as in Abercorn village. These rocks dip north-westerly and underlie the green

*Trans. Royal Soc. Can., 1882, vol. I., sec. IV. "The Quebec Group in Geology."

rocks last described. The breadth of these green, chloritic and dioritic rocks in this section is about six miles.

Copper deposits in Sutton and Brome.

In the north-west portion of the township of Sutton, these rocks are well seen on the road from Sutton Junction west through North Sutton. Both here and in the southern portion of Brome, they contain deposits of copper and iron, the characters of which have been given fully in my report on the "Mineral Resources of Quebec."* The mineral-bearing character of these rocks is seen at a number of points thence northward to the St. Francis River, and several mines were at one time located on this belt. These have, however, long since been abandoned, the ore, while being sufficiently rich in copper, not being concentrated in the several lodes in quantity sufficient to repay the cost of its extraction. The belt becomes narrower as we proceed north, and in Melbourne has a breadth of not more than two miles and a half. The general schistosity of the rock dips to the north-west, and it is overlain by the slaty and quartzose beds of the Cambrian as seen in the St. Francis River, already described, and in the township of Cleveland.

Distribution of pre-Cambrian rocks.

That these pre-Cambrian rocks have been greatly disturbed at a comparatively recent date, is shown by the presence of areas of Cambro-Silurian strata, as in Ely and Stukely, which conform in cleavage with the underlying schists, as well as in that of black slates presumably of Cambrian age at several other points.

Geological position of the green schistose diorites.

The age of the green, schistose, dioritic portion is to some extent doubtful. It is evidently newer than the underlying schists of the Sutton Mountain axis and older than the great bulk of the Cambrian slates and quartzites. It therefore apparently constitutes an intermediate series, having, in certain places, bands of black slates and hard sandstone or quartzite, as at Brome and Richmond, which tend to associate it, from a lithological point of view, more closely with the lowest Cambrian than with the underlying schist. As its volcanic origin is plainly seen in its dioritic and frequently amygdaloidal character, it appears to coincide, to some extent, with division 2 of Dr. Selwyn's classification,† viz., the volcanic group, which he supposed to be probably Lower Cambrian or Huronian. The great degree of schistosity found in the rocks of this area, has doubtless been superinduced at the same period in which the slaty and schistose structure was imparted to the underlying series, as well as probably to the overlying Cambrian slates.

*Annual Report, Geol. Surv. Can., 1888-89, vol. IV. (N.S.), pp. 16-18 K.

†Report of Progress, Geol. Surv. Can., 1877-78, p. 3 A.

Pre-Cambrian east of Memphremagog Lake.

The only other area of rocks in this section which may possibly be of pre-Cambrian age, is that seen in the extension of the Sherbrooke anticline which, in this direction, continues from Massawippi Lake nearly to Memphremagog Lake. On the road from Magog to Fitch Bay, past the east side of Lovering Pond, green mica-schists are seen at the brook-crossing, just south of the Stanstead township-line, on lot twenty-eight, range seven, of Stanstead. They here underlie black, wrinkled, quartz-veined slates of Cambrian aspect, and are exposed nearly to the village of Fitch Bay, at which place also they are underlain by similar slates, the position of the latter being presumably due to overturned structure, and possibly to faulting. On the road from Massawippi Lake to Fitch Bay, one-half mile from the forks of the road, a hill of green chloritic schist with some whitish mica, occurs; dip N. 55° W. $< 75°$, while greenish and grayish mica-schists with clear grains of quartz are seen along the road south of the Bunker Hill ridge which extends from Massawippi Lake to Fitch Bay. As we approach the latter place, the green schists recede from the road and ledges of black and bluish-gray pyritous slates come in, dipping N. 50° W. $< 60°$. These slates hold sandy bands and the surfaces are frequently minutely wrinkled, while in other places they are smooth and shining, and contain small irregular quartz-veins. They are distinctly different in character from the schistose beds, and in the former maps of the area were classed in the Upper Silurian series like the rocks west of Sherbrooke.

Fitch Bay.

The green chloritic schist apparently constitutes the bulk of the ridge known as Bunker Hill, to the south-west of Massawippi Lake. The extension of this ridge to the west of Fitch Bay is seen in similar chloritic schistose rock on the road ascending the hill to Georgeville, as well as on the road to Georgeville from the Narrows, about two miles south-west of the village of Fitch Bay. The rock has very much the same character throughout, viz., that of a schistose altered dioritic rock, occasionally with micaceous bands, and often containing clear grains of quartz. Ledges of this rock crop out as far west as the road from Magoon's Point to Georgeville, near the crest of the ridge, on lots thirteen and fourteen, range two, Stanstead. These rocks apparently are more closely allied to the green chloritic schists of the west slope of the Sutton Mountain area than to the gneissic schists of the central axis. They do not appear on the east side of Memphremagog Lake south of Fitch Bay, the position which they would have occupied in their extension being taken up with granites and black slates and by amygdaloidal diorites. This whole area is so greatly affected with dykes and faults that formations of very diverse age are now intimately associated.

Volcanic and Plutonic Rocks.

Under this heading must be included a very considerable variety of rocks, such as granites, syenites, diorites, dolerites, diabases, serpentines, traps, etc., evidently of several different ages. Many of these occur in low-lying outcrops, while others rise into elevations, and constitute some of the most prominent mountains in the province of Quebec.

Among the most conspicuous as well as most recent of these, are the granitic masses of the east side of Lake Memphremagog and the great series of doleritic hills on the west and north of that lake, as well as those which rise from the comparatively level plain of the St. Lawrence River basin. With these also must be included certain dykes of diabase which cut the fossiliferous rocks of Lake Memphremagog and other places. The anorthosites of the area north of the St. Lawrence and other eruptive masses which are also found in the Laurentian series of crystalline rock, while newer than the limestone and gneiss which they penetrate are presumably older than the diorites of the Eastern Townships. Various kinds of volcanic rocks.

Concerning the dykes which occur around Memphremagog Lake, it may be said that some are massive green diorites, while others are talcose in aspect and schistose in structure, the schistosity being doubtless due to the great amount of pressure which appears to have been exerted on all these rocks, and which has converted the fossiliferous Silurian slates in places into micaceous schists. Dykes at Lake Memphremagog.

As to the exact age of the granitic rocks of the Eastern Townships, we have no directly conclusive evidence in this region. They have long been regarded as belonging to the Devonian period, but this view was doubtless, to a great extent, due to the fact that they were known to alter rocks of supposed Upper Silurian age, and therefore should be newer than the rocks altered. Since that time, however, it has been ascertained that the rocks penetrated by the granites are not Upper Silurian, but something much older, belonging in part to the Trenton formation and in part to the Cambrian or even to the pre-Cambrian; while in no case yet seen by us in the Eastern Townships of Quebec do granitic rocks penetrate Upper Silurian sediments. From the highly altered character, however, of the fossiliferous Silurian, and from the presence of dykes of trappean rocks, it is probable that the age of the granites is not far from the close of the Silurian period. Age of granite of the Eastern Townships.

The action of these granites upon the slates in contact has already been described.* The limestones are rendered micaceous, and the Action of the granite upon the strata in contact.

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 36 J.

slates frequently changed to staurolitic schist; and this action is the same in all the strata acted upon by the granitic masses whether belonging to the Cambro-Silurian or Cambrian systems.

Granite areas east of Lake Memphremagog.

The areas of granite proper, embraced in the portion of the province to which this report relates, are few, the principal being on the east side of Lake Memphremagog, where at the boundary of the state of Vermont, low-lying ledges of this rock occupy the shore on both sides, and extend on the Quebec side nearly to the head of the cove in Cedarville, on lot four, range three, Stanstead. The granite is also seen in contact with the limestone (graphitic) and slates on Province Island, and on a small island between that and the east side of the lake. In all these places the rocks in contact are highly altered, and the granite near the line of contact is generally of a different character from that of the main mass, being for the most part fine-grained and more felspathic. About Beebe Plain, or Stanstead Junction, and on the road thence to the shore of the lake, the contact of granite with the slates and limestones is well seen, the granite occurring as dykes or protrusions from the main mass into the stratified rocks.

Stanstead.

Another dyke-like mass, distinct from that just mentioned, is seen a short distance west of the village of Stanstead, and is described in the Geology of Canada (p. 435), as extending from the fourth lot of the ninth range to the thirteenth lot of the eleventh range of the township.

Concerning the mode of occurrence of the granite at these places, it is remarked in the volume just quoted that* "it appears to displace the calcareous strata, which it penetrates, as these are observed to dip from it in several places. On the fifth lot of the fifth range, [Stanstead] on the east side of the road, within a short distance of the edge of the granitic nucleus, a great number of dykes of the granite are seen, cutting the basset edges of the limestone beds; the whole having been worn down to a horizontal surface. Some of the main dykes are from two to three feet in breadth, and divide into a multitude of irregular and reticulating branches, many of which are no more than the eighth of an inch wide. In the face of an escarpment, which rises from the granite nucleus to this horizontal surface, a large dyke, of which all the others are probably ramifications, can be traced down towards its source."

Magoon's Point.

Another limited granitic area is found on the shore at Magoon's Point, on the east side of the lake, just north of the entrance to Fitch Bay. It occupies the shore on lots twelve and thirteen, range one,

* Geology of Canada, 1863, p. 434.

Stanstead, where it is in contact with black iron-stained slates, and on several small islands a short distance off the shore, granite also occurs, the alteration of the slates in contact into staurolitic schists being visible in every case.

These granitic rocks furnish a very excellent building stone, and quarries have been opened in both the principal masses, not only on the Canadian side, in that near the boundary, but on the Vermont side as well. The granite is white in colour, with black mica, and has already been described in previous reports.

Eruptive mountains east of the St. Lawrence.

The series of eruptive mountains like that of Montreal, and including those of the country east to Shefford, has already been very fully examined and described by Dr. T. Sterry Hunt.* The microscopic examination of the rocks of the great eruptive masses of Potton, Orford and Brompton has not yet been completed, though their distribution has been mapped. As a comparison of the principal features of the rocks of the two areas will be of great importance in throwing light upon the relative age of the two series of eruptions a brief description of the most important masses found in the St. Lawrence basin, taken from Dr. Hunt's report of 1858, is here given.

In the Report of Progress for that year, on page 177, Dr. Hunt says:—"The hills lying to the west of Brome and Shefford are, in the order of their succession, Yamaska, Rougemont, Belœil, Montarville, Mount Royal and Rigaud, all of which are intruded through Lower Silurian strata. A few miles to the south of Belœil is Mount Johnson or Monnoir, another intrusive mass, which, although somewhat out of the range of those just mentioned, apparently belongs to the same series. The mineral composition of these intrusive masses varies considerably, not only for the different mountains, but for different portions of the same mountain."†

Brome and Shefford.

The Mountains of Brome and Shefford, in which are included also the Gale Mountain, which constitutes the western part of the mass of Brome Mountain, are in that report regarded as one great trachytic mass. The rock from the west side of Brome Mountain, near the village of West Shefford, is said to be "coarsely crystalline, lavender-gray in colour, and contained a little brown mica, sphene and magnetic iron, but no hornblende."‡ This portion of the mountain is largely a elæolite syenite.

*Report of Progress, Geol. Surv. Can., 1858, pp. 173-188; Geology of Canada, 1863, p. 667, &c.

†Report of Progress, Geol. Surv. Can., 1858, p. 177. ‡*Ibid.*, p. 175.

Rock of Shefford Mountain.

A specimen from the south side of Shefford Mountain is described as "a coarse, grayish-white felspar, with a little black mica, and closely resembled that just described;" while a second piece "contained a little black brilliant hornblende in crystalline grains about the size of those of rice, with small portions of magnetite and yellow sphene, disseminated in a base which, although completely crystalline, was more coherent and finer grained than that of Brome."

Brome Mountain.

The rock of the Brome or Gale Mountain has lately been used in building the church at West Shefford, and makes a handsome stone for that purpose, splitting out in large blocks and dressing easily.

Yamaska Mountain.

Yamaska Mountain is eleven miles north-west of Shefford Mountain. While the mass differs in character at various points, the greater portion is stated in Dr. Hunt's report to be "a granitoid trachytic rock, which differs from that of Brome and Shefford in being somewhat more micaceous and more fissile."* A large quarry has lately been opened on the north-west flank of the mountain, at an elevation of about 400 feet above the Black River at St. Pie, for paving stone for the city of Montreal. The rock quarried is of a dark gray colour, apparently composed of grayish felspar, nepheline, hornblende and black mica, with a little quartz, is moderately fine grained, and splits and dresses well. This rock therefore belongs to the class of the nepheline syenites.

Quarry.

Dr. Hunt further remarks of this mountain that its south-eastern side "offers a composition entirely different from the last, being a dolerite made up of a pearly or white crystalline translucent felspar, with black brilliant hornblende, ilmenite and magnetic iron. This rock is sometimes rather fine-grained, though the elements are always very distinct to the naked eye, while in other portions large cleavage surfaces of felspar half an inch in breadth are met with, which exhibit in a very beautiful manner the striæ characteristic of the polysynthetic macles of the triclinic felspars. The associated crystals of hornblende are always much smaller and less distinct, forming with grains of felspar a matrix to which the larger felspar crystals give a porphyritic aspect. Finer grained bands, in which magnetite and ilmenite predominate, traverse the coarser portions, often reticulating; while the whole mass is occasionally cut by dykes of a whitish or brownish-gray trachytic rock, which is often porphyritic. If, as is not improbable, these dykes belong to the great trachytic portion of the mountain, it would show that here as in Mount Royal the trachytes

* Report of Progress, Geol. Surv. Can., 1858, p. 177.

are more recent than the dolerites or diorites, but the relations of these different rocks have yet to be made out."*

Probable line of fault.

Of the two mountains just described, it may here be remarked that the more easterly, viz., that of Brome, and Shefford, occurs along the line of contact between the Cambro-Silurian and Cambrian rocks, while the Yamaska Mountain is situated on the line of fault between the Sillery division of the Cambrian and the Lower Trenton formation. It is probable that the Shefford and Brome extrusion is also along a fault line the presence of which is not so clearly indicated as that on which Yamaska Mountain lies, though the amount of dioritic matter is much greater at Brome.

Mount Johnson.

Mount Johnson, or Monnoir, is a small mountain as compared with the others of the district, but is sufficiently conspicuous with its somewhat cone-shaped peak. It is situated about six miles north-east of the city of St. Johns and fourteen miles south-west of Yamaska Mountain. The rocks surrounding it are presumably of Utica-Lorraine age, though outcrops are very rare in the flat country from which it rises.

Dr. Hunt says of this mountain that "it is composed of a diorite, which in general aspect greatly resembles that of Yamaska except that it is rather more felspathic; the finer-grained varieties are lighter coloured and exhibit a mixture of grains and small crystals of felspar with hornblende, brown mica and magnetite. Frequently however the rock is much coarser grained, consisting of a mixture of felspar grains with slender prisms of black hornblende often half an inch long and one-tenth of an inch broad, and numerous small crystals of amber-coloured sphene."† Recent investigations on the rock of this mountain show that much of it also belongs to the class of the nepheline syenites.

Beloeil Mountain.

Beloeil, or St. Hilaire Mountain, is situated about midway between Montreal and the Yamaska Mountain, a short distance east of the Richelieu River, near the line of the Grand Trunk railway. It is due north from Mount Johnson, and on the hypothesis that these eruptive masses came up along north-and-south lines of fracture, would probably lie in continuation of the fault which extends from near Lacolle to St. Johns. The rock is generally a grayish elæolite syenite not unlike, in some respects, that of Mount Johnson, as well as that of certain portions of Yamaska Mountain.

Rougemont.

Rougemont lies nearly on a north-west line between Yamaska and Beloeil. Certain portions of the mass resemble those of the mountains just mentioned. Other portions are a "coarse-grained dolerite in

* Report of Progress, Geol. Surv. Can., 1858, p. 178. † *Ibid.*, pp. 179-80.

which augite greatly predominates; grains of felspar are present, and a little disseminated carbonate of lime. * * * This rock approaches closely the highly augitic dolerite of Montarville. The olivine which characterizes the latter mountain is also very abundant in two varieties of dolerite from Rougemont. One of these consists of a grayish-white finely granular felspathic base in which are disseminated well-defined crystallized grains of black augite and amber coloured olivine, the latter sometimes in distinct crystals. The proportions of these elements vary in the same specimen, the felspar forming more than one-half the mass in one part, while in the other the augite and olivine predominate. By the action of the weather the felspar acquires an opaque white surface, upon which the black lustrous augite and the rusty-red decomposing olivine appear in strong contrast."* The rock of this mountain resembles very closely that of the basic portion of Montreal Mountain.

Montarville Mountain.

The Montarville or Boucherville Mountain is the most westerly of the series east of the St. Lawrence, and is eight miles due east of Longueuil on the bank of that river. The olivinitic character of much of the rock of this mountain is pointed out by Dr. Hunt in the report from which the preceding remarks are taken. Two principal kinds of rock here appear, the one a highly augitic dolerite, the other an olivine dolerite in which the olivine is "in rounded crystalline masses from one-tenth to half an inch in diameter, associated with a white or greenish-white crystalline felspar, black augite and a little brown mica and magnetic iron."† Hand specimens from this mountain also show the mass to be similar to the basic portion of Montreal Mountain.

Montreal Mountain.

The rocks of Montreal Mountain have been recently studied by Drs. Harrington and Adams. In many respect the mass as a whole resembles several of the other eruptive masses already described. Dr. Adams remarks concerning its structure.—

"The main mass of Mount Royal, including all that portion of it which overlooks the city of Montreal, consists of a very basic rock having the mineralogical composition of a theralite very poor in nepheline. Under the microscope it is seen to be made up of labradorite, reddish-violet augite, brown hornblende and brown mica. Olivine is present in many parts of the mass, as well as titanite, apatite and other accessory constituents. Nepheline is present only in very small amount and hauyne can be occasionally detected.

"On the northern side of the mountain this theralite is seen to be broken through by a second intrusion consisting of nepheline syenite.

*Report of Progress, Geol. Surv. Can., 1858, p. 184. † *Ibid.*, p. 182.

This rock is much lighter in colour and can be observed to send arms out into the theralite. It is composed essentially of orthsoclase nepheline and green hornblende, with small quantities of plagioclase, pyroxene, garnet and noscan and other accessory minerals. Dr. Harrington has also found sodalite in it in several places.

"Both of these rocks, as well as the Trenton limestone and Utica shales of the neighbourhood, are cut through by a large number of dykes, still more recent in age, which vary greatly in character and have not as yet been thoroughly studied. They belong however to the bostonite-tinguaite-monchiquite series of dyke-rocks which are consanguineous with, and usually accompany occurrences of nepheline syenite. They are now being studied by Dr. Harrington and myself. A dyke of alnoite found at Ste. Anne de Bellevue is probably also connected with the Mount Royal intrusion."

Rigaud Mountain.

On the west side of the St. Lawrence and on either side of the Lake of Two Mountains, two prominent hills are seen which may perhaps belong to the same period of eruption as those just mentioned. Of these Rigaud Mountain, on the south side of the lake, rises to a height of 750 to 800 feet above it, and extends south-west for several miles. The rock of the mountain presents different characters at different points. It is in part a reddish orthoclase rock apparently a syenite, like some found in the Laurentian area, generally coarsely crystalline like that of Shefford and Gale mountains; while other portions are largely made up of reddish felsite, which is sometimes porphyritic. Still other parts of the mountain consist of a coarse-grained hornblende diorite, in which crystals of black mica are found. This rock is also like much of the dioritic rock found in the Laurentian west and north of Ottawa.

Mont Calvaire.

Mont Calvaire, on the north side of the Lake of Two Mountains, is also composed largely of syenitic or granitic rocks, generally red in colour, in places foliated but not resembling the reddish stratified gneiss of the Laurentian. Other portions of the mountain consist of diorite, trappean rocks, gabbros, and on the north-east flank is a patch of brownish breccia, like that found at St. Helen's Island and on Isle Bizard. This mountain, like those of Rigaud, Montreal, etc., appears to be an intrusive mass of comparatively recent date, and to have cut the Potsdam and Calciferous rocks of the vicinity.

Alteration of diorite to serpentine.

It will be seen that in several of these intrusive masses of the St. Lawrence basin, olivine forms a very important part of the rock constituents, but in none of them has sufficient alteration apparently taken place to produce serpentine to any extent. The

study of the eastern series of these eruptive peaks will, when completed, be of very great interest, since in some of them the alteration of the olivine into serpentine has already been accomplished. A preliminary microscopical examination of some of these was made in 1882 by Dr. F. D. Adams,* from which it was ascertained that the principal mountain masses such as Owl's Head, Orford Mountain and kindred areas, are in some cases altered diabases.

Mountains west of Memphremagog Lake.

In the section to the west of Lake Memphremagog, beginning at the Vermont boundary, and extending in a north-easterly direction thence for about thirty-five miles, is a prominent chain of these eruptive hills. The average breadth of this belt is about four miles, and in it are situated several very conspicuous peaks, among which, beginning at the south, are Bear and Hawk mountains, across the former of which the International boundary line passes; the Owl's Head, rising

Owl's Head and Elephantis.

about 1700 feet above the shore of Lake Memphremagog, and Elephantis or Sugar Loaf Mountain, the eastern outline of whose summit reveals the broken-down lip of a huge crater-like depression on the side next to the lake, occupying the central portion of the mountain mass. In continuation of this to the north, are the Hog's Back Mountain, the Peevy Mountain, and several other prominent hills in the immediate vicinity, the local names of which were not ascertained. These elevations are principally to the west of, and a short distance from, the arm of the lake known as Sargent's Bay, between the lake and the valley of the upper Missisquoi River. From these a chain of medium-sized hills extends through the eastern part of Bolton township to the line of the Canadian Pacific railway, east of Orford Pond, just to the

Orford Mountain.

north of which rises the great mass of the Orford Mountain, the highest peak in the chain and probably in this entire section, with an elevation of 2130 feet above the surface of Lake Memphremagog. This mountain extends northward to Orford Lake, beyond which, on the west side of Brompton Lake, are two prominent masses known as the Carbuncle and Bare mountains, the former being about 500 feet and the

Brompton Lake.

latter about 750 feet above Brompton Lake, which is about seventy-five feet higher than Lake Memphremagog. Between these hills and the Orford Mountain the eruptive area is indicated by a series of less prominent dioritic masses, in which serpentine occurs to some extent; and, crossing to the east side of Brompton Lake, large masses of the latter rock are conspicuous about the west shore of Key Pond or Webster Lake and between this lake and the lower end of Brompton Lake. Thence to the vicinity of Windsor Mills, small outcrops of serpentinous rocks occur from two to four miles south of that village.

*Report of Progress, Geol. Surv. Can., 1881-82, pp. 9 A, 22 A.

Associated strata.

The rocks through which these eruptive masses rise are of various ages. For a distance of from three to four miles west of the shore of Memphremagog Lake, the slates are principally of Cambro-Silurian age, with occasional areas of Silurian or Devonian, closely infolded. The more westerly portion of the area of eruptive rocks is associated with rocks of Cambrian age, for the most part slates and quartzites already described, while great areas of dioritic rocks occer in the underlying or pre-Cambrian system. That all of these eruptive rocks are of the same age is not probable, in fact the difference in their character in the different areas, and their associations in certain cases, tend to establish their different ages.

Comparison of areas east and west of the St. Lawrence and Champlain fault.

Comparing the eruptive rocks of the Memphremagog Lake district with those of the plain of the St. Lawrence, two principal points of difference at once present themselves. Thus in the western area the intrusions are in rocks comparatively unaltered, and for the most part flat-lying shales and limestones filled with fossils, and where alteration occurs this is at the contact with the dioritic masses; while in the eastern area, all the rocks from the pre-Cambrian to the close of the fossiliferous Silurian, are in a high state of metamorphism, the several groups of strata are highly inclined, in some cases so much so, that the fossiliferous Siluro-Devonian is found completely overturned and underlying the Cambro-Silurian as on the east flank of the Owl's Head Mountain. This has frequently produced a foliation in the fossiliferous Silurian dolomitic slates, such that these have now the aspect of true schists and the inclosed corals are drawn out of shape and flattened. In certain of the Cambro-Silurian graptolitic slates, the great metamorphism has almost completely destroyed the form of the graptolites, while the rock has become a graphitic schist. In the case of the eruptive rocks, not only the dykes which are found in the Silurian fossiliferous beds are rendered schistose, so as to impart to their mass the character of a talcose or chloritic schist, but certain portions of the large masses of diabase have also assumed a schistose structure, showing the enormous forces to which the rocks of this area, even at a comparatively recent date, have been subjected.

Action of the diorites upon the slates.

Dyke contacts at Memphremagog Lake.

Fine examples of dyke contacts are seen along the shores of Memphremagog Lake, both on the west and east sides, and on the islands in the vicinity of Fitch Bay. These dykes present very different aspects, some of them being a rather fine-grained diabase, others a whitish felspathic rock, others again are a green talcose schist, while still others are of felsitic granite. The alteration of the sedimentary rocks in contact has already been to some extent referred to. This is seen along the west shore of the lake in the development of crystals,

some of which are apparently dolomitic, in the black Cambro-Silurian slates, and in their hardened and often shattered character, as in the case of the eruptive masses east of the St. Lawrence, and in the intrusion also of dykes of dioritic rock which can be traced direct to their parent mass. Some of these results of metamorphism are also without doubt due to the great crumplings to which these rocks have been subjected; though this would not explain the peculiar local metamorphism witnessed in the slates in contact with the dykes which proceed from the Owl's Head, from Orford Mountain and from the Hog's Back. Around all these, as well as in many other places, local alteration of the slate is seen, its more intense phase extending only a few feet, or, in some cases, inches from the line of contact. Among other places where this is well observed, is a brook flowing down the gorge between the Elephantis and Hog's Back mountains. Here, about 200 yards above the bridge on the road which goes up to the depression in the former, the black and bluish-gray slates are cut by a heavy dyke of moderately fine-grained green diabase which proceeds direct from the Hog's Back Mountain. The slates are locally altered for several feet on either side of this dyke, which has a breadth of about seventy-five feet. Black slates again come in and extend for about five yards to a second contact with the dioritic rock of the mountain mass itself, and here the bluish-gray Cambro-Silurian slates are baked to a dirty or rusty white colour. On the east side of the Elephantis, or Sugar Loaf Mountain, both large and small dykes of hard greenish-gray diorite rock are observed extending from the main mass, and traversing the slates across the bedding planes for some distance from the mountain foot. The slates along the contact of these dykes are locally altered to a hard cherty rock, to which a baked aspect has been imparted. In the micrometer survey of Memphremagog Lake, the position of a number of these dykes along both shores was fixed.

Contact with slates, Elephantis Mountain.

Rocks of Owl's Head Mountain.

The Owl's Head, the most prominent peak in this direction, conspicuous for its cone-like shape, comes directly to the shore on lot sixteen, range ten, Potton. Before reaching the great mass of the diorite, several dykes are seen cutting through the slates. The first of these is forty chains south of Perkins' wharf, and is four feet thick, consisting of green diabase. This is followed for several chains, by pyritous slates, the pyrites being abundant along or near the contact with the dyke. Next comes a second dyke, five chains wide, much of which is a fawn-coloured rock, somewhat schistose, apparently an altered diabase, containing minute garnets and crystals of dolomite, following which are the black altered slates to the Owl's Head diabase.

This rock thence extends for fifty chains, forming the shore of the lake, and the mountain behind rises boldly from the water. At the end of this distance, black, and pebbly slates again come in and form a narrow belt along the lake, for fifty-five chains, or to within twenty chains of the Mountain House wharf. Here they are underlain by the black graphitic limestone of the fossiliferous Siluro-Devonian, which forms a narrow belt of about five to eight chains in width, extending up the hollow behind the Mountain House, where it terminates about ten chains from the head of the small cove which is cut out of these rocks The dioritic rock of the point on which the Mountain House is built, is a breccia or dioritic agglomerate, followed directly after by a diabase rock which thence extends to opposite Round Island, where a band of slates again comes into view. Thence blackish, wrinkled and schistose slates extend to the lighthouse point, in which the "silver mine" is located in a quartz-vein which apparently cuts across the bedding.

The rock of the Owl's Head extends westward to the road along the west side of the mountain and crosses it a little way. Southward it extends nearly to the Bear Mountain, a band of bluish-gray, pebbly slates occurring along the road to Newport, which passes between these two prominent dioritic masses. Diorites, also greenish and sometimes slightly schistose, occur at the International boundary and continue to the lighthouse point on the American side, three-quarters of a mile south of the boundary, where our survey ended.

A dyke of talcose rock, which rapidly hardens after removal from the water, forms a low bluff about one mile north of the boundary. The aspect of this dyke, which is somewhat schistose, is like that cutting the fossiliferous Silurian near Capt. Gully's Cove on the east side, and it is probably an extension of that dyke, as the line of strike would about connect the two places. Talcose rocks.

While the structure of some of these diorites is schistose, so that in hand specimens, they might almost be taken for chloritic schists, the connection of these with the other massive portions of the dioritic masses and their intimate relations with the surrounding stratified rocks, tend to show the difference in age between this group of eruptive rocks and the chloritic schists which form the Pinnacle Mountain of St. Armand east and which extend to the St. Francis River as already described.*

*An interesting paper has recently appeared by Mr. Vernon F. Masters of Indiana University, in which the dykes of Lake Memphremagog are discussed. Mr. Masters classes them under the head of granites and lamprophyres. One at least of the dykes is a typical camptonite, and they all cut the slaty and calcareous rocks with which they are associated. "Camptonites and other Intrusives of Lake Memphremagog." —Amer. Geol., vol. XVI., July, 1895.

Serpentine of Orford Mountain.

Serpentine very rarely, if ever, occurs in the diorite masses which penetrate the Cambro-Silurian of this section. Thus in the Owl's Head, Elephantis and Hog's Back mountains there is no trace of it as yet seen. In the Orford Mountain the only serpentinous portion is a narrow belt of about 200 feet wide on the west flank of the mountain, which may belong to another eruptive mass. But in the Cambrian division of the Missisquoi Valley, the association of serpentine with diorite is frequently seen in the belt of dioritic rocks which extends from the Vermont boundary to Eastman, and which are in close proximity of the pre-Cambrian as seen on the roads from Bolton Centre to the Canadian Pacific railway and in the country about and to the west of Orford Pond and Bolton Forest. Here also are heavy beds of

Magnesite and soapstone.

magnesite with some bands of soapstone, and the rocks present features different from those seen in the eruptive masses near the lake. To the north of Orford Mountain, which apparently is intrusive along the line of contact between the Cambrian and Cambro-Silurian, other large masses about Lake Fraser, Bonallie's or Orford Lake,

Serpentine of Brompton and Webster Lakes.

Long Lake, Brompton Lake and Webster Lake or Key Pond, contain a very considerable admixture of serpentine with the diorite. These masses are surrounded by the purple and green slates and hard sandstones of Cambrian age. The passage of the diorite into serpentine is well seen at several points about the shore of Long Lake, which is near the eastern line of the township of Stukely. Just west of this lake are ledges of slaty serpentine in contact with black and greenish slates, the character of the former being such as to present the aspect of an altered slate, while the slates themselves appear to be frequently highly serpentinous. The two mountains on the west side of Brompton Lake, viz., Carbuncle and Bare mountains, are made up of a mixture of serpentine and diorite; and to the north-west of these, extending for a couple of miles, large ridges of serpentine are seen, bounded on the west by dark purple-red slate, in which the new slate quarry of Brompton Gore is located.

Carbuncle and Bare Mountains.

Diallage, old Orford nickel mine.

In several small islands near the eastern shore of Brompton Lake, not far from the old nickel mine, the variety of serpentine known as diallage is seen, the crystallization being in broad platy masses, and patches of red crystalline limestone are found adhering to the serpentine at several points, as if the latter had been an erupted rock through the limestone. At the nickel mine, three-fourths of a mile from the east shore of the lake, on lot six, range thirteen, Orford, the serpentine is mixed with purple and green slates and limestones in thin bands, the bands of slate in places, twisted and caught in the mass of the intrusive rock. These slates are part of the Cambrian series.

Webster Lake or Key Pond.

At Webster Lake, the slates of the Cambro-Silurian, probably near the contact with the Cambrian, occupy the south end of the lake and the big bay at its south-west angle. The serpentine comes in on the west side of the lake on the north side of this bay. It is generally hard, rubbly, dark-coloured and cherty, with small patches of stiff, hard, somewhat fibrous asbestus of no economic value. The west side of the lake is bordered by a succession of rounded hills, of which four are especially conspicuous. These were all examined for asbestus. They were found to consist of serpentine, for the most part altered or shattered, having a strongly dioritic aspect on weathered surfaces. A large boss of serpentine and hornblendic diorite shows near the lower end of the lake, and two small islets in the northern portion are also composed of hard, rubbly serpentine with diorite. The whole of this serpentine is broken and jointed, and shows no veins of asbestus though occasional patches of a hard, stiff, green, fibrous variety are seen in small thread-like irregular veins from one-eighth to one-sixteenth of an inch in thickness. A vein or band of a hard, whitish-gray, heavy mineral, described as a white garnet, occurs near the foot of a hill of serpentine, midway on the west side of Webster Lake.*

Asbestus.

White garnet.

Serpentine west of Brompton Lake.

The serpentine belt extends across the country between this lake and the foot of Brompton Lake, in a series of hills, which form a conspicuous ridge along the east shore of the latter near the township of Orford and extend northward to opposite the foot of the lake, or to the line between ranges eight and nine, Brompton. In this belt, on lot twenty-six, range nine, the Brompton Lake Asbestus Company's mine is situated. To the north-east of this, several small outcrops are seen in ranges four and five, Brompton, on lots seven and eight. On the road from Sherbrooke to North Stukely, called the old Montreal road, dioritic rocks come into view about three-fourths of a mile west of the outlet of Lake Fraser, the associated stratified rocks being purple slates and grits. At one mile and a fourth east of the stream from Bonallie's or Orford Lake, knolls of serpentine show on the south side of the road. The prevailing rocks from this to Long Lake, are black and gray slates, presumably of Cambrian age, with occasional outcrops of serpentine. These latter rocks, with diorites, are more extensively developed on a road leading north-east, about midway between the outlet of Orford Lake and Long Lake. In this direction a somewhat extensive belt of these igneous rocks extends along the east side of Long Lake, in a series of knolls, rising occasionally into hills of considerable size, and these continue north, at least as far as Ely Brook, the rocks occurring between the hills being dark gray and black slates.

* Geology of Canada, 1863, pp. 496 and 608.

On the west of these serpentinous masses, on lot eighteen, in the tenth range of Brompton, are the bands of purple and red slates, where the quarry, already referred to, has been opened.

Stukely.

The most westerly outcrop of serpentine rocks in this direction, is near the contact of the slates with the crystalline schists, and is seen on a road, to the south, from the Stukely road, on lot twenty-five, range six, Stukely. The sedimentary rocks in contact are black iron-like and grayish slates. This serpentine is very ochreous on weathered surfaces, being decomposed to a depth of nearly one inch, while the rock itself appears to be much broken up. This locality is about half a mile west of Orford Lake. On the post-road, a short distance west of Long Lake, another band of serpentine occurs, which is in direct and sharp contact with beds of black altered slates, and has a very slaty character. A small vein of asbestus was observed here, which was opened by the owner of the farm, but this was soon exhausted and no other trace of the mineral was found.

Asbestus.

Serpentine of Upper Missisquoi Valley.

The most extensive development of serpentine in this area, is found along the valley of the Missisquoi River, from the crossing of the Canadian Pacific railway southward nearly to the Vermont boundary. On the roads connecting this valley with the shore of Memphremagog Lake outcrops of this rock are also seen. South of Bolton Centre, these occur along the east side of the valley; but north of that place several detached hills are observed on the road crossing south-east from Grass Pond, and on the west side of the Missisquoi River. The rocks associated with these serpentines are in nearly every case black and grayish slates with masses of diorites, the great hills of the crystalline schists lying to the west. The most southerly outcrops of the serpentine seen in this direction, are two small knolls on range seven, Potton, about one mile north of the Vermont boundary, and a small outcrop at the forks of the road, lot one, range six. The surface of this area is largely covered with sand drift. No asbestus veins were observed in these serpentine knolls. Further north, on the road from Mansonville to Perkins' wharf, on Memphremagog Lake, a belt of serpentine rock crosses about one mile and a quarter east of Mansonville corner, and has an exposed breadth of nearly half a mile. The nearest rocks on the range are smooth greenish-gray slate and grits with green-gray slates and diorites in the east. The next outcrop of serpentine going northward, is seen on the road from Knowlton Landing to Bolton Pass, on the west slope of the ridge about half a mile east of the Missisquoi River. Here a band of serpentine about fifty yards in width, with black slates on either side, crosses the road, and has lately been opened in the search for asbestus. This is on lot

twenty-eight, range seven, of Bolton. The next cross-road to the lake is from Bolton Centre, eastward, and on this, about a quarter of a mile east of the Missisquoi River, after passing over black and gray slates, a band of serpentine is seen, the first exposures of which are concretionary. The rock, however, is for the most part massive, and is exposed along this road with a breadth of half a mile, the eastern portion being mixed with diorites, which are in turn succeeded by bluish-gray and black slates, in places containing pebbles, and these pebbly slates extend thence to the shore of the lake. This outcrop of dioritic rock appears to be at the contact of the Cambrian and Cambro-Silurian systems. Asbestus of Bolton.

The serpentine rocks are conspicuous on the direct road from Bolton Centre to Eastman, which passes along or between the chain of lakes, and on which the copper mines of this area are situated, viz., the Huntington and Ives mines. They show with diorites, in the cutting along the old Black River railway, on lot twelve, range eight, Bolton, the stratified rocks in contact to the south being black and greenish-grey slates. Near the Huntington mine, the serpentine is apparently interbedded with green chloritic slates, diorites grayish grits and grayish soft sandy slates. Further north, the serpentine is associated with dark purple-gray and black pyritous slates, and in some places the slates have a markedly red tinge. Small veins of asbestus of a tenth of an inch in length, occur in the serpentine along this road, but no veins of workable size were noticed. South of Eastman.

On a road which turns off from that last mentioned about two miles south of Eastman and west of the Missisquoi River, a small outcrop of serpentine shows on lot six, range eight, Bolton. The rocks in contact are grayish, green and purple slates. This outcrop is near the contact of these slates with greenish-gray mica-schists which are presumably of the pre-Cambrian series. Thence to the south, about Trousers Lake, several knolls of serpentine occur. On the road from Bolton Centre to Grass Pond, or St. Etienne de Bolton, several prominent ridges and hills show along the east of the road. These are on range seven, Bolton, on lots seven to thirteen. At one place on lot eight, an attempt to mine asbestus was made, in 1889, without success, the veins being insignificant. The rocks associated with serpentine at this place are black slates, but directly to the west, chloritic and micaceous schists come in. This serpentine appears to be greatly shattered and is frequently slaty in structure, with a rich oily green aspect, unlike that of Thetford but similar to much of that about Orford Pond and the north side of Orford Mountain. The observed serpentine knolls are all to the east of the Grass Pond road, along which the mica-schist series is strongly Bolton. Asbestus mine.

developed, and thence to the west as far south as lot fifteen, range seven, where the gray and black slates and quartzites of the Cambrian appear and extend thence by the road south to Bolton Centre and beyond.

To the south of Orford Pond, a mass of serpentine comes to the shore, and has been cut through by the old Waterloo and Magog railway, now abandoned. Heavy masses of diorite, of the Orford Mountain chain, occur on both sides of the Pond, and the serpentine appears in masses on the road to Bolton Forest along with purple, black and greenish-gray slates. Near Bolton Forest post-office, these green slates become much twisted, schistose and even micaceous, resembling, in this respect, the pre-Cambrian schists. They are cut by granitoid and dioritic masses on the line of the Canadian Pacific railway to the north. West of Bolton Forest, the black pyritous slates and grits of the Cambrian again show, as far as Missisquoi River. These have been described in connection with the serpentine of that district, and it is probable that the schistosity at this place is due to a local alteration.

Serpentine of Melbourne and Cleveland.

New Rockland slate quarries.

The only other areas of serpentine which require brief notice here, are found in connection with the slates of the Melbourne and Cleveland district, and may be called locally the St. Francis River area. At the New Rockland quarries, and at the Melbourne quarry as well, the rock to the west of the principal slate belt is serpentine. This belt forms hills in the vicinity, to the east of the narrow gauge railway, which connects the slate quarry with the Grand Trunk railway, and the rock crosses to the road which runs up the south side of the St. Francis, about three miles and a half south-east of Richmond. In this serpentine, small veins of asbestus have been observed, some of which hold fibre of over half an inch in length, but the quantity is so small that the extraction is not profitable. Crossing the St. Francis, the extension of this band of serpentine is seen on the east side of the river, near Bedard's slate quarry, and here, also, veins of asbestus are visible. It also crops out in occasional masses through the belt of hilly and wooded country between this place and the Shipton Pinnacle, and several attempts have been made to open profitable mines in this section, but hitherto without success. These mining locations are about three-eighths of a mile south of the road going east from St. Cyr's crossing, on lot nine, range nine, Cleveland. The veins of asbestus here are small and irregular, varying from mere threads up to three-eighths of an inch in width, but the fibre lacks continuity and is of little value. The rock is sometimes black and cherty, at others green, or mottled yellowish-green, and at others again greasy looking, like the rock of Bolton. Here the slates associated are the black

Bedard's slate quarry.

Mining areas in Cleveland.

greenish-gray and purple varieties of the Cambrian, while the ridge to the west is composed of schists, po sibly of pre-Cambrian age. The same relations are seen in the serpentine of Melbourne, the slates of the quarry being of Cambrian age, while the schists, &c., to the west belong to the Sutton Mountain anticline.

Areas south of Windsor Mills.

The areas south of Windsor Mills, on lots seven and eight, ranges four and five, Brompton, are probably the most northerly outcrops of the Brompton Lake serpentine belt. In this also the indications for asbestus appeared to be very small, and no veins were seen. The delimitation of the serpentines and diorites of this belt, west and north of Memphremagog Lake, is almost impossible. This country is very rough and hilly, largely forest-covered, except along roads and lakes. Small outcrops of slates and sandstones occur here and there, but frequently the rock between the hill outcrops is concealed by drift. While the indications, as far as seen, are not favourable to the occurrence of asbestus in workable quantity, chromic iron is known to exist at several points and may be found at some time in greater profusion, as in the case of the recent discoveries in the Black Lake and Coleraine districts to the north-east.

Surface Geology.

Marine shells.

The remarks on this subject contained in two preceding reports* are to a large extent applicable to the district covered by the present one. The great plain of the St. Lawrence, east of that river shows the presence of marine clays at many points, the fossils from which are the same as already described from the vicinity of Montreal. Among localities where marine shells are found, may be mentioned, the Grand Trunk railway, one mile east of St. Liboire station, and lot twenty, range six, Stanbridge, where in digging a large ditch a great quantity of shells have been thrown out. The covering of clay and sand drift appears to be of great thickness throughout this area, and has been already well described in the Geology of Canada (p. 925). The marks of ice action are quite numerous where ledges are well exposed, more particularly between the lower end of Memphremagog Lake and the St. Francis River, and to the west of the Sutton Mountain range. At the foot of the lake just mentioned, the course of the striæ is north, tending to N. 20° W. on the Montreal road, south of Brompton Lake, and about Lake Webster. In North Stukely and in Ely, the general course of the striæ, on the west side of the high ridge is

Striæ.

*Annual Reports, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 44 J; 1887-88, vol. III. (N.S.) p. 98 K.

north-west, parallel with the valley of the St. Francis River. Along the course of this stream, the striæ, where exposed, have a similar direction, showing that the local glaciation followed this depression.

Travelled blocks.

That this ice-movement was to the north-west instead of south-east, is seen by the presence of large loose masses of serpentine and dioritic rocks probably from the Orford Mountain range, one large mass weighing not far from 1000 tons being seen on lot twenty-seven, range nine, of Stukely, at some distance north-west (or in the direction of the striæ in the vicinity) from the masses of serpentine about Long Lake, from which it was presumably derived. Where the brook valleys have much depth, the course of the striæ changes to follow these, and this is well seen in the tributaries of the St. Francis, on the north, and of the Missisquoi on the south. Along the latter river, the striæ closely follow the course of the depression through the gap in Sutton and Potton. This appears to confirm the conclusions stated in 1886, that the traces of glaciation observed at the present day are purely of a local character, and that if a continental ice-sheet ever prevailed over this portion of Canada, its traces have long since been removed.

Striæ follow local depressions.

Denudation of Silurian formations.

The enormous denudation to which this area has been exposed, has been briefly alluded to in earlier reports,* and may be seen in the fact that outlying patches of lower Devonian rocks, of very limited extent, occur on the Chaudière River and further north in the township of Langevin, as well as on the shore of Memphremagog Lake, 100 miles to the south-west, being presumably the remains of a wide-spread Devonian area which, in connection with the numerous widely scattered outliers of the Silurian fossiliferous sediments, extended over the greater part of eastern Quebec. The study of the surface geology of this area has recently been taken up by Mr. R. Chalmers of this Survey, whose investigations will doubtless furnish us with much valuable information bearing on the question of the ice-movements and the direction from which the drift was derived.

Economic Minerals.

Little remains to be said on this subject in addition to what is given in the report lately published on "The Mineral Resources of Quebec."† The principal mining industries are confined to asbestus, copper and slate, and of these the more important operations are carried on in areas described in former reports and not in that covered by the present.

* Geology of Canada, 1863, p. 669; Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), 23 J.

† Annual Report, Geol. Surv. Can., 1888-89, vol. IV. (N.S.), part K.

Asbestus.—Several attempts have been made to find asbestus in workable quantities in the southern belt of serpentine, but hitherto without success. Among the places examined may be mentioned, the Montreal road, a short distance west of Long Lake, where a single "gash" vein with fibre of a little more than a fourth of an inch in length was disclosed in a cutting by the roadside. This was apparently the only indication of asbestus at this point. Second, near the shore of Orford Pond, in similar small veins of no economic importance. Third, on lot eight, range seven, Bolton, where two openings were made but very little asbestus was seen at either; small veins, of a fourth of an inch in the widest part and running from two to three feet in length, were found, but nothing of size sufficient to warrant further search. Fourth, on the road from Knowlton Landing to Rexford Corner on lot twenty-eight, range seven, Bolton, where the indications are equally unfavourable. Fifth, the Brompton Lake mine, on lot twenty-six, range nine, of Brompton. This locality was visited twice; on the first occasion before the commencement of operation by the present company and later during the season of 1890 after the expenditure of a large amount of money on the property. Special interest attached to this place from the fact that it represented the most southerly of the large supposed asbestus-producing areas, and promised useful information as to the probability of the serpentine masses of the southern belt containing asbestus in profitable quantity.

Asbestus, Long Lake.

Bolton.

Brompton Lake mine.

The serpentine of this locality is of the hard compact variety and shows the presence of two kinds of asbestus, the one a black stiff fibre from a fourth of a inch to nearly or quite an inch in length, in places several of these small veins being close together. This fibre, from its harshness, is unfitted for spinning or felting and is, in so far as yet known, of but small value. The second variety of asbestus is found in small veins of a fourth to half an inch, of soft whitish-green fibre with but little elasticity or tenacity, the containing rock being a hard blackish-green serpentine, in places passing into the variety known as diallage. The indications seen at that time were regarded as very unfavourable for successful mining. Three pits were opened up by the company, situated on two knolls, of which the southern contains two pits and the northern one. At the principal pit, the clay covering is very heavy and the indications noted in the first visit are borne out by the absence of workable veins of asbestus in any of these. It is not yet known that any asbestus of value has been obtained here.

The new mining areas north of the St. Francis have already been referred to. A good deal of money has been spent in exploratory work,

but the quantity of asbestus so far found is small and confined to small veins of short fibre.

Lake Memphremagog Mining Co.

Copper.—The Lake Memphremagog Mining Company, after spending a considerable sum in development work, has closed down the mine at the Hog's Back Mountain for the present, owing apparently to a lack of profitable market for their ore. This is a pyrrhotite already described in the "Mineral Resources of Quebec," and no further details can here be given of this property.

Huntingdon mine.

The old Huntington mine was pumped out during the autumn of 1890, by Messrs. G. H. Nichols & Co. and some further underground exploratory work carried on in the vein of ore, but no details have been received as to the amount of work done or results obtained.

Iron ore locations.

Iron ore.—The localities in which iron ore occur have been described in "The Mineral Resources of Quebec."* They may, however, be briefly enumerated here. On the west half of lot forty-five, west St. Armand, red hæmatite and specular schist. Iron ore also occurs on lots five and seven and north half of lot nine, range nine, and lot nine, range seven, Sutton; on lots one and two, range three; lot five, range four, and on lots four, five and six, ranges three and four of Brome; on lot two, range fourteen, Bolton, and on lots twenty-one and twenty-two, range fifteen, Orford. The ore in the above-mentioned localities is sometimes magnetic, at others specular, and in places contains a very considerable proportion of titanic acid, reaching sometimes as much as twenty-eight per cent. A deposit of iron pyrites (pyrrhotite) occurs on lot twenty-eight, range nine, Potton, overlain by a deposit of bog-iron ore from one to three feet thick. This is on the west side of the Hog's Back Mountain.

Bog-iron ore.

Chromic iron.

Chromic iron, is reported as occurring on lot twenty-six, range seven of Bolton, and assays have shown the deposit to be sufficiently rich in chromic oxide for shipment. Loose pieces have also been picked up on the west side of Memphremagog Lake, where the serpentines are particularly developed, which have shown a very large percentage of chromic oxide. There is therefore a strong probability that workable deposits of chromic iron will some day be found in some portion of this serpentine belt.

Anorthosite.

Building materials.—The anorthosite rocks of the St. Jérome and New Glasgow areas, are in places largely quarried for paving blocks, for which purpose their toughness renders them well fitted. They are used in Montreal, as also are blocks from the syenite rocks of Yamaska Mountain taken from a quarry on the north-west flank. Similar rock is quarried largely in the Shefford Mountain and used for building

* Annual Report, Geol. Surv. Can., vol. IV., 1888-89.

purposes. A quarry in nepheline syenite, on the west side of the Montreal Mountain, has also been worked for some years for road metal.

Potsdam sandstone.

The Potsdam sandstone, which is so largely developed near the New York boundary between Huntingdon and Hemmingford, as well as along the St. Lawrence and the lower Ottawa, forms an excellent building material, and is used to some extent in Montreal. The Parliament and Department buildings at Ottawa are largely constructed from the stone of this formation. Certain portions of the sandstone, free from iron, are said to be well adapted, when crushed, for glass making, as in the rock from Williamstown and from certain beds in Vaudreuil, and it has also been found suited for hearths and linings of blast-furnaces. The sandstones of the Sillery formation near Granby are also well suited for building stone, and in Quebec many of the large buildings as well as the city wall are constructed from a similar stone found in the vicinity of the city.

Phillipsburg limestone.

The crystalline limestone of Phillipsburg, has already been referred to as furnishing an excellent material for construction and for decorative purposes, and has been somewhat extensively quarried; while the excellence of the limestones of the Trenton, Chazy and Black River formations as developed on the islands of Montreal and Jésus has long been recognized. Extensive quarries in the limestones exist at various places, such as Mile End near Montreal, Côte St. Michel, several points along the Back River, St. Martin's Junction, &c.

Memphremagog slates and flags.

The Silurian and Devonian formations of Memphremagog Lake furnish certain flaggy beds which split out readily and have been used for pavements and flagging generally, being apparently well suited to this purpose.

Yamaska and Brome Mountain syenitic rock.

The syenitic rocks of Yamaska and Brome mountains have been quarried to some extent; that of the former for paving blocks and the latter for building stone, for which purpose it appears well adapted. Quarries in the Chazy limestones of St. Dominique, are also in operation, and considerable quantities of apparently excellent building stone are being shipped from this place. The two principal quarries operating here, in 1890, were owned by the Grand Trunk railway and by Mr. T. H. Howley. The latter, in 1889, put out, with twenty-five men, about 800 yards of dressed stone. The output from the Grand Trunk quarry is probably about the same.

St. Dominique limestone.

South Stukely limestone.

At South Stukely, quarries exist which furnish a crystalline limestone, suitable for building stones, of good quality, from which the church at North Stukely was built and at which also the rock is quarried for

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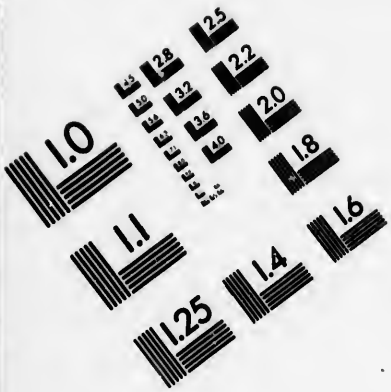

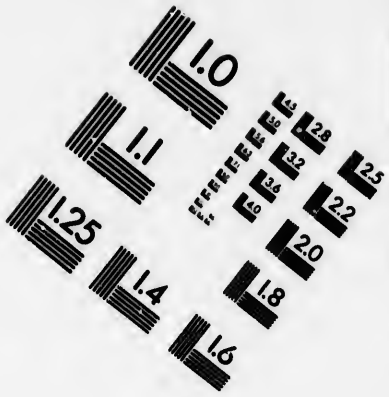

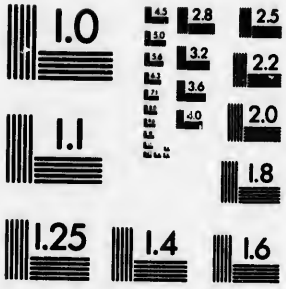

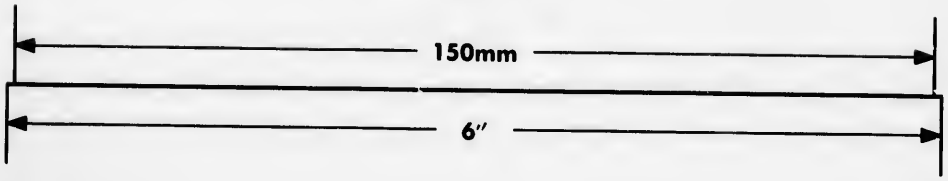

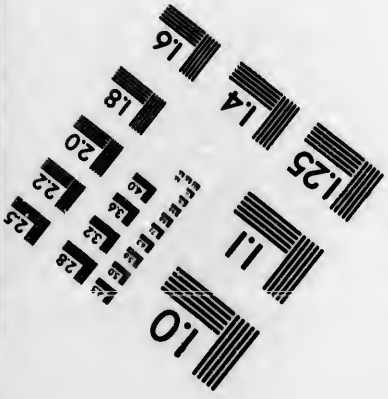

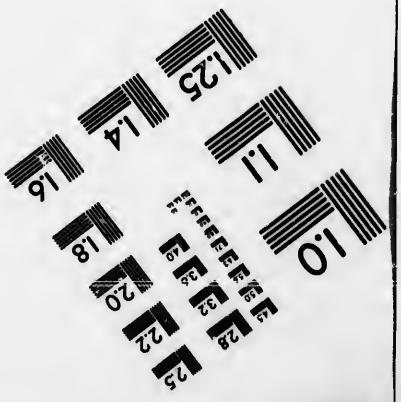

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lime burning by Mr. Goddard, of South Stukely. This is on lot eight, range two, of that place. Mr. Lachance, of Ste. Anne de Rochelle, also burns lime from the crystalline limestones found on the road on lot thirteen, range seven, North Stukely.

New Rockland slate quarry.

The slate industry of New Rockland is being pushed with the usual vigour, a valuable new bench of slates being reported from the eastern side of the quarry, so that the work will be extended at the surface instead of sinking to a greater depth. The new red or purple slate

Brompton Gore quarry.

quarry of Jenkins and Davis in Brompton Gore, was worked to some extent during the season of 1891, but was hindered by the lack of facilities for shipment. The slate appears to be of excellent quality. A deposit of slate on lots four and five, range three, of Brome, owned by Call Bros., shows smooth greenish slates, in the stream below the woollen mill on the south branch of the Yamaska River. These are fissile, but in places are cut by irregular bunches and veins of quartz. They dip north-westerly $< 85°$, and are associated with the green chloritic

Slates of Brome.

schists of the Brome area. Ledges of similar slates occur in the woods near the road leading to Sweetsburg, about three-eighths of a mile west of this stream. These slates are probably in the lowest part of the Cambrian series.

Rankin Hill, &c.

Several of the slate quarries, as at Rankin Hill, east of Actonvale, Kingsey near the St. Francis River, Mawcook between Granby and Abbottsford, in all which the rock is reddish and purple, have been for various reasons abandoned. The old Melbourne or Walton quarry, to the north-east of the present New Rockland quarry, in grayish slates, has also been closed for some years.

Lime-kilns.

Lime-kilns are found in the Papineau range south of Yamaska Mountain, where the dark limestone of the Trenton occurs, and in the Casimir range, L'Ange Gardien, several miles further south, in similar lime rocks.

The rock of the quarries in Montreal Island and on Isle Jésus, as well as St. Dominique have long been utilized for this purpose. The stone used is principally Trenton or Black River and the kilns produce annually a very large quantity of excellent lime.

Brick clays.

The marine clays of the St. Lawrence Valley, furnish excellent material for brick making, and several yards are in operation. Extensive works are found about Montreal, St. Johns, and on the road between Aetonvale and Roxton Falls, as also on the road north of Richmond, about half a mile east of the town. Other local kilns have been in operation of which we have no present returns.

At Laprairie, opposite Montreal, the Laprairie Pressed Brick and Terra Cotta Company, make use of the crushed shale of the Utica formation, and turn out a large amount of excellent bricks. The crushed slate of the Rockland quarry should also make an excellent material for this purpose, and proposals were made several years ago to establish works of this nature in the vicinity. The scheme has, however, apparently been abandoned for the present. Utica shale.

Peat.—Large areas of excellent peat occur in several places, and some of these have been extensively worked. The largest and most easily accessible deposits are probably those on the line of the Canadian Pacific railway at Ste. Brigide, between St. Johns and Farnham, and in the vicinity of the St. Lawrence, near Valleyfield and Beauharnois as well as in Huntingdon. The works at Ste. Brigide and at Port Lewis in Huntingdon, have been closed for some years, but new processes of manufacturing compressed peat may cause these deposits to be again utilized at no distant day. The upper portion of these bogs should furnish an unlimited supply of material for the manufacture of moss litter, now rapidly coming into use, and for which there promises to be a very considerable demand. Peat deposits. Moss-litter

Shell marl, is found in the Seigniory of St. Hyacinthe, near the foot of Yamaska Mountain, and near the road to Granby and St. Pie, in a deposit one foot thick, extending over several acres and covered by a thin layer of peat. It is also reported from lots one hundred and fifty-seven and one hundred and fifty-eight St. Armand, in a deposit covering thirty to forty acres and having a depth of seven feet in places. In Stanstead also, on lots four and five, ranges ten and eleven, it is said to cover an area of twenty acres near the shore of a small lake and to have a depth of thirty to forty feet. Marl also occurs in the Seigniory of Vaudreuil, at Pointe à Cavagnol, as well as on the Island of Montreal between Montreal and Lachine and at Thornberry on the west side of Mount Royal. Shell marl.

Soapstone, is said to occur in the township of Potton on lot twenty-four, range six, and on lot twenty, range five, the band being about three feet thick. It is found also in Bolton, lot twenty-four, range six and on lot sixteen, range five, and lot seventeen, range nine, associated with magnesite. It is also reported on lot four, range four; and in Sutton on lot twelve, range seven. A band of impure soapstone is also seen in a cutting on the Canadian Pacific railway, a short distance west of Orford Pond. Soapstone.

Potstone, occurs in a bed, twenty feet thick on lot twenty-six, range two, Bolton, and also on lot twenty-six, range six of Potton. Potstone.

Whetstone.

Whetstone.—Bands of rock well suited for the manufacture of whetstones and formerly worked, occur on Whetstone Island, Memphremagog Lake, on lot four, range nine, Stanstead; near the upper end of Massawippi Lake on the west side; on lot twenty-three, range six, Bolton; on lot seven, range two, Kingsey, and on lot nine, range eighteen, Orford. Certain bands of mica-schist, associated with the rocks of the Sutton Mountain anticline, should also be adapted to the manufacture of scythe-stones.

Mineral waters.

Mineral Springs.—A "sulphur spring" occurs at Bolton, near the Missisquoi River, about four miles west of Knowlton Landing, and a hotel for invalids was erected at this place several years ago. Springs also occur at Sabrevois, near Pike River village, one of which contains salts of strontia and baryta, while another holds soluble sulphates. Somewhat important springs are also found at St. Hyacinthe, St. Benoit, St. Eustache, Ste. Martine, Beauharnois, &c. These have been described in the Geology of Canada, pp. 542-44.

LAURENTIAN AREA IN NORTH-WEST CORNER OF THE SHEET.

By F. D. Adams, M.Sc., Ph.D.

GENERAL STATEMENT.

Laurentian protaxis.

The continent of North America, as is well known, has been gradually built up by an accumulation of sediment about certain very ancient land areas which are known as its protaxes. Of these the largest and most important is the great northern protaxis, which forms the greater part of northern Canada, having an area of somewhat over 2,000,000 square miles and constituting what Suess has termed the Canadian shield or boss.

The Laurentian area which forms the extreme north-west corner of the sheet at present under discussion, is a portion of the southern margin of this great northern protaxis and thus represents a part of an extremly ancient land area, from the waste of which the clastic Palæozoic strata to the south were derived.

The area of these ancient rocks embraced in the sheet is small, amounting to about 400 square miles; it forms, however, part of a much larger district, stretching to the north beyond the limits of this map, the geology of which has been worked out, and a map of which, with full explanatory report, will appear shortly. In the following pages, therefore, merely a brief general description of that portion of this district lying within the limits of the map accompanying the present report will be given, leaving the more detailed discussion of the district as a whole, and the many problems which it presents, for the fuller report which will appear later.

Character of country.

In the aspects of its relief, this Laurentian country is sharply marked off from the plains, underlain by the Palæozoic—which bound it on the south. It is a somewhat uneven plateau, the edge of which when viewed from the plains appears as a range of hills running in a north-east and south-west direction. The plateau slopes gently to the south-east from an average elevation of about 1000 feet above sea-level at the north-west corner of the map, to about 450 feet above sea-level along the edge of the plain.

The depressions in its surface are generally filled with drift, forming extensive flats, in which are many picturesque lakes of clear water

the largest being Lake L'Achigan in the township of Kilkenny. Four rivers also cross it, namely the North River, the River L'Achigan, the Saint Esprit and the Lac Ouareau River.

The landscape of this Laurentian country is of a pronounced type which, while lacking on one hand the grandeur and sublimity of high mountain regions and on the other the tranquil beauty of the well cultivated lowlands, has a certain rugged beauty of its own, especially when clothed with the brightly coloured foliage of autumn.

The area is about equally divided between the rocks of the Laurentian system and intrusions of anorthosite which break through these.

The Laurentian consists of red and gray orthoclase gneisses, presenting great variations both in structure and composition, with which are associated crystalline limestones, quartzites and amphibolites. These rocks often occur in the form of bands or beds alternating with one another, but in some places the banding is replaced by a more or less distinct foliation due to a parallel arrangement of the individual grains of the various constituents which go to make up the rock. Both structures are often found in the same rock, and when thus occurring together they coincide in direction. In order that a purely objective attitude may be preserved, the term band, rather than bed, is employed in the present report, the latter term being usually associated with the idea of a sedimentary origin, which, however probable, for certain parts at least, of the present district, cannot be considered by any means as demonstrated for the system as a whole.

Two divisions.

In many other parts of the Laurentian, two divisions can be recognized in the system, namely, an upper series characterized by the presence of crystalline limestones, quartzites and gneisses, having the chemical composition of ordinary sediments as well as a preponderating banded structure, which is called the Grenville series, from a township of that name in the County of Argenteuil where it is well developed, and a lower series of gneisses much more monotonous and uniform in character, in which are no limestones, &c., and which possess a foliated rather than a banded structure. This latter series is known as the Fundamental Gneiss, and in many cases closely resembles igneous rocks.

Grenville series.

In the area at present under discussion the two series cannot be so clearly distinguished. Certain parts of the area can be recognized as belonging to the Grenville series, as, for instance, the extreme easterly portion lying to the south of Rawdon and the westerly portion in the St. Sauveur district. Other portions, as much of the St. Jérome

district, has the appearance rather of the Fundamental Gneiss. It has been found impossible, however, to separate the two series and delimit them on the map. Fundamental Gneiss.

Breaking through the gneisses are four masses of anorthosite, an intrusive rock belonging to the gabbro class, but characterized by a great preponderance of plagioclase felspar. Of these the two largest, comprising portions of the townships of Abercrombie and Kilkenny respectively, are really portions of a single very large area, which extends to the north-west beyond the limits of the map, and has a total area of about 1000 square miles. This is known as the Morin anorthosite area, and is rudely circular in shape. The anorthosite occurring in the north-west corner of the present sheet, including the township of Abercrombie, is a portion of the southern extension of the mass, while the anorthosite in the Kilkenny district is the extremity of a large spur, which starting from the eastern side of the mass runs south, following the strike of the gneiss, and finally passes beneath the flat-lying Palæozoic strata of the plains, being at its southern extremity split in two longitudinally by a wedge of gneiss which runs up into it.

Six miles to the north of the limit of the present sheet, these two masses of anorthosite come together and pass into one another, and they will, therefore, be treated of as one and the same mass, which they really are. Anorthosite.

The other two areas, situated about St. Jérome and in the Gore of Chatham respectively, are much smaller and less important.

These anorthosite masses are now known to be intrusive. Owing to the fact that in some places they possess a more or less distinct foliation coinciding with that of the gneiss through which they cut, Logan and the other early Canadian geologists who first examined the area, thought that they, together with a portion of the associated gneisses and crystalline limestones, formed a series of stratified rocks distinct from and reposing upon the Grenville series. This supposed upper series was, therefore, termed the Upper Laurentian, and the anorthosites were considered to be its most characteristic members. The name Norian was also proposed by Sterry Hunt for these rocks, owing to their petrographical resemblance to the norites of Scandinavia, which rocks are now also recognized as intrusive. Although intruded through the Laurentian at a time long preceding the Potsdam, the appearance of these anorthosites antedated at least the termination of the great earth movements which affected the Laurentian in pre-Potsdam times, so that they have been squeezed and foliated together with the gneisses through which they cut.

Overlain by the Palæozoic.

On the upturned edges of these deeply eroded Archæan rocks, both gneiss and anorthosite, the Potsdam sandstone and other Cambro-Silurian rocks repose in flat and undisturbed beds. At some points along the edge of the protaxis, as at St. Canut, to the west of St. Jérome, the Potsdam sandstone is observed resting upon the gneiss; but as the plains are for the most part mantled with drift the actual contact is not in all cases seen, so that the Palæozoic exposures nearest to the Laurentian, in some places consist of the magnesian limestone of the Calciferous, as to the south of St. Jérome, or even of the Trenton limestone, as between New Glasgow and Ste. Julienne.

A small outlier of these Palæozoic rocks occurs on the third and fourth ranges of the township of Abercrombie, about nine miles north of the edge of the protaxis, and proves that the Palæozoic strata once extended considerably further to the north than they do at present, although this outlier probably does not by any means mark their northerly limit.

The Palæozoic strata cover up the gneisses and anorthosites alike, and are evidently of much more recent age, being separated from the Laurentian by the long interval occupied in the upheaval and erosion of the Laurentian area. How long before Upper Cambrian times this folding and erosion took place cannot be determined from a study of this area, but investigations in other portions of the margin of the protaxis makes it very probable it took place in pre-Cambrian times.

THE LAURENTIAN PROPER.

This great system consists, as has been stated above, of orthoclase gneiss, presenting many varieties both in form and composition, alternating and interbanded with plagioclase gneisses, crystalline limestone, quartzite, amphibolite and other crystalline rocks.

Gneiss.

These rocks present many transitional forms. Thus bands of quartzite, holding more or less orthoclase, represent varieties intermediate between true quartzites and quartzose gneisses. Crystalline limestones, again, in certain places become very impure, owing to the presence of grains of various silicates, and may thus be classed as calcareous gneisses.

Orthoclase gneiss preponderates largely, and would, if the crystalline schists were classified in the same detail as the intrusive rocks, be separated, owing to variations in its composition, into a number of varieties, equivalent respectively to the various orthoclastic intrusive rocks, as well as the various transitional members between these

and the plagioclase rocks of the diorite and gabbro families. A common characteristic of all these orthoclase gneisses is the presence of a banding or foliation which may be and often is as well pronounced as the lamination of any sedimentary rock, but which, on the other hand, in some cases is so indistinct that it can only be detected by the examination of large weathered surfaces. Some of the gneisses are highly acid, consisting essentially of quartz and orthoclase feldspar. Most of them, however, contain in addition a considerable quantity of biotite or hornblende, while others, owing to the presence of a considerable proportion of plagioclase as well as of hornblende or pyroxene, with a corresponding diminution in the amount of quartz present, are properly classed as basic gneisses.

Many of the basic gneisses are closely related to and associated with the anorthosite masses. Some probably of igneous origin.

Many of these gneisses differ in no way in composition from igneous rocks. This is especially true of those which from their uniform character and absence of all associated limestones, quartzites, etc., are referable to the Fundamental Gneiss rather than to the Grenville series, although many gneisses in the Grenville series belong to this class as well. These gneisses usually show in a marked manner what is known as a cataclastic structure, produced by the mechanical breaking down of the original web of the crystalline rock, by movements induced by great pressure, which movements cause in the rock a foliation or parallel arrangement of constituents more or less distinct, according to their intensity. In this way a coarse-grained granite may be converted first into an augen-gneiss, and finally into a very finely foliated gneiss in which all the original quartz grains have taken form of thin leaves. This structure is also remarkably well seen in the anorthosite, in most places where it occurs in this area, and will be more particularly described in treating of this rock. Many of these gneisses, at least, were originally of igneous, probably of intrusive, origin. Examples of these are abundant in that part of the area lying between St. Columban and St. Jérome and between this latter place and Ste. Sophie.

In order to ascertain the chemical composition of a typical gneiss of this class, Logan's typical Fundamental Gneiss from Trembling Mountain was selected. An analysis of it is given under No. I.

Analysis.

	I. Gneiss. Trembling Mt.	II. Granite. Carlingford.
Silica	69.24	70·48
Alumina	14·85	14·24
Ferric oxide	2·02	3·72
Manganous oxide	·45	
Lime	2·10	1·48
Magnesia	·97	·40
Soda	4·30	3·66
Potassa	4.33	4·26
Loss on ignition	·70	1·59
	99.56	99·83
Total alkalies	8·63	7·92

It forms almost the entire mass of Trembling Mountain, a long ridge rising on the east side of Trembling Lake to a height of 2500 feet and forming the highest point in the Laurentians of this part of Canada. The mountain does not occur within the area embraced by the present sheet, but lies about twenty miles to the north-west of its north-western corner. The rock, however, resembles closely that occurring at a number of points in the Laurentian area of this sheet. It is rather a fine-grained gneiss, uniform in character and is under the microscope plainly seen to be a crushed or granulated hornblende granite. The analysis shows it to possess a chemical composition quite different from that of the other gneisses and slates described below. The silica is high but the alumina comparatively low. The alkalies are also high, while the lime preponderates largely over the magnesia.

The composition is that of an ordinary granite. The analysis of a granite from the Carlingford District in Ireland, by Haughton, given under No. II., will serve to emphasize this identity.

The composition of most, if not all the gneisses belonging to the lower or Fundamental Gneiss, could be paralleled among the true igneous rocks.

Others probably of sedimentary origin.

The greatest variety in character is found among the gneisses occurring in the vicinity of the limestone bands. Here the gneisses are usually garnetiferous and often contain sillimanite, graphite, rutile, pyrite, and other accessory minerals, the last mentioned mineral when present causing the rock to weather in a very rusty manner. These rusty gneisses are not found except in association with the limestone bands and it is the exception to find the limestone unaccompanied by them.

Owing to the peculiar character of these several gneisses and their continuous association with the limestones and with bands of quartzite, which rocks are certainly not of igneous origin, but are met with in all highly metamorphosed sedimentary series, it was believed that some evidence might be obtained, pointing to a sedimentary origin in the case of these gneisses also. A large number of them were therefore carefully examined.

Under the microscope these do not show the cataclastic structure usually presented by the crushed and granulated igneous rocks of the system. They seem to have recrystallized under the influence of the pressure which has served to crush these other rocks. They are, however, now completely crystalline, no clastic material can be detected in them, although the character and arrangement of the constituent minerals is often suggestive of the metamorphosed rocks found in granite contact zones. The quartzites also, which are very frequently associated with these gneisses and which seldom occur elsewhere, do not, under the microscope, afford anything which could be taken as conclusive evidence of a clastic origin.

Important evidence, however, bearing on their origin was obtained from a study of their chemical composition. Four typical representatives of these gneisses were selected and analysed.

Evidence from chemical composition.

The analyses are given in the accompanying tables, together with analyses of three slates for purposes of comparison. Only one of these gneisses, No. V., is taken from the Laurentian area actually embraced in this sheet, the others however come from the continuation of this area immediately to the north. Analyses Nos. II., V., VII. and VIII. were made for me by Mr. Walter C. Adams, and analysis No. I. was made by Mr. Nevil Norton Evans, Lecturer in Chemistry in McGill University. To both gentlemen I desire to acknowledge my great indebtedness.

I. Gneiss from St. Jean de Matha, province of Quebec. A fine-grained garnetiferous sillimanite-gneiss, containing also much quartz and orthoclase. Graphite and pyrite are also present, the latter causing the gneiss to weather to a very rusty colour. It occurs in thick bands interstratified with white garnetiferous quartzite, the whole lying nearly flat.

II. Gneiss from the west shore of Trembling Lake, province of Quebec. A fine-grained dark-gray gneiss composed of quartz and orthoclase with much biotite, and containing little white streaks which were evidently at one time continuous little bands. These are composed of sillimanite. Garnets appear here and there in

the darker portion of the rock. It occurs near a band of crystalline limestone which occupies the bed of Trembling Lake.

III. An ordinary roofing slate from Wales. Analysed by T. Sterry Hunt. (Phil. Mag., 1854, p. 237.)

IV. A similar roofing slate of Cambrian age, from the large quarries in the township of Melbourne, in the southern portion of the province of Quebec. Analysed by T. Sterry Hunt. (Geology of Canada, 1863, p. 600.)

V. Gneiss from Darwin's Falls near the village of Rawdon, range V. of the township of Rawdon, province of Quebec. It is a highly quartzose garnetiferous gneiss and occurs in well defined bands interstratified with quartzite, which is often highly garnetiferous, the bands being from a few inches to several feet in thickness.

VI. Red slate from near Tinzen in the district north of the Engadine, Switzerland. Highly siliceous, containing 9·12 per cent of silica as quartz. (Vom Rath, Z. d. G. G., 1857, p. 242.)

VII. Gneiss, lot 20, range VII. of the township of Rawdon. Gneiss composed essentially of malacolite, scapolite and orthoclase, and holding a considerable amount of graphite and of pyrite. Weathers very rusty. Occurs in well-defined bands, interstratified with a grayish-weathering garnetiferous gneiss.

Microscopical structure.

The four gneisses I., II., V. and VII., show no cataclastic structure, but when examined with a microscope seem to have undergone complete recrystallization under the pressure to which they have been subjected, no signs of crushing being now visible in the thin sections.

The analyses show that the first three of these gneisses have the composition of slates. Nos. I. and II. have the composition of ordinary roofing slate, as will be seen by comparing these analyses with analyses III. and IV., and are quite different in composition from any igneous rock. The high content in alumina, the low percentage of alkalies and the great preponderance of magnesia over lime, characteristic of slates will be noted.

No. V. is a gneiss which is so highly quartzose that it might almost be termed an impure quartzite, and also has a composition differing from that of any igneous rock, but one which is identical with many highly siliceous slates. No. VI. is such a slate from the Engadine district in Switzerland, and is, as will be seen, almost identical in composition with No. V. Siliceous bands from the Canadian slate quarries also have a similar composition. The alumina here is low on account of the preponderance of quartz, which also lowers the con-

tent of alkalies. The magnesia preponderates over the lime as before. No. VI. lost 1·92 per cent on ignition before analysis, and these figures do not therefore appear in the analysis as given above.

Analysis of sedimentary gneisses.

	I. Gneiss. St. Jean de M.	II. Gneiss. Trembling Lake.	III. Slate. Wales.	IV. Slate. Melbourne.	V. Gneiss. Rawdon.	VI. Slate. Tinzen.	VII. Gneiss. Rawdon.
Silica	61·96	57·60	60·50	64·20	74·70	79·97	51·89
Titanic oxide	1·66	.....	.....	.....	.....	.....	1·66
Alumina	19·73	22·83	19·70	16·80	8·88	8·62	13·67
Ferric oxide	.....	.....	.....	.....	9·64	6·63	1·35
Ferrous oxide	4·60	7·74	7·83	4·23	.....	.....	.....
Feric sulphide	4·33	.....	.....	.....	.....	.....	4·43
M'n'ous oxide	trace.	trace.	trace.	.....	·50	.....	·62
Lime	·35	1·16	1·12	·79	1·07	·76	5·63
Magnesia	1·81	3·56	2·20	3·94	1·87	1·52	4·70
Soda	·79	·60	2·20	3·07	·42	·64	1·95
Potassa	2·50	5·72	3·18	3·26	·95	2·30	8·34
Loss on ignit.	1·82*	1·50	3·30	3·42	1·05	.....	(2·76†)
	99·55	100·77	100·03	99·65	99·08	100·44	100·00
Total alkalies	3·29	6·32	5·38	6·33	1·37	2·94	10·29

The fourth of these gneisses, No. VII., differs entirely from the others. The low content of alumina, combined with low silica, the high alkalies and the preponderance of lime over magnesia mark it off as quite distinct from the slates and gneisses just considered. If it be an altered sediment it is one which has suffered very little leaching during deposition, and must have been of the nature of a tuffaceous deposit, or one formed from the rapid disintegration of an igneous rock having the composition of a basic trachyte or syenite. It is, therefore, a rock which, so far as its composition is concerned, might be either an altered sediment or an altered igneous rock ; and it is impossible, consequently, to draw from its chemical composition any definite conclusions as to its origin.

In the case of those gneisses, then (Nos. I., II., V. and VII.,) whose stratigraphical relations and microscopical character suggest a sedimentary origin, the first three have the composition of slates, that is to say, of clay ; in the case of No. V., of clay mixed with sand, while in the case of No. VII., no definite conclusion can be drawn. To sum up, therefore, it may be said concerning the gneisses of this class, that: (1) their association with numerous and heavy beds of limestone and quartzite ; (2) their prevailing banded character, accompanied by a

*Water.
†Water and graphite (by difference.)

very extensive recrystallization ; (3) the frequent occurrence of graphite in all rocks of the class, and (4) the fact that the gneisses of this class have in many cases at least the composition not of igneous rocks but of sands and muds—combine to make it extremely probable that we have, in the case of many of these rocks at least, extremely altered forms of very ancient sediments.

Quartzite. The quartzite occurs in well-defined bands, in the vicinity of the limestones. It is sometimes quite pure, consisting of translucent or transparent vitreous quartz, but frequently holds garnet, sillimanite or other minerals. It is well seen at Darwin's Falls and elsewhere, near the village of Rawdon, as well as all through the Laurentian district to the south of that place. Amphibolite is a common rock, occurring in association with the gneisses in all parts of the area, but usually in comparatively small amount. It is dark or nearly black in colour, and is seen under the microscope to be composed essentially of plagioclase felspar and dark-green hornblende. The latter mineral occasionally holds a core of pyroxene, suggesting that the rock was originally a gabbro or diabase.

Amphibolite. These amphibolites usually occur as bands in the gneiss and are not confined to the limestone districts, and where the gneiss can be seen to have been greatly stretched or rolled out under the influence of pressure, these amphibole bands can invariably be observed to have been pulled apart into separate pieces, showing that under such pressure they are less plastic than the orthoclase gneiss.

Limestone. The limestones are coarsely crystalline marbles, white or nearly so in colour, sometimes nearly pure, as in portions of the band near St. Sauveur or the occurrence on lot 10 of range VII., of Kilkenny ; but at other times very impure, as in much of the New Glasgow band, the impurities consisting of grains of quartz, pyroxene, phlogopite, graphite and other minerals disseminated through them. So much of this area is occupied by anorthosite intrusions, that the limestones are less abundant than usual in districts underlain by the Grenville series.

As these limestones, however, are important members of the series on account of genetic considerations, as well as owing to the light they throw on the stratigraphical relations of the series as a whole, the several occurrences will be specified.

St. Sauveur. Commencing on the west, there is limestone lying immediately to the west and north-west of the village of St. Sauveur. This is the most extensive development of Laurentian limestone in the area. It, for the most part, underlies a low, undulating drifted tract of country

and is associated with basic, often rusty-weathering gneisses. To the north it is cut off by the Morin anorthosite, whose southern limit here appears as a high and abrupt cliff crossing the country. The limestone has at several points been somewhat extensively quarried for the production of lime, having been burned at intervals for many years—the fact of its being a limestone having been pointed out to the inhabitants by Logan in the early years of the Geological Survey. It is stated to form a very strong lime, but one which from the presence of grains of various silicates disseminated through it, is more or less impure, and which is thus suitable for rough masonry work rather than for interior finishing.

Further south in the augmentation of Mille Isles, similar limestone occurs again, and was supposed by Logan to form a continuation of the same band as that exposed near St. Sauveur.

Another occurrence of limestone, which, however, is small and unimportant, is that on the west side of the North River near St. Jérome. It is seen crossing the road which runs down the west side of the river, a short distance from the town, while blocks of it may be observed at intervals in the fields to the south of the road. Further south, the strike would carry it across the North River where it would be covered up by the Palæozoic rocks. It does not appear, however, on the banks of the river, nor could any continuation of it be found to the north. St. Jérome.

A more important development of limestone, in the form of a band, which, although it can be traced several miles, is still comparatively thin and impure, is found a short distance to the west of the village of New Glasgow, being exposed in the bed of the River Jordan near the edge of the Palæozoic. From this point it can be traced in a direction a little east of north, skirting along the edge of the great anorthosite mass which occupies this part of the sheet, as far as the third range of Kilkenny, a distance of about six miles, where it is lost sight of. If it holds the course as above described, it would be cut off by the anorthosite a short distance to the north of the point where it is last exposed. New Glasgow.

An isolated occurrence of a fine white crystalline limestone is also found on lot 10 of range 7 of Kilkenny, where it forms a low ridge about 100 yards wide, running north-and-south. Kilkenny.

In the northern half of the township of Rawdon, beyond the limits of this map, there is a heavy band of crystalline limestone running through the township from north to south. The southern portion of the township where underlain by the limestone is, however, so heavily Rawdon.

drift-covered that but few exposures are to be seen. On the 4th range, along the road between the village of Rawdon and Ste. Julienne, a few small exposures of limestone protrude through the drift on lots 13 and 15, associated with quartzite and gneiss, which may be a continuation of this limestone to the south, and are so represented on the map. If so, the limestone band is greatly diminished in size to the south.

THE ANORTHOSITE INTRUSIONS.

As has been mentioned above, about one-half of the Laurentian corner of the sheet is occupied by intrusions of anorthosite. Four separate occurrences are represented on the map, but the two larger are really portions of the same intrusion, known as the Morin anorthosite mass, and unite to the north.

Anorthosite intrusions.

This anorthosite is a basic rock belonging to the family of the gabbros, but characterized by the great preponderance of one constituent, namely, the plagioclase felspar, which is so abundant that it often makes up the entire rock. The other constituents are monoclinic and rhombic pyroxenes and ilmenite. No olivine has been found in any of the areas on this sheet. The rock is usually coarse in grain, its structure being especially well seen on the large weathered roche moutonnée surfaces. In its normal condition the rock has a granitoid structure and is deep violet, almost black, on a fresh fracture. The anorthosite in that portion of the area occupying the extreme north-west corner of the sheet, in the townships of Morin and Wexford, as exposed along the road and railway between Ste. Adèle and Ste. Agathe, shows these characters. The same is true of much of the anorthosite beyond the limits of the sheet to the north. The rest of the Morin anorthosite embraced within the limits of the sheet, represents peripheral portions of the mass and consequently shows in a marked manner the effects of the great pressure to which the whole area was subjected before the deposition of the Potsdam. The first effect of this pressure is the production of a brecciated structure in the anorthosite, especially well seen on large weathered surfaces about Ste. Marguerite and elsewhere in the eastern part of the township of Wexford. This brecciated structure is produced by the partial granulation of the rock, the resulting rock consisting of fragments of plagioclase or of the other constituents of the rock, embedded in a species of groundmass made up of smaller grains derived from the breaking-down of the larger individuals. The brecciation being accompanied by a movement of the rock in some definite direction, develops a streaked or irregular banded structure. A very remarkable fact in connection with the

Morin anorthosite.

Effects of pressure.

development of this structure is that wherever the rock becomes granulated it becomes much lighter in colour. This can be observed even in microscopical sections, when the phenomena is seen to be due to the disappearance of the dark dust-like inclusions which give to the felspar its dark colour, wherever the mineral becomes broken up or granulated, and so uniformly are these two processes connected, that it is always possible to predict when examining a thin section under the microscope, just how much of the rock has been granulated by observing its colour, before using polarized light, by which the extent of the granulation is at once made visible. So common is the granulation throughout the area, that even in the most massive and granitoid specimens of the anorthosite, traces of it can usually be found.

Foliation eventually resulting.

When the effects of pressure are more marked, as close to the edge of the area or anywhere in the most easterly development of the anorthosite in the townships of Rawdon and Kilkenny, the granulation becomes much more pronounced and a progressively larger proportion of the rock becomes granulated. This is accompanied by the passage of the streaked structure into a distinct and often perfect foliation, which coincides with the foliation of the surrounding gneiss, and by a bleaching of the rock, until in the varieties showing an advanced stage of granulation only a few small dark remnants of the original coarsely crystalline plagioclase individuals remain, like augen in an augen-gneiss, embedded in a mass of finely granulated plagioclase, often so white that at a distance the rock cannot be distinguished from marble. This variety is well seen about New Glasgow, where it has been extensively quarried for paving stones which are used in Montreal. It is also well seen along the contact near the east end of Lake L'Achigan, gradually becoming dark in colour towards the west end of the lake about St. Hippolyte.

The anorthosite undergoes no change in chemical composition during the granulation above described—the process, as studied under the microscope, appears to be a purely mechanical one. It is thus quite different from that commonly observed and which has been described by Lehman and others in the case of sheared gabbros. In all cases of shearing hitherto described, the pyroxenes under the influence of the pressure are altered to hornblende, while the plagioclase is often altered to saussurite, the resulting rock being an amphibolite not a gabbro. There is reason to believe that the movements which affected these anorthosites took place when the rock was deeply buried and probably also very hot, perhaps near its fusing point.

Contact rocks.

Although, in most places, the Morin anorthosite comes against the gneiss without producing any perceptible alteration, at some parts of its

circumference, especially north-east of Echo Lake, where the contact crosses the townships of Abercrombie and Kilkenny, a rather massive, dark, heavy rock, rich in bisilicates and often holding a little quartz and some untwinned felspar, borders the area and may be a contact product of some kind. The boundary of the typical anorthosite against this rock is usually pretty sharp, but the latter passes gradually into the gneiss of the district. This intervening rock, however, has in the main the composition of gabbro, so that it becomes difficult to decide whether it represents a peculiar and abnormal, possibly altered, form of the gneiss or a contact phase of the anorthosite.

Black gabbro.

Close to the edge of the easterly development of the Morin anorthosite at New Glasgow, and running north for about six miles in a direction very nearly parallel to that of the limestone band in the gneiss just west of the contact, is a band of a peculiar gabbro nearly black in colour, which protrudes through the drift in a series of great roche moutonnée bosses, contrasting in a marked manner with the white anorthosite through which it cuts. The band is narrow, and immediately to the north of New Glasgow sends out an arm about a quarter of a mile long from its eastern side, which cuts across the foliation of the anorthosite. Under the microscope, the rock presents an extremely well marked cataclastic structure, the constituent minerals having been completely granulated under the great pressure to which they have been subjected.

Lakefield anorthosite.

Of the two smaller areas, that which lies to the west of St. Columbin, extending over into the Gore of Chatham and known as the Lakefield area, most closely resembles the Morin anorthosite just described. It is four and a half miles long and about a mile wide, only about one half of it, however, being embraced in the accompanying sheet. The outer portions are fine-grained, foliated, very poor in bisilicates and weather white. The inner portion of the area is more massive, and appears on the whole to be rather richer in ferro-magnesian constituents, which vary in amount from place to place, often giving the rock an irregular banded structure. A rapid change in strike is observable in this area, the anorthosite and its surrounding gneisses in the southern part striking on an average N. 30° W., while about the northern extremity both rocks strike N. 35° to 65° E. Less than a mile to the south of the area, at the very edge of the Laurentian escarpment, a diabase dyke cuts through the gneiss, which is here the country-rock. The dyke contains angular fragments of white anorthosite which in many places are so abundant as to make up the greater part of the whole. These fragments, which were brought up

by the molten diabase, probably mark an underground extension of this Lakefield area to the south.

Only a portion of the St. Jérome area, situated as it is immediately at the edge of the Laurentian axis, is exposed to view. The southern part of it is covered up and concealed by the flat-lying Palæozoic beds which come in a short distance to the south of the town. What proportion of the whole mass is represented by the portion exposed to view it is impossible to say. St. Jérome anorthosite.

It differs considerably from the other areas, in that the anorthosite composing it is not so typical in character, as well as in the fact that there intervenes between it and the gneiss a broad zone of rocks of intermediate character. The anorthosite, or gabbro as it should in this case more properly be called, is seen in its typical development on either side of the Canadian Pacific railway track a few hundred yards south of the station at St. Jérome. The large exposures here are situated about the middle of the area, toward its southern limit as exposed. At this point the rock is fine-grained, weathers brownish-gray and usually has a foliated structure. In some places the structure is more or less distinctly banded, owing to the alternations of portions rather rich in bisilicates with others consisting almost entirely of plagioclase. Individuals of dark-coloured plagioclase, usually small in size but sometimes as much as six inches in length, are abundant in places. They are frequently seen to be curved or twisted and are usually without good crystalline outlines.

Under the microscope, this rock is seen to be composed essentially of plagioclase and pyroxene, the former largely preponderating, with hornblende, biotite, garnet, iron-ore, and pyrite, as accessory constituents, and a few grains of quartz, calcite, chlorite, and apatite. The pyroxene is light-green in colour and is for the most part augite, which is often decomposed to calcite and chlorite—some of it however is trichroic in red, yellow and green tints and is probably hypersthene. The hornblende, which is green in colour, and the biotite are present in but very small amount. The garnet, which is pink in colour, and perfectly isotropic, is often well crystallized and usually has some approximation to good crystalline form. It is generally associated with iron-ore but often occurs in little strings through the rock. The iron-ore is titaniferous, as shown by the leucoxene which frequently appears as its decomposition-product. The quartz, which is present in very small amount associated with the bisilicates, may also be secondary. The little strings, an inch or even less in thickness, consisting of orthoclase and quartz, which run through the rock sometimes parallel Microscopical character.

to the stratification and sometimes across it, are rather abundant but are evidently of later origin.

The rock in its present form probably represents an advanced stage of granulation, for although but little is seen in the way of twisted grains and strain shadows, these are usually not well seen when the granulation is complete. The large remnants of plagioclase crystals on the other hand, which occur abundantly in many parts of the rock, indicate an extensive granulation. At the bridge over the North River at St. Jérome, on the western edge of the area, as well as at a point about a mile and a quarter further north near the northern end of the area, the same rock is well exposed, at the latter locality showing an exceeding well-marked cataclastic structure.

Zone of intermediate character.

This gabbro mass is surrounded by a zone of rocks of varied character, many of which strongly resemble the anorthosite in appearance, but which are quite different in composition. They are well exposed to the west of St. Jérome back from the North River. This zone includes a large quantity of ordinary orthoclase gneiss, and in it occurs the crystalline limestone already described as occurring to the south-west of the village, but it consists chiefly of rocks, which, in addition to augite and plagioclase, contain variable amounts of hornblende, orthoclase and quartz, and which are thus intermediate in character between the gneiss and the anorthosite, some of the many varieties represented approaching more nearly to gneiss and others more nearly to anorthosite in character and composition. It is thus a matter of great difficulty to trace upon a map the exact limits of this zone. In the accompanying sheet, this has been done as accurately as possible by the aid of a microscopical examination of the rocks from a number of points.

This zone surrounding the typical gabbro or anorthosite, probably represents a peculiar border facies of the latter, which in many places has intruded itself into the gneiss parallel to its foliation, giving an appearance of interstratification, while movements, induced by pressure subsequent to the intrusion, serve to render this appearance more deceptive. The orthoclase gneiss and the limestone in this zone are thus of the nature of inclosed or partially inclosed portions of the country-rock.

THE STRUCTURE OF THE AREA.

The foliation or banding of the gneiss in the western part of the Laurentian corner of the sheet has a general north-east strike, which to the east swings around and runs about due north. The change is well shown between St. Jérome and New Glasgow. The northerl

strike is well seen in the narrow mass of gneiss separating the two larger masses of anorthosite, as well as in the Laurentian to the east of the most easterly of these two masses. The anorthosite intrusions also, as has been mentioned, especially toward their sides, show a more or less well-marked foliation which coincides in direction with that of the adjacent gneiss. Thus, in the case of the most westerly of the two large anorthosite masses, which in its extension cuts across the strike of the gneiss, the foliation runs across the contact from the gneiss into the anorthosite; while in the most easterly, which has been intruded into the gneiss in a north-and-south direction, the foliation of the two rocks coincides approximately with the direction of their lines of contact.

Relations of foliation to anorthosite boundary.

The strike in the immediate vicinity of the Lakefield anorthosite, as has been stated in speaking of that area, varies considerably.

North of the limits of the sheet, the strike of the foliation of the gneiss has been found to follow the windings of the boundary of the Morin anorthosite in a remarkable manner, making it evident that although the anorthosite breaks through the gneiss and cuts off the limestone bands in the latter, the foliation of the gneiss is not altogether an original structure, but is, in part at least, secondary, having been caused by the great pressure to which both rocks were subjected after the intrusion of the anorthosite, which has led to movements in the solid rocks.

ECONOMIC RESOURCES.

No mineral deposits of great value have as yet been found within this Laurentian area. The following, however, are worthy of note:—

Iron ore, St. Jérome.

Iron ore—Near St. Jérome, County of Terrebonne.—Two and a half miles south-west of St. Jérome, on the road which follows the northern bank of the river, there is a deposit of magnetic iron-ore. This occurs as several thin bands interstratified with a dark hornblendic rock and with the red orthoclase gneiss of this part of the area—the whole dipping toward the river at a very high angle. As seen in 1886, the ore was exposed by the removal of the drift deposits at a number of points along its strike, and a shallow opening had been made in it at one place. Subsequently, from October, 1891, until March, 1892, the deposit was worked by the Canada Iron Furnace Company; during which time about 365 tons of ore was taken out and shipped to the company's furnaces at Radnor and there smelted. The following information has been kindly supplied to me by Mr. Arthur Cole, B. A. Sc., who was engaged in carrying out the work:—

"Most of the ore was taken out of a pit which when abandoned was about thirty-five feet deep, ten feet broad and twelve feet long. The ore-bed varied from two and a half feet to three feet in width, and was for the most part free from gangue. At a depth of thirty-five feet, the bed had narrowed down to a few inches and was then entirely lost. A drift was driven from the west end of the pit along the bed for about forty feet. The floor of the drift was about fifteen feet from the surface. Work was then discontinued, but was resumed in August, 1892, but this time at a point about one hundred yards further west along the outcrop of the bed. The ore here was in beds varying from a foot to a foot and a half in width. These beds often widened, but they would separate into two beds with an intervening bed of rock. In some places the limits of the beds were very clearly defined, but elsewhere the ore-body gradually faded away into the surrounding rock. About fifty tons were taken out of this opening, which was about ten feet deep and thirty feet long. Work was finally discontinued early in September, as it was found that too much rock was being handled."

A sample of the ore was analysed by me and found to have the following composition:—

Analysis.

Ferric oxide	59·059 p. c.
Ferrous oxide	26·807 "
Titanic acid	None.
Phosphoric acid	·015 "
Sulphur	·001 "
Insoluble matter	9·897 "
Metallic iron	62·191 "
Phosphorus	·007 "
Sulphur	·001 "

The analysis brings out in an emphatic manner the distinction between the iron-ores of the orthoclase gneiss and those occurring in the anorthosite, the former being usually free from titanium, while the latter are rich in this deleterious constituent. This ore, although occurring so near the anorthosite, is quite free from titanium, while the iron-ores of the adjacent anorthosite areas always contain a large percentage of this element. To these belong the two following deposits.

Iron ore, Ste. Julienne.

Rawdon, Range II., Lot 2.—This deposit is situated near the village of Ste. Julienne, and although it has never been actually worked it has attracted a good deal of attention. It occurs in the Morin anorthosite near the eastern edge of the most easterly of the two larger developments of anorthosite shown in the accompanying sheet. The ore occurs in a foliated white-weathering variety of the anorthosite, rather rich in bisilicates and striking from N. 8° W. to N. 25° W. (magnetic) with a

nearly vertical dip. Several black diabase dykes occur in the vicinity. The ore varies a good deal in character, being much poorer in some places than in others, and often takes the form of bands from a few inches to several feet in width generally conformable, or nearly so, to the foliation of the anorthosite, but in a few cases cutting across it. Both the anorthosite and iron-ore are much twisted and faulted, and it is often difficult to determine whether the ore has been erupted through the anorthosite or whether the cases where it cuts across the anorthosite are to be attributed to faulting. It has, however, a general trend in the direction of the strike of the anorthosite, the principal mass being exposed for about 200 feet at right angles to this direction. The "ore" appears to be in reality a variety of the anorthosite, and in most places is too poor in iron to constitute an ore in the proper sense of the term. It is also highly titaniferous and contains iron-pyrites as a frequent constituent. Dr. Hoffmann found a specimen collected by me to contain :—

Metallic iron	42·29 p.c.	Highly titaniferous.
Titanic acid	Large amount.	

Two samples examined by Dr. B. J. Harrington,* gave the following results :—

	I.	II.
Metallic iron	38·27 p.c.	40·71 p.c.
Titanic acid	33·67 "	33·64 "

while a third specimen, in which the iron was not determined, was found to contain :—

Titanic acid	35·09 p.c.

Wexford, Range I, Lot 7.—On this lot a small opening has been made in a dark-coloured heavy massive rock containing a certain amount of iron-ore. The field relations indicate that this is merely a local variety of the Morin anorthosite, exceptionally rich in the darker-coloured constituents of the rock, and a microscopic examination proves this to be the case. When thin sections are examined, the rock is seen to be composed essentially of a dark-coloured pyroxene with plagioclase and iron-ore. A not inconsiderable amount of apatite with a few grains of pyrite, garnet and biotite are also present. The proportion of iron-ore present is comparatively small. A specimen collected to represent the richest portion of the mass was examined by Dr. Hoffmann, with the following results :— Iron ore, Wexford.

Metallic iron	20·27 per cent.
Insoluble residue	58·58 " "
Titanic acid	Decided reaction.

*Report of Progress, Geol. Surv. Can., 1876-77, p. 475.

Kilkenny, Range VII., Lot 7.—This deposit is an impure ochre or limonite, occurring near the edge of the Morin anorthosite, and apparently derived from the alteration of iron-pyrites which occurs as an impregnation in a band of anorthosite intercalated in the gneiss near the limits of the main area. The band of rock through which this limonite is distributed has a considerable width, but could not be everywhere examined at the time of my visit owing to a bush fire which was raging. No mass of the iron-ore over one foot in thickness could be found, however, and the deposit is, I should judge, valueless as a source of iron.

A specimen of the limonite was examined by Dr. Hoffmann, and was found to contain :—

Metallic iron.....	25·75 per cent.
Insoluble matter.....	Large amount.

It also contained a considerable quantity of manganese, but no titanium.

Anorthosite.

Anorthosite.—This rock, although it has been but little used for building purposes, might in many cases be employed with advantage for decorative construction. It may be obtained in unlimited amount in the Morin area, of any colour from deep violet to white. The opalescent varieties occur but sparingly in this district. To judge of its appearance when cut and polished, two large blocks, one of the violet and one of the white variety were collected and six-inch cubes were prepared from them. These were exhibited in the Colonial and Indian Exhibition held in London in 1886. The violet variety was collected on the eastern side of range II. of the township of Morin, and when polished presented a handsome appearance, but was rather dark in colour. The white variety, which was taken from the large exposures at New Glasgow, took a high polish and in this state was found to bear a striking resemblance to marble. It is more difficult to work than marble, but would be more durable and would retain its polish better, especially in exposed situations, and might well be employed for many purposes in construction.

On account of its toughness and durability, this white anorthosite from New Glasgow has been extensively used for paving stones in the city of Montreal, especially on streets where there is a heavy freight traffic. A number of small quarries have been opened in the vicinity of New Glasgow, while a larger one is operated about two miles to the north of the village. The stone is blasted out in large blocks and is then dressed to the required size by means of large hammers. The industry which has thus sprung up is quite extensive, up to the time of my last visit in August, 1891, 541,000 anorthosite paving blocks having been shippped to Montreal by rail.

APPENDIX

Preliminary Lists of the Organic Remains occurring in the various Geological Formations comprised in the South-west Quarter-sheet Map of the Eastern Townships of the Province of Quebec.

BY

HENRY M. AMI, M.A., D.Sc., F.G.S.

The following formations are included in this Appendix, in ascending order:—

Potsdam sandstone.
Calciferous formation.
Chazy formation.
Phillipsburg series (= Fort Cassin rocks).
Quebec City formation.
Trenton, including Black River.
Utica.
Lorraine.
Silurian, including Lower Helderberg and possibly older.
Devonian, including Cauda-galli Grit and Corniferous?

The fossil remains enumerated in this Appendix are grouped by localities under each formation, and under each locality, they are arranged in zoological order.

POTSDAM SANDSTONE.

I. Beauharnois, Que., County of Beauharnois (Geological Survey collection):—

1. Protichnites septemnotatus, Owen.
2. " octonotatus, Owen.
3. " latus, Owen.
4. " multinotatus, Owen.
5. " lineatus, Owen.
6. " alternans, Owen.

II. Ste. Anne, Jacques Cartier County, Que.; (Geological Survey collection):—

1. Scolithus Canadensis, Billings.

CALCIFEROUS FORMATION.

III. Ste. Anne, Jacques Cartier County, Que.; collectors, Logan, Richardson, M. Ramsay, Murray and Ami (Geological Survey collection):—

Hydroida:

1. Stromatocerium calciferum, Dawson.

Brachiopoda:

2. Lingula Irene, Billings.

Gasteropoda:

3. Pleurotomaria gregaria, Billings.
4. Murchisonia Anna, Billings.

Cephalopoda:

5. Orthoceras ordinatum, Billings.

Ostracoda:

6. Leperditia Anna, Jones.

IV. Ste. Anne, Jacques Cartier County, Que. (Dawson collection; Peter Redpath Museum of McGill University, Montreal):—

Brachiopoda:

1. Orthisina grandæva, Billings.

Gasteropoda:

2. Pleurotomaria Anna, Billings.
3. " Laurentina, Billings.
4. Murchisonia Anna, Billings.

Cephalopoda:

5. Orthoceras. (Several species.)

V. Beauharnois, Que., Chateaugnay County, and Norton's Creek, Beauharnois County, Que.; collector, Richardson, 1851 and 1853 (Geological Survey collection):—

1. Palæophycus tubularis, Hall.
2. " Beauharnoisensis, Billings.
3. Camerella calcifera, Billings.
4. Ecculiomphalus Atlanticus, Billings.
5. Ophileta complanata, Vanuxem (=Ophileta compacta, Salter).
6. Pleurotomaria calcifera, Billings.
7. Bathyurus conicus, Billings.

VI. Beauharnois, Que., Beauharnois County (Peter Redpath Museum collection):—

1. Ophileta complanata, Vanuxem (=O. compacta, Salter).

VII. Ormstown, quarry one mile west of village, Chateauguay County; collector, Mr. T. N. Walsh (Peter Redpath Museum):—

Brachiopoda:

1. Orthis sp.

Gasteropoda:

2. Ophileta complanata, Vanuxem.
3. " disjuncta, Hall.
4. Pleurotomaria, sp.
5. Murchisonia, sp.

Cephalopoda:

6. Lituites, sp.
7. Endoceras Becki (?), Billings.

VIII. St. Eustache, Two Mountains County, Que.; collectors, Murray and Richardson (Geological Survey collection):—

Brachiopoda:

1. Lingula Mantelli, Billings.

Cephalopoda:

2. Orthoceras Montrealense, Billings.

IX. Phillipsburgh, Que.; R. W. Ells, 1890 (in buff-weathering dolomite):—

Echinodermata:

1. Palæocystites sp., allied to P. tenuiradiatus, Hall.

Brachiopoda:

2. Orthis Minna, Billings.

Gasteropoda:

3. Subulites, sp.
4. Ophileta complanata, Vanuxem.
5. (?) Raphistoma proavium, Whitfield.
6. Murchisonia Anna (?), Billings.
7. " gracilens (?), Whitfield.
8. " (?) confusa, Whitfield.

Trilobita:

9. Amphion Salteri, Billings.
10. Cheirurus, sp. indt.

CHAZY FORMATION.

X. St. Dominique, Quebec; R. W. Ells, 1890 (from a dark gray semi-crystalline limestone, weathering yellowish brown—at times arenaceous):—

Echinodermata :

1. Crinoidal or cystidean fragments.

Zoophyta :

2. (?) Columnaria incerta, Billings.

Bryozoa (?) :

3. Solenopora compacta, Billings.
4. Branching monticuliporoid, not determined.

Brachiopoda :

5. Orthis acuminata, Billings.
6. Orthis Porcia (?), Billings. (In the arenaceous strata.)

Gasteropoda :

7. Obscure specimen, not determined.

Trilobita :

8. Ampyx Halli, Billings.
9. Asaphus canalis, Conrad.
10. Asaphus, *cf.* A platycephalus, Stokes. (= Isotelus gigas, deKay.)

XI. St. Dominique, Quebec; W. E. Deeks, 1891 :—

Hydrozoa :

1. (?) Strephochetus, sp.

Echinodermata :

2. Palæocystites tenuiradiatus, Hall.*
3. Crinoidal or cystidean fragments.

Bryozoa :

4. Branching monticuliporoidea.

Brachiopoda :

5. (?) Orthis pigra, Billings.
6. Orthis platys, Billings.
7. " costalis, Hall.
8. " sp. indt.

Gasteropoda :

9. Pleurotomaria, *cf.* P. Laurentina, Billings.
10. " (Raphistoma) Crevieri, Billings.
11. Raphistoma planistria, Hall.
12. " lenticulare (?), Sowerby.
13. Trochonema umbilicatum, Hall.
14. Ophileta, *cf.* O. complanata, Vanuxem.
15. Bucania, sp.

Also Bolboporites Americanus, Billings.

Pteropoda:

16. (??) Hyolithes, sp.

Trilobita:

17. Ampyx Halli, Billings.
18. Remopleurides, n. sp.
19. Bathyurus, sp.
20. Bathyurus, *cf.* B. Angelini, Billings.
21. " extans, Hall or allied species.
22. Asaphus canalis, Conrad.
23. Illænus globosus (?), Billings.
24. Amphion or Cheirurus, sp.

XII. St. Dominique, Quebec. List of species recorded by Mr. Billings in "Geology of Canada," p. 206, 1863.

Bryozoa:

1 Ptilodictya fenestrata (MS?).

Brachiopoda:

2. Strophomena alternata, Conrad.
3. Orthis platys, Billings.
4. " borealis, Billings.

Pelecypoda:

5. Vanuxemia Montrealensis, Billings.

Gasteropoda:

6. Pleurotomaria Crevieri, Billings.

Trilobita:

7. Ampyx Halli, Billings.

XIII. St. Dominique, Quebec; T. C. Weston, 1879, and James Richardson, date not given:—

Echinodermata?

1. Bolboporites Americanus, Billings.

Brachiopoda:

2. Orthis platys, Billings.
3. " (Hebertella) borealis, Billings.

Gasteropoda:

4. Pleurotomaria (Raphistoma) Crevieri, Billings.

Trilobita:

5. Ampyx Halli, Billings.
6. Asaphus marginalis (?), Hall. (?=A. canalis, Conrad).

XIV. Two miles south of Abbotsford, Papineau Range Road, Abbotsford, Quebec; W. E. Deeks, 23rd June, 1891:

Zoophyta :

1. Streptelasma (?), sp.

Echinodermata :

2. Blastoidocrinus carchariædens, Billings.
3. Bolboporites Americanus, Billings.
4. Crinoidal or cystidean fragments, not determined.

Bryozoa :

5. Stictopora glomerata, Hall. A form resembling that figured by Hall in vol. i., Pal. N.Y., 1847, from the Chazy limestone.

Brachiopoda :

6. Leptæna, fasciata, Hall. Probably a Rafinesquina.
7. Orthis (Hebertella) borealis, Billings.
8. " or Zygospira sp., too imperfect for determination.

Gasteropoda :

9. Metoptoma Montrealensis, Billings.
10. Raphistoma planistria, Hall.
11. Pleurotomaria calyx, Billings.
12. Maclurea, sp.

Trilobita :

13. Asaphus canalis, Conrad.
14. Harpes or Trinucleus sp., shewing sculptured outer margin of cephalic shield.

XV. Grande Ligne Quarries, Que. ; W. E. Deeks, 27th June, 1891.

Hydrozoa :

1. Stromatocerium or Cryptozoon, sp.

Echinodermata :

2. Blastoidocrinus carchariædens, Billings.
3. Palæocystites tenuiradiatus, Hall.
4. " sp.
5. Cystidean fragments, undetermined.

Bryozoa :

6. Stictopora, sp., *cf.* S. glomerata, Hall.
7. Amplexopora (?), sp., or other genus of branching monticuliporoid.
8. Dicranopora, sp.
9. Solenopora or Cryptozoon, sp.

Brachiopoda :

10. Leptæna, sp.
11. Orthis (Hebertella) borealis, Billings.
12. " platys (?), Billings.
13. " Porcia, Billings.
14. " probably O. (Dalmanella) perveta, Conrad.

15. Rhynchonella plena, Hall.
16. Atrypa (?Zygospira) acutirostra, Hall,
17. Triplesia, sp.

Gasteropoda :

18. Metoptoma, sp.
19. Pleurotomaria calyx, as of Billings.
20. Raphistoma planistria, Hall.

Pteropoda :

21. (?) Hyolithes, sp.

Cephalopoda :

22. Endoceras velox, (=Orthoceras velox, Billings.
23. Orthoceras bilineatum, Hall.

Trilobita :

24. Bathyurus spiniger, Billings.
25. Asaphus canalis, Conrad.
26. Illænus arcturus, Hall.
27. " globosus, Billings.
28. " Bayfieldi, Billings.

Ostracoda :

29. Leperditia Canadensis, v. nana, Jones.

XVI. Island of Montreal, Que.; Thos. Curry, 1888. (Specimens sent to the Geological Survey Dept. for identification—the property of the Peter Redpath Museum of McGill College, Montreal):—

Echinodermata :

1. Malocystites Murchisoni, Billings.
2. " sp.
3. Palæocystites tenuiradiatus, Hall.

XVII. Bord à Plouffe, Que.; W. E. Deeks, 6th July, 1891.

Bryozoa :

1. Intricaria, sp.
2. Branching Monticuliporoids.

Brachiopoda :

3. Orthis (Hebertella) borealis, Billings.
4. " platys, Billings.
5. " Porcia, Billings.
6. " sp.
7. (?) Rafinesquina alternata, (=Strophomena alternata, Conrad *et auct.*
8. Orthis or Strophomena, sp. indt. Too imperfect for identification.

Trilobita :

9. Remopleurides sp.
10. Asaphus, sp., portion of cephalic shield.

Ostracoda :

11. Leperditia, sp., a rather large form for the Chazy formation.

XVIII. St. Martin Junction, Que.; W. E. Deeks, 7th March, 1891 :—

Echinodermata :

1. Blastoidocrinus carchariædens, Billings.
2. Malocystites Murchisoni, Billings.
3. Palæocystites tenuiradiatus, Hall.

Bryozoa :

4. Callopora or Calloporella sp. Bryozoary, consisting of two kinds of zoœcia, one, larger and regularly disposed in rows ; the other, minute mesopores filling intervening spaces.
5. Dicranopora (?), sp.
6. Stictopora glomerata (?), Hall.
7. Frondescent forms of monticuliporoidea.
8. Ramose or branching monticuliporoidea.

Brachiopoda :

9. Lingula, sp. *cf.* L. Huronensis, Billings.
10. Orthis (Hebertella) borealis, Billings.
11. " platys, Billings.
12. " disparilis, Billings.
13. Rafinesquina fasciata or alternata. Same form occurs in the Chazy of L'Orignal, Ont.
14. Rhynchonella plena, Hall.

Gasteropoda :

15. Raphistoma planistria, Hall.

Trilobita :

16. Remopleurides (?) sp.
17. Bathyurus, sp., *cf.* B. Angelini, Billings.
18. Asaphus, sp., fragments of head shield and pleuræ of axis and thorax.
19. Illænus, *cf.* I. globosus, Billings.
20. " sp. indt.
21. Cheirurus, sp. indt.
22. Lichas (?) sp.
23. Harpes, sp.

XIX. Joliette, Que. The following species were collected by N. J. Giroux in 1891, close to the bridge over L'Assomption River, near the Canadian Pacific railway station.

Echinodermata :

1. Palæocystites tenuiradiatus, Hall.

Bryozoa:

2. Monticuliporoidea; requiring microscopic sections before identification.

Brachiopoda:

3. Lingula, sp. indt.
4. Orthis (Hebertella) borealis, Billings.

Gasteropoda:

5. Pleurotomaria Crevieri (?), Billings.
6. Raphistoma planistria, v. parvum, Hall.
7. (?) Bucania sulcatina, Emmons.

Cephalopoda:

8. Orthoceras (?), sp. indt.

XX. Joliette, Que. "Industry Village" of "Geology of Canada," 1863, p. 133.

Gasteropoda:

1. "Pleurotomaria staminea, Hall.
(= Raphistoma stamineum, Hall.)

XXI. Island of Montreal, Hochelaga County, Que.; collectors, Logan, Billings, Richardson and Bell (Geological Survey collection):—

Hydroida:

1. Stromatocerium rugosum, Hall.

Cystoidea and Blastoides:—

2. Malocystites Murchisoni, Billings.
3. " Barrandei, Billings.
4. Blastoidocrinus carchariædens, Billings.
5. Palæocystites tenuiradiatus, Hall.
6. Glyptocystites Forbesi, Billings.
7. Bolboporites Americanus, Billings. This is probably a portion of the interior of one of the cystoidea so prevalent in these rocks.

Crinoidea:

8. Crinoidal columns.

Bryozoa:

9. Monotrypella undulata, Nicholson.
10. Stenopora patula, Billings.

Brachiopoda:

11. Lingula Belli, Billings.
12. Rafinesquina alternata, (Conrad).
13. Orthis (Dalmanella) perveta, Conrad.
14. " " subæquata, Conrad.
15. " " gibbosa, Billings.

16. Orthis Porcia, Billings.
17. " disparilis, Billings.
18. Rhynchonella plena, Hall.

Pelecypoda ;

19. Vanuxemia Montrealensis, Billings.

Gasteropoda :

20. Metoptoma Montrealensis, Billings.
21. Pleurotomaria immatura, Billings.
22. " calyx, Billings.

Vermes :

23. Serpulites splendens, Billings.

Trilobita :

24. Sphærexochus parvus, Billings.

XXII. Island of Montreal, Que.; outcrops of the Chazy formation. Peter Redpath Museum collection :—

Cystoidea :

1. Bolboporites Americanus, Billings.
2. Palæocystites, sp.
3. Palæocystites tenuiradiatus, Hall.
4. Malocystites Murchisoni, Billings.

Blastoidea:

5. Blastoidocrinus carchariædens, Billings.

Crinoidea ;

6. Rhodocrinus asperatus, Billings.

Bryozoa :

7. Phylloporina aspera, Hall.
8. Monticulipora (?), sp.

Brachiopoda:

9. Orthis platys, Billings.
10. " (Hebertella) imperator, Billings.
11. " (Dalmanella) perveta, Conrad.
12. Rhynchonella plena, Hall.

Gasteropoda :

13. Pleurotomaria, sp.

Trilobita :

14. Sphærexochus parvus, Billings.

XXIII. Caughnawaga, Laprairie County, Que.; Peter Redpath Museum collection :—

Echinodermata :

1. Crinoidal or cystidean fragments.
2. Blastoidocrinus carchariædens, Billings.
3. Bolboporites Americanus, Billings.

Gasteropoda :

4. Raphistoma stamineum, Hall.

XXIV. Caughnawaga, Laprairie County, Que. ; collectors, Logan, Billings and Richardson (Geological Survey collection) :—

Cystoidea :

1. Glyptocystites Forbesi, Billings.

Brachiopoda :

2. Orthis acuminata, Billings.

PHILLIPSBURG SERIES.

XXV. Road between Phillipsburg and St. Armand, County of Missisquoi, Que. ; collected by R. W. Ells, J. F. Whiteaves and W. E. Deeks, 1890 :—

Echinodermata :

1. Crinoidal or cystidean fragments.

Brachiopoda :

2. Lingula, sp. indt.
3. Orbiculoidea, sp. nov. (?)
4. Orthis (?) Armanda, Billings.
5. Orthis Electra, Billings.
6. " Minna, Billings.
7. Hemipronites (?), sp. indt.
8. Triplesia lateralis, Whitfield.
9. " calcifera (?), Billings.

Gasteropoda :

10. Pleurotomaria Missisquoi, Billings.
11. " sp. nov. (?), non. P. Hortensia, Bill., nor P. Hortensia, Billings, as of Whitfield, but closely related.
12. " difficilis, Whitfield.
13. " Beekmanensis, Whitfield.
14. " sp. with alation along the outer edge of the body volution.
15. " sp. allied to P. Missisquoi, Billings.
16. Murchisonia, sp., *cf.* M. Vesta, Billings.
17. " Missisquoi, Billings.
18. Bellerophon Palinurus, Billings.
19. Lophospira Cassina, Whitfield.
20. " (?) sp. indt.
21. Holopea Cassina, Whitfield.
22. " arenaria (?), Billings.

23. Holopea, sp. indt.
24. Euomphalus circumliratus, Whitfield.
25. " sp., *cf.* E. calciferus, Whitfield.
26. Ophileta complanata, Vanuxem.
27. Ecculiomphalus volutatus, Whitfield.
28. Raphistoma stamineum, Hall (? = Pleurotomaria docens or calyx, Bill.
29. " sp. indt., No. 1.
30. " sp. indt., No. 2.
31. Maclurea ponderosa, Billings.
32. " sp.
33. Subulites obesus, Whitfield.
34. (?) Calaurops lituiformis, Whitfield.

Cephalopoda:

35. Endoceras, sp. nov. (?)
36. Orthoceras Missisquoi, Billings.
37. " Brainerdi, Whitfield.
38. " explorator, Billings.
39. " Cataline (?), Billings.
40. " Lamarcki, Billings.
41. " bilineatum, Hall (as of Whitfield).
42. Litoceras, sp., *cf.* L. Whiteavesi, Hyatt, (= Nautilus versutus, pars. Billings.
43. " sp.
44. Nautilus (?) sp. A large form. Exact generic relation not definitely ascertained.
45. Schroederoceras Eatoni, Whitfield.
46. " " var. Cassinensis, Whitfield.
47. Eurystomites Kelloggi, Whitfield.
48. " sp. indt.

Trilobita:

49. Agnostus Galba, Billings or a nearly related species.
50. Remopleurides affinis, Billings.
51. Bathyurus Saffordi, Billings (abundant).
52. " sp., probably a new species, closely related to B. marginatus, Billings.
53. " conicus, Billings. (Not the Bathyurus conicus of Whitfield.)
54. " sp., *cf.* B. Cordai, Billings.
55. " sp., with a long and fairly stout terminal spine at the extremity of the caudal shield; a much larger species than B. caudatus.
56. Bathyurellus expansus, Billings.
57. " glandicephalus, Whitfield.

58. Asaphus canalis, Conrad.
59. Illænus simulator, Billings.
60. " sp. Too imperfect for identification.
61. Cheirurus, sp.
62. Lichas, sp., *cf.* L. Champlainenense, Whitfield.

Ostracoda :

63. Leperditia, sp. indt.

XXVI. Boundary line, lot 122, east of St. Armand P. O., 150 yards west of road to mill, Missisquoi Co.; Que. Collectors: R. W. Ells and W. E. Deeks, 1891.

1. (?) Solenopora compacta, or Girvanella, sp.

Echinodermata :

2. Crinoidal fragments.

Brachiopoda :

3. Orthis, sp. indt.
4. " sp. with acutely rostrate umbo.
5. " sp. No. 3, not determinable.
6. Strophomenoid shell, with thread-like striæ at the beak which widen out anteriorly into coarse angular costæ.
7. Triplesia, sp.

Gasteropoda :

8. Pleurotomaria, sp. indt.
9. Ophileta, sp., *cf.* O. complanata, Vanuxem.
10. " sp.
11. Raphistoma or Trochonema, sp.

Cephalopoda :

12. Orthoceras Missisquoi vel O. furtivum, Billings.

Trilobita :

13. Dolichometopus (?) sp.
14. Bathyurus, sp., probably a new species.
15. " Saffordi, Billings.
16. Asaphus canalis, Conrad, or a very closely related species.
17. Cheirurus or Amphion, sp.

Ostracoda :

18. Leperditia, sp.

XXVII. Bedford, Que., lot 20, range VI., tp. of Stanbridge, Que. J. F. Whiteaves, 1878.

Brachiopoda :

1. Lingula, sp., probably a new species.
2. Orbiculoidea, n. sp.
3. Orthis Minna, Billings.

Gasteropoda :

4. Bellerophon Palinurus, Billings.
5. Maclurea ponderosa, Billings.

Trilobita :

6. Agnostus Galba (?), Billings.
7. Remopleurides affinis, Billings.
8. Bathyurus Saffordi, Billings.
9. " breviceps (?), Billings.
10. Bathyurellus expansus, Billings.
11. Illænus simulator, Billings.

Ostracoda :

12. Leperditia, n. sp.

NOTE.—There are also fragments of what appear to be a Cheirurus or Amphion and a cast of the larger or body volution of a large gasteropod probably a Holopea or Pleurotomaria.

XXVIII. Phillipsburg, Que.; Billings, &c. (Geological Survey collections.)

The following species were described by Mr. Billings from the Phillipsburg limestones as follows :—

Echinodermata :

1. Palæocystites tenuiradiatus, Hall. Pal. Foss., vol. I., p. 63.

Brachiopoda :

2. Orthis (?) Armanda, Billings, ibid., p. 303.

Gasteropoda :

3. Pleurotomaria Postumia, Billings, ibid., p. 91.
4. Murchisonia Hyale, Billings, ibid., p. 33.
5. Pleurotomaria Missisquoi, Billings, ibid., p. 191.
6. Ophileta abdita, Billings, ibid., p. 189.
7. Maclurea ponderosa, Billings, ibid., p. 239.
8. Metoptoma Niobe, Billings, ibid., p. 37.

Cephalopoda :

9. Nautilus Pomponius, Billings, ibid., p. 26.
10. Cyrtoceras Aristides, Billings, ibid., p. 316.
11. Orthoceras repens, Billings, ibid., p. 312.
12. " Catulus, Billings, p. 313.
13. " Missisquoi, Billings, p. 314.
14. " Cato, Billings, p. 315.
15. " Cataline, Billings, p. 315.
16. " Sayi, Billings, p. 315.
17. " Tityrus, Billings, p. 316.

Trilobita :

18. Dikelocephalus Missisquoi, Billings, p. 199.

Besides the above Phillipsburg fossils recorded by Billings, Prof. Whitfield also records the occurrence of Cryptozoon Steeli, Brainerd and Seely, in Bull. Am. Mus. N. Hist., vol. III., No. 1, p. 6, 1890.

XXIX. One mile and a half east of Phillipsburg, Que.; purchased from George Hogle, Esq., 1890.

Brachiopoda :

1. Orthis, sp. indt.

Gasteropoda :

2. Pleurotomaria, sp.

Cephalopoda :

3. Orthoceras, *cf.* O. furtivum, Billings.
4. " sp.
5. " sp., *cf.* O. Tityrus, Billings.

Trilobita :

6. Bathyurus, sp., *cf.* B. Saffordi, Billings.

XXX. Lot 22, Con. VI., Stanbridge, Que.; R. W. Ells, 1890.

Echinodermata :

1. Crinoidal fragments.

Brachiopoda :

2. Lingulella, sp. nov.
3. Discina, sp. nov.
4. Orthis Corinna, Billings.
5. " Armanda, Billings.
6. " cf. O. Minna, Billings.
7. " sp. nov.
8. " sp. indt.
9. Leptella decipiens (?), Billings.
10. " sp.
11. Strophomena Aurora (?), Billings.
12. " sp. nov. With prominent thread-like radiating lines, between which can be seen numerous and concentrically arranged wrinkles or rugæ resembling those of *Strophomena (Leptagonia) rhomboidalis*, Wilckens, and *Strophomena Stephani*, Barrande.

13. Porambonites, sp. nov., or other rhynchonelloid brachiopod, whose affinities are not as yet ascertained.

Gasteropoda :

14. Pleurotomaria, sp.
15. Clisospira curiosa, Billings.

Cephalopoda :

16. Orthoceras Missisquoi, Billings.
17. " sp.

Cirripedia :

18. Turrilepas, sp. nov. No. 1. Opercular valve of a species of Turrilepas with coarsely-marked raised or prominent concentric lines of sculpture when seen under a magnifying lens.

19. Turrilepas, sp. nov. No. 2. Opercular valve marked by very fine, closely-arranged, concentric lines. Both species (18) and (19), Nos. 1 and 2 of this collection—are distinct from Turrilepas Canadensis, Woodward, described by Dr. Henry Woodward* from the Utica of Ottawa, Canada.

Trilobita :

20. Agnostus, sp. nov.
21. " Galba, Billings, or n. sp.
22. (?) Dikelocephalus, sp. (pygidia).
23. (?) Dolichometopus, sp.
24. Remopleurides affinis, Billings.
25. Bathyurus Saffordi, Billings.
26. " Nero (?), Billings, or a very closely related form.
27. " sp.
28. Bathyurellus expansus, Billings.
29. " validus (?). Billings.
30. Asaphus Huttoni (?), Billings.
31. " canalis (?), Conrad
32. Ullænus consimilis, Billings.
33. " arcuatus, Billings.
34. " incertus, Billings.
35. " simulator, Billings.
36. " tumidifrons (?), Billings.
37. Cheirurus prolificus, Billings.
38. " Vulcanus (?), Billings.
39. " sp.
40. Lichas Jukesii, Billings.
41. Harpides desertus, Billings.
42. Harpes Granti, Billings.

XXXI. Lot 22, Con. VI., Stanbridge, Que. Collection made by R. W. Ells, J. F. Whiteaves, and W. E. Deeks, in 1891.

The following additional species to list from preceding locality were noted :—

Bryozoa :

1. Zoarium somewhat resembling that of *Intricaria.*

*Geol. Mag., vol. VI., p. 271, London, 1889.

Gasteropoda (?) :

2. Clisospira curiosa, Billings.

XXXII. One mile south of Bedford, Que., R. W. Ells, 1890.

Gasteropoda :

1. Maclurea ponderosa, Billings.

XXXIII. Stanbridge, Que., J. F. Whiteaves, 1890.

Gasteropoda :

1. Pleurotomaria, sp.
2. Maclurea ponderosa, Billings.

Trilobita :

3. Bolbocephalus (?), sp. indt.

XXXIV. Three-eighths of a mile north of Mystic Station, C.P.R., Stanbridge, Que., R. W. Ells and W. E. Deeks, 1890.

Brachiopoda :

1. Leptæna (Plectambonites), sp.
2. Orthis (?), Armanda, Billings.
3. Orthis Minna, Billings.
4. " sp. indt., No. 1.
5. " " No. 2.

Gasteropoda :

6. Maclurea ponderosa, Billings.

Cephalopoda :

7. Orthoceras sp. Annulations distinct, showing transverse lines of growth developed and preserved on the test of the shell.

Trilobita :

8. (?) Remopleurides, sp.
9. Asaphus, sp., *cf.* A. canalis, Conrad.
10. Illænus, sp., *cf.* I. fraternus, Billings.
11. " tumidifrons, Billings.
12. " sp. indt.
13. Cheirurus Polydorus? Billings.
14. " (?) sp. indt.

XXXV. Between Bedford and Farnham, Que. (Mystic station), Dr. R. W. Ells, 1890.

Brachiopoda :

1. Trematis or Lingula, sp. indt.
2. (?) Acrotreta, sp. indt.
3. Eichwaldia, sp.
4. Skenidium (?) sp.

5. Orthis apicalis, Billings.
6. Triplesia radiata, Whitfield.

Pteropoda :

7. Conularia plana, Whitfield. Or a closely related species.

Cephalopoda :

8. Cyrtoceras, sp.
9. Orthoceras, sp.

Trilobita :

10. Bathyurus, sp.
11. " Cordai, Billings.
12. " Saffordi, Billings.
13. Æglina, sp.
14. Amphion Westoni, Billings.
15. " or Cheirurus, sp.
16. Proëtus micropyge ? Corda. Or a closely related and new species.

Ostracoda :

17. Primitia cristata ? Whitfield.

XXXVI. One mile and a quarter east of Phillipsburg, north of the road to St. Armand, Que. Dr. Ells, Mr. J. F. Whiteaves, and Mr. W. E. Deeks, August 11th, 12th, 13th and 14th, 1890.

Hydrozoa :

1. Stromatocerium or Cryptozoon, sp.

Brachiopoda :

2. Leptæna ? sp. indt.
3. Orthis, sp., *cf.* O. Minna, Billings.
4. " Corinna, Billings.
5. " Armanda, Billings.
6. " Electra, Billings. (= Dalmanella Electra.)
7. " n. sp.
8. (?) sp. indt.
9. Triplesia calcifera, Billings.
10. " radiata, Whitfield.
11. " sp.

Gasteropoda :

12. Pleurotomaria Missisquoi, Billings.
13. " vagrans ? Billings.
14. " *cf.* P. difficilis, Whitfield.
15. " Beekmanensis, Whitfield.
(? = P. Calcifera, Billings.)
16. Murchisonia, sp. No. 1.
17. " sp. No. 2.

18. Helicotoma, sp.
19. Bellerophon, sp.
20. Tryblidium pileolum, Whitfield.
21. Platyceras acutum, Whitfield.
(=Tryblidium acutum, Whitfield.)
22. Ecculiomphalus (Phanerotinus) intortus, Billings.
23. " sp. indt.
24. Ophileta bella, Billings. (Euomphalus proper).
25. Calaurops lituiformis, Whitfield.
26. Fusispira, sp. indt.

Cephalopoda:

27. Orthoceras, sp., *cf.* O. bilineatum, Hall, also O. Cataline, Bill., Fig. 5, Bull. Am. Mus., N.H., vol. III., pl. 2.
28. Orthoceras, n. sp.
29. " sp.
30. " Lamarcki, Billings, or a closely related species.
31. " Cataline, Billings.
32. " furtivum (?), Billings.
33. Cyrtoceras, sp., *cf.* C. Raei, Whitfield.
34. " Kirbyi (?), Whitfield.
35. " (?), sp.
36. Gyroceras, sp., No. 1.
37. " (?) sp., No. 2.
38. Lituites Farnsworthi, Billings.

Trilobita:

39. Asaphus canalis, Conrad.
40. " sp.
41. Nileus, sp. indt.
42. Bathyurus Saffordi, Billings.
43. Bathyurellus expansus (?) Billings.
44. Bolbocephalus Seelyi, Whitfield.
45. Illænus, sp.
46. Cheirurus, sp.

XXXVII. Lot 21, range VI., Stanbridge, Quebec; Ells and Deeks, 1890.

Hydrozoa:

1. Hyalostelia (?) sp. Rod-like spicule (?) of a palæozoic sponge related to this genus, if not the same.

2. Cryptozoon, sp., *cf.* C. Steeli, Brainerd and Seely (n. sp.)—Bull. Am. Mus. Nat. Hist., vol. II.

Brachiopoda :

3. Leptæna (Plectambonites) sp.; a large form.
4. Orthis Evadne (?), Billings.
5. " sp. indt.
6. " sp. No. 1.
7. " sp. No. 2.
8. Triplesia radiata, Whitfield.
9. " calcifera, Billings.
10. " *cf.* T. lateralis, Whitfield.

Gasteropoda :

11. Pleurotomaria (?) sp., not sufficiently well preserved to ascertain definitely.

Trilobita :

12. Bathyurus Saffordi, Billings.
13. " sp., *cf.* B. quadratus, Billings.
14. " sp.
15. Illænus, sp.

XXXVIII. Stanbridge, Que., probably lot 20, range VI.; described and recorded by E. Billings in "Palæozoic Fossils," vol. i, pp. 301–335.

Brachiopoda :

1. Orthis Corinna, p. 302.
2. " Minna, p. 303.
3. Camerella breviplicata, p. 304.
4. " polita, p. 305.
5. " (?) costata, p. 305.

Gasteropoda :

6. Murchisonia Missisquoi, p. 307.
7. Bellerophon Palinurus, p. 311.
8. Ophileta bella, p. 310.

Trilobita :

9. Asaphus (?) curiosus, p. 318.
10. Bathyurellus expansus, p. 318.
11. Amphion Westoni, p. 321.
12. " convexus, p. 323.
13. Cheirurus Glaucus, p. 323.
14. " Vulcanus, p. 324.
15. " prolificus, p. 325.
16. Remopleurides affinis, p. 325.
17. Illænus simulator, p. 327.
18. Harpes Granti, p. 326.

19. Illænus incertus, p. 332.
20. Lichas Jukesii, p. 335.

QUEBEC (CITY) FORMATION.

XXXIX. Lot 19, range II., Stanstead, Que. Collected by H. M. Ami and R. W. Ells, 1886, in a cutting on the main road, on the eastern side of Lake Memphremagog, about 100 yards north of the entrance to the grounds and residence of the late Sir Hugh Allan. Determined by Dr. Charles Lapworth.

Graptolitoidea:

1. Diplograptus foliaceus, Murchison (=Diplograptus pristis, Hall.)
2. Dicellograptus, sp., allied to D. Forchammeri, Geinitz.
3. " divaricatus, Hall.
4. Climacograptus perexcavatus, Lapworth.
5. Corynoides calycularis, Nicholson.
6. Dicranograptus sp. (?).

XL. Lot 7, range XV., Magog, Que. Collected by H. M. Ami and R. W. Ells, 1886, about 150 yards south of the forks of the road along the west side of Lake Memphremagog. Determined by Dr. Charles Lapworth.

Graptolitoidea:

1. Dicranograptus ramosus, Hall.
2. Diplograptus angustifolius, Hall.
3. " foliaceus, Murchison.
4. " perexcavatus, Lapworth.
5. Climacograptus bicornis, Hall.
6. " cœlatus, Lapworth.

XLI. Castle Brook, Willard's Mill, lot 5, range XV., township of Magog, Que. Collections made here by Dr. R. W. Ells and W. E Deeks, 1890, and by H. M. Ami assisted by H. B. Cushing, 1894.

1. Leptograptus, sp. indt.
2. Dicellograptus, probably n. sp.
3. Dicranograptus ramosus, Hall.
4. Climacograptus bicornis, Hall.
5. " " var. scalaris.
6. " n. sp.
7. Diplograptus foliaceus, Murchison.
8. " angustifolius, Lapw.
9. Glossograptus ciliatus, Emmons.
10. Corynoides, sp.

XLII. Bolton. A small collection—marked "loose"—probably from lot 6, range XIII. of Bolton, west side of Lake Memphremagog, Que.

1. Climacograptus bicornis, Hall.
2. Diplograptus foliaceus, Murchison.
3. " angustifolius, Lapw.

XLIII. Drummondville, Que. Collected by a member of the Geological Survey Staff, 1863. In a rusty weathering indurated graptolitic shale.

1. Leptograptus, sp.
2. Dicellograptus sextans, Hall.
3. Climacograptus, sp., *cf.* C. bicornis, Hall.
" " " var. scalaris.
4. (?) Dendrograptus simplex, Walcott.
5. Leptobolus, sp., or a closely related genus of small brachiopod, too imperfectly preserved and irregularly compressed to be identified with certainty.

XLIV. Farnham Centre, Lot 26, Range I, Que. ; T. C. Weston, 1872. In a dark blue indurated limestone, weathering brown.

1. Obscure specimen of what appears to be *Bolboporites Americanus*, Billings.

Bryozoa :

2. Pachydictya, sp. A diminutive form of the genus.

Brachiopoda :

3. Lingula, sp., *cf.* L. Iole, Billings, or allied species. This form may eventually prove to be a *Schizambon*.
4. Small Orthis-like or leptænoid shell, with two distinct kinds of longitudinal costæ. Fifteen (15) larger radiating costæ from the beak to the outer margin, and smaller and more numerous costæ between these larger ones—usually four in number between two of the larger costæ counted along the outer margin. Genus and species not determined. A diminutive form allied to Leptæna.
5. Orthis, sp., resembling O. delicatula, Billings.

Trilobita :

6. Ampyx Halli, Billings. Very small form. Cephalon, ·5 mm. in breadth, and ·85 mm. in length.

XLV. Farnham, Que., Lot 26, Range I. ; J. Richardson, 1861. In a dark blue indurated brown weathering limestone.

Brachiopoda:

1. Obolelloid shell. Generic relations obscure.

2. Leptæna, sp. A smooth variety which resembles L. sordida, Billings, and L. lævissima, McCoy, in "Synopsis of Silurian fossils of Ireland," p. 27, pl. iii, fig. 7, 1846. A. Leptella.

3. Leptæna, sp., *cf. Orthis quinquecostata*, McCoy, p. 33, pl. iii, fig. 8 of "Synopsis of the Silurian fossils of Ireland," McCoy, 1846, and subsequently described as Leptæna quinquecostata, McCoy. Length of hinge line in Farnham specimen = 1·25 mm. Possibly Leptella.

4. Leptæna, sp. Probably a Plectambonites, like P. sericea, (Sowerby).

5. Strophomena, sp., resembles very closely "*Orthis undulata*, McCoy" in his "Synopsis of the Silurian fossils of Ireland," p. 36, pl. iii, fig. 22, 1846.

6. Strophomena, *cf.* S. Aurora, Billings, but much smaller, apparently a diminutive form with coarse and fine striæ alternating.

7. Orthis, sp. *cf.* O. Electra, Billings. With rather strong radiating costæ. This form appears to be a true Dalmanella.

8. Orthis, *cf.* O. delicatula, Billings.

9. " sp., indt.

10. Rhynchonella or Camerella (Triplesia). Too imperfect for identification.

Cirripedia:

11. Turrilepas (?), sp.

Trilobita

12. Triarthrus, sp.; *cf.* T. Fischeri, Billings, or T. Angelini, Linnarsson.

13. Ampyx Halli, Billings.

14. Asaphus- or Illænus-like fragments, too imperfect for determination.

15. Lichas (?), sp. An obscure portion of the cephalic shield of a trilobite resembling this genus.

16. Dalmanites, sp., of the type of Dalmanites callicephalus, Green.

Ostracoda:

17. Leperditia, or Beyrichia, sp.

XLVI. Lot 41, ranges V. and VI., West Farnham, Que.; T. C. Weston, 1876. (Two collections, *A* and *B*).

A—In light-coloured rock and shales.

Gasteropoda:

1. Cast of the interior of a gasteropod, probably a Pleurotomaria or Holopea.

2. Ophileta (?) bella, Billings. Referable to the genus Euomphalus.
3. Lophospira (?), sp. indt. Portion of the last or body volution of a large gasteropod, *cf.* Lophospira Cassina, Whitfield.
4. Maclurea, sp.

Trilobita:

5. Illænus or Asaphus, sp. Too imperfect for identification.

B—In black rusty-weathering shales.

Echinodermata:

1. Crinoidal or cystidean fragments.

Brachiopoda:

2. Leptæna (?), sp. indt.
3. Orthis, sp. Too fragmentary for identification.

Trilobita:

4. Bathyurus, sp. A very diminutive form.

XLVII. Lot 41, Range V., Farnham, Que.; J. Richardson, 1861. In a compact, light-coloured limestone, made up of small irregularly-rounded pellets showing oolitic structure.

Gasteropoda:

1. Bucania, sp. Probably a new species. Not Bellerophon Palinrus. Umbilicus open with fairly sharp keel on back.
2. Maclurea, sp., *cf.* M. ponderosa, Billings. A very small but tolerably perfect cast of a species of Maclurea, in characters and proportions agreeing with M. ponderosa, Billings.

XLVIII. Lot 32, range III., Farnham, Que.; J. Richardson, 1861. Farnham Centre, Que.; T. C. Weston, 1872. In black, rusty, weathering and wrinkled shale.

Graptolitoidea:

1. Fragments of graptolite, genus and species undeterminable showing the hydrothecæ only on one side of the polypary. There are visible some sixty (60) hydrothecæ in the space of five (5) centimetres—two and two-thirds ($2\frac{2}{3}$) inches. The shale resembles that of Castle Brook, Lake Memphremagog.

XLIX. Road, Farnham Centre to Cowansville, $2\frac{1}{2}$ miles west of Cowansville, lot 26, range VI., Dunham, Que.; R. W. Ells, 1890. In a very coarse and hard bluish-gray limestone.

Echinodermata:

1. Crinoidal or cystidean fragments.

Brachiopoda ·

2. Leptæna (Plectambonites) sp. Fragment.

3. Orthis, type of Dalmanella testudinaria Dalman. A very small and diminutive form.

Trilobit · :

4. Asaphus or fragment of asaphoid trilobite.

5. Illænus, sp., pygidium, not unlike the pygidium of Illænus Bayfieldi, Billings. Note—Also an obscure bryozoary allied to *Ptilodictya*.

L. Allan's Corners, Que.; R. W. Ells, 1890.

Echinodermata :

1. Crinoidal fragments similar to those found in preceding locality (lot 26, R. VI., Dunham, Que.).

Bryozoa :

2. Ptilodictya, sp., or allied genus.

Brachiopoda :

3. Leptæna (Plectambonites) sp. like P. sericea, Sowerby.

4. Leptæna decipiens, Billings. (= Leptella decipiens, Hall).

5. Orthis (Dalmanella) testudinaria, Dalman.

6. Triplesia, sp., *cf.* T. calcifera, Billings. A small and diminutive variety of the above.

Trilobita :

7. Asaphus, sp.

8. Dalmanites, sp.

LI. Lot 26, range I., East Farnham, Que.; Geological Survey collection.

The following notes were prepared by the late Mr. E. Billings.

"The fossils of the Farnham limestones are for the most part in a fragmentary condition, and not determinable specifically. The following genera have, however, been recognized :—

"1. *Graptolithus.* A species closely resembling G. bryonoides of the Lévis.

"2. *Ptilodictya*, like *P. acuta* of the Trenton. This genus is unknown below the Chazy.

"3. *Stenopora.* This genus ranges from the Lévis upwards.

"4. *Orthis.* Ranges from the Menevian upwards.

"5. *Leptæna.* One species, L. decipiens, occurs in the Lévis.

"6. *Ampyx.* Ranges from the Lévis upwards.

"7. *Dalmanites.* Not known below the Trenton.

"8. *Lichas.* Lévis upwards.

"9. *Triarthrus.* Lévis upwards.

"10. *Trinucleus.* Not known below the Trenton.

"11. *Agnostus.* Occurs in the Lévis and older rocks in America. In Europe, somewhat higher.

"The following are the peculiarities of this collection:—

"The genera of trilobites characteristic of the Lévis are absent. The genera (of trilobites) that do occur, are those of the higher rocks. The brachiopoda are more like those of the Trenton than those of the Quebec group. *Ptilodictya* and *Stenopora* are also types that had their greatest development after the general fauna of the Lévis became extinct. The graptolite is of a type characteristic of the Lévis and of the Skiddaw slates. The *Agnostus* is one of a type that ranges from the Lower Silurian downwards.

"The most curious character is that of the two genera (*Agnostus* and *Graptolithus*) which are common in the Lévis, and represented by full-sized individuals. But all those characteristic of the higher rocks are minute. The trilobites when perfect were mostly not more than three or four lines in length. This may be thus accounted for. It is known that on their first appearance many genera and even families consist of only very small species. The Trenton forms at Farnham, therefore, may be the ancestors of the species that afterwards came in. The fossils thus far collected, at this locality, furnish no evidence whatever that the rock is older than the Lévis, but rather that it is a stage more recent than the limestone of Point Lévis and Phillipsburg."

"E. B."

LII. Clarenceville, Que., range III., one mile and a half west of village, on the road from Lacolle, Que.; R. W. Ells and W. E. Deeks, 12th June, 1891. (Range III., Township of Foucault, Que., between Richelieu River and Missisquoi Bay.)

Graptolitoidea:

1. Diplograptus foliaceus, Murchison.
2. " angustifolius, Hall.
3. " pristis (?), Hisinger (as of Hall).
4. Dicranograptus ramosus, Hall.
5. Climacograptus bicornis, Hall.

LIII. Lot 20, range V., Stanbridge, Que.; about half a mile north of road to North Stanbridge, R. W. Ells, 1890. In a dark grayish-blue pyritiferous limestone.

Graptolitoidea :

1. Diplograptus, sp. An obscure graptolite referred with some doubt to the genus Diplograptus showing hydrothecæ, about ten (10) in the space of one centimetre.

2. Graptolite. A number of stipes which appear to show hydrothecæ only on one side of polypary, not determinable.

Brachiopoda :

3. Lingula, sp., of the type of L. Irene, Billings.

4. (?) Obolus ? Murrayi, Billings.

5. Lingula, *cf.* L. Quebecensis, Billings, young individuals.

6. Leptella, sp. Like L. decipiens, Bill., or closely related thereto.

7. Orthis, sp. of the type of O. delicatula, Billings, but distinct when compared with Newfoundland specimens of O. delicatula. There are seen to be from 12 to 14 radiating lines with smaller ones intercalated.

8. Orthis (Dàlmanella) sp. indt.

9. " sp. indt. A small form with ten (10) rather fine costæ of the type of *O. Ella.*

Gasteropoda :

10. Euomphalus, sp. The same form occurs in the Champlain Market rocks, Quebec City.

11. Scenella or Metoptoma, sp.

Pteropoda :

12. Hyolithes or Coleoprion, sp.

Trilobita :

13. Bathyurus-like trilobite, small head shield only preserved.

14. Asaphus, sp. Eye of Asaphus or closely related genus.

15. Illænus, sp. indt. pygidium.

16. " sp. Too imperfect for identification.

Ostracoda :

17. Isochilina or Polycope, sp. indt.

LIV. Shore, Missisquoi Bay, three-eighths of a mile south of Phillipsburg, Que. R. W. Ells, August, 1890.

Graptolitoidea :

1. Climacograptus, n. sp. (?)

2. " bicornis ? Hall.

3. ? Dicranograptus sp.

TRENTON FORMATION.

BLACK RIVER DIVISION.

LV. Pointe Claire, Island of Montreal, Que.; collectors, Logan, E. Billings and G. Barnston, jr. (Geological Survey Museum, Ottawa):—

Zoophyta :
1. Columnaria Halli, Nicholson.
Pelecypoda :
2. Cyrtodonta subcarinata, Billings.
Gasteropoda :
3. Pleurotomaria Arachne, Billings.
Cephalopoda :
4. Actinoceras Bigsbyi, Stokes.
Trilobita :
5. Bathyurus extans, Hall.
6. Encrinurus vigilans, Hall.

LVI. Pointe Claire, old quarries for stone in piers of Victoria bridge, Jacques Cartier Co., Island of Montreal, Que. Peter Redpath Museum collection, McGill University, Montreal.

Hydroida :
1. Stromatocerium rugosum, Hall.
Zoophyta :
2. Tetradium fibratum, Safford.
Bryozoa :
3. Pachydictya acuta, Hall.
Brachiopoda :
4. Trematis Montrealensis, Billings.
Pelecypoda :
5. Cyrtodonta Huronensis, Billings.
6. " sp.
Gasteropoda :
7. Murchisonia perangulata, Hall.
8. Helicotoma larvata, Salter.
Cephalopoda :
9. Orthoceras multicameratum, Hall.
10. Gonioceras anceps, Hall.
Ostracoda :
11. Primitia leperditioides, Jones.
Trilobita :
12. Bathyurus extans, Hall.
13. Encrinurus vigilans (?), Hall.

LVII. One-eighth of a mile above the ferry, St. Vincent de Paul, Isle Jésus, Laval Co., Que. Collected by Dr. R. W. Ells and Mr. J. F. Whiteaves, 1895. Determined by Mr. Whiteaves in September, 1895.

Plantæ :

1. Licrophycus Ottawaënsis (?), Billings.

Hydroida :

2. Stromatocerium rugosum (?), Hall.

Zoophyta :

3. Tetradium fibratum, Safford.
4. Columnaria Halli, Nicholson.
5. Streptelasma corniculum, Hall.

Bryozoa :

6. Pachydictya acuta, Hall.

Crinoidea :

7. Glyptocrinus, stem fragments.

Brachiopoda :

8. Strophomena incurvata, Shepard.

Pelecypoda :

9. Cyrtodonta Huronensis, Billings.

Gasteropoda :

10. Murchisonia gracilis, Hall.

Cephalopoda :

11. Gonioceras anceps, Hall.
12. Actinoceras Bigsbyi, Stokes.
13. Cyrtoceras, several species.
14. Orthoceras "

TRENTON DIVISION.

LVIII. St. Dominique, Que. Higher beds, W. E. Deeks, 19th June, 1891.

Echinodermata :

1. Crinoidal or cystidean fragments.

Bryozoa :

2. Prasopora Selwyni, Nicholson* (= P. lycoperdon, Vanuxem).
3. Other species of Monticuliporoids requiring micro-sections.

Brachiopoda :

4. Discina or Trematis sp. Too imperfect for determination.
5. Orthis (Dalmanella) testudinaria, Dalman.
6. Orthis tricenaria, Conrad.
7. " sp.
8. Platystrophia biforata, Schlotheim, var. lynx, Eichwald.

*Micro-section 2137, Geol. Surv. Can., prepared by Mr. T. C. Weston.

9. Strophomena incurvata, Shepard, Hall.
10. Rafinesquina alternata (Conrad), Emmons.
11. Plectambonites sericea, Sowerby.

Cephalopoda :

12. Orthoceras (?) sp.

Trilobita :

13. Trinucleus concentricus, Eaton.
14. Calymene senaria, Conrad.
15. Asaphus, sp.

LIX. St. Dominique, Que. ; T. C. Weston, 1879, and J. Richardson, date not given. The rock is a sub-crystalline limestone traversed in many directions by white veins of calcite.

Bryozoa :

1. Prasopora Selwyni, Nicholson.
2. (?) Monotrypella Trentonensis, Nicholson.

Brachiopoda :

3. Orthis tricenaria, Conrad.
4. Platystrophia biforata, Schlotheim, var. lynx, Eichwald.
5. Strophomena incurvata, Shepard.
6. Rafinesquina alternata (Conrad), Emmons.
7. Plectambonites sericea, Sowerby.

Trilobita :

8. Asaphus platycephalus, Stokes.
   (= Isotelus gigas. DeKay.)
9. (?) Encrinurus vigilans, Hall.

LX. St. Pie, Que. ; Thos. C. Weston, 1879. In a dark gray impure limestone with white veins of calcite. Not classified :—Solenopora compacta, Billings.

Bryozoa :

1. Prasopora Selwyni, Nicholson.
2. (?) Monotrypella Trentonensis, Nicholson.

Brachiopoda :

3. Orthis (Dalmanella) testudinaria, Dalman.
4. Platystrophia biforata, Schlotheim, var. lynx, Eichwa'd.
5. Rafinesquina alternata (Conrad), Emmons.
6. Plectambonites sericea, Sowerby.

Gasteropoda :

7. Bellerophon bilobatus, Sowerby.
8. Murchisonia gracilis, Hall.

Trilobita :

9. Calymene senaria ?, Conrad.
10. Asaphus platycephalus ?, Stokes.

LXI. Papineau Road range, two miles south of Abbottsford, Que., one-eighth of a mile west of railway between Abbottsford and L'Ange Gardien ; R. W. Ells. Two collections.

A.

Echinodermata :

1. Crinoidal fragments.

Bryozoa :

2. Prasopora Selwyni, Nicholson.
3. Pachydictya acuta, Hall.

Brachiopoda :

4. Lingula riciniformis ?, Hall.
5. Orthis (Dalmanella) testudinaria, Dalman sp.
6. Platystrophia biforata, Schlotheim, var. lynx, Eichwald.
7. Rafinesquina alternata (Conrad), Emmons.
8. Plectambonites sericea, Sowerby.

Cephalopoda :

9. Endoceras pro[illegible]rme, var. tenuistriatum, Hall.
10. Orthoceras bilineatum, Hall.

Trilobita :

11. Trinucleus concentricus, Eaton.
12. Calymene senaria, Conrad.
13. Asaphus platycephalus, Stokes.

B.

LXII. Papineau Road, two miles south of Abbottsford, Que., near railway crossing ; R. W. Ells, 1890. In a black unevenly bedded and somewhat indurated limestone :—

Brachiopoda :

1. Plectorthis plicatella (Orthis), Conrad.
2. Dalmanella testudinaria (Orthis), Dalman.
3. Orthis tricenaria, Conrad.

LXIII. Highgate Springs, Vermont (near Canadian boundary line). H. M. Ami and R. W. Ells, 1883.

Bryozoa :

1. Pachydictya acuta, Hall.

2. Prasopora Selwyni, Nicholson.
3. Other monticuliporoidea requiring micro-sections.

Brachiopoda :

4. Orthis (Dalmanella) testudinaria, Dalman.
5. Orthis (Plectorthis) plicatella, Conrad.
6. Orthis (Dinorthis) pectinella, Emmons.
7. Rafinesquina alternata (Conrad), Emmons.
8. Strophomena incurvata, Shepard.
9. Rhynchotrema inæquivalvis, Castelnau.
   (= Rhynchonella increbescens, Hall.)
10. Plectambonites sericea, Sowerby.

Gasteropoda :

11. Bellerophon bilobatus, Sowerby.
12. Raphistoma lapicida, Salter.

Pteropoda :

13. Conularia Trentonensis, Hall.

Cephalopoda :

14. Orthoceras arcuoliratum, Hall.
15. 16. Orthoceras, two species as yet undetermined.

Trilobita :

17. Trinucleus concentricus, Eaton.
18. Calymene senaria, Conrad.
19. Asaphus megistos, Locke.
20. Harpes Ottawäensis, Billings.

LXIV. Mile-End Quarries, &c, Island of Montreal, Hochelaga County, Que. Classified list of species compiled from various sources.

Asteroidea :

1. Edrioaster Bigsbyi, Billings.

Cystoidea :

2. Pleurocystites squamosus, Billings.
3. " exornatus, Billings.
4. Glyptocystites Logani, Billings.
5. " " var. gracilis, Billings.
6. " multiporus, Billings.

Crinoidea :

7. Dendrocrinus acutidactylus, Billings.
8. " proboscidiatus, Billings.
9. " cylindricus, Billings.
10. Heterocrinus Canadensis, Billings.
11. " tenuis, Billings.

12. Archæocrinus pyrifomis, Billings, sp.
13. Cleiocrinus grandis, Billings.

Bryozoa:

14. Subretepora reticulata, Hall (= Intricaria reticulata, Hall, of former reports).
15. " Dawsoni, Ulrich.
16. Protocrisina exigua, Ulrich.
(= Gorgonia? perantiqua, Hall.)
17. Phylloporina Trentonensis, Nicholson.
18. Pachydictya acuta, Hall.
19. " triserialis, Ulrich.
20. Phænopora incipiens, Ulrich.
21. Nematopora ovalis, Nicholson.
22. Arthronema tenue, James sp.
23. Amplexopora superba, Foord.
24. Prasopora Selwyni, Nicholson.

Brachiopoda:

25. Lingula quadrata, Eichwald.
26. " Kingstonensis, Billings.
27. " riciniformis, Hall.
28. " Progne, Billings.
29. " Daphne, Billings.
30. " Philomela, Billings.
31. Schizotreta Pelopea. (= Discina Pelopea, Billings).
32. Orbiculoidea lamellosa, Hall (= Discina Circe, Billings).
33. Trematis terminalis, Emmons.
34. " Montrealensis, Billings.
35. Orthis (Plæsiomys) subquadrata, Hall.
36. " (Dalmanella) testudinaria, Dalman.
37. " (Dinorthis) pectinella, Emmons.
38. Platystrophia biforata, var. lynx, Eichwald.
39. Rafinesquina deltoidea, Conrad sp.
40. " alternata, (Conrad) Emmons.
41. Plectambonites sericea, Sowerby.
42. Rhynchotrema inæquivalvis, Castelnau.
43. Zygospira recurvirostra, Hall.
44. " deflecta, Hall.
45. Anastrophia hemiplicata, Hall.

Pelecypoda:

46. Avicula Hermione, Billings.

47. Modiolopsis carinata, Hall.
48. " faba, Conrad.
49. Ctenodonta dubia, Hall.
50. " nasuta, Hall.
51. " astartæformis, Salter.
52. Ambonychia bellistriata, Hall.

Gasteropoda:

53. Ecculiomphalus Trentonensis, Conrad.
54. Cyrtolites compressus, Emmons.
55. Bellerophon bilobatus, Sowerby.
56. Trochonema umbilicatum, Hall.
57. Cyclonema Montrealense, Billings.
58. " Hageri, Billings.
59. Holopea symmetrica, Hall.
60. " Nereis, Billings.
61. Subulites subfusiformis, Hall.
62. Metoptoma Trentonensis, Billings.
63. Conularia Trentonensis, Hall.
64. Murchisonia gracilis, Hall.
65. Pleurotomaria Americana, Billings.

Cephalopoda:

66. Orthoceras strigatum, Hall.
67. " bilineatum, Hall.
68. Cyrtoceras Juvenale, Billings.
69. " macrostomum (?), Hall.
70. Endoceras proteiforme, Hall.
71. " " var. lineolatum, Hall.

Vermes:

72. Serpulites dissolutus, Billings.
73. Cornulites flexuosus, Hall.

Trilobita:

74. Trinucleus concentricus, Eaton.
75. Calymene senaria, Conrad.
76. Cheirurus pleurexanthemus, Green.
77. Asaphus platycephalus, Stokes (=Isotelus gigas, DeKay).

Ostracoda;

78. Leperditia Canadensis, var. nana, Jones.

LXV. Joliette, County of Joliette, L'Assomption River, Que.; collector, H. M. Ami, 1881.

Graptolitoidea:

1. Diplograptus, *cf.* D. putillus, Hall.

Bryozoa :

2. Pachydictya acuta, Hall.
3. " sp. indt.
4. Ptilodictya maculata, Ulrich.
5. Monotrypella Trentonensis, Nicholson.
6. Prasopora Selwyni, Nicholson.
7. Amplexopora Canadensis, Foord.
8. Solenopora compacta, Billings. (Zoological affinities in question.)

Crinoidea :

9. Glyptocrinus ramulosus, Billings.

Brachiopoda :

10. Orthis (Plectorthis) plicatella, Conrad.
11. " (Dalmanella) testudinaria, Dalman.
12. Rafinesquina alternata, (Conrad) Emmons.
13. Plectambonites sericea, Sowerby.

Pteropoda :

14. Conularia Trentonensis, Hall.

Gasteropoda :

15. Cyclonema bilix, Hall.
16. Trochonema umbilicatum, Hall.
17. Pleurotomaria Progne, Billings.

Cephalopoda :

18. Endoceras proteiforme, Hall.
19. " multitubulatum, Hall.

Vermes :

20. Serpulites dissolutus, Billings.

Trilobita :

21. Calymene senaria, Conrad.
22. Asaphus platycephalus, Stokes.
23. Illænus, *cf.* I. Milleri, Billings.
24. Cheirurus pleurexanthemus, Green.

LXVI. Joliette, Canadian Pacific Railway quarry, between the two bridges on L'Assomption River, Joliette County, Que.; collector, N. J. Giroux, October, 1892 :—

Graptolitoidea :

1. Diplograptus or Climacograptus, too imperfect for identification.

Bryozoa :

2. Amplexopora or Batostoma sp.
3. Pachydictya acuta, Hall.

4. Ptilodictya maculata, Ulrich.
5. Solenopora compacta, Billings.

Brachiopoda :

6. Lingula Philomela (?), Billings.
7. " or Discina sp., too imperfect for identification.
8. Orthis (Dalmanella) testudinaria, Dalman.
9. Orthis tricenaria (?), Conrad.
10. Rafinesquina alternata (Conrad), Emmons.
11. Strophomena incurvata, Shepard.

Pteropoda :

12. Conularia quadrata, Walcott, or allied species.
13. " Trentonensis, Hall.

Trilobita :

14. Acidaspis spiniger, Hall.
15. Cheirurus pleurexanthemus, Green.
16. Asaphus platycephalus, Stokes.
17. Illænus Milleri, Billings.

UTICA FORMATION.

XLVII. Clarenceville, Que., range IV., ridge east of the village; R. W. Ells and W. E. Deeks, 12th June, 1891.

Spongiæ :

1. ? Cyathophycus reticulatus, Walcott.

Graptolitoidea :

2. Climacograptus, sp.
3. Orthograptus quadrimucronatus, Hall.

Cephalopoda :

4. Endoceras proteiforme, Hall.
(? = Orthoceras lamellosum, Hall).

Trilobita :

5. Triarthrus sp., *cf.* T. glaber, Billings.
6. " Becki, Green.

LXVIII. Lacolle, Que., half a mile east of the village, in river along side of road to Grand Trunk station. R. W. Ells and W. E. Deeks, 12th June, 1891.

Graptolitoidea :

1. Climacograptus, sp. Same form also occurs at Holland Patent, N.Y., and is referable to C. bicornis, Hall, by most writers.

2. Diplograptus mucronatus (?), Hall.

Brachiopoda :

3. Plectambonites sericea, Sowerby.

Trilobita :

4. Triarthrus Becki, Green.

LXIX. Lacolle, Que.; one-eighth of a mile west of the Richelieu River bridge, 12th June, 1891. R. W. Ells and W. E. Deeks.

Graptolitoidea :

1. Orthograptus quadrimucronatus, Hall.

Trilobita :

2. Triarthrus Becki, Green.

LXX. Montreal ; below piers, at low water, north end of Victoria Bridge, Point St. Charles. Collector, Thos. Curry, 1891.

Graptolitoidea :

1. Dendrograptus simplex, Walcott.
2. Reteograptus ? Eucharis, Hall.
3. Orthograptus quadrimucronatus, Hall.
4. Climacograptus Scharenbergi (?) Lap.

Cephalopoda :

5. Endoceras proteiforme, Hall.

Trilobita :

6. Triarthrus Becki, Green.

LXXI. Montreal, Que.; also collected by Thos. Curry, on the western extremity of St. Helen's Island, and at low water in the harbour, from blocks obtained in dredgings by Public Works Department.

Graptolitoidea :

1. Climacograptus sp.
2. Leptograptus flaccidus, Hall.
3. Diplograptus sp.

Brachiopoda :

4. Leptobolus insignis.
5. Orthis (Dalmanella) testudinaria, Dalman.

Vermes :

6. Cornulites immaturum, Hall.

Cephalopoda.

7. Orthoceras lamellosum, Hall.

LORRAINE FORMATION.

LXXII. Chambly, Que. W. E. Deeks, 1890.

Echinodermata:

1. Crinoidal fragments.

Graptolitoidea:

2. (?) Orthograptus quadrimucronatus, Hall.

Brachiopoda:

3. Pholidops subtruncatus, Hall.
4. Rafinesquina alternata, (Conrad) Emmons.
5. Streptorhynchus Trentonensis, Winchell and Schuchert.
6. Leptæna (Plectambonites) sericea, Sowerby. Two varieties of this species occur in the collection.
7. Rhynchotrema inæquivalvis, Castelnau, sp.
8. Zygospira Headi, Billings.

Pelecypoda:

9. Pterinea demissa, Conrad.
10. Lyrodesma pulchellum, Emmons.
11. Orthodesma pholadis (?), Conrad.
12. Modiolopsis curta, Hall.*
13. " faba, Conrad.
14. Ambonychia (Byssonychia) radiata, Hall.

Gasteropoda:

15. Bellerophon bilobatus, Sowerby.
16. Murchisonia gracilis, Hall.
17. " Milleri, Hall.

Trilobita:

18. Calymene, sp. indt.
19. Illænus, sp. indt.
20. Proëtus, sp.

LXXIII. St. Hyacinthe, Que. ; W. E. Deeks, 1891 :—

Echinodermata:

1. Crinoidal stems and fragments.

Hydromedusæ:

2. (??) Sagenella ambigua, Walcott, parasitic on the shell of an orthoceratite.
3. Orthograptus quadrimucronatus, Hall.

*Also Clidophorus planulatus, Conrad, and a species of Climacograptus.

Bryozoa :

4. Monticuliporoidea, requiring micro-sections.

Brachiopoda :

5. Lingula, sp. indt.
6. Orthis (Dalmanella) testudinaria, Dalman.
7. Leptæna (Plectambonites), sp.
8. Rhynchotrema inæquivalvis, Castelnau.
9. Zygospira modesta, Say.

Pelecypoda :

10. Clidophorus planulatus.
11. Nucula levata, Hall.
12. Modiolopsis curta, Hall.
13. " faba, Conrad.
14. " modiolaris (?), Conrad.
15. Lyrodesma post-striatum, Emmons.
16. Orthodesma pholade, Conrad.

Gasteropoda :

17. Cyrtolites ornatus (?), Conrad.
18. Bellerophon bilobatus, Sowerby.
19. Trochonites, sp.

Cephalopoda :

20. Endoceras proteiforme, Hall, probably Orthoceras lamellosum, Hall.

Trilobita :

21. Trinucleus, sp. Portion of the ornamented border around the cephalic shield.
22. Triarthrus, sp., *cf.* T. Becki, Green.

LXXIV. Yamaska River, one mile and a half below the mouth of Servailles River, near St. Hyacinthe, Que. N. J. Giroux, 1890.

Echinodermata :

1. Crinoidal columns and other fragments.

Hydromedusæ :

2. (?) Alecto or other related genus.

Brachiopoda :

3. Lingula, sp.
4. Pholidops subtruncatus, Hall.
5. Orthis (Dalmanella) testudinaria, Dalman.
6. Orthis (Dinorthis) pectinella, Conrad.
7. Orthis (Plectorthis) plicatella, Hall.
8. Rafinesquina alternata, (Conrad) Emmons.

9. Strophomena Trentonensis, Winchell & Schuchert).
10. Plectambonites sericea, Sowerby.
11. Rhynchotrema inæquivalvis, Castelnau.

Pelecypoda:

12. Modiolopsis, sp.
13. Ambonychia (Byssonychia) radiata, Hall.

Gasteropoda:

14. Cyrtolites, sp.

Cirripedia:

15. Turrilepas (?), sp.

Trilobita:

16. Trinucleus concentricus (?), Eaton. Possibly a new form.
17. Triarthrus (?), sp. indt.
18. Calymene senaria, Conrad.
19. Asaphus megistos, Locke.

LXXV. Rougemont, Que.; Thos. Curry, 1872.

Echinodermata:

1. Crinoidal fragments.

Brachiopoda:

2. Lingula curta (?), Hall.
3. Pholidops subtruncatus, Hall.
4. Orthis (Hebertella) occidentalis, Hall.
5. (Dalmanella) testudinaria, Dalman.
6. Plectambonites sericea, Sowerby.
7. Rafinesquina alternata, (Conrad) Emmons.
8. Strophomena nitens, Billings.
9. Zygospira Headi, Billings.

Pelecypoda:

10. Orthodesma parallelum, Hall.
11. Clidophorus planulatus, Conrad.
12. Orthodesma pholade Hall.
13. Pterinea demissa, Conrad.

Gasteropoda:

14. Bellerophon bilobatus, Sowerby.
15. Cyclonema?? sp. indt.
16. Cyrtolites ornatus, Conrad.

Trilobita:

17. Calymene senaria, Conrad.
18. Asaphus sp.

LXXVI. River des Hurons, Que. T. Curry, 1872.

Pelecypoda :

1. Ambonychia (Byssonychia) radiata, Hall, sp.
2. Pterinea demissa, Conrad.
3. Modiolopsis modiolaris, Conrad.
4. " anodontoides, Conrad.
5. " pholadiformis, Hall.
6. Clidophorus planulatus, Conrad.
7. Orthodesma parallelum, Hall.

Trilobita :

8. Triarthrus Becki, Green.
9. Asaphus megistos, Locke.

SILURIAN FOSSILS.

LXXVII. North Stoke, Que. H. M. Ami and R. W. Ells, 1886. (Not previously published. S. E. Sheet.)

Zoophyta :

1. Favosites Gothlandicus, Lamarck. The corallites in these specimens measure a trifle over two (2) millimetres each, five corallites in the space of a little over ten millimetres. The largest corallites measure three (3) millimetres.

2. Favosites, with much smaller corallites than sp. No. 1, *cf. F. Helderbergiæ*, Hall. Aperture or breadth of each corallite about one millimetre, or ten corallites in the space of one centimetre.

3 Syringopora, sp. indt.

4. Zaphrentis, sp. About forty (40) radiating lamellæ in the circumference of the polyp.

Echinodermata :

5. Crinoidal fragments. Both large and small fragments, probably referrable to two distinct species.

Brachiopoda :

6. Obscure markings like the spiral supports of Atrypa reticularis.

7. Obscure cast of Spirifera, *cf.* S. Niagarensis, but smaller than Ontario or New York representatives of that species.

Gasteropoda :

8. Straparollus, sp. Three volutions—one large and two much smaller. Shows also the nepionic stage of the shell, &c., with measurements as follows:—

(1.) Embryonic shell, 1 mm. across.
(2.) 1st volution 3 " "
(3.) 2nd " 8 " "
(4.) 3rd or body volution 15 mm. across.

The specimen is preserved as a mould of the exterior or possibly as a mould of the cast of the interior of the shell.

LXXVIII. "Georgeville," Que.; A. Webster, 1879 :—

Zoophyta :

1. Halysites catenularia, Linnæus.
2. Favosites Gothlandicus, Lamarck. A tolerably well preserved specimen, showing the mural pores, &c.; resembles the form occurring near Tuck's Landing, Sargent's Bay, on the west side of the lake.
3. Favosites, sp., *cf.* F. favosus, Goldfuss. With exceptionally large corallites.
4. Zaphrentis, sp.

Echinodermata :

5. Fragments of crinoidal columns.

LXXIX. Capt. Gully's point, opposite Owl's Head, Lake Memphremagog, Que.; Ells, 1890.

Hydroida :

1. Stromatoporoid (undetermined).

Zoophyta :

2. Favosites Gothlandicus, Lamarck.
3. " with smaller corallites, and resembling F. Helderbergiæ, Hall.

LXXX. Round Island, Lake Memphremagog, Que.; Ells, July, 1890 (in a dark gray glossy pyritiferous calc-schist; obscure fossils).

1. Stromatopora, sp.
2. Heliolites, sp. Very imperfectly shown.
3. Favosites, sp. indt.

LXXXI. Knowlton Landing, Que.; Ami, 1886, (now known as Tuck's Landing P.O., Que.), Sargent's Bay, Lake Memphremagog, Que. :—

Plantæ :

1. Psilophyton, sp.

Zoophyta :

2. Favosites Gothlandicus, Lamarck

Bryozoa :

3. Polypora or Monticuliporoid.

Brachiopoda :

4. Rhynchonella, sp.; type of R. Wilsoni, Sowerby.

LOWER HELDERBERG DIVISION.

LXXXII. St. Helen's Island, St. Lawrence River, opposite Montreal (Dawson collection ; Peter Redpath Museum of McGill University):—

Besides numerous fragments of crinoidal columns, &c.

Zoophyta :

1. Favosites, *cf.* F. Gothlandicus, Lamarck.
2. " resembling F. Helderbergiæ, Hall.
3. " ? sp. indt
4. Pachypora ? sp.
5. ? Zaphrentis sp. No. 1.
6. " sp. No. 2.
7. Undetermined cyathophylloid coral.

Bryozoa :

8. Callopora or Calloporella sp.
9. Polypora, *cf.* P. perangulata, Hall.
10. Fenestella (?) sp. indt.
11. Ptilodictya ? sp.

Brachiopoda :

12. Chonetes, *cf.* C. melonica or n. sp.
13. Orthis, probably Orthis (Rhipidomella) eminens, Hall.
14. Orthis (Rhipidomella) oblata, Hall.
15. " resembling somewhat Orthis (Orthostrophia) strophomenoides, Hall.
16. Strophonella punctulifera, Conrad.
17. " cavumbona, Hall.
18. Strophodonta varistriata, Conrad, showing tendency towards var. arata.
19. Strophodonta varistriata, Conrad. Var. This form is more strongly arcuate than the type specimens figured.
20. ? Strophodonta Becki, Hall or Streptorhynchus Woolworthanum, Hall.
21. Leptagonia rhomboidalis, Wilckens.
22. Strophomenoid shell resembling somewhat Streptorhynchus radiatum, Vanuxem.

23. Spirifera concinna, Hall.
24. " " (large variety).
25. " *cf.* S. Cumberlandiæ, Hall.
26. " n. sp. (?); also another of the type of S. arenosa, Conrad.
27. " cycloptera, Hall.
28. " sp. with from eighteen to twenty costæ on each side of the mesial sinus. General appearance very much like S. pennata (=S. mucronata), not quite so arcuate and the concentric lines of growth are not so strongly lamellose or rugose.
29. Spirifera, *cf.* S. perlamellosa, Hall.
30. Atrypa reticularis, Linnæus.
31. Trematospira multistriata, Hall, or closely related species.
32. ? Leiorhynchus, sp. indt. Unlike L. multicostum, Hall.
33. Rhynchonella abrupta, Hall.
34. Rhynchonella, *cf.* R. acutiplicata, Hall.
35. " æquivalvis (?), Hall, possibly a Rensselæria.
36. " formosa, Hall. Since referred to the genus Stenoschisma.
37. " nucleolata, Hall.
38. " nobilis, Hall. One of the specimens found in conjunction with this species bears a strong resemblance to *R. Campbellana*, Hall.
39. Rhynchonella pleiopleura or multistriata of Hall.
40. Rhynchonella ventricosa, Hall.
41. Eatonia sinuata, Hall, or a closely related species.
42. Pentamerus galeatus, Dalman.
43. " pseudogaleatus, Hall.

Pelecypoda:

44. Pterinea, sp., *cf.* P. textilis, Hall. A small variety.

Gasteropoda:

45. Platyostoma depressum, Hall.

DEVONIAN FOSSILS.

LXXXIII. Sargent's Bay, Lake Memphremagog, west side. Collected by H. M. Ami, 1894.

Spirophyton cauda-galli, Vanuxem. This plant is sometimes referred to the genus *Taonurus*, and as a rule characterizes a special horizon in the Helderberg Mountains of New York State and elsewhere. It has been met with in Eastern Quebec and New Brunswick. At this locality the flag stones on which this species occurs abundantly

are inclined at right angles to the horizon along the side and bed of a small stream which flows into the bay about three-quarters of a mile above Tuck's Landing.

LXXXIV. Owl's Head, Lake Memphremagog, Que. From the Devonian limestone "belts" referred to by Sir Wm. Logan and Mr. E. Billings in the "Geol. of Canada, 1863," p. 436.

Hydroida :

1. Stromatopora concentrica, Goldfuss.

Zoophyta :

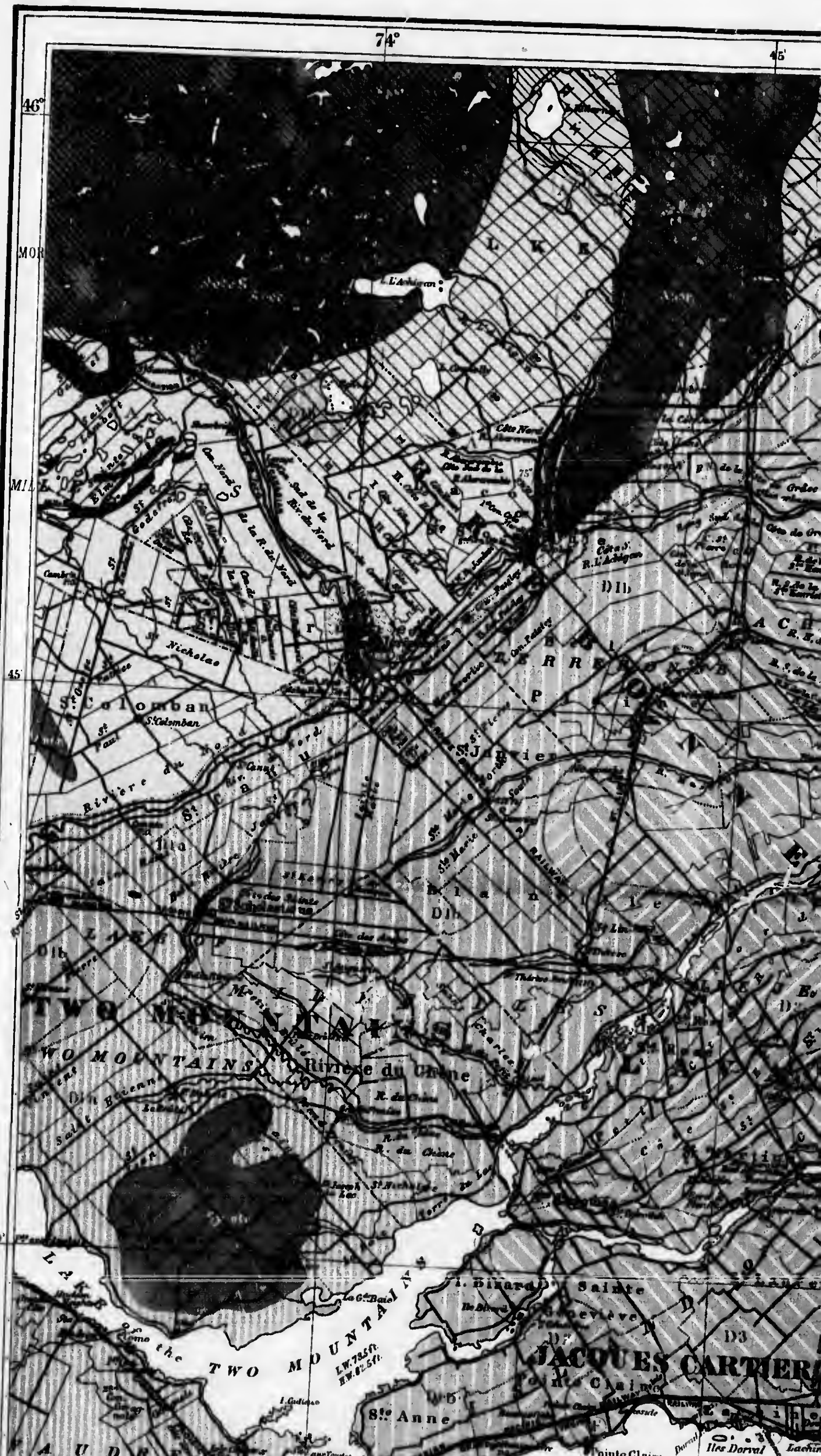
2. Favosites Gothlandicus, Lamarck.
3. " basalticus, Goldfuss.
4. " polymorpha, Goldfuss.
5. Zaphrentis, sp. indt.
6. Heliophyllum, sp. indt.
7. Diphyphyllum arundinaceum, Billings.
8. Syringopora Hisingeri, Billings.

Echinodermata :

9. Crinoidal fragments.

Geological Survey Department,
Ottawa September 20th, 1895.

S.W. Sheet



Legend.

Devonian.

- *Lower Devonian*

Silurian.

- *Lower Helderberg*
- *Medina*

Cambro-Silurian.

- D5 — *Hudson River (Lorraine)*
- D4 — *Utica*

West of the St Lawrence and Champlain Fault.

- D3 — *Trenton and Black River*
- D2 — *Chazy*
- D1b — *Calciferous*
- D1a — *Potsdam sandstone*

East of the St Lawrence and Champlain Fault

- D3b — *Black and grey graptolitic slates of Memphremagog Lake etc.*
- D3a — *Farnham black slates and limestone*
- D2b — *Mystic and Bedford limestones and slates*
- D2a — *Upper part of Phillipsburg and St Armand section*
- D1b — *Lower part of Phillipsburg and St Armand section (Levis)*
- D1a — *(Presumably upper portion of Sillery)*

Cambrian.

- *Upper Cambrian* — C3 — *Sillery slates, sandstones and conglomerates*
- *Lower Cambrian* — C1 — *Olenellus zone, Lower Potsdam of Billings Georgia Series of Walcott*
- *Cambrian (undivided)* — C

Huronian ?

- *Pre-Cambrian* — AB

Laurentian

Geological Survey of Canada.

GEORGE M. DAWSON, C.M.G., LL.D., F.R.S. &c, DIRECTOR.

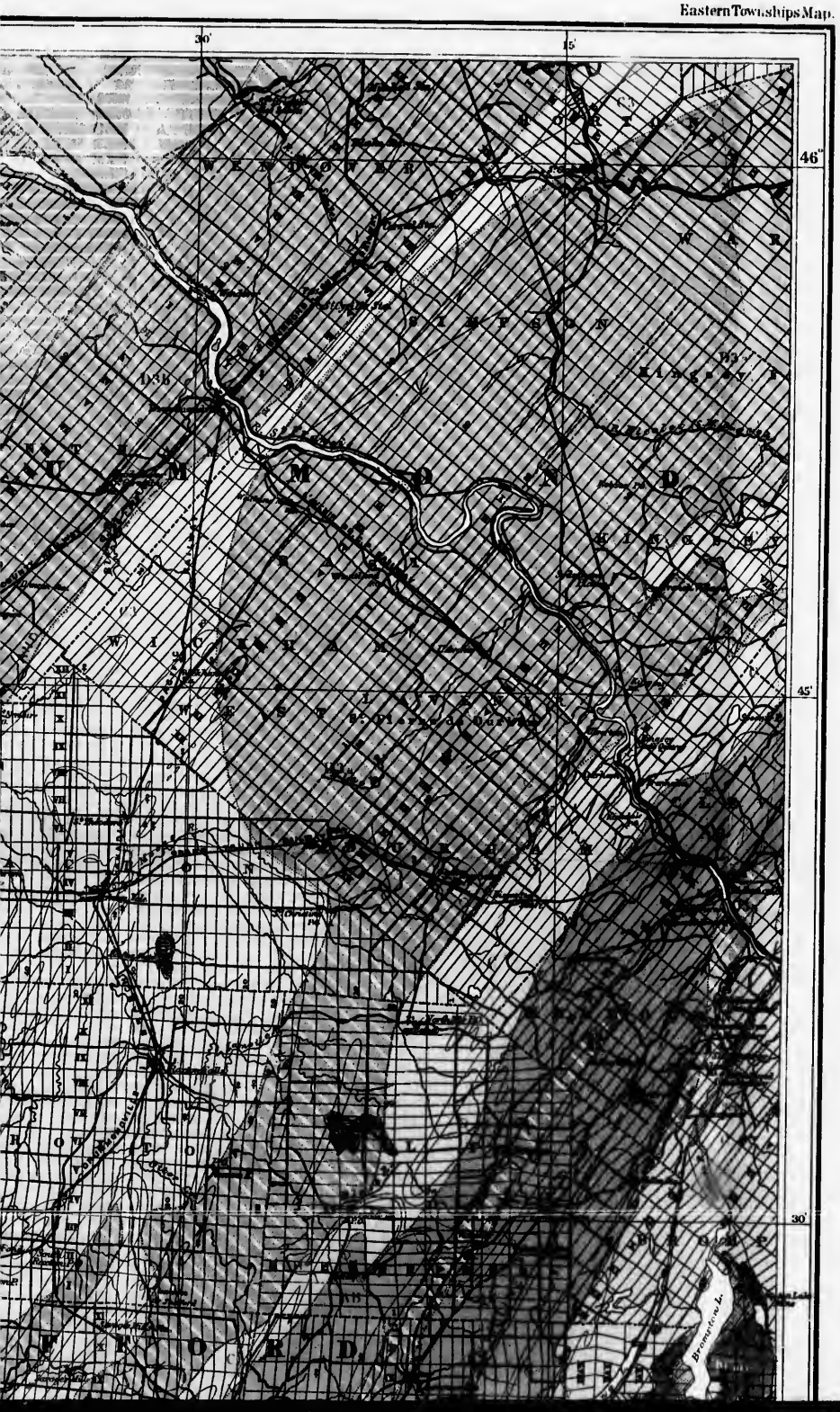
1896.

Geological Survey of Canada.

GEORGE M. DAWSON, C.M.G., L.L.D., F.R.S.&c., DIRECTOR.

1886.

Eastern Townships Map.



NOTE 1.

The Devonian areas in south-western Quebec, recognized by characteristic fossils, are of very limited extent. They are only two in number and are found on the west side of Memphremagog Lake. The largest is on Sargent's Bay, a short distance above the wharf at Knowlton Landing, where *Taonurus cauda-galli, Psilophyton, and Bythotrephis* are found. The other area is near the Mountain House at the Owl's Head Mountain Landing, the fossils from which are chiefly corals. The horizon of the Sargent's Bay rocks is the lower portion (*Cauda-galli* grit) of the Upper Helderberg of the New York scale of formations, while the limestones of the Owl's Head Landing are probably the equivalents of the Corniferous.—(Dana's Manual of Geology, 4th Ed.)

NOTE 2.

The Lower Helderberg of Memphremagog Lake is largely a limestone formation. While not highly fossiliferous at many points, shells and corals occur at various places and clearly indicate the horizon.

The rocks classed as Medina on the map, are reddish shales and sandstones, which as yet have not yielded fossils. They overlie the Lorraine shales and were therefore assigned, by Sir W. E. Logan, to the Silurian system. The formation is difficult to outline, owing to the mantle of drift over much of the area where it occurs, and the boundaries are therefore, to a certain extent, conjectural.

The road from Phillipsburg on Missisquoi Bay to St. Armand Station on the Central Vermont Railway, crosses an almost continuous section of rocks, mostly limestones, which present certain peculiar features. They have been described in the Geology of Canada 1863, pp. 844, 680, under the heading Quebec group (Phillipsburg series). The rocks dip uniformly to the south-east till within a short distance of the railway, when a synocline appears in their upper part. The portion about Phillipsburg and the strata to the north and south, extending along this road for about three fourths of a mile, is regarded as equivalent to the Calciferous (Levis), while the upper portion is supposed to represent the Chazy formation. These rocks, in the vicinity of Bedford, Stanbridge, Mystic, &c., contain local developments of limestone and limestone-conglomerates, from which a great number and variety of fossils have been obtained. It has, however, been found that while certain affinities exist between these and the fauna of the typical Calciferous and Chazy of the Ottawa basin, the fossils as a whole present features markedly distinct. There is also a lithological difference in the strata of the two localities. These peculiarities are supposed to be due to differences in the circumstances of deposition of the two areas, now brought into contact along the line of the St. Lawrence and Champlain fault. This fault extends from Phillipsburg to Quebec and thence eastward, separating the flat-lying formations of the St. Lawrence on the west from the highly inclined strata on the east.

The small outcrops of limestone at St. Helen's Island and Isle Ronde in Montreal Harbour are associated with volcanic breccias, but have yielded a very characteristic fauna indicating their position at the top of the Silurian system.

NOTE 3.

No definite break has yet been found in Canada between the Calciferous formation and the Potsdam sandstone, the passage between the two, both in eastern Ontario and western Quebec, being gradual. After consideration of all the evidence from the stratigraphical and palæontological standpoints, it has been decided to include them in one category as representing the basal portion of the Cambro-Silurian system. The areas of each have, however, been distinguished, where known, by a difference in the barring. Lithologically these formations are entirely distinct from the Levis and upper part of the Sillery formation, (formerly Lauzon), which are supposed to be their equivalents in age, a difference presumably due to different conditions of deposition. The Potsdam sandstone and the Calciferous are also everywhere nearly flat, while the Sillery and Levis are highly inclined, sometimes overturned, and extensively faulted.

NOTE 4.

The Sillery of the North-east map-sheet of the "Eastern Township" series, is divisible into two portions, an upper and a lower, the former of which consists largely of reddish and green shales and greenish sandstones with limestone-conglomerates, the upper part of which is apparently the downward extension of the Levis formation. On the present map the rocks are well seen between Abbottsford and Granby and thence northward for many miles. The lower part of the Sillery is undoubtedly Cambrian and in the St. Lawrence River section contains characteristic fossils, *Agnostus*, etc., at certain points. The highest beds of the Sillery (Lauzon) do not appear in this area and the red and green slates, sandstones and grits of this area are therefore all probably Cambrian. The horizon of the Cambrian rocks on both sides of the Pre-Cambrian of the Sutton Mountain anticline, has not yet been definitely decided owing to an apparent absence of organic remains in the strata. The slates and quartzites at the base, are probably the equivalents of the Georgia series of Vermont (Olenellus zone) while the strata from Frelighsburg to Sweetsburg, etc., probably represent the Upper Cambrian. In the Cambrian of this area are the slate quarries of Melbourne and vicinity, which have been worked for many years, and are of great economic importance.

NOTE 5.

The strata which compose the Sutton Mountain anticline, are believed to be of Huronian age. They undoubtedly underlie the lowest Cambrian. They do not resemble the typical Laurentian gneiss of the Grenville series north of the St. Lawrence river, but are not unlike the rocks which have been described as the "Hastings series" in Ontario, both in the character of the schists and the crystalline dolomites. They contain deposits of copper ore at several points, and the most productive copper mines of the "Eastern Townships" belong to this division. Gold has been reported from the gravels of some of the streams on the west side of the axis in Sutton, but nothing definite as to the value of the deposit has been ascertained. Gold has also lately been found in quartz veins cutting the strata of this series near Dudswell, north-east of Sherbrooke.

D1b	Calciferous	D1b	Lower part of Phillipsburg and St. Armand section (Levis)
D1a	Potsdam sandstone	D1a	(Presumably upper portion of Sillery)

Cambrian

Upper Cambrian	C3	Sillery slates, sandstones and conglomerates
Lower Cambrian	C1	Olenellus zone. Lower Potsdam of Billings. Georgian Series of Walcott
Cambrian (undivided)	C	

Huronian ?

Pre Cambrian	AB

Laurentian

	Laurentian Limestone
A	Laurentian Gneiss and Granite

Igneous

Br	Breccia
Di.Do.Dia. Sy	Diorite, Dolerite, Diabase, Syenite &c.
S	Serpentine
Anor	Anorthosite
	Zone of mixed rocks about St. Jérome Anorthosite
Gr	Granite

Iron Copper

Strike and Dip

Glacial Striæ

Fossils

Dyke

Asbestus

Compiled and drawn by Robert Barlow, Chief Draughtsman, Montreal, 1868, with additions and corrections to 1895 by the Geological Survey

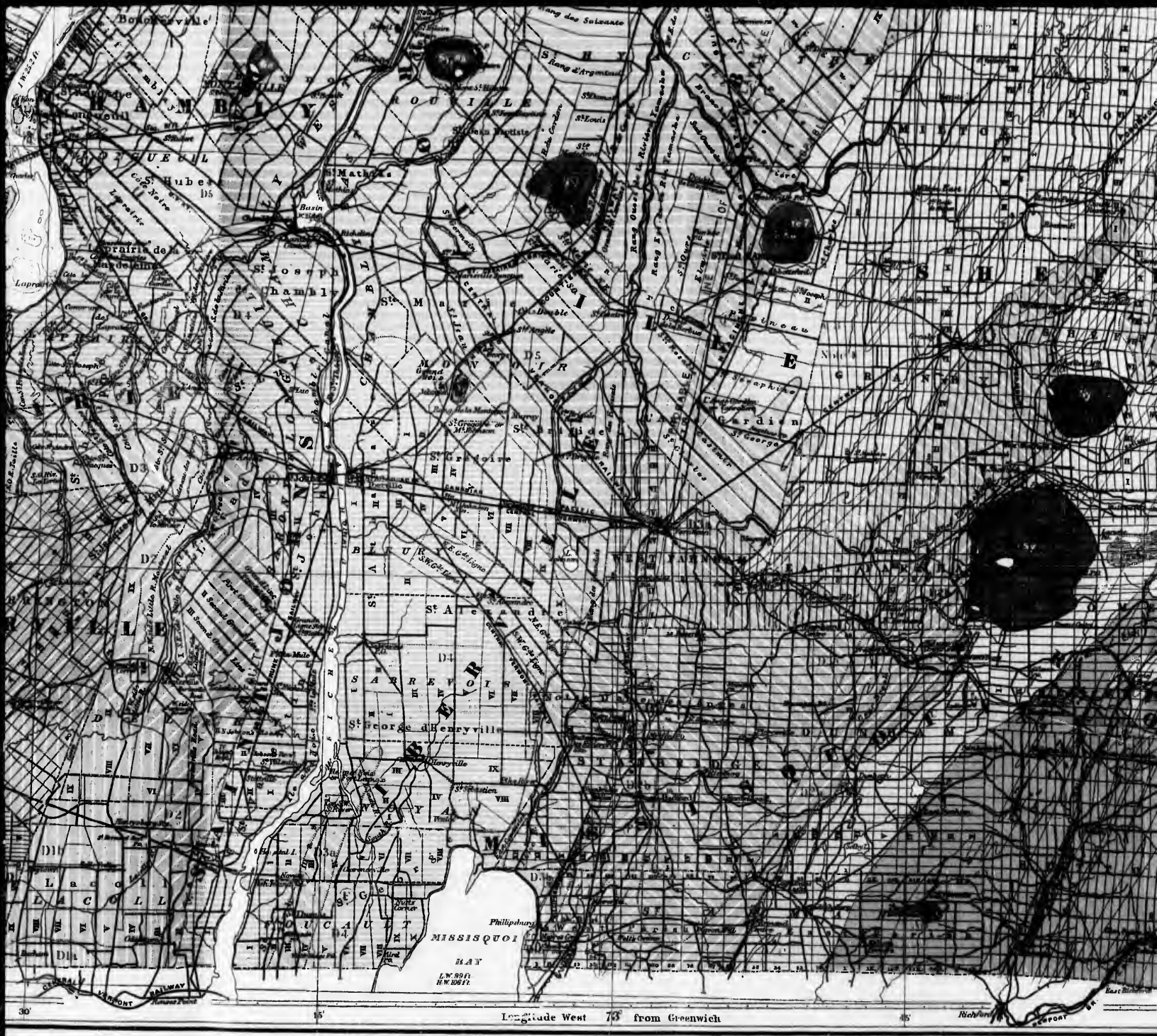
The Sabrevois Lithographic and Publishing Company Montreal

PROVINCE OF QUEBEC.

Montreal Sheet

(Eastern Townships Map)

Nat. Scale 1/253440

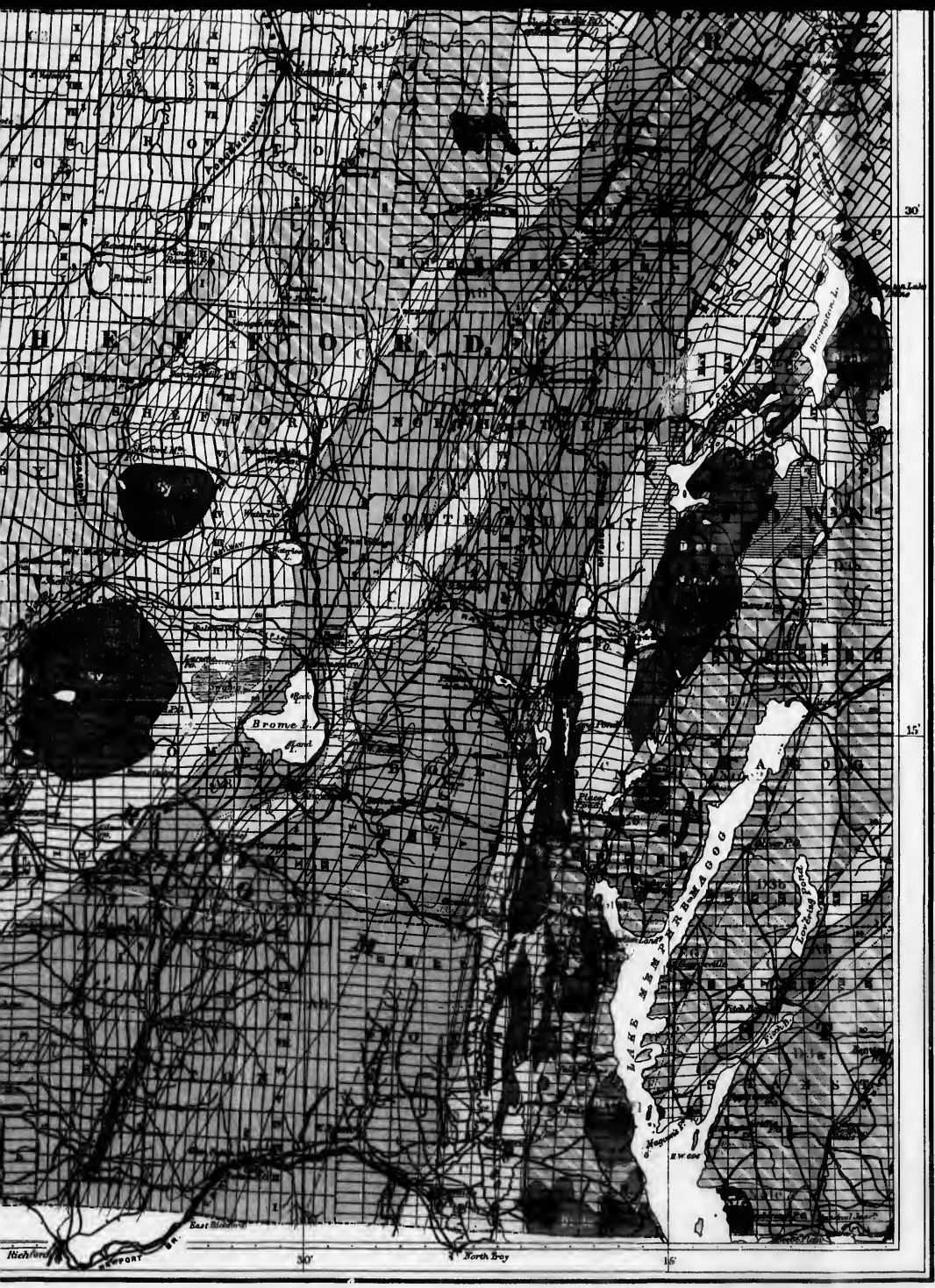


The Survey-ion Lithographic and Publishing Company, Montreal

PROVINCE OF QUEBEC.
Montreal Sheet.
(Eastern Townships Map)

Nat. Scale: 1/253440

15 Miles



Accompanying Part J. Vol VII (New Series)

Geologically surveyed by Sir W. E. Logan, R. W. Ells & F. D. Adams

rocks are well seen between Abercorn and Granby, and thence eastward for many miles. The lower part of the Sillery is undoubtedly Cambrian and in the St. Lawrence River section contains characteristic fossils, *Agnostus*, etc., at certain points. The highest beds of the Sillery (Lauzon) do not appear in this area and the red and green slates, sandstones and grits of this area are therefore all probably Cambrian. The horizon of the Cambrian rocks on both sides of the Pre-Cambrian of the Sutton Mountain anticline, has not yet been definitely decided owing to an apparent absence of organic remains in the strata. The slates and quartzites at the base, are probably the equivalents of the Georgia series of Vermont (Olenellus zone) while the strata from Frelighsburg to Sweetsburg, etc., probably represent the Upper Cambrian. In the Cambrian of this area are the slate quarries of Melbourne and vicinity, which have been worked for many years, and are of great economic importance.

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NOTE 6.

The Laurentian of the country north and west of the St. Lawrence is part of the great Archæan nucleus of the North American continent and represents the oldest system of rocks in Canada. It consists in part of foliated quartzose gneiss of more or less uniform character, which probably constitutes the basal portion of the system, and in part of more distinctly banded gneisses varying considerably in character, often containing much garnet and sillimanite, and associated in many places with bands of quartzite and crystalline limestone. This latter series consists in part at least of altered sedimentary strata and belongs to the "Grenville series" of Sir W. E. Logan. It is believed to repose upon the foliated gneiss before mentioned, and to form an upper series in the system. Its delimitation against the lower gneiss is not attempted in this area.

All these rocks are broken through by intrusive masses of anorthosite, etc., which are more recent than the Grenville series, since they cut it. They, however, are not more recent than the latest dynamic movements in the area, as they frequently show a foliation induced by pressure, especially about the borders of the masses. The old classification in which these anorthosites were regarded as constituting an Upper Laurentian series, resting on the Grenville series, is now abandoned.

NOTE 7.

The breccias found on the Island of Montreal, and at a few points in the vicinity, are presumably connected with the eruptive mass of Mount Royal. They are well seen at St. Helen's Island and Ile Ronde in the harbour of Montreal, at the White-horse Rapids on the Back River, on the west side of Ile Bizard, and on the east flank of Mont Calvaire. They are cut by dykes of diorite, which must, therefore, be of later date, and from their intimate association with the fossiliferous Lower Helderberg limestones of St. Helen's Island they are probably not far different from these in point of age.

The eruptive masses seen in the Montreal Mountains, Belœil, Yamaska, etc., as well as in the chain of hills west of Memphremagog Lake, and to the north east towards the Chaudiere River and beyond, (see North-east sheet) all present a marked resemblance to each other, and are presumably of very similar age. Specimens from a number of these were examined some years ago by Dr. F. D. Adams, (Report of Progress, Geol. Surv. Can., 1880-81-82) who found the rocks of the eastern belt to be largely an altered diabase. These masses penetrate strata of widely different age, being found associated with all the formations from the lowest Cambrian to the top of the Silurian. Portions of these diorites have been altered to a serpentine, which, however, varies in physical character and mineral contents at different points. In some of these mountain masses, the upper part is frequently fine-grained, while the lower part, and often the bulk of the mountain, is comparatively coarse-grained and syenitic. The most prominent hills of the eastern area are Mount Orford, Hog's Back, Elephantis, Owl's Head, &c., while to the north-east are the Ham Mountains, Adstock, Cranbourne, &c. (See North-east sheet.)

In the serpentine masses are found asbestus (chrysotile) chromic-iron and magnetite. The eruptive masses of Memphremagog Lake are certainly, in part, newer than Lower Helderberg.

The granite masses are found to the east of this lake. They cut slates and limestones of Cambro-Silurian age, probably Lower Trenton, and by their action have developed crystals of staurolite, chiastolite, mica, &c., in the adjacent strata. The period of the intrusion is probably about the same with that of the dioritic masses just described.

In the area west of Memphremagog Lake, serpentine outcrops are quite frequent. They are associated with diorites and are often of very limited extent, so that their delineation on the map is not always possible. The larger and more important areas have, however, been indicated by barring.