

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.

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

REPORT

ON THE GEOLOGY OF A PORTION

OF THE

EASTERN TOWNSHIPS

RELATING MORE ESPECIALLY TO THE

COUNTIES OF COMPTON, STANSTEAD, BEAUCE, RICHMOND
AND WOLFE.

BY

R. W. ELLS, LL.D.



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

Director of the Geological and Natural History Survey of Canada.

SIR,—I beg to submit herewith my report on the work of the past two seasons, 1885 and 1886, on the geology of a portion of the Eastern Townships of Quebec.

The accompanying map is the south-eastern quarter-sheet of that known as the map of the Eastern Townships, compiled by the late Mr. R. Barlow, and first engraved in 1868, but hitherto published only as a topographical map. Although many additional surveys have been made since that date, in several of the townships embraced in the quarter-sheet, these have not all been incorporated in full, since, while not affording much assistance in the interpretation of the geology, it is found that such a course would further delay the present publication.

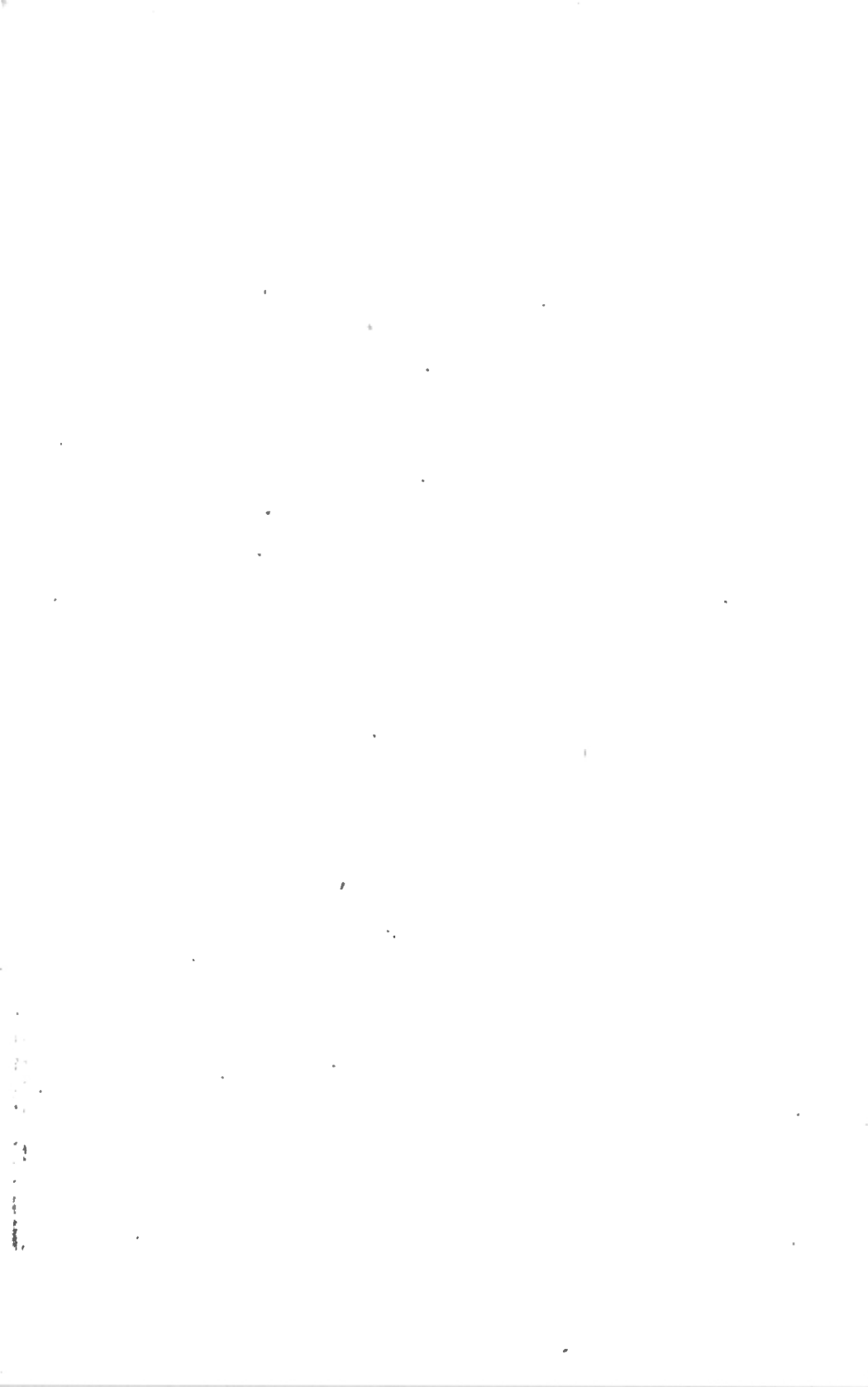
I have the honor to be,

Sir,

Your obedient servant,

R. W. ELLS.

Ottawa, April 12th, 1887.



REPORT
ON THE GEOLOGY OF A PORTION
OF THE
EASTERN TOWNSHIPS OF QUEBEC,
RELATING MORE ESPECIALLY TO THE
COUNTIES OF COMPTON, STANSTEAD, BEAUCE, RICHMOND
AND WOLFE.
BY
R. W. ELLS, LL.D.

The present report embraces the results of the work of the past two seasons, devoted to the revision and completion of the geological survey of that part of the province of Quebec, shown in the south-eastern quarter-sheet of the map of the Eastern Townships. Great progress has been made in the development of this portion of the province during the last twenty years, evidenced by the construction of the several lines of railway which centre in the city of Sherbrooke, as well as by the opening of hundreds of miles of settlement roads, by which large areas, formerly inaccessible, have now become comparatively open to investigation. Greatly increased facilities for the study of the geological structure of the district, are in consequence afforded.

A large amount of exploratory work had been done in former years ^{Work of former years.} by various members of the Survey staff. Among these may be mentioned the late Sir Wm. E. Logan, Dr. T. Sterry Hunt, Dr. Selwyn, Messrs. Richardson, Weston, Webster, and Brown; and various reports, having a bearing on the geology and mineral wealth of this section of country, have appeared from time to time. The principal of these, published by the Survey, are:—

Reports bearing
on the subject.

- Sir W. E. Logan—1847-48—On the Geology of portions of Lower Canada, more especially of the Eastern Townships.
- “ 1849-50—On the Geology of Lower Canada south of the St. Lawrence.
- “ 1850-51—On the Gold of the Chaudière Valley.
- “ 1863—Geology of Canada, the Quebec Group, etc.
- Mr. A. Michel—1863-66—On the Gold Region of Lower Canada.
- Dr. T. Sterry Hunt—1863-66—On Gold Assays of Quartz from Eastern Canada.
- Mr. Jas. Richardson—1863-66—On the Geology of the Quebec Group in the Eastern Townships.
- Dr. A. R. C. Selwyn—1870-71—Notes and Observations on the Gold-fields of Quebec and Nova Scotia.
- “ 1877-78—Observations on the Stratigraphy of the Quebec Group and the older Crystalline Rocks of Canada.
- “ 1880-81-82—Notes on the Geology of the South-eastern Portion of the Province of Quebec.
- “ 1882—The Quebec Group in Geology.—Trans. Royal Soc. Canada. Vol. I.
- “ 1884—Descriptive Sketch of the Physical Geography and Geology of the Dominion of Canada. Part I.
- Mr. Frank D. Adams—1880-81-82—Notes on the Microscopic Structure of some Rocks of the Quebec Group.

Among other papers bearing on the subject may be mentioned:—

- Mr. G. F. Matthew—1865—Geology of Southern New Brunswick, Cupriferous Rocks of South-eastern New Brunswick, compared with those of the Eastern Townships of Canada.
- Prof. H. Y. Hind, 1865—Geology of New Brunswick; the Quebec Group.
- Dr. T. Sterry Hunt—1878—Second Geological Survey of Pennsylvania; A History of the Taconic and Quebec Group Controversy.
- Sir Wm. Dawson—1883—Appendix to Life of Sir W. E. Logan; the Quebec Group.
- Dr. Selwyn—1883—Review of the same.

A review of the various reports above enumerated would, no doubt, be interesting, but is to a great extent rendered unnecessary in this place, since the history of the Quebec group, with the several opinions held from time to time regarding the geological position of its several divisions, has already been given in part by Dr. T. Sterry Hunt.

Topographical
work done.

In order to fix more precisely the limits of the different formations, as well as to render the map more complete, a large amount of topographical work was necessary. It has not been possible in the time at our disposal to add all the new surveys made since the engraving of the map in 1868, but enough has been done, it is hoped, to enable us to present an intelligent view of the complicated structure which prevails over much of the area in question. I have been assisted in this work throughout by Mr. N. J. Giroux, C.E., P.L.S.

From our examinations, as well as from those of previous observers in this field, the following geological systems have been recognized:—
Systems recognized.

E. Silurian.

D. Cambro-Silurian.

C. Cambrian.

A. B. Pre-Cambrian.

Crystalline and igneous rocks, volcanic and plutonic.

E. SILURIAN.

By reference to the Geology of Canada, 1863, and to the large geological map, 1866, it will be seen that a very considerable portion of the area of the accompanying map was then supposed to be occupied by rocks of this age. They were held to cover a great part of the counties of Beauce, Richmond, Wolfe, Stanstead, Compton and Sherbrooke. The earliest examination of the area by the Geological Survey was made in a hasty traverse by Sir Wm. E. Logan, in 1847, the results of which are given in his Report for 1847-48. This related more particularly to the area lying east of a line extending from the head of the east bay (Fitch Bay) of Lake Memphremagog to the mouth of the Famine River, on the Chaudière. The characters of the various rocks seen in this section are there clearly stated, while their age was inferred to be Silurian, or in part Devonian, on the supposition that they formed the westward prolongation of the members of these systems as recognized in the Gaspé peninsula.

All these rocks were supposed to be closely related, but were divided into two formations, the one highly calcareous, the other apparently devoid of limestone. The first or calcareous formation was stated to have a breadth of about twenty miles, and to be composed of arenaceous and micaceous limestones, which are at times crystalline, interstratified with fine and coarse mica-slates. It was further stated that on a line of section drawn from the metamorphic ridge of the Massawippi Mountain east to Canaan, the limestone was much more abundant in the first three miles than in the remaining distance, and was usually of a dark color, sometimes approaching a dull, earthy black, and frequently separated by thin, black carbonaceous shales, having a satiny lustre on fresh fracture, resulting probably from the presence of very fine scales of mica, the former weathering often to a deep brown, and the slates to a brownish-black. Other varieties of limestone are grey, striped, banded and white. They frequently contain a considerable quantity of iron-pyrites, disseminated in cubes up to nearly an inch in size. The fossiliferous character of these rocks,

Early work of Sir W. E. Logan, 1847.

First views as to the structure.

Section between Massawippi Mountain and Canaan.

Localities for
fossils.

more particularly as displayed at Dudswell and around the shores of Lake Memphremagog, was pointed out by Sir Wm. Logan. The fossils differ considerably at various points. The Dudswell rock contains immense quantities of corals, often of large size, together with crinoids; while at Georgeville and Potton Ferry, now Knowlton's Landing, in Sargent's Bay, calcareous strata are found, which, while containing somewhat similar organic remains, appear as a whole to belong to a later period. A limited outcrop at Magoon's Point was recognized by Sir Wm. Logan as fossiliferous, only by the presence of small crinoid stems. Closely allied forms were also observed in an outcrop of limestone on the north-east side of the Chaudière River, mid-way between the Famine River and the village of St. George, Beauce, in which brachiopod shells are also abundant. All these fossiliferous beds were at that time supposed to represent the lower portion of the calcareous formation.

Section
between
Fitch Bay and
Canaan.

Returning to the line of section between Fitch Bay and Canaan, the mica-slates, which are interstratified with the calcareous beds in the first three miles of the section mentioned, are usually soft and fine, resembling clay-slates with addition of mica. But in the remaining seventeen miles of the first portion, this calcareous character is less marked, the rocks becoming coarser and more quartzose, though beds of impure siliceous limestone still occur at intervals as far as Lot 6, R. VIII., Barford. Black slaty beds, displaying crystals of chialstolite, appear in places. The whole formation is highly pyritous, and the beds have a very uniform dip to the north-west for the greater part of the distance. Many corrugations or folds doubtless occur, by which the calcareous or other beds are brought to the surface at various points.

From the locality noted above in Barford to Canaan, a distance of about twelve miles, the limestones are apparently wanting; mica-slates, black and grey, with bands of hard quartzose grits, being the prevailing strata.* These are, like the preceding, pyritous, and dip north-westerly at angles of 40° to 90°. They are also often highly metamorphic, but in most cases this feature is plainly due to local intrusions of granite. Throughout the greater part of this extensive area no fossils have yet been found.

Rocks of the
eastern area
formerly
regarded as
belonging to
one series.

No attempt was made in 1847 to separate the fossiliferous beds of Dudswell and other places from the non-fossiliferous slates and black graphitic limestones of the section just described, though a very considerable difference in the lithological aspect of the rocks of the two series is manifest. The descriptions of the various members as given

* See page 433, *Geology of Canada*, 1863.

in 1847-48 were repeated in 1863 (see Geology of Canada, Chap. XVI, Gaspé Series); and, in addition to the large area already noted, a second and somewhat extensive basin-shaped tract was described as presumably forming part of the same series. This was stated to occupy the country extending north-east from Lake Memphremagog, on both sides of which, slates and limestones, both of the fossiliferous and non-fossiliferous series, are developed, to the vicinity of Ham Mountain; bounded on the west by the serpentinous belt of Shipton, Melbourne and Brompton, and on the east by the range of hills known as the Stoke Mountains, the extension of which to the south-west reaches Lake Memphremagog between Georgeville and Fitch Bay, near Magoon's Point. The sediments in this area differ somewhat from those already described. The calcareous beds are to a large extent absent, while there is a greater development of the greyish and black plumbaginous slates. Their Silurian age was inferred by Sir Wm. Logan from the presence of limited areas of slates and limestones, holding fossils, such as corals and crinoids, like those of Dudswell, and which were at that time supposed to constitute an integral portion of the rocks of this area, the upper beds being regarded as Devonian and the lower beds as Silurian and referable to the Gaspé series.

Central or St
Francis area

The rocks of the eastern area are now regarded as the extension northward into Canada of those described by Prof. Hitchcock, under the heads of "Calcareous mica-schist" and "Coos group," (see his Report on Geology of New Hampshire, 1877.) In the map accompanying that report the distribution of these groups into Quebec is given for a distance of about twenty miles north of the boundary. Following the geological map of Canada, 1866, the calcareous portion, embracing the limestones and slates of the first three miles of the section east of Massawippi Lake and Fitch Bay, are colored as belonging to the Helderberg formation (Devonian), and supposed to be the equivalents of the fossiliferous limestones of Georgeville and Sargent's Bay. The aspect of these beds and their relations to the associated rocks will be presently considered.

Report of Prof.
Hitchcock, 1877.

While, therefore, the lithological character and non-fossiliferous condition of much of these sediments afford but little evidence by which their Silurian age can be determined, yet several areas belonging to this horizon are clearly recognized; and these for the portion of the province included in the accompanying quarter-sheet map, may be thus briefly described.

Two distinct
series recog-
nized.

The most northerly exposure, omitting that which has already been referred to as occurring on the Chaudière, is found on Lots 20-23, R. III., Lambton, at the narrows of Lake St. Francis, and about four miles from the head of the lake. This outcrop of fossiliferous rocks is

Areas of true
Silurian rocks,
Lake St.
Francis.

Mode of occurrence.

first referred to in the Geol. Survey Rep. for 1849-50, p. 51, and later in the Geology of Canada, 1863, page 429, under the head of Upper Silurian. The rocks are brownish and greyish dolomitic slates and limestones, which in places contain an abundance of corals, for the most part apparently of Silurian genera. The band is very narrow; it occupies a limited margin along the east side of the first point, and terminates at seventy-five yards from its extremity, where the fossiliferous beds rest against highly metamorphic talco-felspathic and quartzitic schist, which in some places passes into a conglomerate, and belongs to a much lower horizon. A second exposure, also of very limited extent, occurs at the extremity of the adjacent point to the west, separated from the former by a very narrow inlet. These fossiliferous rocks are apparently in closely infolded lenticular basins. Shorewards, they are seen in a small knoll to the right of the road leading down the north side of the lake from Lambton village. Their unconformity to the underlying schists and gritty beds is here quite clear; the newer beds dipping N. 80° E. $< 25^{\circ}$, and the older N. $< 60^{\circ}$. This outcrop of the Silurian is not more than fifty yards wide. Easterly, its limit cannot be ascertained, owing to the dense forest growth, but the beds do not apparently extend to any great distance, seeming rather to occupy the crest of a low ridge which extends from the narrows of the lake in this direction. On the south-western or opposite side of the lake, the fossiliferous rocks do not appear at all, though the slates and conglomerates are well developed a short distance to the west.

Limestones of Stratford and Lake Aylmer.

Proceeding south-westerly, the next exposures of limestone are seen in the vicinity of Stratford P. O. and on the shores of the points at the entrance of Ward's Bay, on Lake Aylmer. In these outcrops no fossils have yet been observed. The Stratford beds and all those to the east of the lake are evidently distinct from those just described, being probably the extension of the limestones seen in the first part of the section between Massawippi Lake and Canaan. They are arenaceous and graphitic, and of black and dark grey colors, and presumably belong to the older series presently to be described. Other outcrops of limestones, nearer the east shore of Lake Aylmer, are highly dolomitic and crystalline, and are apparently a part of the hard felspathic, chloritic and micaceous schist series which forms a prominent ridge in this direction.

Silurian of Ward's Bay.

The beds on Lake Aylmer at the entrance to Ward's Bay, though showing no fossils, resemble much more closely the recognized Silurian limestones of other localities. Their unconformity to the underlying slates, grits and conglomerates is also very manifest, and they have at this point the structure of a shallow synclinal, which is probably

the northern extremity of the St. Francis River basin; since similar rocks can thence be traced continuously to the vicinity of Dudswell. At various places these are highly fossiliferous. Thus, about one mile to the north of Weedon village, large corals and crinoids, probably of Silurian age, are found in the limestones, which form an apparently continuous belt extending along the road to Lake Aylmer, where they unconformably overlie hard, cherty, felspathic and somewhat gneissic rocks, fragments of which are found in the beds near the contact. Between Weedon and Marbleton, the rocks of this series are seen at intervals, in a depression which is bounded on the west by a high ridge of grits and conglomerates, which extends from Marbleton to Garthby and which evidently belongs to an older series. Near Marbleton, the Silurian limestones are in places comparatively unaltered, in others highly metamorphic. This alteration is more apparent at Lime Ridge, where the extensive works of the Dudswell Lime and Marble Company are situated, and where ridges of highly crystalline limestone occur, in which the quarries of this company are opened. Their Silurian age is, however, evidenced by the presence of crinoids and corals, even in the most altered portions. On Lot 22, R. VII., Dudswell, outcrops of crystalline limestone are also found, of excellent quality and in great variety of color. Some of the beds are of the kind known locally as "black and gold," and referred to by Sir W. E. Logan, *Geology of Canada*, 1863, pp. 432 and 827, where their resemblance to the celebrated Portor marble of Italy is pointed out. Attention was directed to the possible economic value of this deposit as early as 1847, and during the past year a company has been formed in Sherbrooke for the purpose of thoroughly testing its value. A channelling machine has been set to work, and an area of about forty feet square stripped, to get rid of the somewhat shattered surface stone. The marble becomes much more compact in the second bench, and presents a great variety of colors and markings, some of which are exceedingly beautiful. Some of the ledges are composed almost entirely of corals, often of large size, the internal structure of which, when brought out by polishing, presenting a handsome and striking appearance.

Fossiliferous
limestones of
Weedon.

Marbleton and
Lime Ridge.

Dudswell
marble quarry.

The crystalline character of the limestone continues at intervals to within half-a-mile of Dudswell Corner, although comparatively unaltered limestone and shale also show here and there along the road from Lime Ridge and in the fields adjoining. In places the rocks have a very rusty, dolomitic look, weathering to an intense brown. They rest upon slates and gritty schists of the older series which flank the range of the Stoke Mountains. A short distance south of Dudswell, the attitude of the beds appears to indicate the extremity of the syn-

Dudswell
centre.

clinal basin in this direction. The valley of the St. Francis River, between this place and Sherbrooke, is largely occupied by sand and gravel, and the exposures are very few, while those seen appear to belong to the lower graphitic limestone series, presently to be described.

Flagstone
quarries at
Dudswell.

On the eastern side of the lake at Dudswell, the rocks are more flaggy, and a number of flagstone quarries have been opened within the past four years. The stone is admirably suited for that purpose, and a market is easily obtained in Montreal.

Limits of the
Silurian basin.

The eastern limit of the Silurian basin at this place is difficult to determine, owing to the great covering of drift, but it appears to be not far from the beginning of the ridge near the line between the townships of Dudswell and Bury, where black ferruginous slates and hard arenaceous limestones of the lower series come in. The southern limit of the basin is also to some extent conjectural.

North Hatley.

In the vicinity of North Hatley, at the outlet of Massawippi Lake, fossiliferous shales, similar to those already described, are seen, resting unconformably upon the black, graphitic limestones. The fossils apparently indicate a Lower Helderberg horizon. The outcrop is very limited, but the rocks resemble those seen near Georgeville and Knowlton's Landing, on Lake Memphremagog. The areas of Silurian around this lake, though not within the quarter-sheet map now referred to, may nevertheless be briefly noted, as they are connected with other areas within the map further to the north-east. The largest of these occupies both sides of the lake, from the outlet at Magog village to a distance on the east side of nearly three miles above Georgeville. On the west it terminates at Gibraltar Point, on the north side of the entrance to Sargent's Bay. A smaller, but disconnected, wedge-shaped area extends south from Knowlton's Landing, on the west side of the bay, for several miles, the contact between the Silurian rocks and the underlying black limestones and shales being marked by a fault. Traces of plant stems are found in some of the sandy layers of this area, which resemble very closely those seen in the beds of Lower Helderberg age at Dalhousie, on the Bay of Chaleurs.

Memphre-
magog Lake.

Limit of
Silurian at
Magog.

The Silurian rocks do not extend far inland on either side of Lake Memphremagog, but form a narrow margin resting on black slates and sandstones, the former of which contain graptolites of Cambro-Silurian age, and are of an entirely different character. At the foot of the lake, the Silurian basin evidently terminates in the flat ground along the lower part of the Cherry River about two miles from the shore, the contact with the Cambro-Silurian strata being visible on the road to Lake Fraser, on Lot 2, R. XVI., Magog. On the west side of the lake, the contact is seen on the road at the brook crossing on Lot 5, R. XV., Magog.

The only other areas of Silurian rocks noted in this section are found in the township of Stoke, except a very small outlier in the western part of Dudswell. In the former locality, sandy and calcareous slates, with thin and impure limestone bands, brownish-grey in color, form a narrow basin, infolded with the older rocks, and extend from the middle of L. 14, R. V., Stoke, to L. 10, R. X., Dudswell. At Stoke Centre, these fossiliferous strata rest upon hard schistose conglomerate and bluish-grey slate on the west, and on the east are bounded by hard, white-weathering felspathic quartzites, which are associated with black, iron slates, presumably of Cambrian age. These Silurian rocks are well defined, not only by their characteristic fossils, but by their lithological resemblance to recognized Silurian strata seen at other points. The Stoke area is apparently separated into two portions, the more northerly of which, extends from Lot 12, R. X., along the road through North Stoke into Ste. Camille, and is largely composed of conglomerates, associated with dolomitic brownish slates, the former made up of pebbles of hard grit and slate in a slaty and gritty paste. In places this conglomerate is difficult to distinguish from others which belong to a much older horizon, except for the evidence of the contained fossils. These are mostly corals and crinoid stems, which resemble those found near Georgeville. On Lot 11, R. XII., Stoke, half-a-mile to the west of the main road, there is a considerable outcrop of crystalline limestone, similar to that of Lime Ridge. This basin apparently terminates not far from the forks of the road from North Stoke to Marbleton. Its eastern limit is probably near the depression marked by the brook which flows from this road to Stoke Centre, the coral-bearing conglomerate and shales occupying the slope of the hill to the west, while the first rocks seen to the east are the hard, iron slates which flank the Stoke Mountain range.

Silurian areas
of Stoke.

Further north, on a new road between Lime Ridge and Ste. Camille, a small outcrop is seen on Lots 14 and 15, R. IX., Dudswell, resting unconformably upon hard quartz grits and black slates.

The very marked contrast which exists between the fossiliferous Silurian rocks just described, and the slates and sandstones, many of which are highly quartzose, together with the dark-grey and often graphitic limestones, so abundant in the great area to the south-west, will be apparent to anyone who carefully studies the characters of the several series. Confirmatory evidence that the greater part of the rocks formerly regarded as Upper Silurian really belong to older systems, is furnished by the presence, at several points, of serpentines, conglomerates and hard quartz-schists, similar to those recognized as constituting an integral portion of the volcanic

Contrast between the
Silurian and
associated
rocks.

Graptolites.

belt of the Eastern Townships. The recent discovery also of graptolites and other fossils of Cambro-Silurian age in these so-called Silurian sediments, bears still more strongly in this direction, and lends confirmation to the correctness of the somewhat extensive changes made in the accompanying map, as compared with that of 1866.

Complicated structure.

The present distribution and mode of occurrence of the various patches of Silurian rocks, make it highly probable that strata of this age once covered a very considerable area; and that, in the subsequent periods of disturbance and folding, these became so intricately involved with the underlying older rocks, which apparently ranged from the Pre-Cambrian to the Cambro-Silurian, as to make these remnants appear, at first sight, to be integral parts of the older systems.

D. CAMBRO-SILURIAN.

Three principal areas.

To this system must now be referred certain areas of graphitic, blackish or dark-grey limestone, with, in several localities, associated slates and sandstones, already in part described; and for convenience of reference, these may be divided into eastern and western areas. To the latter belong the calcareous rocks of Richmond, Danville, Warwick and Arthabaska. To the former, those of Stanstead, Hatley, Compton and Eaton, with their extension north-east to Stratford and Lake St. Francis, formerly considered as of Silurian, or in part Lower Devonian, age, but now known to contain fossils similar to those found in the limestones of the western areas, and which have been since 1874 recognized as of Cambro-Silurian, probably Trenton Utica, age. To this system also must be assigned a considerable thickness of black, blue and grey, often plumbaginous slates, with sandstones, which occupy the greater part of the large area north of Memphremagog Lake, also described in former reports as of Silurian age, but whose unconformable relations to the recognized fossiliferous Silurian just described, together with the presence of fossils, graptolites, etc., similar to those found in the St. Lawrence area, renders the present change necessary.

Kinds of rocks in the eastern areas.

The characters of many of the rocks of the eastern areas have already been described in the preceding chapter. Associated with the limestones, however, are certain blackish and bluish slates, which from their peculiar aspect are easily recognizable over a great extent of country. These are frequently thickly dotted with ochreous spots, probably resulting from the decomposition of a ferruginous dolomite or bitter spar. On fresh surfaces these spots have a pearly lustre and a brownish-grey color. Many of the sandstones also are similarly dotted, but the spots are generally smaller. The rocks have frequently

a brownish tinge, and are charged with cubes of iron pyrites, generally of small size, but at times reaching dimensions of nearly an inch. Near the contact with the granites, these strata are considerably altered, crystals of chialstolite and mica being produced, and a somewhat gneissic or schistose structure imparted for a short distance from the granitic mass. In places the graphitic slates are minutely wrinkled, and quartz veins, oftentimes of considerable size, are observed at various points.

The sediments which are found throughout the greater part of the area north of Lake Memphremagog, and on either side of that sheet of water for several miles, differ somewhat from those of the eastern section. They consist mostly of different colored slaty rocks, often in large slabs which in places have been quarried for flagging stones, more particularly on the west side of the St. Francis River, in rear of Brompton Falls. The limestones are apparently confined to very limited areas, and in character are like those of Richmond and Hatley. As in the eastern area, the slates are frequently ochre spotted. They are also occasionally well defined by a regular alternation of color bands, black, grey or bluish, giving them a characteristic striped appearance, which on freshly uncovered surfaces is very distinct. This feature of the slates is exceedingly persistent, certain bands being easily traced almost without a break from near the Vermont boundary northward beyond the Chaudière River, at which place they are well displayed on the road down the west side of the Gilbert stream. These slates are for the most part highly cleaved, and their bedding is very obscure, except where a good cross section is afforded by a cliff or cutting. In the vicinity of South Ham village, and in the northern part of the township of Ste. Camille, hard, cherty, felspathic-looking slates occur, which break with a conchoidal fracture, and very closely resemble strata seen at various points along the south side of the River St. Lawrence, as at Griffin Cove, Marsouin, etc., where they are associated with, and apparently form an integral part of, what has been regarded as the Hudson River or Utica formation. (See Geol. Sur. Rep., 1880-81-82, p. 18 pp.)

The Central or St. Francis River area.

Hard cherty slates of South Ham.

The rocks of the western area have already been very fully described in earlier reports, and their lower or Cambro-Silurian age established. They presumably occupy much of the flat country lying to the west of the ridges of altered slates and other metamorphic rocks seen at Arthabaskaville and which extend thence south-westerly towards the St. Francis River. They also occur in unconformable patches or narrow strips upon the older schists, and occupy depressions between the Cambrian and Pre-Cambrian hills. Sections of the limestones from different and widely separated points show them to be largely

The western area.

Unconformity to underlying schists.

Age determined by means of the microscope.

composed of organic remains, the microscopic examination of which proves them to belong to the Trenton group, their horizon being apparently about that of the upper portion of the Chazy formation.

Graptolites of Lake Memphremagog first noted by Sir W. E. Logan, 1847.

In 1847, Sir W. E. Logan found graptolites in loose pieces of slate on Lot 5, R. XIV., Bolton, now the township of Magog. It was stated that these were evidently not far removed from the place whence they were derived. (See Geol. Sur. Rep., 1863-66, p. 31.) During last season, 1886, an examination was made of this locality with the hope of finding these fossils *in situ*. This expectation was realized by the discovery of highly graptolitic slates in at least two places, the first on Lot 7, R. XV., Magog, about 150 yards south of the forks of the road along the west side of the lake; the second on the eastern side of the lake, on Lot 19, R. II., Stanstead, in a cutting on the main road, about 100 yards north of the entrance to the grounds and residence of the late Sir Hugh Allan. The fossils of both places appear to belong to the same horizon, and may be from portions of the same beds which appear on either side of a sharp synclinal that underlies the basin of the lake. They have been submitted to Prof. Lapworth, who has made a special study of graptolites, and he has kindly reported on these as follows:—

Lot. 7, R. XV., Magog.

Prof. Lapworth's remarks.

"Matrix, soft, thin-bedded and flaking silvery shales, greenish-gray in color (originally black), apparently altered and spotted by contact metamorphism.

1. *Dicranograptus ramosus*, Hall.
2. *Diplograptus angustifolius*, Hall.
3. *Diplograptus foliaceus*, Murchison (= *pristis*, Hall.)
4. *Diplograptus perexcavatus*, Lapworth.
5. *Climacograptus bicornis*, Hall.
6. *Climacograptus cœlatus*, Lapworth.

The fossils are all in a most miserable state of preservation, but all the forms named above are easily recognizable. These fix the age of the strata as Utica or Marsouin or Norman Kill, but somewhat higher in the series than the typical Norman Kill beds. They may safely be termed Upper Llandeilo or Lower Bala, and placed generally above or about the horizon of the Trenton or Utica rocks of the western area.

Lot 19, R. II., Stanstead.

1. *Diplograptus foliaceus*, Murchison.
2. *Dicellograptus* sp., allied to *D. Forchammeri*, Geinitz.

3. *Dicellograptus divaricatus*, Hall.
4. *Climacograptus perexcavatus*, Lapworth.
5. *Corynoides calycularis*, Nicholson.
6. *Dicranograptus* sp. ?

The state of preservation of these fossils is so poor that it is impossible to identify any of them with absolute certainty. They are all clearly of the same general facies as those of Magog, but better specimens should be obtained before the matter can be satisfactorily determined."

The beds from which these graptolites were obtained are probably Crinoid stems. the same as those noted by Sir W. E. Logan in 1847, referred to above. They consist of greyish and blackish, often highly plumbaginous slates, with occasionally coarser sandy beds. A short distance south of the locality, on the west side of the lake, crinoid stems were found in ledges of similar slates along the road-side.

The slates just described have a very considerable development. Distribution. They extend north-easterly through Brompton, Wotton, Ste. Camille and thence to the Chaudière. They have a breadth of ten to twelve miles in their widest part, which is in the township of St. George de Windsor. Throughout their whole extent they vary but little in character, and can generally be recognized without difficulty, even though fossils are not often seen.

Returning to the western area, we find presented in the townships of Melbourne, Cleveland and Shipton one of the most puzzling problems connected with Eastern Townships geology, and concerning the true explanation of which much discussion has arisen. Complicated structure of the western area.

In the Geology of Canada, 1863, pp. 239-40, it is stated that "the lower black shales which are brought into view along the line of the Boyer and Stanbridge anticlinal, near Farnham, are intimately associated with thin black and dark grey limestones which contain fossils, the aspect of which is more recent than might be expected in the Potsdam formation." The difficulty of separating these two series seemed so great that Sir Wm. Logan says:—"Except, however, where such fossiliferous strata are known to occur, the black slates and limestones will be provisionally described as older than the Quebec group." These rocks, on being traced to the north-east, were found to extend continuously past the Kingsey ridge and to occupy the valley between Danville and Richmond, whence they could be traced at intervals south-westerly into Ely and Stukely. While there is every reason to believe that the calcareous rocks of the Danville and Richmond depression are of the same horizon as the fossiliferous limestones of Farnham, it has been quite conclusively established, as already pointed out, by microscopic examinations of Early views of Sir W. E. Logan.

Correct view of
the structure
first indicated
by Dr. Selwyn.

the contained organic remains, that these do not belong to the Potsdam, but are much more recent in age, and are, in fact, a part of the Trenton group, brought into their present position as has been pointed out by Dr. Selwyn in the publications mentioned, p. 6 J, by an intricate system of folding and faults.

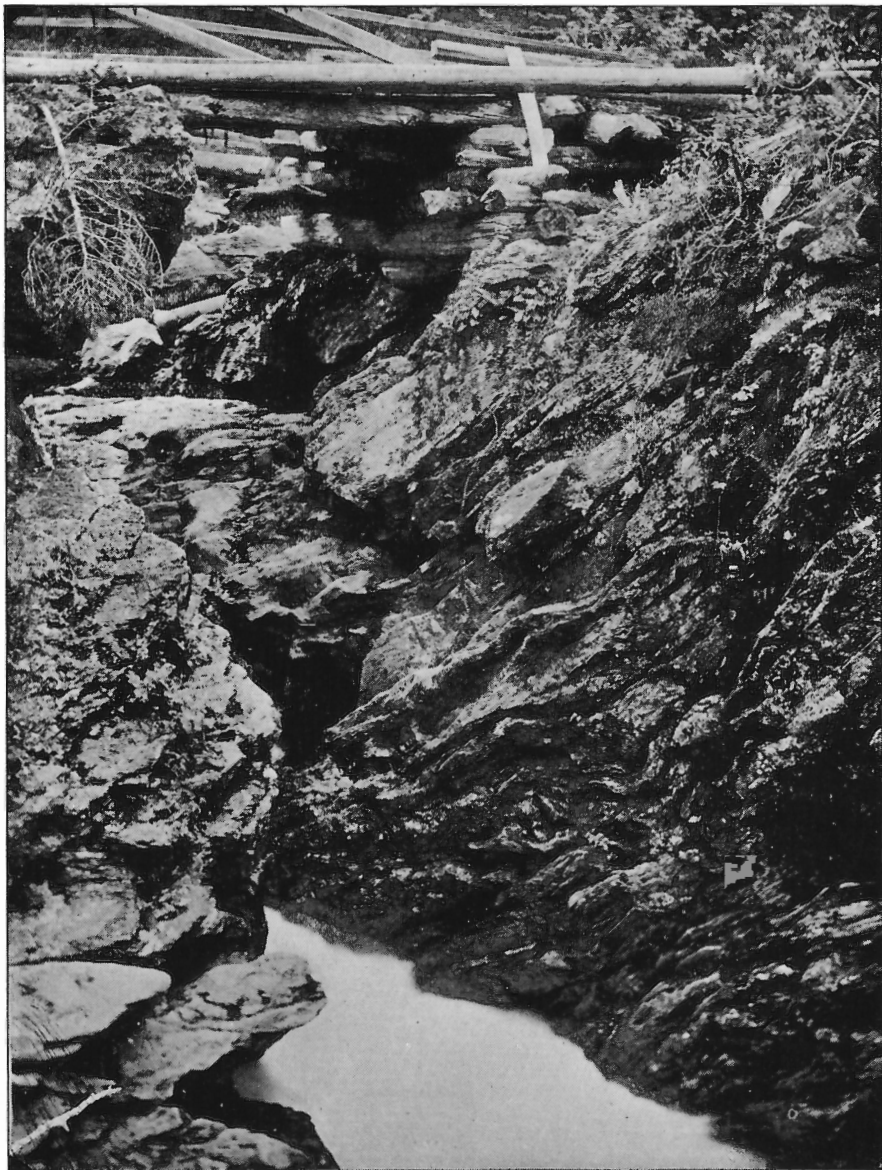
Structure at
Danville and
vicinity.

From Melbourne, north-east to a distance of several miles beyond Danville, the black limestones and calcareous slates form a very continuous but generally narrow band, confined for the most part to the depression along which the Grand Trunk Railway is constructed. At several points the structure seems to be that of a true anticlinal in the calcareous beds, making them appear to underlie the great series of hard metamorphic schists and slates, with serpentines and quartzites, which constitute the prominent ridges on either side, and between which, in places, there appears to be a real conformity. Hence, it was formerly supposed that there was a regular passage upward from the limestones at the base into the overlying schists and associated rocks. On careful examination at other points, this apparent conformity is, however, found not to exist, since, by tracing these rocks to the north, the relative position becomes reversed and the limestones are found to rest at many points unconformably upon the altered rocks. These relations are well seen at Arthabaskaville, at Warwick, and along the road thence toward Kingsey Falls. At other points also, as at Trout Brook P. O., in Tingwick, and at several places between Castlebar and St. Patrick's Hill, the limestones occur in patches, often of very limited extent, resting unconformably on the schists.

Gorge of the
Nicolet River.

The section which is perhaps most difficult of interpretation is that found in the Nicolet River at the gorge, about a mile east of the Danville road. At this point a well defined anticlinal is apparent in the black limestones, and on the south-east side these appear to dip regularly beneath highly metamorphic schists and hard quartzose rocks. The succession to the west is wanting at this point, the surface being largely covered with drift. There is nothing at this locality to disprove the apparent structure, except the more highly altered character of the overlying series as compared with the fossiliferous character of the limestones beneath. To the north, however, on a road leading east from the main road which extends from Castlebar to St. Patrick's Hill, a true anticlinal structure is seen, the lowest beds being hard metamorphic slates and schist, upon which the limestones are placed unconformably, an order of things which is noted at several other points in this direction. A somewhat similar structure to that found at the gorge of the Nicolet is exhibited along the line of the Grand Trunk south of Danville for some miles, where the calcareous beds are observed to dip apparently beneath the older

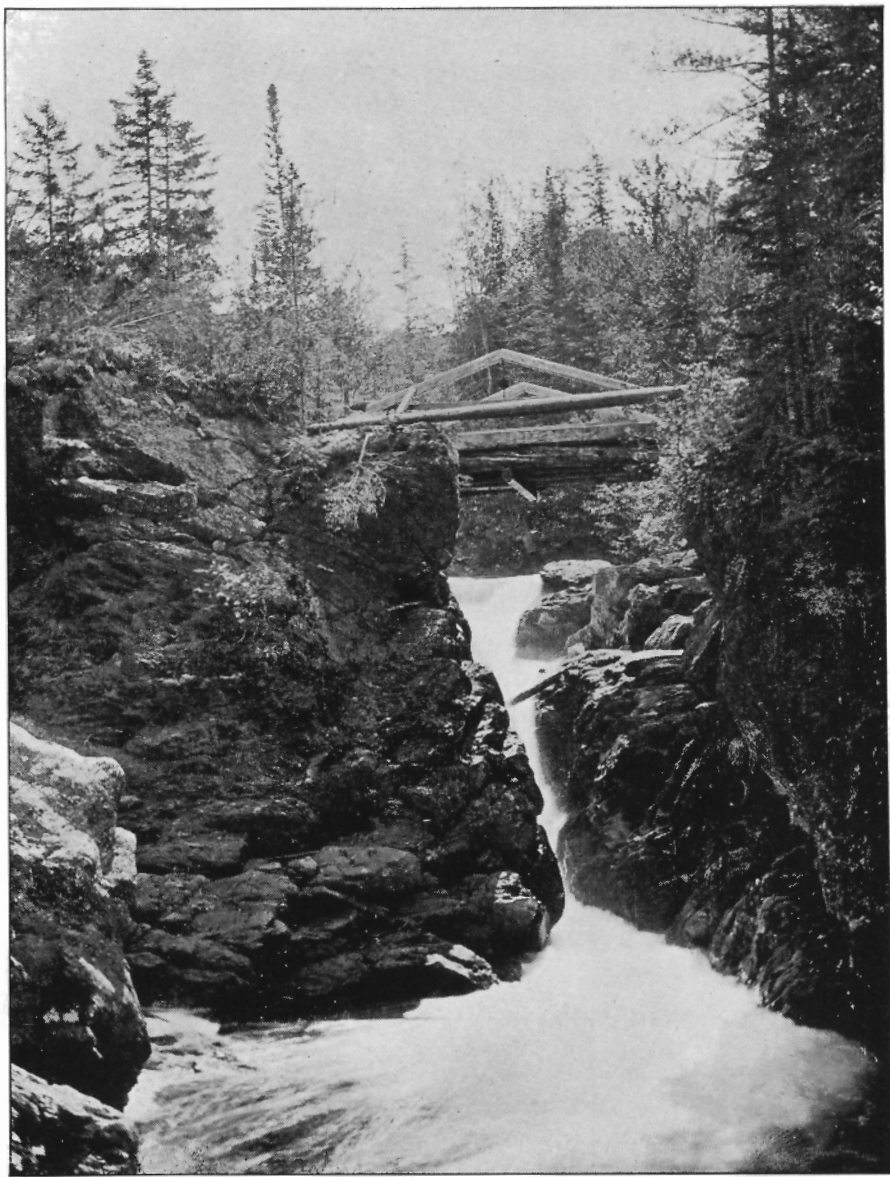
Grand Trunk
south of Dan-
ville.



T. G. WESTON PHOTO., 1879.

IVES-PROCESS; G. E. DESBARATS & SON, MONTREAL.

GORGE OF THE NICOLET RIVER, SHIPTON, QUEBEC;
SHOWING THE JUNCTION OF PRE-CAMBRIAN SCHISTS WITH CAMBRO-SILURIAN
CARBONACEOUS LIMESTONES.



T. C. WESTON, PHOTO., 1873.

IVES-PROCESS; G. E. DESBARATS & SON, MONTREAL.

GORGE OF THE NICOLET RIVER, SHIPTON, QUEBEC;
SHOWING THE JUNCTION OF PRE-CAMBRIAN SCHISTS WITH CAMBRO-SILURIAN
CARBONACEOUS LIMESTONES.

looking rocks on either side. Careful examinations of these localities, however, disclose the presence of profound faults throughout this whole region. The limestone strata near the contact with the over-lying beds are frequently crushed and distorted, while there is often a wide diversity in the dips of the two series. In this way at the gorge also, where apparently a heavy transverse fault, just to the north of Danville Village, complicates matters considerably, we must refer the apparent superposition of the schists upon the limestone to the occurrence of a sliding fault, probably of considerable extent, by which the older measures have been thrust upward into their present position. Heavy faults.

South of Danville, towards Richmond, the position of this fault can be ascertained with considerable accuracy. It evidently crosses the St. Francis River, and extends towards the Vermont boundary, along the line of the Missisquoi River and Valley, as a similar displaced condition of the various rock formations is visible in this direction. This, however, is an area which requires to be yet worked out in detail. Potton and Danville fault.

To the north of Danville, the fault evidently continues in the direction of the depression leading towards Warwick station. The surface is, however, so deeply covered with sand, and rock exposures are so rare, that it has not been attempted to define its position with any pretence to accuracy. The limestones and calcareous slates of the newer series doubtless continue to occupy the valley in this direction. They are well exposed in the stream at Gilman's mills, west of Danville, and at several points further to the west, as indicated on the map. To the north their contact with the overlying schists which form a prominent ridge extending from the vicinity of Kingsey Falls to the crossing of the Ruisseau des Pins, at Warwick, is seen on Lots 24 and 25, R. V., Tingwick. Danville and Warwick.

At Arthabaskaville, the contact, or superposition of the limestones of the newer series upon the older schists, is seen at a mill on the east branch of the Nicolet River, whence the former extend north-westerly to Arthabaska station, where they are again well exposed in the stream, dipping south-easterly, and showing the presence of a synclinal between these places. To the south-west of the former locality, the outline of the Cambro-Silurian keeps near the main road leading through St. Madore to Warwick, the characteristic fossiliferous limestones being seen about three-eighths of a mile north-west of Warwick station, as well as at several points along that road. The connection of the Danville area with the great area of the flat country west of Arthabaskaville has not yet been traced, owing to the covering of sand, but to the south-west the fossiliferous limestones show at several points Arthabaskaville.
Drift-covered country.

on the road along the west side of the ridge leading to Kingsey, as far as Lot 23, R. I., Warwick, whence their contact with the underlying series is again seen.

Kingsey Falls
and French
Village.

The contact of the limestones is further noted a short distance to the west of Kingsey Falls, whence, with a curving outline, it extends in the direction of French Village.

Present views
of the structure
considered.

That the views concerning the structure and relations of the two series of rocks above described are probably correct, is evidenced by a glance at the stratigraphical position of the Quebec group, as given in the Geology of Canada, 1863, where it is stated to be intermediate between, and to comprise portions of, the Calciferous and Chazy. The horizon of the fossiliferous black limestones being conclusively established as not lower than Chazy, it is manifest that their assumed position beneath rocks which have formerly been regarded as the equivalent of the Levis and Sillery formations, but which are probably, in some cases at least, much older, cannot be sustained; and that the peculiar stratigraphical relations now seen at certain points can only be explained, as above described, by a series of faults and intricate infolding of newer with older rocks, a feature already pointed out in the preceding chapter as also affecting the position of certain Silurian areas. To the south-west of Richmond, the fossiliferous limestones which have been recognized in the direction of Stukely are brought into intricate association with highly metamorphic strata through similar agencies. At South Ely, fossils have been found in these rocks which resemble those of Danville and Arthabaskaville, but the precise outlines of these newer areas have not yet been traced.

Fossils of
South Ely.

The areas of fossiliferous limestones and associated graphitic and calcareous slates just described are for the most part situated on the west flank of a broad belt of rocks of various characters, portions of which are highly metamorphic, resembling very closely Pre-Cambrian rocks of other localities; while other portions, much less altered, have more the aspect of Cambrian sediments. The consideration of these groups will be presently taken up.

Limestones of
the St. Francis
area near
Windsor.

West side of
Lake Mem-
phremagog.

At several points, resting upon the latter, more particularly in the central area, similar limestones occur. These are seen on the north side of the St. Francis River, on Lot 5, R. XII., Windsor, as well as on the south side of that stream. A considerable area is also found on the upper part of Sargent's Bay, and in the vicinity of East Bolton and Peasely's Corners, and, extending south of that bay, between the Sugar-loaf Mountain and the road up the west side of Lake Memphremagog.

The limestones of the area lying to the east of the Massawippi and Stoke Mountain range, formerly regarded as Silurian, but

now proved, from the evidence of the contained fossils, to be Cambro-Silurian, have already been described. In the sections of rock from Hatley, the microscope revealed the presence of crinoids, and other fossils, like those of the Melbourne and Danville area. Their unconformity to the overlying Silurian fossiliferous beds was first pointed out by Sir Wm. E. Logan. (See Geological Survey Report for 1847-48, p. 48.)

Fossils in the black limestones of the Eastern area at North Hatley.

East of the line which bounds the calcareous portion of this formation in the eastern area, the limestones are rarely seen. With the exception of the limited outcrop in Barford, already noted, none were observed till we reach the village of West Stewartstown, on the Upper Connecticut River, in the adjoining state of New Hampshire, where the siliceous limestones, presumably of this formation, have been observed by Prof. Hitchcock. (See Geology of New Hampshire, 1877, p. 41.) On the line of the International railway, about three miles west of Marston station, a small cut is made in limestone of this character, and is the only indication of these rocks in this direction east of Robinson station.

Limestones of West Stewartstown, N. H., noted by Prof. Hitchcock.

The calcareous beds, while not continuous to any great extent in either direction, apparently occupy crumpled or possibly overturned synclinal basins in the ochre-spotted slates and sandstones, which might in this case indicate the denuded crests of small anticlinals, of which doubtless a number exist in the thirty miles between the metamorphic ridge and the New Hampshire boundary. In no other way can we account for the enormous thickness which would otherwise result from such a continuous and regular series of north-westerly dips as are found in this area.

Probable structure of the Eastern area.

The extension of these beds can be traced north-easterly to the Chaudière River, and thence in an apparently unbroken area along the boundary between Quebec and Northern Maine. The distribution of the several groups has not yet been worked out in this direction, but limestones similar to those just described are found on the north-east branch of the St. John River, indicating the presence of rocks of Cambro-Silurian age in that vicinity.

Extension northward.

On the Chaudière, between the outlet of Lake Megantic and the junction of the Famine River, about three miles below the forks of the Du Loup, a distance in all of some forty-three miles, the rocks are for the most part argillaceous and micaceous slates, in places blackish and graphitic, with grey sandstones, some of which are hard and resemble quartzite, while others are schistose. Beds of sandy limestones, in many cases too impure for burning, are seen at intervals, and the rocks are often intersected with veins of quartz, some of which may be auriferous. The character of the sediments in this area is similar to that

Distribution on the upper Chaudière.

of those in the line of section between Massawippi and the New Hampshire boundary.

Association
with older rocks
on the Chau-
dière below the
Famine River.

On the Chaudière, a belt of hard green quartz-schist, seamed with quartz veins, comes in on the west side of the Famine River. These are associated with beds of hard, twisted altered slates, which in places are plumbaginous, and resemble in many respects the slates of the Ditton gold field. They are underlain half a mile lower down by hard felspathic schists, containing talcose matter, which in places pass into gritty or schistose conglomerates. These doubtless belong to an older series. Thence to the Gilbert River hard iron slates and quartziferous schists, sometimes highly felsitic, occur. On the west side of the latter stream the banded slates of the Wotton area are again seen, and are here apparently the continuation of the middle or St. Francis River division of the Cambro-Silurian, described in former pages, and which can be traced through Garthby and Price to this point. Further detailed examination is, however, necessary to work out the exact structure of the several groups of widely differing rocks in this section. Except in bands of black and grey graptolitic slates on either side of Lake Memphremagog and in the areas of dark fossiliferous limestone of Hatley and other places, no fossils have been found throughout any part of this Cambro-Silurian area, presenting in this respect a marked contrast to the areas of Silurian rocks. At one point on the International railway, between Spring Hill and Marston stations, certain markings which somewhat resemble fucoids, but the nature of which is uncertain, were found in the sandy slates. The Cambro-Silurian age, assigned to these rocks in the present report, is based chiefly on the fact that they are intermediate between the black fossiliferous limestones already mentioned, and a series of black wrinkled slates and schistose, though often massive, sandstones, which constitute the rocks of the gold fields of Ditton, Emberton, and the country about the head waters of the Du Loup, and which in character precisely resemble those of the gold fields of Nova Scotia, long regarded as of Cambrian age.

Rocks for the
most part barren
of fossils.

Stratigraphical
relations to the
older rocks.

It is possible, however, that a portion more immediately overlying the older, or what must be now regarded as the Lower Cambrian, may belong to the upper part of that system, but at present we have no palæontological evidence to warrant such a separation, and they are therefore described as a portion of the Cambro-Silurian system.

Granitic
intrusions.

Throughout the area in question, intrusions of granite are frequent. At times these occupy large areas, at others they form bosses of limited extent, or even occur as dykes. Their action upon the strata in contact with them is everywhere the same, producing a high degree of metamorphism, well indicated by the presence of crystals of mica,

chiastolite and staurolite, and at times by the development of a gneissic structure in the sandstones, while the slates frequently assume a schistose appearance, differing but little from that observed in the older crystalline rocks. Similar metamorphism is at times noted at points far removed from any visible granitic exposure. In such cases it is probable that the granite is at no great distance below the surface. This feature is observed at the marble quarries in Dudswell, where the metamorphism, is evidently local, and presumably proceeds from the presence of underlying masses of granite rock. In places, where these granite masses now form hills, with an elevation of 800 to 1,000 feet above the surface of the surrounding country, the denudation of the slates and sandstones around their base must have been enormous.*

Development
of chiastolite
and other
minerals.

C. CAMBRIAN.

Underlying the great series of slates, sandstones and limestones just described is a second series in many respects resembling these, with no calcareous beds in so far as has been ascertained, nor any fossils which would definitely fix their precise age. In position they are intermediate between what are now held to be Cambro-Silurian sediments, and the crystalline schists presently to be considered, and which are now admitted to represent, in part at least, the upper portion of the Archean or Huronian system.

Stratigraphical
position of the
Cambrian
rocks.

These rocks present a considerable variety of characters, embracing slates of various colors, purple, black, green and grey, along with sandstones—often so highly quartzose, as to form in places a hard quartzite—quartziferous schists and conglomerates. The sandy and quartzose beds are very similar to some of the so-called Sillery sandstones of the Quebec group, and the few indistinct fossils that have been found in similar slates elsewhere are considered by Prof. Lapworth to be of Cambrian age, while other parts of the series may perhaps represent some of the lowest members of the same system.

Characters of
the various
rocks.

The conglomerates are of two kinds, the one largely composed of pebbles of granitoid rock, quartzite, slates, and hard felspathic schist, in a slaty or sandy paste, the other, which may perhaps more properly be regarded as an *agglomerate*, is largely made up of dioritic pebbles in a dioritic paste, with some intercalated beds of sandstone and hard grits. Portions of the slate series are schistose, finely wrinkled and often pyritous. The paste of the conglomerates is at times also schistose, and frequently has talcose matter disseminated in it.

Conglomerates
and agglomer-
ates.

* I do not concur in the explanation which regards the granite as the cause of the metamorphism. It is itself, I believe, as much a part of the effect of the metamorphosing agencies as is the present condition of the other rocks referred to.—ALFRED R. C. SELWYN.

Unconformity. These rocks are apparently unconformable, and in places clearly so, to the bluish and banded slates and limestones of the Cambro-Silurian system on the one hand, while they are in like manner unconformable to the underlying ridges of crystalline rocks, from the debris of which they are largely formed.

Limestone conglomerates. As compared with the rocks of the St. Lawrence area, these are on the eastern side of the central axis, distinguished by an almost entire absence of limestone conglomerates which form so conspicuous a feature in the former. Such conglomerates are, however, found in at least two places, the first on lots 5 and 6, Range IX., Chester, the second on lot 25, Range V., Weedon. The slates, more especially in the lower portion, are often schistose, and have a minutely wrinkled and ligneous aspect. The sandstones also are frequently schistose, and in places have almost a gneissic structure, as if subjected to great lateral pressure, or shearing, and, as a whole, are more quartzose than those of the Cambro-Silurian system. In places, quartz is very abundant in the form of veins, which range in size from mere threads to a thickness of several feet, and occasionally interlace in all directions.

The rocks which are now regarded as Cambrian for the most part flank the ridges of crystalline schists and gneissic rocks. They are well seen in connection with these on the extension of the Sutton Mountain anticlinal to the north-east, where they are largely developed in the townships of Shipton, Tingwick, Chester and Wolfestown. The Cambrian strata at times appear to lie in intricately infolded basins, at others they are seen to lap around the ends of the ridges of older rocks. They are divided into two great areas by the Stoke and Massawippi Mountain range, the more westerly underlying the Cambro-Silurian rocks of the St. Francis River areas, while that to the east presumably underlies the stretch of country between this range and the New Hampshire and Maine boundary. The rocks in both areas are to a large extent affected by crumpling, but this is perhaps less apparent in the eastern area, where, after passing the calcareous beds mentioned in the last chapter, there appears to be a somewhat gradual passage to lower strata as we reach the eastern limit, and in this direction it has been found difficult to draw any sharply defined line between the two systems.

To the lower or Cambrian system, Prof. Hitchcock has referred a belt composed principally of blackish, wrinkled slates and schistose sandstones which form a ridge extending north-east from the vicinity of Canaan, between Hall's and Indian streams, to the Quebec boundary, (see map accompanying *Geology of New Hampshire, 1877*) and which presents a well-defined anticlinal structure. This anticlinal can be easily recognized in the adjoining townships of Emberton and Ditton,

Cambrian divided into principal areas by the Stoke Mountain range.

Cambrian recognized by Prof. Hitchcock.

whence it can be traced to the north-east, past the outlet of Lake Megantic to the road up the Du Loup, or main branch of the Chaudière, where it is seen on Lot 25, Kennebec Road Range, in the township of Linière. Throughout its whole extent, the rocks are alike, though perhaps there is a somewhat less percentage of the black slates to the north-east. Quartz veins, running for the most part with the bedding, though at times transverse to it, are found at many points. Some of these are undoubtedly auriferous, as evidenced by the quantity of loose and coarse gold found in the valley of the Little Ditton and on the several branches of the Chaudière, the gold at times being found, with ragged quartz attached, in close proximity to quartz veins. Their auriferous character is also clearly shown by the official assays of the quartz, from a number of leads (see Geol. Survey Report 1863-66, Hunt and Michel) and more fully referred to in the chapter on Economic Minerals. Argentiferous galena, is also found in considerable quantity and of a richness which promises profitable returns, if economically and properly worked, more especially in the townships of Risborough and Marlow. A fair percentage of gold, reaching half an ounce to the ton, has also been obtained from one of the veins of the Marlow Silver Mines by Prof. J. T. Donald, of Montreal; and according to Prof. E. Pagé, of Laval University, the silver in one of the veins ranged as high as 430 ounces to the ton, while in others yielded from 29 to 260 ounces.

Extension of
the Eastern
area.

Auriferous
quartz veins.

Silver ore.

What is now regarded as probably the line separating the Cambrian rocks of Emberton and Ditton from the Cambro-Silurian of the eastern area, crosses the road from Ditton, through Auckland, about Lot 46, R. I., Emberton; those to the east being principally the black slates and gneissic or schistose sandstones of the gold series, while to the west are the banded and ochre-spotted slates and pyritous sandstones, associated with the limestones already described. At several points, however, in the great Cambro-Silurian area to the west, as on the roads between Sawyerville and Martinville, out-crops of hard, quartz-veined slates and sandstones occur, from which gold has been reported, and which may be the crests of Cambrian ridges exposed by denudation, but the separation of which from the Cambro-Silurian is not at present practicable.

Probable line
of separation
between the
Cambrian and
the Cambro-
Silurian.

In character and aspect, the gold-bearing slates of Ditton and the area to the north-east, almost exactly resemble, as already intimated, the rocks of the Nova Scotia gold series. This is seen in the peculiar wrinkled appearance of the black slates, with similar quartz-veins, while much of the massive sandstone is almost precisely similar to the so-called whin of the eastern coast. Near the United States boundary, these rocks rest upon greenish chloritic and felspathic

Resemblance
of the Cam-
brian of Ditton
to the rocks of
the Nova Scotia
gold series.

Contact with
Huronian of
the Maine
boundary.

schist, with diorites and gneisses, the former of which are sometimes massive, at others slaty, and hold quartz and epidote. Their contact with the Cambrian on the road which leads south through Emberton is seen about the line between ranges II. and III. Further south, on the height of land overlooking Lake Sophy, the rocks are hard felspathic schists of Huronian aspect. The line between the Cambrian and older series, while it cannot be followed closely, owing to wilderness and drift-covered country, is supposed to extend in a nearly straight course north-easterly to the upper end of Lake Megantic. On the International railway, it crosses about two miles west of the summit of the pass through which the railway enters the state of Maine, the last Huronian rocks seen in this direction being greyish-green talcose, smooth and wavy schists; succeeded, a little further west, by the greyish schistose sandstones and black and grey slates of the Cambrian series.

Chiaustolite-
schist.

Near the lower part of the exposed Cambrian slates, large ledges of purple-tinged chialtolite-schist occur, with hard, green and whitish-grey altered sandstone, interstratified with blackish-grey schistose slates and grits. The presence of the chialtolite crystals is probably due to the influence of a great mass of granite, indications of which, on the west side of the lake, are seen in veins of small size. The chialtolite schist has a breadth of half-a-mile northward from the granite mass. While these schists are also found in the Cambro-Silurian areas near the granitic rocks, their alteration does not appear so marked as in those just described, the areas being generally quite limited; but in the Cambrian, certain belts are found, as shown by the large blocks seen at various points, which are studded with large and coarse crystals of staurolite, exactly like the staurolite schist seen in the Nova Scotia series near the contact with the granites. These have not yet been found in any part of the Cambro-Silurian areas.

Staurolites.

Cambrian of
the central or
principal
metamorphic
belt.

The Cambrian rocks, associated with the central, or principal metamorphic belt, present characters somewhat different from those just described. Prominent among these are considerable areas of conglomerates, already briefly noted, which apparently form the lowest beds of this group, and are in part described in the Report for 1877-78, p. 3 A, where their horizon is stated to be presumably that of the lower portion of this system. The volcanic agglomerates are more particularly developed in the western portion of the area, while the true conglomerates, composed of *débris* of the old ridges in a slaty paste and with slaty bands throughout, are well seen in the eastern part. They are well displayed on lots 2 to 6, ranges III.-IV., Orford, in rear of the city of Sherbrooke, whence they can be traced in an almost continuous belt to Lake Aylmer. North of this they appear in force on the road

Conglomerates
near Sher-
brooke and
northward.

from D'Israeli station, on the Quebec Central railroad, to the head of Lake St. Francis, on lots 21 to 30, ranges II. and III., Price. Asso- Siliceous grits. associated with these, are heavy beds of siliceous grits, occasionally holding scattered pebbles and containing grains of clear quartz from the size of pin-heads up to nearly half an inch in diameter. What is probably the further continuation of this belt appears on the Chaudière between the Famine and Gilbert Rivers, the characters of which have already been described in the preceding chapter.

To the south-west of Sherbrooke, these conglomerates have a considerable development along the flank of Massawippi Mountain and on the road between the head of Massawippi Lake and Magog, where they rest upon greenish, chloritic schists, and are in turn unconformably overlapped by the banded and spotted slates of the Cambro-Silurian system. Massawippi Mountain.

Another group of rocks, well defined in character and easily recognized, at several points overlying unconformably the crystalline schists of the Sherbrooke ridge, and intermediate between these and the graphitic limestones, consists for the most part of dark-grey, often blackish schistose slates, somewhat glossy and in places thickly filled with cubes of iron pyrites. The surfaces are minutely wrinkled, and they closely resemble the wrinkled black slates of the Ditton gold fields, as well as portions of what have been regarded as Cambrian or possibly lower Cambro-Silurian slates in New Brunswick. These have an older and more altered aspect than the ordinary slates of the Cambro-Silurian area of the St. Francis basin. They are exposed in the vicinity of Lennoxville and on the road to the south-west in rear of that place; also along the Belvidere road south of Sherbrooke and on the east side of the Magog River and Little Magog Lake, where they contain quartz veins, which have been opened up in the search for gold. They extend from the south-west part of Massawippi Lake along the south side of the high metamorphic ridge, known as Bunker Hill, and thence along the north side of Fitch Bay to the shore of Memphremagog Lake at Magoon's Point. In this section, they appear to dip beneath the schists, as do also the graphitic limestones on the south side of Fitch Bay, a peculiarity of structure due, doubtless, to an overturned synclinal, as well as to a probable line of fault along the east side of the metamorphic ridge from this locality to Lennoxville and beyond. Cambrian slates of Lennoxville and vicinity.

In the counties of Wolfe and Richmond, other areas of rocks, presumably of this age, occur, intimately associated with the crystalline schists. Throughout this section, the prevailing dips of the several formations are to the north-west, and an apparent conformity exists between the crystalline portion and the slates and quartzose beds. This peculiarity, however, appears to be due in great measure to Their extension south-west. Cambrian of Wolfe and Richmond counties.

Intricate association with the older schists.

Resemblance to the Cambrian of the St. Lawrence.

Volcanic rocks pertaining to this system.

Their extent.

Faults.

Their relations first pointed out by Dr. Selwyn.

Distribution northward.

intimate infolding, whereby the comparatively unaltered slates are made to appear as integral parts of the older schist series. At some points, also, more especially near the extremity of the ridge, the slates are seen to overlap or sweep around in such a manner as to indicate an unconformity between the two sets of rocks. The slates of the upper portion are of various colours, purple, green, grey, and black, and no fossils have as yet been found at any point throughout their entire extent. They resemble the dark-red and olive colored slates, &c., along the St. Lawrence, which are now regarded as older than the Levis graptolitic zone, and underlie unconformably the black limestones of Warwick and Danville. The associated quartzose grits often contain blebs of clear quartz, resembling in this, as well as in other particulars, much of the rock seen in the vicinity of the quarries near Sillery Cove, above the city of Quebec, and they are presumably of the same age. The slates are also frequently cut by quartz veins like those of the Ditton gold field.

Closely connected with the hard quartzites, schistose grits and slates just described, is a considerable development of volcanic rocks, which include diorite, dioritic agglomerate and breccia, dioritic schist, diabase and serpentine, etc. These form a well defined belt, extending from near the Vermont boundary west of Memphremagog Lake, with some interruptions for nearly or quite 150 miles. It crosses the river St. Francis a short distance east of Richmond, and the Chaudière in the vicinity of the Bras stream. This series is separated from the metamorphic and other rocks of the Sutton Mountain anticlinal by a fault, probably of considerable extent, clearly indicated in the depression between Richmond and Danville, whence it can be traced south-west down the valley of the Missisquoi River.* Indications of other faults of greater or less extent are also seen at various points, more particularly in the valley of the Nicolet, north of Danville, but the difficulty of tracing these in a country so largely covered with drift is such that their accurate delineation cannot now be attempted.

The rocks of this series are fully described in the Geological Survey Report, 1877-78, pp. 5 and 7 A. After crossing the St. Francis, the principal area extends with a uniform width almost to the northern boundary of the township of Shipton, when it suddenly bends to the eastward and terminates in the great mass of dioritic rock known as the Little Ham Mountain. The continuation of the same belt reappears in the prominent ridge known as Big Ham Mountain, a distance of about four miles intervening, which is occupied by slates of Cambrian aspect. From Big Ham Mountain the volcanic group

* This is the Potton and Danville fault described by Dr. Selwyn in Vol. I., Trans. R. S. C., pp. 12-13.

continues almost without a break, and with a considerable breadth through the townships of Ham, Garthby, the eastern part of Wolfestown, and Coleraine, into Thetford, and includes the celebrated asbestos-bearing serpentine of this section. In all these areas the serpentines are closely associated with the diorites, of some portions of which they are undoubtedly, in part at least, an alteration product. Their relations can be well studied along the line of the Quebec Central railway north of Coleraine station and on the road between that place and Wolfestown, where in the vicinity of Belmina P. O. they are seen in direct contact with the black Cambrian slates on the one hand, and with hard whitish granulite on the other.* The latter, which sometimes assumes the nature of a granite, frequently occurs as huge masses or dykes cutting the serpentine rocks, both here and at Black Lake and Thetford. These rocks will be described more fully in a subsequent chapter.

Association of
serpentines
with dioritic
rocks.

From the consideration of the facts here presented, the presence of three well defined Cambrian areas is recognized. Of the most easterly, or that near the New Hampshire and Maine boundary, the western limit is a tolerably direct line from the northern angle of the boundary in Emberton, to the line between Ranges VI. and VII. Metgermette, its eastern limit passing into the adjoining state about the line between Spalding and Risborough, in which direction it rests upon the Pre-Cambrian rocks which constitute the range of mountains forming the height of land along the International boundary.

Limits of the
several Cam-
brian areas.

The second is exposed on either side of the Stoke Mountains and Sherbrooke anticlinal, whence it extends in a belt from four to six miles in width to the Chaudière, concealed in places by overlying beds of Silurian and Cambro-Silurian age, and separated from the eastern area by the great Cambro-Silurian crumpled synclinal of Compton and Beauce, while the third or western area also appears on both sides of the Sutton Mountain anticlinal, overlain in its central part by the great Cambro-Silurian basin of the St. Francis River area in the east, and by the black limestones of the Arthabaska district to the west. The rocks of the western area are much more irregularly distributed than in either the central or eastern section.

A.B. PRE-CAMBRIAN.

In the early reports of the Geological Survey up to 1869, no Pre-Cambrian rocks were recognized in the Eastern Townships. The areas of crystalline schists, gneisses and limestones, with the serpentines and associated strata, were all referred to the several divi-

* A similar contact with the black slates is well exposed on the Bras stream about three miles up from the Chaudière River.—A. R. C. SELWYN.

Early views
concerning the
metamorphic
rocks.

sions of the Quebec group, viz., the Levis, Lauzon and Sillery, of which the Levis was held to be newer than Potsdam, while the Sillery, in which a great variety of rocks were included, was considered the most recent, and these highly metamorphic rocks were supposed to be the equivalents of the two formations, Calciferous and Chazy, as developed along the south side of the St. Lawrence, their different aspect being due to an intense regional metamorphism which had affected the rocks of the Green Mountain range and of its extension into the province of Quebec for many hundred miles. In 1869, in the report of the late Mr. James Richardson on the country between the Chaudière River and Temiscouata Lake, the presence of an older series, composed of quartzites, slates and conglomerates, which were regarded as belonging to the Potsdam formation, was recognized. (See Geol. Survey Report 1866-69, p. 120.) No attempt was, however, made to trace these older rocks to the south-west of the Chaudière, and the remarks in the Report referred to do not appear to have been intended to apply to the area now under consideration.

First official
publication
regarding the
existence of
Pre-Cambrian
by Dr. Selwyn
1877-78.

The first official publication on the part of the Geological Survey, in which dissent from the views expressed in 1863 was made, is found in the Geol. Survey Report 1877-78 (Dr. Selwyn) pp. 3 and 14 A, where it is stated that the crystalline portion of the Quebec group evidently belonged to a much older system than that hitherto assigned to it, and that, in part at least, it included rocks of Huronian and Lower Cambrian age, which were found to be non-fossiliferous, and were held to be distinct from the fossiliferous portion of the St. Lawrence area, which contained a fauna, apparently partly of Cambrian and partly of Cambro-Silurian age. The views here expressed were put forward in greater detail in the Transactions of the Royal Society of Canada, Vol. I., 1882 by Dr. Selwyn, and re-stated in the Geol. Survey Report for 1880-81-82, p. 2 A, as well as in his Descriptive Sketch, etc., 1884.

Subsequent
papers.

As the change of views above mentioned has led to considerable discussion, a brief sketch of the structure of this portion of the province, as brought out by the examinations of the last two years, may here be presented.

General sketch
of the struc-
ture.

Between the Maine boundary and the great plain of the St. Lawrence valley, which may be said to have its eastern limit at Athabaskaville, three prominent hill features are observed. Of these, the first, and most easterly, is seen in the height of land which constitutes the International line between the province of Quebec and the states of Maine and New Hampshire; the second is the Stoke Mountain range and its extension in either direction, and the third forms the broken and hilly country of Wolfestown, Chester, Tingwick and Shipton, which may be said to mark the prolongation in part, at

least, of the principal range of the Green Mountains, the most prominent part of which, after entering Canada from Vermont, is seen in Sutton Mountain, which attains an elevation of about 4,000 feet. These ridges indicate three well defined anticlinals, approximately parallel to each other, the intermediate synclinals being occupied by the Cambrian and newer rocks already described.

Three principal anticlinals.

The rocks of the eastern areas are described by Prof. Hitchcock in the *Geology of New Hampshire, 1877*, and indicated in the map accompanying that Report as belonging to his Lyman and Lisbon groups, and are held to be of Huronian age. They consist of tough, greenish granites, in places resembling a protogine, with talcose, chloritic and micaceous schists, fine grained gneissic granites and smooth talcose slates, which extend across the south-eastern portion of Quebec for some miles, occupying the south-eastern part of the townships of Emberton, Ditton, Woburn and Clinton, which lie to the south and south-west of Lake Megantic and the eastern portion of Ditchfield, and probably also a narrow margin in Spalding, although, owing to the unoccupied and inaccessible character of this area, the exact outlines are to some extent conjectural. Stratigraphically, they underlie the rocks of Ditton, which have already been described as of Lower Cambrian age, and like the slates and whins of the gold series of Nova Scotia. The reasons, therefore, for assigning these border rocks to a Pre-Cambrian horizon may be considered as fairly conclusive, but as much of the country is at present inaccessible, or so largely covered by drift, as to conceal the underlying strata, it is highly probable that limited areas of Cambrian and other slates may occur, especially in Woburn and Chesham, the outlines of which cannot now be mapped.

Lyman and Lisbon groups of Prof. Hitchcock regarded as Huronian.

Character and distribution in S. E. Quebec.

Relations to the Cambrian.

The anticlinal axis, seen in the Stoke Mountain range, and already alluded to in a general way, can be traced from the shore of Memphremagog Lake north-east past the city of Sherbrooke, where it is well exposed, and thence to Lake St. Francis. East of Lakes Weedon and Aylmer, it forms a ridge, with an elevation of 500 to 600 feet above the water of these lakes, and extends for more than twenty miles in length. The rocks are hard, flinty, greenish, white-weathering, felspathic schists, with talcose, chloritic and quartziferous slates. Near the summit of the ridge, on the road from Gould to Weedon, masses of granitic and dioritic rocks occur, as well as dolomitic schists, the whole presenting a marked resemblance to Huronian strata. The dolomitic portion is sometimes much decomposed, and on weathered surfaces is of a deep orange color. This ridge has a maximum breadth of about three miles on the road from Lake Aylmer to Stratford. It is separated from the mass of the Stoke Mountain range by the overlap of the Silurian lime-

Stoke Mountain anticlinal.

Ridge east of Lake Aylmer.

Small outcrop
near Weedon
church.

stones and slates of the Dudswell basin, but a small outcrop of gneissic and felspathic rocks, the debris of which enters into the composition of the overlying Cambrian conglomerates, is seen about half a mile north-west of Weedon church.

Stoke Mountain proper.

The principal mass of the Stoke Mountain range extends from the road leading from Dudswell Corner to North Stoke, southwest into the township of Ascot, with an elevation of 1000 to 1200 feet above the River St. Francis. It consists of hard gneissic felsite, granitic gneiss, hard felspathic schist, chloritic, talcose, and micaceous schist, with diorites. Through the township of Stoke it presents a serrated ridge, but approaching the St. Francis between Sherbrooke and Lennoxville, it rapidly sinks, and is apparently separated from another area on the south side of that river by a belt of black slates, probably of Cambrian age, which cuts across the range in a well defined depression. The ridge again appears on the south side of the St. Francis and extends south-westerly, attaining an elevation of 1000 feet above the river, on Lot 9, R. XI, of Ascot, just east of the Belvidere road, sinking thence to the foot of Lake Massawippi. Another prominent belt, known as Massawippi Mountain, extends for several miles along the west side of Massawippi Lake, with an elevation of 800 to 900 feet above its surface. This is also broken across at the upper end of the lake by the depression through which the road to Magog passes from Ayer's Flat, but immediately re-appearing under the local name of Bunker Hill, it continues with considerable persistence along the north side of Fitch Bay to Lake Memphremagog. Many of the schists in this area are highly nacreous, and they constitute the principal copper bearing belt in this direction. The axis in the chloritic and epidotic rocks is seen in the lower part of the Magog River, which flows through the city of Sherbrooke, whence it can be traced across the St. Francis into Ascot and Stoke.

Ridge south of
Sherbrooke.

Massawippi
Mountain.

Anticlinal at
Sherbrooke.

The age of these metamorphic rocks is inferred from their general lithological character, as well as from the fact that they are apparently unconformably overlain by the Cambrian slates and conglomerates so well exposed in the neighbourhood of Lennoxville and in rear of Sherbrooke.

The Western or
Sutton Mountain
anticlinal.

The western division, concerning which most difference of opinion has arisen, is that which has been already referred to as forming the extension of the Green Mountain or Sutton Mountain range, the rocks of which, in Prof. Hitchcock's map of Vermont and in the accompanying sections, are described under the head of Green Mountain gneiss, and held to constitute the basal portion of all the formations in this direction, in this agreeing with Dr. Selwyn's determination published in 1877. In this map, the anticlinal structure of this complicated

Prof. Hitchcock's views.

area is well pointed out. As much of the confusion which exists as to the correct interpretation of the geology of this part of the Eastern Townships has arisen in connection with the structure of this range, the several opinions bearing upon it which have appeared from time to time may here be briefly stated.

The earliest mention of this mountain is found in Logan's Report for 1847-48, p. 52, where it is described as "standing between two anticlinals, which run into one, and might, therefore, be supposed to possess a synclinal form; the strata were, however, observed to maintain dips, generally at high angles, in opposite directions from the axis of the mountain, with much constancy, on the Sutton and Potton, the Brome and Bolton and the Stukely roads, which the axis crosses, and the probability of this anticlinal form seems to be supported by one or two facts in Ely which require further examination. The anticlinal form of Sutton Mountain would appear to throw the two eastern belts of associated dolomites, soapstone and serpentine in Sutton Valley into the shape of a trough, and they would probably join northwardly a few miles beyond Stukely Mills." On page 53, it is also stated "that the rocks above described in connection with the Sutton Mountain anticlinal occur north-easterly to the Chaudière."

In Geology of Canada, 1863, p. 251, while the same apparent general anticlinal of Sutton Mountain is described, it is stated that "it may include the whole or a portion of the Sillery sandstones, which, standing in an anticlinal attitude, would seem to have resisted or escaped the denuding forces that have worn out the valleys on the anticlinals of Sutton and Potton." On the hypothesis then advanced, that the Sillery formed the upper member of the Quebec group, the fact that the rocks supposed to be of this age constituted the apparent axis of this range could only be accounted for on the theory of a double inverted synclinal. In pursuance of this theory it is there stated that "the belts of magnesian rocks which are at the base of the mountain on its opposite sides, should in this structure be carried to a junction on the central anticlinal axis after turning on the synclinals which occupy the two flanks of the mountain, but though these belts have been traced northward for upward of twenty-five miles, their point of union has not yet been observed."

Though the area above described does not appear in the accompanying quarter-sheet map, the explanation of the structure above quoted is held to be important and almost necessary for a clear understanding of the stratigraphical relations of the various groups seen in the third area in the north-western portion of the map above referred to.

The theory of inverted synclinals, which is requisite to explain the

Probable lower position of the Sillery.

Views of Dr. Selwyn, 1877.

True anticlinal structure.

Great fault between the mountain series and the Cambro-Silurian.

Extension northward of the Sutton Mountain anticlinal.

apparent lower position of the Sillery, becomes unnecessary if we regard the so-called Sillery as constituting the lowest member of the Quebec group, a supposition which appears to be fairly well sustained by the work of the last few years along the south side of the St. Lawrence, see Geol. Survey Rep. 1880-81-82, p. 31 DD., and still less so if we take the more reasonable view that the axis of the Sutton Mountain range is not composed of rocks belonging to any portion of the Quebec group, but rather to a much older series, either Lower Cambrian or Pre-Cambrian in age, as asserted by Dr. Selwyn since 1877 and in his various subsequent publications, enumerated page 6 J of the present report.

The latter view is also supported by the apparently regular anticlinal structure pointed out by Sir Wm. Logan in the reports quoted above, as well as by the lithological characters of the rocks which constitute the mountain range, and by the sequence of formations on either side. To the east, in the valley of the Missisquoi River, we find these metamorphic rocks in abrupt contact with those which comprise the volcanic group of Dr. Selwyn, and which are now described in this Report under the head of Lower Cambrian; this contact is marked by a line of fault, which undoubtedly represents many hundreds if not thousands of feet, while to the west there is an apparently regular upward sequence as far as Frelighsburg, near which place the rocks of the anticlinal are overlapped by sediments of lower Cambro-Silurian and possibly by those of upper Cambrian age.*

The north-east extension of the Sutton Mountain anticlinal reaches the St. Francis River in the vicinity of Melbourne, whence it continues with a regular course to Danville. The relations of the various groups of rocks in this direction, as well as in the township of Ely to the south, are very obscure, owing to the presence of several faults, which have apparently brought the Cambro-Silurian fossiliferous strata into close proximity with those of much lower horizons. Near Danville, the anticlinal is deflected more to the east, and so continues to the vicinity of the line between the townships of Ham and Wolfestown, when it gradually resumes its more northerly and normal course. The axis is well seen near the village of North Ham; thence passing through the western part of Wolfestown, it crosses the township line of Halifax between Ranges I. and II., beyond which it has been traced by Dr. Selwyn, though not in detail, through Ireland to beyond the Chaudière River, which it crosses in the vicinity of Beauce Junction. The rocks of this area in Wolfestown and Chester are precisely similar to those seen on the road between South Bolton and Knowlton.

* See Section, Quebec Group in Geology, p. 12, Vol. I., Transactions of the Royal Society of Canada.



T. C. WESTON, PHOTO., 1873.

PRE-CAMBRIAN CONTORTED SCHISTS,
RANGE VIII., LOT 15, SHIPTON,
QUEBEC.

IVES-PROCESS : G. E. DESBARATS & SON, MONTREAL.

In Shipton and in the southern part of Tingwick, the older rocks of the anticlinal are apparently concealed by the Cambrian and Cambro-Silurian sediments, which throughout Chester and in part of Wolfestown appear to occupy areas of considerable extent, superimposed upon the crystalline schists and kindred rocks after the manner of infolded basins. Frequently, an apparent conformity exists between the two series, the upper of which may possibly mark the southward extension of the rocks which were described by Mr. Richardson, Geol. Survey Rep. 1866-69, as probably of Potsdam age.

Overlapping
and infolded
areas of Cam-
brian.

A fourth but limited area of Pre-Cambrian rocks occurs in the town-ship of Garthby, and is well seen on the road leading from Sanborn to D'Israeli station on the Quebec Central railway. The rocks are greenish chloritic, and often highly micaceous schists, frequently with disseminated crystals of some greenish mineral, which has the aspect of chlorite. Talcose schists also occur in this belt, which has throughout a decidedly Pre-Cambrian character. It is surrounded by Cambrian sediments and is intersected by the dioritic and serpentinous masses which extend north from Big Ham Mountain.

Pre-Cambrian
of Garthby.

The areas which have just been described constitute the principal copper bearing belts of the Eastern Townships. Copper ores are found at many points throughout their whole extent; and in this respect as well as in lithological character they closely resemble the copper-bearing rocks which form the upper part of the Pre-Cambrian of New Brunswick and the Huronian of the Bruce Mines, etc. A very manifest similarity is also observed between these rocks and those which are now classed as Archæan in Scotland and England, and which by some authorities are held to constitute the upper members of the Pre-Cambrian, while by others they are regarded as forming the basal portion of the Cambrian system. They have been described, by Dr. Hicks, in Wales, under the names of Dimetian, Arvonian and Pebidian. Whatever may be the exact age of these altered rocks, their present aspect entitles them to be classed as very ancient sediments. And though, in view of the great alterations which may result from intense regional metamorphism, there is no reason why many of the ordinary sedimentary rocks of Cambrian, Cambro-Silurian or even Silurian age, should not assume much of the character of those just described, it is now tolerably clear that they constitute the lowest of all the geological formations encountered in this portion of the province.

Copper-bearing
rocks.

Their similar-
ity to the Ar-
chæan of Scot-
land and
England.

CRYSTALLINE AND IGNEOUS ROCKS.

Plutonic and Volcanic.

Granite.—The granites of the area under consideration have been referred to in previous reports. In 1847-48, attention was directed to

Early views
relating to the
granites.

Compared with
similar rocks in
New Brun-
swick.

Six principal
areas recog-
nized.

Barford and
Barnston.

them by Sir Wm. E. Logan, as being particularly adapted for building stone. Later, in 1849-50, their intrusive character was pointed out, and the position of the principal masses given. The statement was at that time advanced that these rocks might constitute a chain of hills extending from Lake Megantic to Bathurst on the Bay of Chaleurs, a hypothesis not, however, supported by later investigation. In the *Geology of Canada*, 1863, attention was also directed to the presence and distribution of these rocks, and their intrusive character, indicated by their mode of occurrence and their action upon the surrounding strata, are clearly pointed out, (see pages 430, 434.) On page 452, where a comparison is made between the granitic rocks of New Brunswick and those of the Eastern Townships, Maine and Vermont, it is suggested that all these granites are probably contemporaneous in age. The statement, however, that these rocks in the Eastern Townships intersect the Devonian strata, and that, as a consequence, they belong probably to the close of that period, must here be corrected; since the rocks which were then held to be Devonian, viz., the black graphitic limestones and mica schists of the east side of Memphremagog Lake, and the area lying to the east, have been now found to belong to older systems, and to be in part at least, Cambro-Silurian. There is, therefore nothing in this part of the Townships to indicate any age for the granites later than the close of the Silurian, since they are not seen at any point to penetrate strata of later date. They differ somewhat from the granites of New Brunswick in composition and color, those of the latter province, for the most part, being reddish, while the Township granites are generally white. Their intrusive character is, however, clearly defined, not only by the metamorphism of the slates and limestones in contact, but by the number and character of the veins and dykes which, issuing from the principal mass, penetrate the surrounding sedimentary strata and ramify in all directions.*

The principal granitic areas are six in number. Of these, the most southerly is in the townships of Barnston and Barford, where it marks the northern limit of the great granite mass of northern New Hampshire, well seen in the hills on either side of the Grand Trunk railway to Island Pond. Its most prominent feature in Canada is the Barnston Pinnacle. It extends along the boundary for some fifteen miles, terminating eastward at Little Leach Pond and occupies the greater part of the two first ranges north of the province line. The rock is generally white, composed of quartz, white orthoclase

* I hold that there is nothing whatever in the mode of occurrence of these granites which certainly proves them to be intrusive in the ordinary acceptation of that term. They are more probably formed *in situ* by the same metamorphic agencies that have altered the adjacent strata, and the so-called dykes are probably due to segregation; in fact the latter are rather veins than dykes. See Report on Nova Scotia Lower Cambrian rocks, Part F.—A. R. C. SELWYN.

and black mica. At the contact with the slates, it becomes finer in texture, a feature also frequently noted in connection with the granites of New Brunswick. Alteration at the contact with the slates.

Further west, similar granites appear in Stanstead township in limited outcrops, and occur at intervals to the shores of Memphremagog Lake. The principal outcrop is seen on Range IV., V. and VI., lots 1 to 5 inclusive, where, however, much of the highly altered slate and limestone is intricately involved with the granite. Near the extremity of Magoon's Point also, on the shore of the Lake, a small outcrop penetrates black, irony slates, presumably of Cambrian age, producing staurolites or kindred minerals. These granites have been worked for building-stone, the quality of which is excellent. A somewhat remarkable dyke of this rock is seen a short distance west of Stanstead village, extending for about four miles with the bedding of the enclosing slates, and with an exposed breadth of twenty-five to forty yards. In the vicinity of Barnston Corner also, two small outcrops are noted, the first, and smaller, about three-fourths of a mile west of the village, with an exposed breadth of forty yards, constituting a knoll in the Cambro-Silurian slates and limestones, the other about one mile east of the Corner, as a broad dyke, running with the bedding of the slates and limestones for a distance of over a mile, and crossing the road from Barnston to Coaticook. The action upon the sedimentary beds is distinct, crystals of mica and chialtolite being produced in the adjacent strata. Further east, in Barford and Hereford, other limited areas are found and are indicated on the map. From the frequency of the outcrops, however, and the generally altered condition of the various rocks in this direction, it is probable that the granites may underlie, at no great distance, a great part of this portion of the province, appearing only where exposed by denudation. Barnston Corner.

To the north, the next granitic area is that known as the Great Megantic Mountain, situated near the corner of the townships of Hampden, Marston, Ditton and Chesham. The granites of this locality, which form a lofty range of hills extending some nine miles, with a maximum breadth of four miles, are similar in character to those of Barnston already described. The Megantic Mountain area is separated by slates and sandstones from a third considerable area, seen at Scottstown, on the International railway, whence it extends eastward on that line for about three miles, and north-westward for a like distance. The action of the granites on the slates is here also well defined by the presence of mica and chialtolite crystals, and a gneissoid texture is imparted to the sandstones. The country occupied by this area is generally low, and the exposures are comparatively few, patches of slates being intermixed with the intrusive rocks. Great Megantic Mountain.
Scottstown.
Chialtolites.

Little Megantic Mountains.

A fourth range of hills is seen in Whitton and Gayhurst, of about the same extent as the Victoria range, known locally as the Little Megantic Mountains, while a fifth area occupies the greater part of the country lying between the road leading from Stratford to Stornoway and the upper part of Lake St. Francis, where, along the Felton River and the several lakes of that section, prominent granitic peaks are seen. The rock here occurs also frequently in the form of dykes of all sizes, mixed with altered gneissic sandstones and slates, the separation of which in the swampy and barren country about the lakes is for the most part impracticable.

Lake St. Francis.

Further to the west, about midway on Lake St. Francis, a dyke of granite appears on either shore; on the west side, having an exposed breadth of thirty yards only, cutting slates of Cambro-Silurian or Cambrian age, while on the east side, it has a width of several hundred yards. It, however, does not apparently extend to any great distance inland, the country in the vicinity being generally low and the exposures confined to low-lying ledges on the beach.

Ditchfield.

Chiaistolite-schist.

The only remaining area of granite of considerable size is that in the township of Ditchfield, about the upper part of Lake Megantic. Spurs, presumably from this mass, show on the west side of the lake, on the road between Ranges I. and II., Lot 2, Marston, where slates of purple tinge are altered to a highly chiaistolite-schist. Other dykes occur on the shore of the lake on either side of Moose Bay, but do not extend far inland. The northern margin of the principal area, which is on the east side of the lake, is seen on the road which extends between Ranges II. and III., Ditchfield, on Lot 30, where beds of grey and purple slates, are altered to highly metamorphic schist, filled with chiaistolite, for a distance of nearly half a mile from the contact. Granite rocks thence occupy the country in the vicinity of Spider Lake, though much of the surface being swampy, ledges are not frequently exposed, and it is probable that schistose slaty rocks are here to some extent, intimately associated with the volcanic series. They apparently extend across the boundary into Maine, where they are displayed about the head waters of the Dead stream. They are also seen in the high hills of eastern Woburn and Chesham, the surface in this direction being generally very rugged and broken.

Spider Lake and vicinity.

To some extent, the outlines of the granite masses are of necessity conjectural, since large portions of the surface are covered with drift, over which, however, granite boulders are thickly strewn.

While it cannot be definitely stated from the contacts of the granite with the associated rocks in this portion of the province what the precise age of their intrusion may be, since in no case are they associated with strata newer than Cambro-Silurian, yet it may be inferred

to be not far from the close of the Silurian period. Certain areas of granitic rock, however, seen in the Stoke Mountain range and at several other points, are clearly older, since their debris is found abundantly in the conglomerates of Cambrian age already described. Their character and composition also differ very widely from those of the granites just described.

While there is, apparently, no doubt as to the intrusive nature of much of these rocks, no indications are seen to warrant the hypothesis that such intrusion was attended by any great disruptive force, by which the overlying strata were thrust asunder to such an extent as is now occupied by the granitic masses. It appears more reasonable to suppose, that the great bulk of these granites have risen quietly from below, and in their ascent have eaten away, or incorporated in their mass, the various strata with which they came in contact.* This theory is supported to a certain extent by the frequent outcrops of these rocks, which would seem to indicate their presence at no great depth, over a very large part of this area, as well as by the fact that no change occurs in the strike of the various beds on either side, even of the largest intrusions. Where local deflections of strata are found, they are more often in connection with smaller outcrops, and may sometimes be referable to other causes. The alteration of the surrounding sediments extend with great uniformity in all directions from the granitic masses. Disruption of the contiguous strata is, however, seen along the borders of the large areas, in the presence of dykes or veins, ranging in thickness from mere threads up to several feet, which intersect the strata, sometimes along the bedding planes, and at times forming a perfect network.

Diorites.—Dioritic rocks are found at many points throughout the Townships, sometimes in masses of large extent, as in the Big and Little Ham Mountains, and in the peaks along the western side of Lake Memphremagog; at others, as bosses and dykes. With these are often associated dioritic agglomerates, serpentines and serpentinous breccias. The largest and most important areas are found in a belt which can be readily traced from the Vermont boundary, north-east for over one hundred miles, crossing the Chaudière River, and extending into the townships of Cranbourne and Ware.

Throughout the greater part of this area, the dioritic rocks are intimately associated with the quartzites, quartziferous schists, and black, red and green slates, which are now described under the head of Cambrian. To the south-west, the most prominent features are Hawk, Bear, Owl's Head, Sugar-loaf, Elephantis and Hogs-back

* This is not intrusion in the ordinary acceptance of that term, but rather the metamorphic process referred to. See Note page 36 J.—ALFRED R. C. SELWYN.

Dioritic peaks
of Lake Mem-
phremagog
and vicinity.

The Ham
Mountains.

General course
of the volcanic
belt.

Big Ham
Mountain.

Extension to
the north-east.

Mountains, some of which may mark the sites of extinct volcanoes. These hills are situated near the west side of Lake Memphremagog, south of Sargent's Bay; and about four miles due north-west from the foot of Memphremagog Lake, are the great masses of dioritic and serpentinous rocks which form the Orford or Victoria Mountains. The central portion of the belt is marked by two prominent hill masses, called the Little and the Big Ham Mountains, the outlines of which are almost identical, and further east, about four miles north of the foot of Lake St. Francis, is another huge cone-shaped peak, resembling the Owl's Head to the south. This readily seen for many miles in all directions, and is known locally by the names Bull Mountain and Owl's Head. The Ham Mountains apparently divide this belt into two areas; the south-western portion is occupied by smaller outcrops of volcanic rocks, seen in a number of hills, some of which are of small extent, in the vicinity of Brompton, Long and Orford Lakes, where dioritic and serpentinous rocks are closely associated. Two somewhat parallel bands of these rocks apparently exist in this area; the most westerly being seen in the serpentinous and dioritic masses of Melbourne, Cleveland and Shipton, where the former portion apparently ends, the diorites being continuous, however, to the Little Ham Mountain; the other, that seen about the Brompton Lakes, where it has a somewhat extensive development, and continues in the direction of Windsor Mills.

The course of the principal belt is generally north-east, following the prevailing trend of all the formations; but in Cleveland and Shipton, it assumes a transverse twist which also affects the Pre-Cambrian and other formations in the vicinity, and changes the strike for some miles in the townships of Wotton and Ham to an almost easterly course. The prolongation of the Melbourne and Shipton ridge, which apparently terminates at the Little Ham Mountain, after an interval of about five miles, occupied by slates and sandstones, re-appears in the Big Ham Mountain, which is on Lot 2, Range XI., Ham, and rises boldly, from the somewhat flat country around its base, to a height of 1150 feet, forming a magnificent hill feature in the landscape. Thence the diorites extend with a gradually curving outline to the north-east, crossing the road from South Ham to Garthby, and continuing through the latter township, as well as the eastern part of Wolfestown, Coleraine and Thetford, where it is conspicuously marked by the large elevation of the Bull Mountain already noted, which is near the junction of the townships of Adstock, Thetford and Coleraine. As in the Brompton belt, diorites are more prominent at the extremities, while the central portion is characterized by the presence of serpentines, which in this direction have a great develop-

ment, especially in Coleraine and Thetford, with some large areas in Wolfestown, now of great importance as the seat of the asbestos industry, which will be described in greater detail under the head of Economic Minerals.

Smaller areas of dioritic rocks are numerous. Of these, probably the most important is seen in the township of Ascot, where it traverses the area of the copper-bearing schists, extending from Lot 19, Range V. of Ascot, south-westerly at intervals to Lot 27, Range IV., Hatley. This belt has a considerable development in the vicinity of some of the copper mines, situated to the south of Sherbrooke. Diorites, of more limited extent, occur also on the line between Westbury and Stoke, but these are of comparatively recent age, since they have altered the slates with which they are in contact.

Dioritic rocks
of Ascot.

In the Megantic area in Clinton, Chesham and Emberton, dioritic masses are also seen. Two prominent hills are noted, the one on Lot 10 and 11, Range I. and II., Clinton, the other on Lot 25 and adjacent, Range VII., Clinton. They are apparently part of the chloritic slate series, and may belong to an earlier date than many of those of the central and western area. It is probable that the diorites of the several localities have come to the surface at widely different periods, for while some have manifestly exercised a metamorphosing action on the Cambro-Silurian strata, at other places, the lower beds of the Cambrian are largely made up of their debris.

Diorites near
the Maine
boundary.

Serpentine.—The mode of occurrence, origin and distribution of *Serpentines*. *serpentines* have been fully discussed by Dr. Hunt and others, and a variety of opinions have been expressed respecting them. The serpentines are of various shades and colors, frequently associated with magnetic and chromic iron ores but they are chiefly of importance from containing at many points, in workable quantity, veins of chrysotile or fibrous serpentine. Within the last few years, these have been profitably worked, and asbestos mining now bids fair to form one of the leading industries of the province.

Throughout the greater part of the volcanic or dioritic belt already described, these serpentinous rocks occur at intervals. To the south-west the most important areas yet recognized are in the vicinity of Orford Mountain and lake, and about Brompton and Long Lakes. An extension of this belt is seen, on Lots 12-13, Ranges IV. and V., Brompton, and this is apparently the northern limit of these rocks in this direction.

Their distri-
bution.

The south-western belt is largely developed in the townships of Mel-bourne and Cleveland, and extends into Shipton and Tingwick. In the former township it is well seen at the Melbourne slate quarry, where it is brought into contact with the slate by a fault. Thence it can be traced

The south-
western area.

Asbestos.

with considerable regularity to the St. Francis River, crossing which it re-appears on Lot 6, Range XV., Cleveland. It is here intimately associated with hard quartziferous schists and slates. Further north, the prolongation of this belt is seen on Lot 9, Range XV., of this township, as well as at several points midway. It again re-appears at the five roads on Lot 9, Range III., of Shipton, now known as Asbestos P. O., in a small knoll, in which the asbestos mine worked for some years by Mr. Jeffrey, of Richmond, is situated. It again re-appears on the road to Wotton on Lot 7, Range II., and on the south-west shore of Lake Richmond, on Lot 27, Range X., Tingwick. The last outcrop now known in this direction is on a branch of Trout Brook, and was reported by Mr. A. J. Morrell, of Danville, as occurring on Lots 21-22, Range XI., Tingwick.

Massawippi
Mountain and
vicinity.

In the vicinity of Massawippi Lake, outcrops of serpentine are found in the Hedge-Hog Mountain, Lot 15, Range VI. and VII., and in small areas on Lot 11, Range VI., Hatley. Serpentine, associated with soapstone and diorites, are also found on Lots 19-20-21, Range V., near the shore of the lake, the soapstone being apparently of excellent quality. They occur in what is probably the south-west prolongation of the metamorphic belt of the Ascot copper mine. Similar limited outcrops are found along the road from North Hatley to Capelton, on Lot 26, Range II., and Lot 27, Range I., Hatley.

Hatley.

North-eastern
area.

The most important area of these rocks is that which, terminating southward in Big Ham Mountain, extends north-easterly to and beyond the Chaudière River. In this belt, serpentines are first seen in several hills on the south side of the outlet of East Nicolet Lake and on the west shore, where, on Lots 19-20 of the Gore adjoining Range XI., a vein of magnetic iron ore is seen, having a thickness of six feet at the surface, and is said to increase to eleven feet in the shaft at a depth of twelve feet. About 100 tons of ore have been taken from this vein. The serpentine here is dark green in colour, and is said to contain a small quantity of grey copper ore. According to Mr. Coulombe, who first opened this mine in 1881, the serpentine extends south-west from this point to near the foot of the Ham Mountain, on Lot 16, Range XI., Ham. It occupies also all the islands in the lake and the south and east shores, extending in a ridge towards the road leading to Garthby village.

Iron ore of
Nicolet Lake.

Soapstone.

On the south end of the lake a considerable area of soapstone is seen on Lot 22, Range I. (old numbering 43-44), owned by Mr. E. Clark, of Sherbrooke. A similar deposit is found on Lot 25 (old numbering 49-50), Range II. The principal mass of the serpentine stops on Lot 55, though the mineral is found associated with the diorites on the Garthby road.

To the south-west of Breeches Lake, serpentine again forms a prominent ridge, reaching the shore of the lake, and appearing also in several islands in that sheet of water. The north end of this lake is apparently occupied by dioritic rocks, which here have a breadth of about two miles, but on Ranges IV., III. and II. of Wolfestown, a prominent ridge of the serpentine appears and comes to the road leading from Wolfestown to Coleraine station. On the north-east flank of this ridge on Lots 23 and 24, Range II., the asbestos mines of Belmina are situated. The serpentine here is associated with considerable masses of whitish granulite, a rock composed principally of felspar and quartz, but in places, from the addition of mica, becoming a true granite. This appears in places to cut the serpentine after the manner of true dykes, and to its presence may possibly be ascribed some of the frequent faults which affect these rocks and which are disclosed in the asbestos workings. The opinion is also held by some of the managers of the asbestos mines that the presence of these dykes affects favorably the quality and amount of the asbestos.

Crossing into the adjoining townships of Ireland and Coleraine, the serpentine forms a very rugged country to the west of the Quebec Central railway, the bold and rugged peaks and ridges, as seen to the south-west of Black Lake, constituting very prominent features in the landscape. These ridges take their rise a short distance north of the boundary between Ireland and Wolfestown, and extend thence, apparently without any serious break, into the township of Thetford. In the eastern part of Coleraine also, in the vicinity of Caribou and Little St. Francis Lakes, several hills, occupying a considerable area, are found. The further extension of this belt northward has not yet been traced, the country being for the most part unopened and in places thickly wooded. In the vicinity of Black Lake station and between this point and Thetford, the serpentine is largely intermixed with white weathering granulite, and in so far as yet known, this area constitutes the richest asbestos ground in the province. Throughout all these localities the serpentine presents generally a massive appearance. No indications of banding or interstratification were observed at any point, with possibly the exception of a very limited outcrop seen on Lot 16-17, Range II., S. E., Garthby. It is presumable that in most cases at least the rock is to a great extent an alteration product of some form of dioritic rock, rich in olivine, as already pointed out in reference to the serpentines of the Shickshock range by Dr. Harrington and Mr. F. Adams. See Geol. Survey Report, 1882-83-84, pp. 19-20 F.

Throughout the whole of the serpentine areas indications of asbestos are found, the veins ranging from mere threads up to four and even six inches in length of fibre. The rock is often affected by faults,

which are well seen in the asbestos workings, and which cut off the mineral veins in the same way as faults in ordinary sedimentary strata affect mineral lodes. This feature will be further considered in the remarks on asbestos.

SUPERFICIAL GEOLOGY.

While it has not been possible, in the time at our disposal, to make any very exhaustive study of the superficial geology of this district and the various phenomena in connection therewith, some attention was paid to the distribution of the drift deposits, more especially with a view to determine their connection with the auriferous character of much of the sand and gravel, which occur over a very large area. Wherever glacial striæ were seen, their direction was carefully taken, though in many cases it was impossible to determine, especially in a flat exposure, in what direction the ice had passed. Conditions similar to those which have been described as affecting the distribution of glaciers in Gaspé and Northern New Brunswick (see Geol. Survey Report GG, Mr. Chalmers, 1882-83-84 and 1885), will probably be found to have prevailed to a large extent in this area.

Distribution of
fine gold.

The source of the drift possesses considerable importance when we consider that in nearly every brook or stream throughout the Eastern Townships from the Chaudière to the Vermont boundary, traces of gold can be obtained in almost every pan of gravel washed. It is also found in the country lying to the north-east of the Chaudière, but its limit in that direction has not yet been determined. At several points also in connection with the Central ridge, more particularly at Dudswell, Stoke, and Little Magog Lake, indications of the precious metal have been found, but it is not yet known to exist in quantity sufficient to yield profitable returns to ordinary mining.

Theory of the
universal ice
sheet con-
sidered.

The theory of a universal ice sheet of many hundreds of feet in thickness does not now appear to meet with much support as applied to this region. Proceeding south-east from the St. Lawrence basin, three principal ridges, already described, with elevations from 1000 to nearly 4000 feet above the sea, would have to be surmounted, which would require a propelling force imparted to the glacier, the source of which cannot be found in any great continental elevation related to the St. Lawrence Valley. The great diversity also observable in the direction of the striæ at different points would appear to be opposed to this theory, for over a great portion of the eastern Cambro-Silurian area, there is a general course either to the south-east or north-west. If we accept the former course as that in which the ice passed, we must explain the manner in which the ice sheet overcame the gradual ascent from the valleys of the Massawippi and St.

Objections to
the theory.

Francis Rivers, which have an elevation of 550 feet above the sea level to the height of land on the Maine border, which reaches an elevation of from 1800 to 3800 feet.

The theory which ignores for the most part the existence of the great continental ice sheet, pre-supposes the presence of local glaciers which formed along the summits and crests of the principal mountain ranges, from which the ice descended in either direction, influenced largely by existing topographical features. Theory of local glaciers.

Since there is strong presumptive evidence to support the view expressed on previous pages, that the probable source of the gold of the Townships is largely in the areas of Cambrian slates which flank the old ridges of the boundary and the central axis, we may briefly consider what effect the application of the local glacier theory would have upon the present known distribution of the alluvial gold of this section.

On this view, these local glaciers would be shed on either side from the great mountain ridge along the Maine and New Hampshire boundary. The character of the drift in Northern Maine has not yet been closely worked out, but on the Canadian side it is evident that the debris, resulting from the disintegration of the Cambrian gold-bearing slates, would be carried north-westerly and distributed generally over the great Cambro-Silurian area of Compton, Stanstead and Beauce counties. This view is also sustained by the direction of the glacial striæ where visible; since on the south-eastern slope of the boundary chain, we find the course of the ice to have been S. 65° E., directly down the mountain, while on the Quebec slope, the course is N. 65° W., or directly opposite, the bearings being given with reference to the true meridian, with an assumed variation of 15° W. A general north-westerly course is also observed about Lake Megantic as well as further south in Ditton and Emberton. In Hereford, along the lower part of the valley of Hall's stream, only one observation was taken, where the course was S. 20° E. in the direction of the stream, and may indicate the existence of a local glacier which passed southward along the valley of the Upper Connecticut River. Effect of the action of local glaciers on the auriferous drift.

To the north, on the Chaudière at St. George, and in Risborough on the Du Loup, a general direction of N. 55° W. was found all along the course of these streams, the descent from the boundary on the Kennebec road to the forks of the Du Loup and Chaudière being about 1200 feet by aneroid. Courses of the glacial striæ.

We may, therefore, infer with some show of reason that a glacier of considerable extent descended from the height of land in this direction westward. It is very doubtful, however, if this surmounted the 1000 or 1400 feet elevation south of Sherbrooke and in the Stoke Direction of glaciers.

Striæ on Massawippi Lake.

range, since on the east side of this ridge, between Fitch Bay and Massawippi Lake, we find striæ on the south side of the Bunker Hill ridge, apparently descending towards the Massawippi valley. To the north, however, in the considerable depression between Lennoxville and Richmond, through which the St. Francis flows, the course of the striæ would seem to indicate that a part of the main glacier at least passed in this direction, the direction of the markings being in the line of the valley.

Memphremagog Lake.

In the vicinity of Memphremagog Lake another set of striæ are seen, which appear to indicate the presence of a local glacier which proceeded from the volcanic chain, marked by the great masses of Hawk and Bear Mountains, the Owl's Head, and Elephantis; the markings on the rocks along the side of the lake would indicate a passage of the ice in a northerly direction, the courses ranging from N. to N. 25° W., following the outline of the lake itself, and possibly continuing northward to join the main stream down the valley of the St. Francis.

Stoke Mountain range.

Along the west side of the Stoke Mountain also, the principal striæ have a north-westerly course towards the valley of the Wattopekah River, while in the country south of and in the vicinity of Ham Mountain the striæ have a south-east course on the west side and a south-west course on the east side of that elevation, as though the ice streams were converging into the same valley, and thence would join the main St. Francis valley stream in the direction of what is now Windsor Mills.

Lake Aylmer.

Farther to the north, in Garthby and Lambton, the markings also indicate the passage of the ice sheet from the higher lands of the volcanic belt into the depression of Lake Aylmer. These may mark the existence of very local glaciers of small size. The striæ noted in the valley of the St. Francis, east of D'Israeli station, would lead to the inference that the ice followed generally the depression of this stream, but as a large part of the surface is now thickly covered by drift, the striation cannot be traced for any distance.

In connection with this branch of the subject, the following list of striæ, noted principally during the summer of 1885, is here presented, the bearings being corrected to the true meridian, the variation being assumed as 15° west and north:—

LOCALITIES.

List of striæ.

One mile west of Lennoxville, on road to Sherbrooke.....N. 25° W.
 North side of St. Francis River, one mile east of Sherbrooke..N. 35° W.
 Road half a mile west of Wilson's Mills.....N. 60° W.
 Two miles west of Barnston Cor., on road to Ayer's Flat.....West.
 Cor. of roads S. W. end of Massawippi Lake.....N. 20° W.

- Two miles S. W. of Massawippi Lake on road to Fitch Bay...S. 25° E.
 Top of ridge, one mile and a half north from Magoon's Point,
 on road to Georgeville N. 30° E.
 On road one mile south of Georgeville..... N. 5° W.
 Two miles south of Georgeville, on road to Fitch Bay..... N. 15° E.
 Head of Fitch Bay S. 25° E.
 Half a mile north of Fitch Bay P. O., on road.....S. 5° W.
 One mile and a half east of Magog, on road to Ayer's Flat.... N. 5° E.
 Road to Sharon's Mine..... N. 5° E.
 West side of Massawippi Lake N. 15° W.
 Cor. of Magog Road, on road from Ayer's Flat to Kateville... N. 5° W.
 Road west of Sherbrooke, in rear of Brompton Falls N. 65° W.
 Road up hill south of Lennoxville, half a mile from town.... N. 35° W.
 Road half a mile north of Stoke Lake—two sets.... S. 80° W., N. 60° W.
 Half a mile south of Cookshire, on road to Eaton N. 35° W.
 Road through Newport, two and a half miles east of Island
 Brook P. O..... N. 50° W.
 Road crossing on line between Ditton and Emberton..... N. 55° W.
 Boundary line overlooking Lake Sophy N. 45° W.
 Lot 49, Range VII., Ditton..... N. 55° W.
 Half a mile west of Chartierville P. O., Emberton N. 55° W.
 North-west side Memphremagog Lake, near outlet..... N. 5° W.
 Four miles north of Sherbrooke, on road to Ascot..... N. 55° W.
 Road between Brompton and Ascot, four miles west of Sher-
 brooke..... N. 30° W.
 Brompton and Orford line, six miles west of Sherbrooke.... N. 30° W.
 Four miles north of Sherbrooke, on road to Stoke Centre.... N. 65° W.
 Corner of road, Lot 3, Range II., Ascot..... N. 20° W.
 Compton Village..... N. 50° W.
 Two miles east of Coaticook, on road to Hereford..... N. 35° W.
 Valley of Hall's Stream, Hereford..... S. 20° E.
 One mile south of Ascot Cor., on road... .. S. 60° E.
 Road through North Stoke, Range XIII..... N. 75° W.
 Road from North Stoke to Ste. Camille, near small Lake....
 N. 35° W., N. 53° W.
 Road Ste. Camille to South Ham, $\frac{3}{4}$ mile south of Ham village N. 65° W.
 Near Ham Court House—two sets..... S. 75° W., S. 30° E.
 Three miles north of Ham Court House..... S. 75° W.
 Ham Corner..... N. 60° W.
 Two miles west of Big Ham Mountain, road going south.... West.
 Road through Range XI., Tingwick..... S. 60° W.
 Ste. Camille, near corner..... S. 15° W.
 Half a mile north of Ascot line, on road to Stoke..... N. 40° W.
 Road, Lot 9, Range VI., Melbourne..... N. 50° W.
 Road Ham to Shipton, at crossing Middle Branch of Nicolet
 River..... N. 25° W.
 Road Ham to St. Adrien, Lots 5 and 6... .. N. 5° W.
 Road on ridge north of Victoria Bay, west side of Lake Me-
 gantic..... N. 50° W.
 Three miles east of Maine boundary, on International railway..S. 65° E.

International railway, eight miles east of Agnes.....	N. 65° W.
Wolfe town, road through Belmina, Lots 13-24, Range II.	N. 75° W.
Road Dudswell to Ste. Camille, Lot 26, Range X.....	West.
Road Marbleton to Ham, four miles south of Ham Corner....	West.
Ste. Camille, Lot 35, Range II.....	West.
Ham, Lot 24, Range IV.....	S. 80° W.
Road one mile west of Garthby station.....	S. 65° E.
Quebec Central railway, one mile and a half south of Coleraine station.....	S. 60° E.
Crossing of St. Francis River, D'Israeli station.....	S. 10° E.
Road D'Israeli to Lambton, two miles east of station.....	S. 5° W.
Forks of road, Lambton to St. Romain.....	N. 30° W.
Road from Lake St. Francis to St. Romain.....	N. 65° W.
St. Romain Corner.....	N. 65° W.
Stornoway Corner.....	N. 75° W.
Victoria range road, half a mile south of railway.....	N. 60° W.
Silver Mine, Risborough.....	N. 60° W.
St. George, Beauce.....	N. 55° W.

Marine beds
absent.

Through the whole area under consideration, no traces of marine beds were observed. Allowing the amount of subsidence at Montreal to range from 470 to 500 feet, if we suppose this to have been uniform for the St. Lawrence area, the part submerged would probably be bounded on the east by the high ridge beginning at Arthabaska and extending to the south-west, and embracing the great stretch of level country lying to the east of the St. Lawrence.

Sand and gravel
drift.

Deposits of blue clay are found along the valleys of some of the streams in the higher lands of the interior, at levels of 500 to 1,000 feet above the sea, but these are all apparently of fresh water origin. Large quantities of sand and gravel drift are also found along the course of the principal rivers, as along the St. Francis between Lake Aylmer and Lennoxville, and lower down between Sherbrooke and Melbourne. These are well seen for a few miles on either side of Windsor Mills, where they form large conical or ridge-shaped hills, having elevations of fifty to a hundred feet above the present flood plain. Great quantities of sand drift are also found in the vicinity of Danville, and along the depression toward Warwick. On the International railway, east of Lennoxville, several deep cuttings in stratified gravels and sand are seen at a height of about 300 feet above that town, and on the road between Brookbury and Robinson, a short distance west of the latter place, a well defined kame is observed having a north-westerly course.

Boulder drift.

In the townships of Clinton and Woburn, considerable areas are thickly strewn with granite boulders, which have presumably been derived from the great granitic mass of the boundary, lying to the south-east of Lake Megantic, indicating a north-westerly movement. On

the road also through Whittön, between the foot of Lake Megantic and St. Romain, granite boulders are distributed on either side of the range of the Little Megantic Mountains, while in Marston and Hampden, along the old Megantic road, similar boulders are abundant, which have evidently proceeded from the Victoria Mountain chain. Whether the presence of the gold found so generally distributed over the great Cambro-Silurian area between the central and the eastern ridge, and which is, for the most part, in a very fine state of division, is due to glacial action or to pre-existing causes, is at present, to some extent, at least, an open question. In the Cambrian belts, however, nuggets of good size are found, and much of the gold is coarse. The same coarse character is reported at several points on the eastern slope of the central axis, and is also observed in much of that obtained from the Gilbert, and adjoining tributaries of the Chaudière River. Upon the view of the structure already stated in previous pages, that the ridge between this stream and the Famine, is of Cambrian age, and the presumed equivalent of that found along the eastern boundary, this peculiarity can be easily explained, since this area would then probably prove to be the source of the gold.

Character of the drift gold in the eastern Cambro-Silurian area.

Coarse gold.

The presence of old river valleys has of late been recognized in connection with several of the streams which flow into the Chaudière, though no attention has as yet been directed to the finding of these ancient channels, except in that district. Among those known to exist may be mentioned that of Slate Creek, at St. George, now being worked, the Famine, and the Gilbert, and on the opposite side, the Pozer stream, with presumably some portions of the Chaudière itself. These channels, judging from that already opened on Slate Creek, are many feet below the present level of the stream, and it is from these that the greater part of the gold yet obtained in this district has been taken.

Pre-glacial river valleys.

By the kindness of Mr. A. A. Humphrey, Manager of the St. Onge Gold Mining Co., the following statement of strata, passed through in the last shaft sunk on the old channel of Slate Creek, is here presented :

	FEET.	
Boulder clay, boulders, both native and foreign	40	Section of drift at Slate Creek, Beauce.
Sand	2½	
Boulder clay	20	
Stratified clay, without pebbles	60	
Quicksand, small pebbles and fine gold	40	
Sand and gravel, containing gold in quantity, often coarse	4	
	166½	

It is evident from the above table that these old channels had not only been excavated, but had been partly filled up, and the streams

Distribution
of drift.

diverted to their present courses, long prior to the glacial action by which the boulder clay was distributed. It would also appear from the lack of gold in the boulder clay, and from its presence in the underlying and more ancient sands and gravels, that the causes which were principally instrumental in the formation and distribution of the alluvial drift, over the greater portion of the Cambro-Silurian area, were distinct from those which strewed the surface so thickly with granitic and other boulders, and that [they preceded the latter by a very considerable interval of time.

Character of
soils.

While the character of the soil is to a large extent dependent upon the nature of the underlying rock, certain causes may at times intervene, by which the superficial deposits that arise from simple disintegration of the strata may be affected favorably or otherwise. These causes are principally two in number, viz., the subsequent effects of glacial action in some form, or the redistribution of surface material by the action of water, either marine or fluvial. Since it has been shewn that no traces of marine action exist in this part of the province, whatever changes have taken place as regards the distribution of the original surface soil, must be due either to the latter cause or to the agency of land ice.

As a rule, the most fertile soils are found to be made up of the disintegrated calcareous strata of the great Cambro-Silurian basin. A similar degree of fertility should also characterize the portion underlain by Silurian sediments, but for the fact that the principal area, which is found on the St. Francis River, north of Dudswell, has been covered subsequently by a considerable thickness of alluvial sand and gravel. In the areas occupied by the more sandy sediments of the Cambrian, and by those of the older metamorphic rocks, though good soils are found at intervals, such areas are generally limited, and their fertility is, in many cases, due to other causes than the decay of the immediately underlying rocks.

Character of
soil as affecting
settlement.

The difference in the nature of the soil is also very clearly shewn by the character and distribution of the various settlements. Thus in the townships which extend for some ten to fifteen miles east, from the central metamorphic ridge, embracing the western portion of the counties of Compton and Stanstead, where the limestones are more particularly developed, the country is intersected in every direction by roads, and flourishing villages are numerous. Here also some of the most famous farms in Canada are situated, among which may be mentioned that of the Hon. J. H. Pope at Cookshire, that of the Hon. Senator Cochrane at Compton, and that of Mr. Pierce, near Stanstead Plain. The eastern part of these counties, with a large proportion of Beauce adjoining, though of late years beginning to be opened up, is yet

largely a wilderness; the soil, as a rule, being more sandy and stony and in places largely covered with boulder drift, and much less productive than that of the section just described, while its elevation above the sea level, ranging from 1,000 to 1,800 feet, is such that early frosts are frequent, and the ripening of the less hardy grains rendered somewhat uncertain.

Throughout the townships of Wotton, Ste. Camille and St. George de Windsor, the decay of the Cambro-Silurian slates has produced large areas of excellent land, much of which is still uncleared. Good land.

The country occupied by the metamorphic rocks has generally a rugged and broken surface, and as already stated these rocks do not, as a rule, afford a very fertile soil. The same remarks also apply to that portion where the volcanic belt of the Lower Cambrian is found, though the overlying basins of Cambrian slates frequently present a good soil, well adapted for agricultural purposes.

ECONOMIC MINERALS.

Gold.—By reference to the reports of the Geological Survey, 1847-48, p. 76, it will be seen that the first discovery of gold in the province of Quebec, is supposed to have been made in the Chaudière valley, by a daughter of one of the *gensitaires* of Mr. C. DeLery, on a small stream called the Touffe des Pins, a branch of the Chaudière River, and shortly after, acting upon this discovery, loose pieces were picked up by Mr. DeLery himself in this stream. This fact was communicated to the public in Silliman's Journal, vol. 28, p. 112, 1835, by Capt. F. H. Baddeley, R.E. Subsequent examination of this locality resulted in the finding of small lumps and grains which were simply collected by hand, and the value of the gold so obtained from the time of the first discovery to the end of Oct., 1847, was estimated at about \$300. The source of the gold was not at that time definitely known, though it was supposed to be from some of the numerous quartz veins seen in that neighborhood. In this report also, attention was called to the occurrence of gold in a vein in the vicinity of Sherbrooke, found in making an assay for copper; the amount, however, was held to be of no economic importance, being only about (\$1.00) one dollar per ton of rock, except in its bearing upon the possibly richer auriferous character of the quartz veins in this section of the country. Early history of the Chaudière gold-field.
Gold near Sherbrooke.

In the Geological Survey Report for 1849-50, attention was also directed to the further discovery of gold at several points along the valley of the Chaudière, as far as the Metgermette, about fifteen miles south-east and above the mouth of the Famine River. Other localities in which it was at that time noted, beside the Touffe des Pins, were the Ruisseau Lessard, the Ruisseau du Lac Moulin, the Bras, about The Chaudière and its tributaries.

one mile below the Great Fall, and the Guillaume or Calway, just below the fall in that stream, the quantity found, however, being comparatively insignificant.

Extent of the
gold-fields
known in 1850-
1851.

In the Report for 1850-51, it was further stated that the auriferous district was known to embrace an area of 3,000 to 4,000 square miles, and to occupy nearly the whole of the province lying to the south-east of the prolongation of the Green Mountain range into Canada. The lowest point in the valley of the Chaudière, where gold was found in the drift, was a small stream on the left side of the river, not far within the south-east boundary of the Seignior of Ste. Marie. Thence, ascending the river, it was found on four tributaries in the Seignior of St. Joseph, one of which joined the stream from the left, about one-fourth of a mile below the parish church. Of the other three on the right, the lowest was about two miles below the church, the next, two miles above it, and the third was the Rivière des Plantes, near the south-east boundary of the seignior. In Vaudreuil, Beauce, traces of gold were found on the Guillaume and the Bras, on the latter of which and its tributaries, it was traced for a distance of twelve miles. In addition to the other streams already noted, it was found in Aubert de L'Isle on the Famine, for a distance of about ten miles from its mouth, and in the Ruisseau De L'Ardoise, one mile further up the Chaudière, and on the Pozer stream on the opposite side of the river, for about three miles up from its mouth. On the Du Loup, it was found almost continuously from its junction with the Chaudière, almost across the townships of Jersey and Marlow, as well as in nearly all its tributaries for several miles, being apparently more abundant or more generally distributed in this section of the country than further down the river, where first discovered. On the main Chaudière, above the Du Loup, it was traced for a distance of sixteen miles to the south-west boundary of Dorset.

Gold of Duds-
well and
vicinity.

Farther to the south, it was also found on the St. Francis at Dudswell, at Westbury, and near the joint corner of the townships of Stoke, Eaton, Westbury and Ascot, as also near the town of Sherbrooke. In all these localities, the gold obtained was from the drift only.

Geology of
Canada 1863.

Attention having now been directed to the auriferous character of the localities mentioned, further examinations were made by the Geological Survey, but more largely by private individuals and companies. The results of these explorations and trials appeared in the several reports of the Survey, and were summarized in the *Geology of Canada*, 1863, pp. 518 and 520. The source of the gold was at that time supposed to be the crystalline schists of the Notre Dame range; the materials from their disintegration being spread over a considerable area to the south. Native gold with galena was also reported from

Supposed
source of the
gold.

quartz veins at the Rapids of the Chaudière, near St. Francis, as also in a vein with copper glance and bitter spar in Leeds, Lot 15, Range XIV. (Geology of Canada, 1863, p. 730 and 739.)

Mention was also made of the finding of gold in the drift along the Magog River, in Lots 2, 3 and 6, Range XIII, Ascot. The results of washings on the Chaudière in 1851-52, made under very disadvantageous circumstances, and with ordinary appliances, showed a very fair margin of profit, and the conclusions then arrived at were, that the amount of gold obtainable by washing on the river was such as, with skilled labor, to warrant the outlay of capital in its extraction, and that by the employment of the hydraulic process, largely adopted in Australia and in California to work gravels which contain a very small proportion of gold, very profitable returns should be made. Unfortunately, the only attempts of any importance made in this direction on the Du Loup and Chaudière, although no official returns are at hand, do not appear to have been as successful as was anticipated, though it does not of necessity follow that a failure in a first attempt should condemn the system for the entire district.

The labors of the Select Committee, appointed by the Quebec Government, in 1855, to obtain definite information as to the extent and resources of the Canadian gold fields, brought to light a large amount of information, much of which is of great importance, as relating to the value of this section as a gold producing district, and the testimony of all the witnesses seemed to point to a conviction on their part, that under more favorable conditions than apparently then existed, owing in part to difficulties in the matter of titles, royalties, etc., very profitable returns could be realized.

The returns of the amount of gold obtained since that date would also, if available, aid us in forming more definite conclusions as to the gold producing capabilities of the district, though it should be borne in mind that all, or nearly all, the mining yet carried on in the province, in so far, at least, as can be ascertained, has been done in a comparatively rude way, and without much attention to modern improved methods. The results obtained, therefore, even if unsatisfactory, should not be regarded as conclusive, especially when contrasted with the very different results which should follow a judicious investment of capital and proper scientific modes of working.

The results of the examination of the Chaudière district by Mr. A. Michel, with more particular reference to the possibly auriferous character of the quartz veins, and the assays of a number of specimens of quartz, from different localities, by Dr. T. S. Hunt, are given in the Geol. Survey Report 1863-1866. These results, indicating the existence of veins carrying gold in paying quantity, were very favor-

Gold on the
Magog River.

Profitable
returns warranted by the
explorations of 1851.

Report of the
Select Committee of the
Quebec Government, 1855.

Reliable re-
turns not
available.

Examinations
by Messrs.
Hunt and
Michel.

able, the assays, in some cases, showing a percentage quite as high as the average obtained for quartz veins in California, Australia, or Nova Scotia. As might naturally be expected, several samples gave no gold, but this is a feature common to all countries, and only shows that all parts of the same vein are not equally auriferous. The most satisfactory method of testing these leads would evidently be to subject large quantities to trial in a stamp mill, and till this is done, their actual value, must, to some extent at least, remain in doubt. That some of the veins contain gold in paying quantity, we already know. In this connection, we will here quote the results obtained by Dr. Hunt and Mr. Michel. The assays of Dr. Hunt embraced some thirty-one samples, obtained from twelve localities, each in portions of 100 grammes. The following results were obtained, the value of the gold being estimated at \$20 per oz. Troy of 480 grains:—

Assays of
quartz by
Dr. Hunt.

1. Vaudreuil.—L. 83, R. I., N.E. Two assays. No trace of gold.
2. " L. 21, Con. St. Charles. Five assays. Of these, four gave an average of 6 dwts. 13 grs.—\$6.76, the fifth of which contained a large scale of gold at the rate of 4 ozs. 18 dwts.—\$101.29. The average being for the five samples, \$25.66.
3. " L. 62, R. I., N.E. Two assays. No trace of gold.
4. " L. 19, Con. St. Charles. Six assays. Mean of four gave 4 dwts. 21 grs.—\$5.03. Two others, counting scale of gold, 3 ozs. 2 dwts.—\$64.07. Average of six assays, \$24.71.
5. " L. 39, R. I., N.E. Two assays. No trace of gold.
6. " L. 20. Con. DeLery. Two assays. Mean, 14 dwts. 16 grs.—\$15.15.
7. " L. 53, R. I., N.E. Two assays. No trace.
8. " L. 59, R. I., N.E. Two assays. "
9. Aubert De Lisle.—L. 9, R. I. Two assays. "
10. Aubert Gallion.—L. 30, R. I. Two assays. "
11. Linière.—L. 76, R. I. Two assays. "
12. " L. 2, R. I. Two assays. Mean, 6 dwts. 13 grs.—\$6.76, per ton of 2,240 lbs.

Remarks of Dr.
Hunt on the
auriferous
character of the
quartz veins of
the Chaudière
district.

Dr. Hunt says:—"If we compare these assays with those mentioned by Mr. Michel, we shall see full proof of the irregularity with which gold is distributed in the gangue. The quartz from several of these veins was assayed by Dr. A. A. Hayes, of Boston, whose results, which are worthy of the highest confidence, are given by Mr. Michel, together with other assays by persons unknown to me, but probably reliable. The quartz of No. 1 had given in Boston \$37.00, and in another assay on the spot \$106.00 to the ton. The mechanical assay by Mr. Michel also yielded a portion of gold, while two assays by me gave no trace of the precious metal. Again, in the case of No. 2, Dr. Hayes obtained \$77.56, and Mr. Coban \$54, while an assay of the same vein yielded me \$101.29, and from others a mean of \$6.76. No. 3, in like manner,

is said to have furnished gold, though none was found in the specimen just assayed. Nos. 4 and 6 yielded gold to Dr. Hayes and myself, while yet No. 8, which gave traces of gold to Mr. Michel's mechanical assay, and of No. 11, which is said to have yielded gold to a New York assayer, the specimen furnished me yielded no trace."

Assays of specimens from the Marlow silver mine made by Prof. J. T. Donald, of Montreal, show that the quartz leads of that locality, in addition to the silver and lead, contained gold, in most cases only a trace, but in one instance, half an ounce to the ton. This amount even, if constant, would pay a large proportion of the expense of working this part of the property.

Assays by Prof. J. T. Donald of Montreal.

There is one feature of the Chaudière district, to which attention has not, till within the last few years, been directed, viz., the existence of old river channels, not only in connection with the main stream, but along its several tributaries. The importance of this feature has been pointed out by Dr. Selwyn. (See Geological Survey Report for 1870-71, pp. 275-76.) The value of these old channels was established on the Gilbert stream, where a large amount of gold was obtained some years ago under most unfavorable conditions, several pieces being found which were stated to be worth over \$1,000 each. Upon the cessation of work on this stream, the St. Onge Brothers began operations on a small stream above the Famine, known as Slate Creek, and again established the existence in this direction, of an old river bed, which was reached at a depth of 165 feet, nearly 100 feet below the present bed of the stream. In the bottom of this old channel a layer of gravel, now being worked by the St. Onge Mining Co., having a thickness of four to six feet, was found. Great difficulty was experienced in sinking the shafts, owing to the quantity of quicksand encountered, and repeated trials were made, extending over a period of several years before the bed-rock was reached. From the table of the materials passed through in this shaft, which was given on page 49 J, it is evident that the gold underlies the clay at the top and is entirely confined to the lower sands and gravels above the bed-rock.

Importance of the old river channels as a source of gold.

Old valley of Slate Creek.

Doubtless, by the judicious expenditure of money in exploration, many other old channels will be found, indications of such being visible in the Famine River, the Pozer stream, and at other points. That much of the gold is derived from veins *in situ* is pretty conclusively established from the assays already quoted, as well as from its coarse character and the size of many of the nuggets obtained, clearly indicating that their source is not far removed. Further evidence is afforded by the presence of pieces of gold-bearing quartz, in which but slight indications of abrasion are apparent, both the gold

True source of the alluvial gold of the Chaudière district.

and quartz being but little worn and proving conclusively that they were derived from the veins in the immediate vicinity.

Ditton gold-field.

Lack of official returns.

Auriferous veins of the Ditton River.

Unsatisfactory methods of working.

Course of the Ditton quartz veins.

All the reports bearing upon the gold of Quebec refer only to the Chaudière valley. Other areas are known which promise quite as good returns to capital well applied; among them may be mentioned the upper waters of the Salmon River, more particularly in the township of Ditton. That attention has not been directed to this locality is in large measure due to the fact that what is regarded as the most promising field for work is entirely in private hands, and no royalty being in consequence paid to the Government, no official returns are available as to the amount of the precious metal obtained. Alluvial gold has, however, been found there, and worked for many years. The place where operations have been more particularly carried on is on the Little Ditton stream, on Lots 23 and 24, R. IX., Ditton. Nuggets ranging in value from \$50 to \$150 are reported as having been found. The rocks are black, wrinkled, and sometimes pyritous slates and grey sandstones, in character similar to much of those on the upper part of the Chaudière, and also to those of the gold series of Nova Scotia. Veins of all sizes, up to several feet, traverse the slates, generally with the bedding, though occasionally transverse to it. No attempt has yet been made, in so far as could be ascertained, to test the value of these veins, though that some of those on the Little Ditton are auriferous is proved by the finding of ragged gold in quartz in close proximity, and below them in the bed of the river.

Though a considerable amount of work has been done on this stream and a large quantity of gold obtained, no scientific mining has been attempted. The ground being generally low, the facilities for getting rid of tailings are very poor, and in many of the trials the bed-rock does not appear to be reached. From the specimens already obtained, and the generally favorable results of the work already done under unfavorable circumstances and with ordinary appliances, it is evident that much rich ground must exist in this vicinity.

The veins seen on the Little Ditton apparently extend south-west through Emberton, the belt evidently being the continuation of that in Maine near the boundary between the Hall and Indian streams. To the north-east they can also be traced for several miles, and the anticlinal seen in this locality is recognized in the upper waters of the Du Loup, as already pointed out in the remarks on the Cambrian.

As regards the true source of the gold, while it may be generally stated to be found in nearly every brook or stream in the South-Eastern Townships, more especially east of the Stoke Mountain range and the extension to Lake Memphremagog, the precious metal over the greater part of this area is in an exceedingly fine state of division, as though

derived from some distance. This is characteristic of the country which is, for the most part, occupied by Cambro-Silurian sediments; whereas, when we approach the belt which is supposed to be of Cambrian age, the gold becomes coarser and the quartz-veins are probably auriferous. This feature has also been pointed out in earlier reports, though the greater portion of the strata were then held to be of Upper Silurian age. The resemblance of these Lower Cambrian rocks to those of the gold series of Nova Scotia, which have long been regarded as of the age of the Lower Cambrian, was pointed out some years ago by the late Sir Wm. Logan (see *Geology of Canada*, 1863, p. 745), and has been already referred to in this report. The probability that these rocks are of the same age as those of the Nova Scotia area is manifestly very important in connection with the question of the occurrence of gold in paying quantities, and is a point that should not be lost sight of in future operations. In that province, within the last few years, the finding of new and wonderfully rich deposits is frequently reported, and it can safely be said that the prospects of highly profitable mining never looked so bright as at the present time. The prospecting in eastern Quebec has as yet been largely confined to one locality, in which the results have often been satisfactory, while a large area of similar rocks remains comparatively untouched, and the true value of the gold-fields of the Townships cannot be said to be yet ascertained.

Gold probably derived from the Cambrian slates.
Comparison with the gold areas of Nova Scotia.

The erection of one or more improved stamp mills, by which the quartz-veins of the Chaudière district and those of the township of Ditton might be practically tested, would do much to settle this question. Only one attempt in this direction was made, some years ago, but, either through defects in the mill itself or through bad management in the working, the returns from it could not be depended upon, and persons interested in the quartz industry soon lost confidence in its efficiency to thoroughly test the question at issue.

Best methods of testing value of quartz veins.

The official yearly returns of the amount of gold obtained from the Chaudière district will be found in the report by Mr. E. Coste, M.E.

Silver and Argentiferous Galena.—In *Geology of Canada*, 1863, p. 517, the presence of silver in the copper ores of Acton, Ascot and Upton was pointed out; the quantity, however, was insufficient to render it of economic value. The assay of a portion of a vein from the rapids of the Chaudière, at St. Francis, Beauce, which carried argentiferous galena, blende, mispickel, pyrite and native gold, gave 69 per cent. of lead and 32 ounces of silver to the ton of 2,240 lbs., while a second sample gave 256 ounces of silver to the ton, with traces of gold and silver in the other ingredients of the vein.

Silver from the rapids of the Chaudière near St. Francis, Beauce.

Within the last half-a-dozen years, several veins of argentiferous

Silver mine of
Risborough and
Marlow.

galena have been discovered, more especially near the boundary of the townships of Risborough and Marlow; they have been opened to some extent and favorable prospects were found. The localities where work was principally done are on lots 1, 2 and 3, ranges XIV., XV. and XVI., Risborough, and lot 1, range VII., Marlow. From the examination of this property, in September, 1885, the following description was obtained, although mining operations, which had been going on under the management of Mr. J. Fraser Torrance, M.E., had ceased in the spring of that year.

Description of
the property.

At the first or more northerly shaft, the rock is a hard, greyish sandstone, with interstratified beds of black and grey slates, finely wrinkled and in places containing cubes of iron-pyrites. It dips generally south-easterly $< 70^{\circ}$ to 75° , as nearly as could be ascertained. The vein, which is styled the "main vein," has a width of ten to twelve inches, composed of quartz, carrying galena, copper and iron-pyrites, and some blende, in some places heavily charged, in others comparatively barren, probably from a half to a third of the vein carries ore in fair quantity. This shaft was about thirty feet deep, and the vein is of uniform width for that distance. The rock in contact is slightly charged with iron-pyrites. Twenty feet west of this shaft, another vein of about ten inches, called the "north vein," carries ore of a peculiar quality. The gangue is a rusty white quartz, with brownish, grey slates on the north wall, and a dyke of very hard brownish dioritic rock, spotted with greenish gray, separates it from that in the shaft just described. The ore, where exposed at the surface, is confined to the north side, but as only three or four shots have been fired, the opening is small.

Several veins.

In the second or small shaft, sunk about thirty-five feet south of that seen in the north shaft, the lode goes down vertically, with a width of about one foot. It is apparently not as rich as the main vein, but carries galena, blende and pyrites irregularly disseminated, the former, so far as observed, in comparatively small quantity. This vein cuts across the bedding at a small angle, and is intersected by another vein of irregular size, ranging from a few inches to nearly two feet in width. The diorite does not show in this shaft. This latter vein has also been opened 130 feet east, where it crops out in the spur of a knoll, and has a course of about N. 68° E. The shaft is eighteen feet deep.

Nearly a mile south-west, another opening has been made in slates and sandstones of similar character, which dip S. 15° E. $< 70^{\circ}$, on a vein of rusty white quartz, from sixteen to eighteen inches wide, styled the "Armstrong vein," which cuts across the bedding and carries minerals similar to those already described. The trench being

full of water, the proportion of ore could not be definitely ascertained, but the mineral appears to be disseminated in bunches, large portions of the vein being barren, others comparatively rich. A short distance to the south-west of this, two other veins were noted, of which the largest (the "Senator vein") has a width of eighteen to twenty inches, the other of about three inches. In character of gangue and contained mineral, this resembled closely the last. The containing rocks are hard sandstones and wrinkled slates, like those of the Ditton gold-field. Rocks similar to those of the Ditton gold-field.

The vein seen in shaft No. 2 was intersected by a cross-cut put in 1,400 feet south-westerly from that point.

On lot 1, range VII., Marlow, veins, ten to twelve inches thick, were seen, cutting slates and sandstones similar to those just noted, carrying in places a large quantity of blende and pyrites, with some galena. The rocks here dip S. 10° E. < 89°. The principal vein dips S. 40° E. < 45°, but smaller veins of an inch or more run with the bedding planes.

Assays of the ore from these several veins show the presence of a fair proportion of silver. These have been kindly furnished me by Mr. F. Torrance, and are as follows:—One specimen from the "north vein," assayed by Rev. E. Pagé, of Laval University, gave 430 ounces of silver per ton of 2000 lbs. One from the outcrop of the "Senator" gave 260 ounces per ton, and one from the "main vein," assayed by Prof. Richards, of the School of Technology, Boston, a little over 29 ounces per ton. The assays by Prof. Richards from a quantity of the ore taken from the Armstrong and Senator veins, gave good returns. Assays by Prof. J. T. Donald, of Montreal, gave for the "Armstrong vein," half an ounce of gold per ton, with traces only of the precious metal from the other leads. Assays made by Mr. Hoffmann, in the laboratory of the Geol. Survey, from different veins, and ordinary samples gave 43.663 ounces of silver to the ton, with traces of gold. Galena is also reported by Mr. Gordon, of Sherbrooke, in what may be the extension of this belt south-westward, in the township of Spalding, about three or four miles north of the International railway, and the same distance west of the boundary, though no particulars are to hand concerning the exact location. Traces of galena were also observed at several places in the quartz veins of Ditton and Emberton, but no attention has as yet been paid to these. Assays of galena from the several veins.

Copper Ore.—The distribution and mode of occurrence of this mineral, have been so exhaustively discussed in former reports (see *Geology of Canada*, 1863, pp. 709–737, and *Geol. Survey Report* 1863–66, pp. 29–45, and in the appendix to that volume), that but little need be said on the subject. Of the numerous mines and localities there described, the greater part have been closed for some years, owing, to some extent, Distribution of the copper ore given in Geol. Sur. Rep. 1863–66.

*The Capelton
mines.

to the low price of copper, and the low grade of the ore obtained. Those worked at present are confined to the township of Ascot, in the vicinity of Capelton, where mining is still carried on by two companies, the Orford Copper and Sulphur Company, and J. H. Nichols & Co. The ores are shipped in the raw state to New York, and there treated for the manufacture of sulphuric acid, after which, the residue is worked for copper. The operations of the former company are confined to one shaft, the "Crown Mine," over 1300 feet in depth, with levels driven in the vein, which has a thickness ranging from one to over forty feet, for a hundred yards or more. The copper-bearing lode is affected by faults which have, however, not as yet had any serious effect on the value of the property, being generally of small extent. The amount of copper in the ore ranges from three to five per cent. On the property of the second company two shafts are sunk, the Albert and the Betsey. In the former, the vein was reported to have a width of fifteen feet, but as in the Crown mine, this varies. In the Betsey, a thickness of four feet was reported. The total output from this mine in 1885, was 25,000 tons, and from the Crown Mine 16,000 tons. The quality of the ore is apparently the same at both places.

Attempts were made some years ago to reduce the ore on the spot, and extensive smelting works were erected in connection with the old Capel mines, and on the Eustis property at the Crown Mine. The experiment, however, was not successful, owing to the rapid decline in the value of copper, and these expensive works are now rapidly falling into ruins. It seems pretty clearly established that in the case of the low grade ores, rich in sulphur, such as are found in this section, the only profitable method of handling them, is that now adopted, viz., by the utilization primarily of the sulphur. Details of production to date can be found in Mr. Coste's report, Part S.

Iron ore of
Sherbrooke,
Smith's Mine.

Iron Ore.—Deposits of magnetite of considerable extent are known to exist at several points, principally in what is regarded as the lowest series of rocks. Of these, apparently one of the most important is seen in the immediate vicinity of Sherbrooke, on Lot 21, Range VI., Ascot, on property owned by Mr. Stephen Smith. The vein, which is from ten to fourteen feet wide, occurs in hard chloritic and felspathic schists, associated with quartz and jasper. The ore, of which about 500 tons have been extracted, is slightly calcareous and of excellent quality. The locality was referred to in the Geol. Survey Report for 1847-48, p. 87, under the head of Jasper, and the presence of the iron was noted. Assays of the ore, recently made by Mr. Hoffmann, gave 54.074 per cent. of metallic iron.

Ascot, Clark's
Mine.

A probably larger deposit is found on Lot 8, Range IX., Ascot, on the property of Mr. E. Clark, near the summit of a ridge, having an

elevation of about 1,000 feet above the St. Francis River, at Sherbrooke. The ore is mostly a slaty magnetite, with some hæmatite, and the country rock is largely a chloritic schist; the veins are of different sizes, ranging from a few inches up to masses of ten or twelve feet in width, and are irregularly distributed in the schists, in places following the bedding. The assay of this ore, by Mr. Hoffmann, gives only 28.392 per cent. of metallic iron. Another important deposit of magnetite is found on the west side of Nicolet Lake, in serpentine, and already alluded to on page 42 J. The amount of work done is not sufficient to test the value of the property. A shaft, twelve feet deep, has been sunk in a vein six feet thick at the surface, and reported to increase to eleven feet at the bottom, about one hundred tons of excellent looking ore has been extracted, but no assays have yet been made to test its quality.

Nicolet Lake,
Reid's Mine.

Chromic Iron is found in connection with the serpentines at several places in the area under consideration. A deposit on the south side of Lake Nicolet, Lot 4, R. II., Ham, was opened some years ago, and about ten tons extracted (See Geol. Can. 1863, p. 749), but the indications were not sufficiently favorable to warrant a continuation of the work. Within the last five years several openings have been made near Belmina, principally by Mr. W. Grey, (L. 24, R. III., Wolfestown), on the crest of the serpentine ridge at this locality. The deposits are apparently of the nature of irregular pockets. From the most important of these about twenty tons were extracted from a shaft fifteen feet deep. The vein was five feet wide at the surface, but decreased to three feet at the bottom of the shaft. Two hundred yards east of this spot a second opening was made, which produced two to three tons in pieces scattered through the serpentine. Other small deposits were also found, and in all about twenty-five tons were obtained. None of these were deemed of sufficient importance to warrant the expenditure of much capital. No sale has yet been made of the ore, a certain percentage of chromic acid being requisite to render it suitable for shipment to the English market.

Old opening on
Lake Nicolet.

Chromic iron of
Belmina.

Antimony Ore.—This mineral occurs at only one point in the Townships, in sufficient quantity to render it of economic importance, viz., on Lot 28, R. I. (old numbering), South Ham. The deposit was first noted in Geology of Canada, 1863, p. 876, and more fully described by Mr. Willimott, Geol. Survey Rep. 1880-81-82, p. 3 gg. The property has within the last two years changed hands, and is now owned by Dr. James Reid, of Inverness. Exploratory work is now being carried on with a view to thoroughly test the value of the mine by means of an adit driven in from near the bottom of the hill in which the ore veins

South Ham
antimony
mine.

are situated, and which it is expected will cut the antimony-bearing strata at a lower level than was reached in the shafts, but nothing definite as to the results has yet come to hand.

Asbestos.—Asbestos mining in the province of Quebec may be said to be comparatively a new industry. Beginning in 1878, it has within the last seven years risen to one of the most important enterprises in this portion of the Dominion. At the request of several of the companies interested in this branch of mining, an examination was made of the principal areas where asbestos is found in workable quantities, the results of which, though necessarily imperfect, are here presented as tending to throw some light upon the progress and present condition of this enterprise.

Situation of the principal asbestos mines.

Asbestos mining is carried on at several points along the line of the Quebec Central railway, viz., at Thetford, Black Lake, in the township of Coleraine, and at Belmina, in Wolfestown. Some work has also been done near Coleraine station. Near Danville, at a point four miles from the Grand Trunk railway, a mine of considerable extent has also been operated for several years.

Companies engaged in mining.

The various companies engaged in mining asbestos at Thetford are King Bros., the Boston Asbestos Packing Co., Irving, Johnston & Co., and Ross, Ward & Co., while at Black Lake are situated the mines of the Anglo-Canadian Co., Frechette's, and the Scottish Canadian Co., formerly the Lionais-Martin property. These all lie along or near the line of the Quebec Central railway, which crosses the properties at Thetford, while at Black Lake it is from a quarter to half a mile distant from the workings. At Belmina, which is four miles distant from the railway at Coleraine station, a small force of men, from six to eight only, have been engaged for several years, mostly in exploratory work, on property owned by Mr. John Bell, of London, Eng.

Distribution of the principal serpentine areas.

The various asbestos mines now operated in the Eastern Townships are all situated on portions of the great serpentine or volcanic belt which extends with tolerable directness, though with frequent breaks, north-eastward from the Vermont boundary for some distance beyond the Chaudière River. Large areas of these rocks also occur in the Shickshock Mountain range, in the northern part of the Gaspé Peninsula, in rear of Ste. Anne des Monts, and they re-appear in this direction on the lower part of the Dartmouth River. Indications of asbestos are found at most points throughout the whole formation, though the mineral appears, in so far at least as at present known, to be most abundant in the localities named above, where mining is now carried on; but there is apparently no reason why it should not be found in paying quantity at other points, especially if we suppose that the

presence of the masses and dykes of granulite, already referred to, really favorably affects the presence of asbestos.

The asbestos traverses the serpentine in irregular veins, from mere threads to a thickness of three and even in some cases of over six inches, and the fibre, unless affected by the dislocations of the containing rock, is always at right angles to the sides of the fissure. The veins are, in many cases, somewhat impure from the admixture of grains or small irregular threads of chromic iron, which break the continuity of the fibre, and the mineral has then to be carefully cobbled in order to separate these impurities. Near the surface the veins are also affected to some extent by the infiltration of water, by which the asbestos is discolored, and its value correspondingly reduced. This is especially noticeable in cases where the serpentine is shattered at the surface, either by the action of the weather or from other causes, but this discoloration ceases as the rock becomes solid. As a rule, the asbestos veins increase in value or quality of fibre as lower depths are reached. They are not, however, continuous; the size frequently varies, and like all mineral veins, they are affected by faults or slides, which often cut off completely a valuable working face. In such cases the slickensided character of the faces of the fault is very marked, and sheets of impure or imperfectly formed asbestos are found lying along them. The veins have often the aspect of true segregation veins, and the containing walls have in many places a different aspect for a distance of half an inch to three inches on either side.

Mode of occurrence of asbestos.

Character of the veins.

Asbestos mining was commenced at Thetford, in 1878, by what is now known as the Boston Asbestos Packing Co. The demand at that time was exceedingly limited, and considerable difficulty was at first experienced in finding a market. The output for that year did not exceed fifty tons; but its value was soon ascertained, and explorations in the serpentine belt at this place resulted in finding the mineral in workable quantity over a considerable area.

Commencement of operations.

The Thetford River here seems to mark the western limit of the serpentine, the rocks on the other side of the stream being altered slates and sandstones. To the east of the railway, which cuts directly across the mining properties, the serpentine forms a knob with an elevation of ninety to one hundred feet above the track. Most of the works are confined as yet to this portion, and consist of open cuts made on the face or on the top of the hill. But little has as yet been done, apparently, to ascertain the value of the part lying between the railway and the river.

Western limit of serpentine at Thetford mines.

The quality of the asbestos in all the four mines at this place may be stated as excellent. The fibre is fine and readily worked, and the veins are, for the most part, especially in the lower cuts, compara-

Quality of the mineral.

Size of veins.

tively free from iron or other impurities; they vary from half an inch or even less to four inches in width, though in the quarry of Johnston & Co., a breadth of over six inches was observed. The fibre in these large veins does not, however, appear to be of such good quality, in so far as yet worked, as in those of less size, and veins of one inch and a half to three inches give as good material as can be wished. Numbers of such veins yielding fibre which ranks as extra firsts, are found in all the mines at this place. At times these appear as a perfect network interlacing the surrounding walls of the openings, and can be counted by the dozen.

While all of these properties may be said to be about equally promising, that of the Boston Company may be specially mentioned, both for the amount of its output, which will probably equal that of the three others combined, as well as for the excellent way in which the property has been developed by its experienced manager, Mr. Thos. Sheridan, with a view to successful future operations. This property illustrates also the remarkable increase both in quality and quantity of fibre as the depth of working increases, a feature now clearly established at all the mines, not only in this vicinity, but also at Black Lake, the proportion of seconds to firsts rapidly diminishing in the lower cuts.

The profitable output of asbestos is at present apparently only limited by the demand. The amount extracted since the commencement of operations may be briefly stated thus:—

Output at the
Thetford
mines.

Boston Asbestos Packing Co., opened 1878.

Output for 1886, say 700 tons.

Total output to end of 1886, say 3,000 tons.

King Bros., opened 1881.

Output for 1886, say 250 tons.

Total output to end of 1886, say 850 tons.

Irving, Johnston & Co., opened 1879.

Output for 1886, say 400 tons.

Total output to end of 1886, say 2,500 tons.

Ross, Ward & Co., one quarry only.

Output, three years, to end of 1886, say 400 tons.

Cost of ex-
traction.

The cost of extraction varies in different localities, and depends to some extent upon the amount of barren rock encountered, which, owing to faults, is greater in some cuts than in others. It may, however, be safely put down at \$20.00 to \$25.00 per ton.

Prices of
asbestos.

The prices at present obtained for asbestos, at points of shipment along the railways, range from \$50.00 to \$55.00 per ton, for second quality, to \$80.00, or even \$100.00 for firsts, a considerable proportion of that taken from the lower cuts realizing the latter figure. The

Markets.

markets are Great Britain, Germany, Belgium, United States and Italy.

The majority of the veins worked range from three-fourths of an inch to two and a half inches. The rock is blasted out and carried to the dumps, where it is broken up and carefully cobbled by old men and boys, who grade it according to color as well as purity of the fibre, with due regard to its length. The wages paid for laborers in the quarry range from \$1.00 to \$1.10 per day, and for boys and cobbers fifty cents.

Mode of working.

Wages.

The comparison of the cost of extraction with the value of the raw material, shews a very large margin for profit. The works at this place are, however, carried on for the most part during the six months of summer and autumn only, since it has not been found advantageous, in view of the still limited market, to undergo the inconvenience and extra expense of continuing the quarrying during the winter. As the market increases, however, the mode of working will doubtless adjust itself to the demand.

The properties worked at Black Lake station are situated on the west side of a steep ridge of serpentine which rises to an estimated height of about 900 feet above the lake.

The Black Lake mines.

The three areas already mentioned are contiguous, and the workings are situated from a fourth of a mile to half-a-mile from the railway. They consist of open cuts as at Thetford, made in the face of the hill, in all of which veins of excellent asbestos are disclosed, ranging in thickness up to four inches. The fibre in most of these is somewhat discolored from the infiltration of water through the shattered serpentine, and as a consequence the greater part of the output has so far graded as seconds and thirds. In most of the openings, solid rock is now reached, and the quality is improving. These mines have not been in operation as long as those of Thetford, but the increase in the output from year to year shews their rapidly growing importance.

Shattered character of the serpentine at surface.

The Anglo-Canadian, formerly Hopper's, mine—

Output for 1886, say.....	550 tons.
Total output to end of 1886, say.....	1,500 "

Output at the Black Lake mines.

Frechette's Mine, worked only one year—

Estimated output for 1886.....	200 "
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Scottish Canadian—

Estimated output for 1886.....	250 "
Estimated total to end of 1886.....	700 "

On the latter property a large amount of heavy exploratory work has been done.

The cost of mining at Black Lake varies but little from the average of that at Thetford, and may be stated at \$25.00 per ton.

Cost of mining.

There are several other properties in the vicinity of Black Lake, on which the exploratory work done, though not very extensive, shews in-

Contiguous
areas at Black
Lake.

dications that a profitable output may be expected. These are known as the Reid and Hayden properties, and are situated on lots 27 and 28, R. B., Coleraine. In various open cuts on the sides of the hills, numerous veins are disclosed, ranging up to a width of two and a half inches, with surface indications apparently in no way inferior to those of the adjoining areas now being worked at this place, or even to those at Thetford, not only as regards the size and number of veins, but also as to the quality of the fibre.

Between these lots and Caribou Lake, the serpentine extends in an apparently continuous ridge, and also shows at intervals very good indications. This area has not as yet been explored to any extent, and but little can be said as to its actual value.

About Little Lake St. Francis also, ledges of serpentine are exposed, which deserve careful examination.

Coleraine
station and
vicinity.

In the vicinity of Coleraine station, serpentine is seen; but the principal ridge, which extends southward from Black Lake, keeps to the west about one mile and a half, where it forms a conspicuous hill feature. This has been but little prospected, but during the past year an opening was made on its south-eastern extremity, which disclosed the presence of a number of veins of asbestos, one of which was nearly four inches wide near the surface. Sufficient work was not done, however, to determine their persistence and value.

An interesting feature in connection with this opening is the presence of mica in considerable quantity in direct contact with the asbestos, a feature not observed elsewhere.

Wolfestown.

The asbestos mines of Wolfestown are situated at Belmina on the north-eastern extremity of a serpentine ridge, which extends, with several inter ruptions, south-westerly from the road leading from Coleraine station, to Wolfestown P.Q., to the vicinity of Lake Nicolet. These mines are owned by Mr. John Bell, of London, Eng., and though a considerable amount of money has been expended, it has been largely on exploratory work. The surface indications, while not equal to those

Belmina Mine.

of the Black Lake area, yet shew at several points numbers of veins, some of which reach a width of one inch and a half and even two inches. A very fair showing of workable veins, to some extent affected by faults, has been exposed in the upper part of a deep cut, and an attempt is now being made to intersect these at a lower level. If the rate of increase noted at the places already described occurs here, there should be good paying ground when the lower level is driven past the capping of barren rock, provided the veins already disclosed are not cut off by the faults above mentioned. Only a small force of men is employed, and it would be very difficult, from the limited amount of work done, to express any decided opinion as to the value of this property. Dykes

and large masses of white granulite, similar to those of Thetford and Black Lake, are found in the cuttings and in the adjoining hills.

The total quantity of asbestos taken from this area, which is known as the Belmina Mine, is about twenty-five tons.

In addition to the properties described above, the only other point known to us at which asbestos has been worked successfully, is on Lot 9, R. III., Shipton, about four miles from Danville. The outcrop of the serpentine here is quite limited, with steep sides all round. It contains a quantity of veins, mostly of small size, though the quality of the fibre is good. Faults have apparently affected the value of this property considerably, some very good veins, with a width of two inches, having been completely cut off at a depth of fifty feet from the surface. The output, however, has been considerable; that for the year ending 28th Aug., 1886, being 455 tons, though from various causes it is now much less than formerly, the mine not being worked at present to its full capacity. Jeffrey's Mine,
near Danville.

It will be seen from the facts here presented that the asbestos interests of the province are exceedingly important; and judging from the rate of increase for the last six years, it will soon assume very large proportions. The demand is annually increasing as new uses for the material are being found, and from the prospects presented, not only in the mines already opened, but in those areas contiguous, and which appear equally rich, the supply is practically limitless.

Soapstone or talc.—The character and distribution of Soapstone are given, so far as then known, in Geol. of Can., 1863, pp. 469 and 496. While deposits occur at many points in the serpentines and talcose slates of the Townships, the most important in the area now under consideration are found in the townships of Hatley, Ham, and Wolfestown. At the first locality areas of steatite of considerable extent, much of which is of excellent quality, are seen on Lots 19, 20 and 21, R. V., along or near the north-west shore of Lake Massawippi. These have apparently not been utilized, except to a very limited extent for local purposes. In Ham, deposits are found on Lots 43 and 44, new numbering, R. I., near the south extremity of Lake Nicolet, on property owned by Mr. E. Clark, of Sherbrooke, as well as on Lots 49 and 50, R. I., owned by Dr. J. Reid. Mr. Clark has opened his property very slightly, and has removed none for shipment. The soapstone of Wolfestown on Lot 19, R. I., owned by Mr. Calvin Carter, is a pure variety in places translucent in thin plates, and occurs as a bed from one to ten feet thick, in black and grey talcose schist. It has been used for the manufacture of slate pencils and tailor's chalk. A considerable quantity has also been ground and bolted, and is then well Hatley.
Ham.
Wolfestown.

adapted for a filler in the manufacture of paper. When mixed with a small proportion of white lead, it forms a hard cement-like pigment, which is claimed by Mr. Carter to equal in resistance many of the more expensive fire-proof paints. The price of this talc, ground and delivered in bags at the nearest railway station, Coleraine, is \$8.00 per ton of 2,000 lbs. Good sized slabs, of fine quality, can be obtained from this locality. It is also excellently adapted for the manufacture of gas burners.

North Stoke.

Mineral Pigments.—The only deposit of this nature which came under our observation, and to which special attention need be directed, is on Lot 12, R. XIII., Stoke, on the property of Royal M. Gansby. Two shades were observed, one yellowish and one reddish-brown; by calcination, the former assumes a pinkish tinge, and the latter a darker color. This pigment has been tested by Mr. L. J. Giroux, of the Canada Atlantic railway, and found to answer well for ordinary purposes; it is about equal to what usually retails for one and a-half to two cents per pound. When mixed with the ground talc of Mr. Carter's mine, it is said to form a very durable coating for outside work. Reference was also made in the Geol. Survey Rep. 1847-48, to the occurrence of stone paint on Lot 13, R. IX., Stanstead, as the result of the decomposition of bluish-grey and talcose slates, the colors being ochre, yellow, and greyish-white. The material, mixed with oil, has been used locally for house painting.

Stanstead.

Dudswell
marble quarry.

Marble.—A large deposit of crystalline limestone, forming a marble of very excellent quality, is found in the township of Dudswell, at Lime Ridge and vicinity. Its occurrence on Lot 22, R. VII., was pointed out by the late Sir Wm. Logan. (Geol. Surv. Rep. 1847-48, and subsequently in Geology of Canada, 1863, pp. 627, 827.) Within the last two years, attention has been again directed to this locality, and a company has been formed in Sherbrooke to thoroughly test the value of the property. The marble is of several colors, takes a beautiful polish, and presents a very handsome appearance, especially a kind known locally as "black and gold," the yellow being due to the presence of veins of dolomite. There are also various shades of grey. In places the ledge is composed almost entirely of fossil corals, the polished slabs of which present a very peculiar and pretty mottled aspect. The company has set up a channelling machine, and the upper and somewhat shattered layer has been removed to a depth of about four feet from the surface, in order to test the soundness of the beds beneath, the result being apparently satisfactory. They have also erected a sawing apparatus for the purpose of cutting the blocks into slabs. Sufficient work had not been done at the time of our visit to thoroughly test the quarry, but the prospects seem favorable.

Limestone.—A portion of this deposit has been worked for some years by the Dudswell Lime and Marble Co., whose quarry is situated at Lime Ridge. Six draw-kilns are now in operation with a capacity of 1,000 bushels each. The quarry, which is at one extremity of a ridge of highly crystalline limestone of very fine quality, has now a working face of about 100 feet by 50. The facilities for working and shipment are excellent, and the output is very large. A constantly increasing demand is met with, the market embracing the greater part of eastern and south-eastern Quebec and the adjoining states. Complete returns to date will be found in the report by Mr. E. Coste, M.E.

Flagging Stone, of very fine quality, is also found near by in Lot 15, R. V., Dudswell, also first pointed out in the Geol. Survey Report for 1847-48, p. 83. Four quarries are now in operation, owned principally by Bentley & Sons and Henry Sunbury. The rock which dips south-easterly at an angle of twenty to thirty degrees, is a bluish dark limestone, in regular beds, ranging in thickness from one to eight inches, with dark shaly partings. Stones of almost any required size can be taken out. The quarries have been opened but a short time, but the market is rapidly increasing. At present almost the entire output is sent to Montreal, where it is largely employed.

Flagging is also found in connection with the Cambro-Silurian slates near and in rear of Brompton Falls, on the road west from Sherbrooke to Melbourne, and on the property of Duncan Haggart. The rocks here dip north-westerly, are nearly vertical, and present a good face for working. Large slabs have been taken out and used for flagging in Sherbrooke and locality, and give good satisfaction. The cleavage is not sufficiently regular for roofing slates.

The limestone of Lake Memphremagog, in the vicinity of Oliver Corners, also in places afford good quarries of flagging, which have been used locally to some extent, and appear to be of excellent quality.

Granite.—The granites of this area have already been fully described in earlier reports as affording excellent building stone. They cleave readily and dress easily. They have been largely used in the construction of bridges on the several lines of railway, as also in Sherbrooke, where they are seen in the new Eastern Townships Bank and the new Post Office and Custom House. They are also used locally and are in considerable demand for monuments.

The principal quarries are in the township of Stanstead, near the extremity of Magoon's Point, on Lake Memphremagog, and near Stanstead Junction or Beebe Plain. Outcrops of granite also occur between Barnston and Coaticook, and at other points, which have already been mentioned in previous pages.

Serpentine.—The distribution of this rock has already been given. Blocks and slabs have been taken out and polished, at intervals, for many years ; some are admirably adapted for interior decorative purposes, and are very beautiful. The stone, however, is not suited for exterior work as it weathers rapidly and loses its polish. Difficulty is experienced in getting out large and perfect blocks owing to the presence of numerous small flaws and the jointed character of the rock which renders it difficult to split in any given direction, but for the manufacture of small articles it furnishes a handsome and easily worked material.

New Rockland
Slate Co.

Slate.—Only two slate quarries are at present in operation, that of the New Rockland Slate Co., in the township of Melbourne, and the Danville School Slate Quarry, which has been closed for some years, but lately re-opened by a new company. The details of the former, which is now being worked on a very extensive scale, will be found in Mr. Coste's report. To facilitate transport, the Company have, during the past year, built a line of narrow gauge railway from the Grand Trunk to their quarry, a distance of about four miles.

Danville
Slate Co.

At the Danville quarry the work so far has been largely of a preliminary nature. The old excavation has been cleared out, new buildings and dressing sheds erected, and improved machinery put in. The character of the slate is excellent, especially for the manufacture of school slates, though the Company purpose extending their business by manufacturing other lines, as mantles, billiard-table-tops, &c. Prospecting has also been going on in a band of red slates in the vicinity, the results of which have not yet been ascertained.

Whetstones.—Rocks suited for this purpose have long been known to exist, and are described as occurring in the altered slate series of Memphemagog Lake, as well as in similar rocks in North Hatley, (See Geol. of Can., 1863, p. 809), and in the township of Stanstead, but little has of late been done towards the development of this industry, and no returns as to production are to hand.

Brick-clay, while found at many points, is used for the manufacture of bricks, in so far as at present known, at only three places, viz., Sherbrooke, Lennoxville, and Ascot station, the largest output being at the first locality. The returns of each will be found in the report of Mr. E. Coste, M.E., Part S.