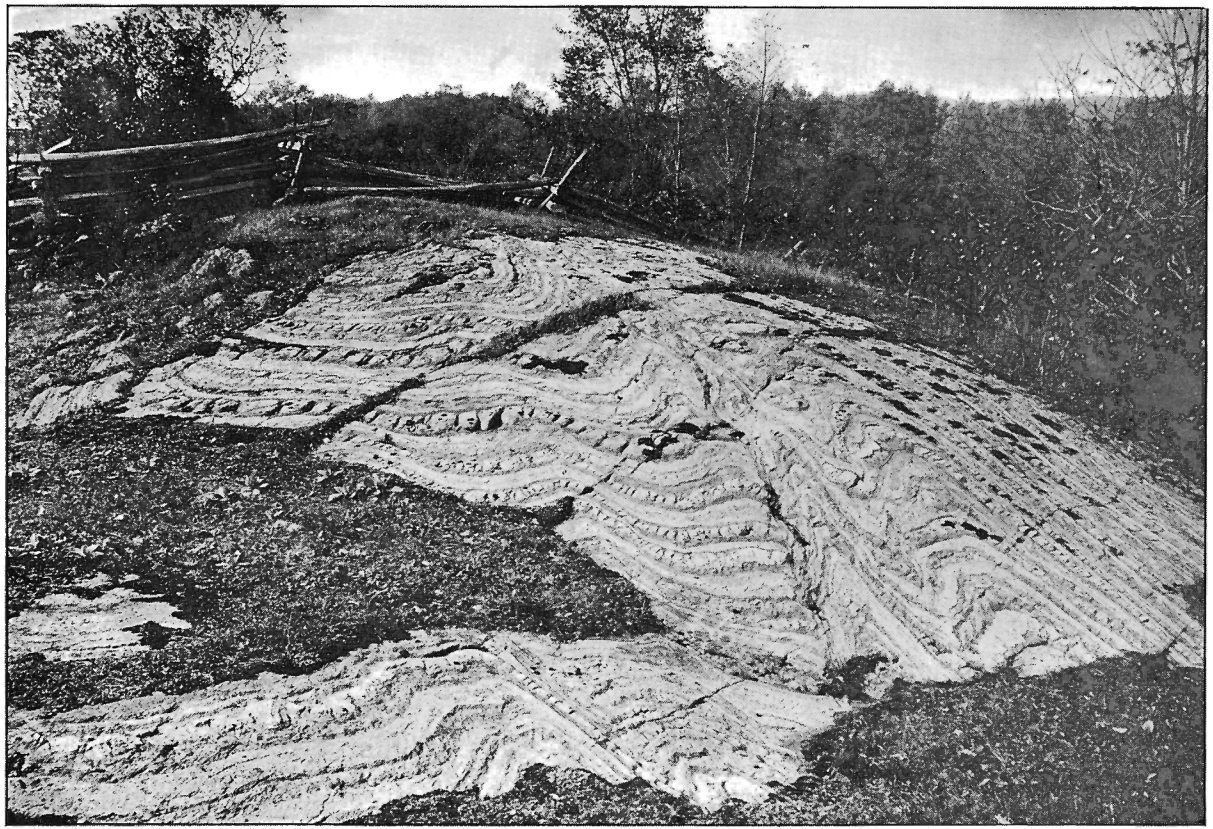

CONTORTED GNEISS, NEAR FERRY LANDING, OPPOSITE MONTEBELLO, ALFRED TOWNSHIP PRESCOTT COUNTY ONT.

GEOLOGICAL SURVEY OF CANADA,
ROBERT BELL, M.D., D.Sc., LL.D., F.R.S., DIRECTOR.

REPORT

ON THE

GEOLOGY OF

ARGENTEUIL, OTTAWA AND PART OF PONTIAC COUNTIES,

PROVINCE OF QUEBEC,

AND PORTIONS OF

CARLETON, RUSSELL AND PRESCOTT COUNTIES,

PROVINCE OF ONTARIO,

BY

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

OTTAWA:
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1901.

No. 739.

To Robert Bell, M.D., LL.D., F.R.S., &c.,
Director and Deputy Head,
Geological Survey of Canada.

Sir,—I beg to submit herewith a report on the geology, mineral resources and general characters of the country along the Ottawa river and the area adjacent, comprised in map-sheet No. 121 of the Quebec and Ontario series. Much of the work was done several years ago, but delay in publication has arisen owing to the compilation of the map. This has now been prepared, and is ready for the engraver, on a scale of four miles to the inch.

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

R. W. ELLS.

Ottawa, March 1, 1901.

REPORT

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The present report embraces the work of several seasons, and relates principally to the areas lying to the north of the Ottawa river, comprised in map-sheet No. 121, of the Ontario and Quebec series. In addition to a large part of the counties of Argenteuil and Ottawa, and Pontiac, it comprises portions of the counties of Carleton, Russell and Prescott, situated to the south of the Ottawa river. This river traverses the southern portion of the map-sheet and furnishes an excellent base-line for observations, as well as affording good facilities for the study of several of the rock formations along its course. Area included in report and accompanying map.

The area included in the map is not far from 4,000 square miles. It extends from the western limit of the Eastern Townships series, already published, to a line drawn north from a point about ten miles above the city of Ottawa. North of the area included in the map, several lines of exploration were carried on, especially along the upper waters of the principal streams, with the object of better elucidating certain points of structure in the old series of crystalline rocks, the details of which cannot appear on the accompanying map-sheet. A small portion of the eastern half of the sheet has already been published in connection with a report by Dr. F. D. Adams on the structure of certain rock-formations north of Montreal.* Area described

* Annual Report, Geol. Surv. Can., vol. VIII., (N.S.), 1895, part J.

District examined.

In the area north of the Ottawa river an examination was made of the district traversed by the North, Rouge, Nation, Lièvre and Gatineau rivers, and farther west, of the Black and Coulonge rivers, extending to a distance north from the Ottawa of from fifty to one hundred miles. In connection with this, a large amount of exploratory work was done nearly twenty-five years ago by Mr. L. R. Ord, at that time attached to the staff of the Geological Survey, the results of which have never yet been published, but which will be found incorporated in the present report.

Work of Mr. Louis R. Ord.

Former reports on the area.

Several previous reports have appeared on portions of the country, notably by Sir William Logan and Mr. H. G. Vennor. That of Sir William Logan will be found in the Report of Progress for the years 1853-54-55-56. A preliminary report on the area south of the Ottawa was published by Mr. A. Murray in 1852-53. Most of the results of this work will be found summarized in the Geology of Canada, 1863.

Reports by Mr. Vennor.

Mr. Vennor's reports on the area will be found in the annual volume for 1873-74, which had a direct reference to the occurrence of plumbago and apatite in this district, and in that for 1876-77, which also embraced certain points relating to the structural relations of the several division of the crystalline rocks.

Much of the exploration of the area north of the Ottawa had, of necessity, to be conducted by means of canoes, owing to the unsettled character of large portions of the district. Nearer the Ottawa, the country is fairly well opened up by roads and settlements are numerous.

General character of the rocks.

The rocks north of the Ottawa are for the most part confined to the crystallines of the Grenville series and to the Fundamental Gneiss, now regarded as representing the older Laurentian. There are also large areas of granite and other intrusive rocks which are newer than the former division, since they distinctly cut all the members of the series.

Formations along the Ottawa river.

Along the Ottawa river itself, and in the area southward towards the St. Lawrence, the Palæozoic formations have a wide development. They range from the base of the Potsdam sandstone to the top of the Ordovician or Cambro-Silurian system, with occasional outliers of the Medina to the south-east of Ottawa city. These formations are well exposed in the townships of Rigaud, Hawkesbury, L'Orignal, Caledonia, Alfred, Plantagenet, Clarence and Cumberland. Several outcrops of the Grenville series occur in this direction, notably in the township of Alfred, opposite the village of Montebello. At Rockland mills, near the river, there are also indications that the crystalline rocks are not far removed, since the lowest portion of the Potsdam is made up of large

pieces of gneiss and limestone which form a conspicuous feature in the basal portion of that formation at many points.

In the extreme eastern part of the sheet, Rigaud mountain, a prominent ridge rises a short distance south of the Ottawa and extends for several miles. The mountain is composed largely of granite and porphyry, and is of more recent date than the Calciferous dolomites which appear in close proximity to the west. It is probably contemporaneous with the elevation known as Mount Calvaire, which rises on the north side of the Lake of Two Mountains, and it forms the most westerly of the remarkable chain of eruptive hills which are so conspicuous throughout the area east of Montreal. Rigaud mountain.

From the fossiliferous strata, so well seen to the south of the Ottawa, large and characteristic collections of fossils have been from time to time obtained, mainly by one of my assistants, Dr. W. E. Deeks, M.A., and the limits of the several formations have been defined as well as the drift-covered character of a great part of this area would permit. Fossiliferous strata.

On the north side of the Ottawa the fossiliferous formations are very limited. East of Ottawa city they are confined principally to a narrow fringe of Potsdam sandstone and Calciferous dolomite, but opposite that city they comprise in addition the Chazy, Black River and Trenton limestones.

In the eastern portion north of the river, the Calciferous dolomites are quite extensively developed between the line of the Canadian Pacific railway and the Ottawa river, extending from Grenville to St. Scholastique, where they are underlaid by the Potsdam sandstone. Along the Grenville canal, and thence along the river to Carillon, the relations of the Calciferous to the Chazy can be well studied. The general distribution of these formations was given on the large map of Canada published in 1866.

The series of explorations begun by Sir William Logan in 1853, was subsequently carried on for some years by Mr. Richardson, and later by Mr. James Lowe, one of his assistants, who surveyed a number of lakes with their connecting waters, more especially those pertaining to the Rouge and Nation systems, the instruments employed being the prismatic compass and Rochon micrometer. These surveys extended northward on the Rouge river to the head waters of the Macaza and the Ruisseau Froid, which are branches of the Rouge from the north-east, crossing the north-western portion of the township of Montcalm. Mr. Lowe also surveyed the main stream of the Rouge northward from Work done by Mr. James Lowe. Early surveys.

the end of Logan's surveys to the creek which discharges Big Nominingue lake, from which by a chain of lakes with several short portages, Maskinongé lake is reached. This is one of the largest bodies of water belonging to the Rouge system. In connection with this work also, the chains of lakes on the upper portion of the North Nation were surveyed, including Simon, Whitefish, au Sable, Vert, Long, Sugar-bush, des Isles and a number of smaller sized lakes, the whole forming an extensive series, belonging to the three branches of the Nation. A synopsis of this work will be found in the report for 1863-66, pages 11 to 27, as well as of the work done by the same explorer in the townships of Buckingham and Lochaber.

Report by Mr. James Richardson.

A description of the country along the upper Gatineau from its source to the mouth of the Desert river is given in the Report of Progress for 1870-71, by Mr. James Richardson, in which the presence of several bands of crystalline limestone, associated with gneiss, which is the prevailing rock in this area, is noted. This river was also traversed by Mr. L. R. Ord, in 1877, in connection with his explorations along the Lièvre, and the chain of lakes between this river and the Gatineau was then also surveyed. Among these are several of large size, including Whitefish and Thirty-one Mile or Grand lake. An examination was also made by Mr. Ord of the Desert river west of the Gatineau and of its principal tributary, the Eagle, as also of the chain of lakes at their head-waters. East of the Gatineau a traverse was made by the same gentleman, of the country between this river and the Lièvre, by way of Baskatong creek and lakes to the height of land which was reached by way of Piskatosin river and lake, the descent to the Lièvre being made by the Tapanee, which enters that stream about ninety-five miles in a direct line north of its junction with the Ottawa near Buckingham. From these examinations, we have a fair knowledge of the country along these portions of the Gatineau and Lièvre rivers. As the results of Mr. Ord's explorations in this district have never been published, and as they contain many points of general interest, both as regards the character of the country and the distribution of the several divisions of the crystalline rocks, they will be given in a subsequent chapter.

Exploration by Mr. L. R. Ord.

Exploration by Dr. R. Bell.

The upper portion of the Gatineau was also descended by Dr. R. Bell, from its source to the mouth of the Desert river in connection with his explorations along the upper Ottawa in 1887. Our own examinations northward ended at this point, so that from all these sources we have now a large amount of available information relating to the structure and resources of this northern area.

Nearer the Ottawa the series of examinations already alluded to as carried on by Mr. Vennor more than twenty-five years ago were somewhat extensive. They included a somewhat detailed study of the formations north of the river in the townships of Templeton, Hull, Buckingham, Portland and Lochaber. The results of much of this work were given in the Reports of Progress for 1873–74 and 1876–77. Examinations were also made by him of a broad stretch of country to the north along the upper Rouge and thence eastward into Morin, embracing a portion of the great area of Anorthosite, subsequently described by Dr. F. D. Adams, in the report for 1895.

Exploration by Mr. H. G. Vennor.

Surveys were also conducted in 1878 in the townships of Buckingham and Lochaber by Mr. Adams, who was then acting as assistant for Mr. Vennor, and later, in 1883, by Mr. J. F. Torrance, more particularly in connection with the apatite deposits of Ottawa county, whose report on the area was published in the Report of Progress for 1882–3–4.

Exploration by Dr. F. D. Adams.

More recently a systematic survey of the important mining areas in the Buckingham district was made by Messrs. E. D. Ingall and James White in 1888–89, and a very excellent and accurate map has been constructed on a scale of forty chains to the inch, which shows the principal topographical features, the position of the various mining locations and the chief geographical divisions. This map has not as yet been issued by the department. A number of valuable papers by Drs. Hunt, Harrington and others, relating principally to the deposits of apatite and plumbago, have appeared at different times. That by Dr. Harrington, on the apatite deposits, is contained in the Report of Progress for 1877–78, while a very valuable paper on the plumbago of the Ottawa district by Dr. Hoffman is contained in the Report for 1876–77. Further notes by the writer of this report, more especially relating to the occurrence of economic minerals in this area will be found in the report on 'Mineral Resources of Quebec,' published in the Annual Volume for 1888–89.

Surveys by Messrs. E. D. Ingall and James White.

Papers by Drs. Harrington and Hunt.

The country north of the Ottawa is intersected by several large rivers and dotted by numerous lakes. Of the former the principal streams more especially connected with the area under discussion, are, beginning with the most easterly, the North, Rouge, North Nation, Lièvre, Gatineau, and further west the Coulonge and the Black.

Character of country north of the Ottawa.

Several of these can be traversed by canoes for distances of nearly 250 miles from their junction with the Ottawa, while by comparatively short portages, the great chains of lakes which lie all over this northern

country, are rendered easy of access. Within the last twenty year also, many colonization roads have been constructed, and by this means large areas, formerly accessible with difficulty, can now be traversed with comparative ease. Along the river Rouge a good carriage road now extends for over one hundred miles, or to a point fifteen miles beyond the mouth of Nomininguе creek, while quite recently a line of railway has been completed which connects Montreal with that river at what was once known as Iroquois chute, now Labelle, which is about seventy miles from its mouth. A road has also been made connecting this point with the Jesuit settlement on Big Nomininguе lake, and thence down the Nation to the old settlements nearer its mouth. Several other important colonization roads have also been lately made into the hitherto almost unknown country to the west of the Rouge, and a narrow gauge railway has been opened which runs from St. Sauveur, north of St. Jérôme, into the wilderness country to the east of that river about the Sixteen-Island lake, reaching the Rouge in the township of Arundel. The opening of these roads has made a number of areas available, situated among the Laurentian hills, which are underlaid by the limestones of the Grenville series, bands of which, often of considerable extent, occur throughout this portion of the province, and form the sites of some of the most valuable farming lands in the district.

The district along the Rouge river.

On the Lièvre river settlements extend to beyond the junction of the Kiamika, nearly 100 miles from its mouth, though roads are not yet made for the entire distance. A cross road has, however, recently been opened up to connect this point with the settlements on the upper Rouge, which has also been extended westward to meet the settlements on the upper Gatineau above the mouth of the Desert. The character of much of this upper country is much less hilly than that nearer the Ottawa, and, while large portions are occupied by drift sands, certain areas valuable for purposes of settlement, are already being occupied. Along the Gatineau, roads extend to a considerable distance above the Desert river, and the completion of the railway to this point will render easily accessible a large area of excellent agricultural land. The greater value of this district is due to the fact that a broad belt of crystalline limestone extends northward in this direction for many miles, and, as a consequence, the usually rugged aspect of the granite and gneiss country disappears to a large extent. Much of the country along the Gatineau for nearly a hundred miles from its mouth has been settled for many years. The extension of the line of railway from its present terminus at Labelle on the Rouge across the upper country to the Gatineau will also open up a large tract of

The country along the upper Lièvre and Gatineau rivers.

hitherto inaccessible country which promises to furnish large areas of excellent farming land. This agricultural character is often largely due to the presence in places of areas of sandy loam or deposits of sand and clay, which occur, not only along the immediate courses of the principal streams, but also occupy considerable portions of the surface, and out of which the hills of gneiss and granite rise, either in long chains or in isolated masses. This drift character of country pertains to the area fifty to seventy miles inland from the mouth of the several rivers rather than to that along their lower portion, and excellent crops of wheat, oats and potatoes are raised in all the settlements from the Coulonge eastward. The excellence of much of the soil throughout this district is doubtless due to the decay of the calcareous members of the crystalline rocks, which in the country along the several streams, while presenting rarely any continuously widespread development, show their presence often in a series of narrow outcrops, separated by intervals of grayish and reddish gneiss. The greater development of these calcareous rocks along the valley of the Gatineau is seen in the townships of Masham, Cawood, Aldfield, Low, Aylwin, Wright, Bouchette and Maniwaki, adjoining the river on the west, while on the east side they have a very considerable development in the direction of Thirty-one-mile lake and the areas to the north and south.

Agricultural resources.

Crystalline limestone.

In regard to the general physical features of this northern area, it may be remarked that the usually rugged character, seen from the Ottawa valley, to some extent disappears to the northward, so that although there is of necessity a general increase in elevation, there is a greater preponderance of level country. Much of this is occupied with deposits of sand, as in the case of the Kazubazua plains to the west of the Gatineau, but this sandy feature is also distinctly observable over large areas on all the streams from the Rouge westward to Lake Temiscaming. It also appears on the south side of the Ottawa about Pembroke and for many miles to the south and west, in the direction of the Petawawa and on to Chalk river. Much of this drift is a pure siliceous sand, but it is often found to overlie deposits of a stiff blue clay which resemble in character the marine clays of the Ottawa basin, though marine organisms are very rarely visible. These clay-deposits have been noted almost as far north as the height of land between the Ottawa waters and those which fall into James bay, at elevations of fully one thousand feet above the sea-level. On some of the streams, such as the Black river, and on long stretches of the Rouge, the channel for the greater part of its course is cut out of the sand, and rock exposures are rarely seen except when the hills approach the river.

Sandy plains of the Gatineau.

Clay-deposits.

The crystalline rocks.

For convenience of description, the crystalline rocks may be divided into three groups, viz., the gneissic, the calcareous and the massive, the latter being generally intrusive, though in places having a foliated structure. The continuity of these rocks with those which appear to the south of the Ottawa is interrupted by their concealment beneath the broad area of the Palæozoic formations of the lower Ottawa basin, but in the preparation of this report, as the crystallines have by far the greatest development, they will be first considered and the distribution of the fossiliferous sediments will then be given.

Anorthosite rocks.

Report by Dr. F. D. Adams.

In the counties of Argenteuil and Ottawa, while the presence of igneous rocks has been noted at many points, and under different forms, the great bulk of these is found further to the east in the counties of Terrebonne, Montcalm and Joliette. Here a great area of anorthosite, for the most part massive, but in places showing a well-defined foliation, occurs. This area has been carefully studied for some years by Dr. F. D. Adams, and a reference to the character and general distribution of the rocks in this district as then known, is found in the summary report of the Geological Survey for 1887-88, in which he states that, in his opinion, it may be safely concluded that the rocks comprising the principal area of anorthosite referred to, as well as most, if not all the smaller areas, are of eruptive origin.

Early views regarding age of anorthosites

Views of Dr. Selwyn on anorthosites.

The eruptive character of the Labradorite rocks, formerly regarded by Logan and his co-worker as altered sedimentaries and held to constitute the upper division of the Laurentian system, was, however, pointed out by Dr. Selwyn several years before. Thus, in the Geological Report for 1877-78, in discussing the general question of the structure and relations of the Laurentian rocks, he says: 'If it is admitted—which, in view of the usual associations of Labrador felspars, is the most probable supposition—that these anorthosite rocks represent the volcanic and intrusive rocks of the Laurentian period, then also their often massive and irregular, and sometimes bedded character, and their occasionally interrupting and cutting off some of the limestone bands, as described by Sir W. E. Logan, is readily understood by any one who has studied the stratigraphical relations of contemporary volcanic and sedimentary strata of palæozoic, mesozoic, tertiary and recent periods. Chemical and microscopical investigation both seem to point very closely to this as the true explanation of their origin. That they are eruptive rocks, is held by nearly all geologists who have carefully studied their stratigraphical relations. But I am not aware of any one having suggested that they are the products of volcanic action in the Laurentian, or perhaps Lower Huronian epoch;

doubtless as Mr. Leeds says, 'profoundly metamorphosed,' as, of course, they would be from having suffered all the physical accidents which have resulted in producing the associated gneisses, quartzites, dolomites, serpentines and schists.

'When we recall the names of Dahl, Kerulf and Torrell, in Norway; Maculloch and Geikie, in Scotland; Emmons, Kerr, Hitchcock, Arnold Hague, and others in America; all of whom consider these norites of eruptive origin, we may well pause before accepting Dr. Hunt's conclusions respecting them, and that they should often appear as 'bedded metamorphic rocks' (the opinion expressed respecting those of Skye by Prof. Haughton, of Dublin) is quite as probable as that we should find the mineralogically similar dolerites occurring in dykes and bosses and in vast beds interstratified with ordinary sedimentary deposits of clay, sand, etc., as we do over wide areas in Australia and elsewhere.' Dr. Selwyn's report for 1877-78.

Additional evidence as to the eruptive nature of these anorthosite rocks is found in the summary report by Mr. H. G. Vennor, in the annual volume for 1879–80. Mr. Vennor carefully examined a large area to the north of St. Jérôme in the latter year, and in summing up his conclusions as to the relations of the crystalline limestones of the Grenville series to the associated rocks says, 'In these explorations, perhaps the most important results arrived at were in connection with the bands of crystalline limestone on the western side of the labradorite area, and the junction of these with the great mass of anorthosite rocks already mapped and described by Logan. These limestones, as a whole, appear to be perfectly conformable with the stratified anorthosites, but are occasionally interfered with and disturbed by intrusions (?) of the more massive and granitoid variety of labradorite. This last rock—in which there are no indications of stratification—occupies a very considerable area in the townships of Abercrombie, Howard, Morin, Wexford, Wolfe, Beresford and Doncaster. Its exact outline is not easily ascertained, but I have laid down a provisional line that will indicate sufficiently closely the area occupied by it—some 250 to 300 square miles. .....'And again, in referring to the Trembling lake and Green lake bands of limestone, he says 'there are occasional recurrences of the granitoid labradorite, and many of these exposures have the general appearance of eruptive rocks. One of these masses has been indicated by Logan as occurring in the north-west corner of DeSalaberry, and was here supposed to cover (unconformably) and conceal the further run of the limestone, but we succeeded in tracing this latter continuously around the western side of the former to a connection with the Lake Sam band.'

Mr. H. G. Vennor s report, 1879-80

Relations of the limestones and anortho site rocks.

Dr. Selwyn's conclusions.

In connection with this statement of Vennor's, Dr. Selwyn remarks that 'if the foregoing determinations by Mr. Vennor, which are given in his own words, are correct, they seem very conclusively to prove what I have already stated to be my opinion, viz., that the labradorite or Norian rocks of Hunt do not constitute an unconformable upper Laurentian formation, but occur in part as unstratified intrusive masses, and in part as interstratifications with the orthoclase gneisses, quartzites and limestones of the Laurentian system, as developed in the Grenville region, and mapped by Sir W. Logan.'

Distribution of the anorthosites.

A small portion of map-sheet 121 has recently been published in connection with a report by Dr. Adams* on the anorthosite areas in the country north of St. Jérôme, in the counties of Terrebonne and Montcalm, whence these rocks extend into the county of Argenteuil. In the area embraced in this map, the anorthosite occupies the whole of the township of Beresford and a large part of Wolfe, Howard, Morin and Doncaster. The northern limit of the mass which is a gabbro rather than an anorthosite in certain places, was traced by descending the Devils river, the left branch of which takes its rise in a large lake south of Lac des Baies, near the upper waters of the east branch of the Rouge. Thence, flowing south, it passes several miles to the east of Trembling mountain, and for a part of its course is near the contact between the gneiss and the gabbro which constitutes the rock in the north-western portion of the eruptive area. Along the general line of contact of the anorthosite with the gneiss the latter is frequently deflected from its usual line of strike, as though the gneiss had been pushed to one side by the intrusion, and pegmatite veins are common. This feature is especially well seen where it is in contact with the limestone of the Grenville series as in Morin and Abercrombie, the limestone being abruptly terminated against the eruptive mass. To the west of this, in the county of Argenteuil, true anorthosites are rarely seen, in so far as our observations have extended, but areas of syenite occur in Chatham and Grenville, in portions of which a gabbro character is recognized, and masses of pyroxene in the country more immediately adjacent to the Lièvre and Gatineau rivers may possibly be the equivalent in point of time with the eruptives of the area north of St. Jérôme. Further west along the Ottawa, to the south of Portage du Fort, true anorthosites however occur, and are clearly intrusive in the limestone of the Grenville or Hastings series which has a considerable development in that direction. In addition to these, other rocks such as pegmatite, porphyry, diorites, diabase, &c., are

Their contacts with crystalline limestones.

Syenite of Grenville and Chatham.

Anorthosites of Portage du Fort.

*Annual Report Geol. Surv. Can. vol. VIII., (N.-S.). part J.

found at a number of places, but their distribution and characters will be given in a later chapter.

Logan's report for 1853-56.

The earliest report on the geology of the country north of the Ottawa river, published by Logan, in the Report of Progress for 1853–54–55–56, dealt with the structure and distribution of the Laurentian gneisses and limestones of the townships of Grenville, Chatham, St. Jérôme, &c. In this, particular attention was given to the distribution of the several bands of limestone which are there well displayed, as well as to the occurrence of the syenitic mass of Chatham and Grenville and to the presence of several well defined dykes of greenstone which traverse the area for considerable distances. A second report appeared in 1858, relating principally to the distribution of the limestones and to the drift of the Grenville area, but the results of the work in this district were summed up in the chapter on the Laurentian in the Geology of Canada, 1863. In the opening sentences of this chapter it is stated that 'the rocks which compose the Laurentian mountains were shown by the Geological Survey, in 1846, to consist of a series of metamorphic sedimentary strata underlying the fossiliferous rocks of the province. They are altered to a highly crystalline condition, and are composed of highly felspathic rocks, interstratified with important masses of limestone and quartzite. Great vertical thicknesses of the series are composed of gneiss, containing chiefly orthoclase or potash felspar, while other great portions are destitute of quartz and composed chiefly of a lime soda felspar, varying in composition from andesine to anorthite, and associated with pyroxene or hypersthene. This rock we shall distinguish by the name of anorthosite.'

Early views as to the structure of the Laurentian rocks.

Generally regarded as altered sediments.

All of these rocks, with the exception of the areas of syenite already alluded to were therefore held to be altered sediments, and the anorthosites were regarded as a great altered mass which covered unconformably the gneisses and limestones of the Lower Laurentian, the latter forming the Upper Laurentian series. This view was held for some years to correctly explain the true structure of the system until the later work on the anorthosites, already alluded to, induced a change in opinion as to its true origin. According to the old views, the crystalline limestones occurred at several horizons in the gneiss, no less than four distinct areas of the limestones being recognized, and the whole series of gneiss and limestone was estimated to have a thickness of no less than 22,750 feet of which the volume of the latter division was estimated at 4,770 feet. The thickness of the anorthosite or upper Laurentian member of the series was regarded as doubtful, but was given as 10,000 feet. Several of interesting papers, relating to the

Supposed thickness of the Laurentian, 1863.

structure of these oldest rocks have appeared since the date of the report just referred to, and within the last twenty years there has been a gradual change in opinion on the subject, as the result of much careful and detailed work, both in the field and the laboratory, so that it is now very conclusively established that much of what has been regarded as altered sediments and so described in the earlier reports must now be accepted as altered igneous rock. Under this head must now be placed the greater bulk of the gneissic rocks which form so large a portion of the Laurentian system as well as much of the pyroxenic and feldspathic rocks in which are to be classed the great bulk of the white binary granites, or pegmatites so often associated with the crystalline limestones. These limestones, however, with their associated bands of grayish quartzose gneiss, often very rusty in character, as also well defined beds of whitish quartzite, may readily be assumed as representing true sediments in a very high state of metamorphism, to which may be added certain areas of reddish-gray, and sometimes black gneiss, so that we have, if we consider the whole series under the head of Laurentian, two easily separable portions, viz., an altered igneous and an altered sedimentary series. In this report therefore, wherever practicable, this distinction will be maintained.

Limestones quartzites and rusty gneiss.

THE COUNTRY NORTH OF THE OTTAWA RIVER.

Arrangement of report.

The seven large rivers already mentioned as traversing the country to the north of the Ottawa, divide the district into as many portions. These we propose to describe in order, proceeding from the east to the west, and we will therefore first consider that between the North river and the Rouge river. In this we will first indicate the distribution of the crystalline limestones as assisting very materially in the attempt to depict the structure of the system generally, and the old term 'Grenville series' will be used to indicate the crystalline limestone and associated gneiss, as distinct from the great series of granite-gneisses which underlie them and which may be styled the Fundamental gneiss.

Grenville series and Fundamental gneiss.

Southern limit of the crystalline rocks.

Over the greater part of this area, the rocks are crystalline, their southern limit, north of the Ottawa being defined by a line drawn along the course of the North river from St. Jérôme to Lachûte, and thence in a nearly straight line to Calumet station on the Canadian Pacific railway, two miles east of the Rouge river, on which stream the outcrops terminate at the road crossing just above its mouth. In this distance the crystalline rocks, consisting largely of granite and gneiss

of various kinds, with which, however, are several well defined bands of the Grenville limestones, are directly overlaid by the Potsdam sandstone. The rocks are not continuously exposed, owing to great and wide-spread deposits of clay, which extend to the Ottawa, and out of which outcrops of gneissic granite appear as in the large ridge to the east of the village of St. Andrews; but the characteristic rocks of the Potsdam along with the upper or Calciferous member of the formation appear at a number of points as at Lachute, and several places along the road thence to St. Jérôme, along the south side of the North river. At the former place both these divisions can be readily studied in good outcrops, containing the characteristic fossils of the formation. Nearer the Ottawa river these Calciferous beds are overlaid by the gritty beds of the Chazy, which are well seen along the canal from Grenville to Carillon. To the east of the village of St. Andrews, which is situated near the mouth of the North river, a well defined ridge of reddish granite with a gneissic structure forms a prominent hill feature and is flanked on the south by the Potsdam sandstones, which on the north bank of the Ottawa have an inclination of about twenty degrees. These beds were not, however, seen in direct contact with the granite. On the north side of Jones island, in the Ottawa, to the south of this granite ridge, similar granitic rocks appear, while to the south, on the other side of the river the long ridge of Rigaud mountain rises to an elevation of over 500 feet just to the rear of Rigaud village. This mountain has been described in the report for 1894 as presumably belonging to the same series of eruptive masses which occur in the Eastern Townships, and it is possible that the St. Andrews ridge may belong to the same period. The St. Andrews ridge extends along the north bank of the Ottawa for nearly five miles, with a breadth of from one to three miles. It is separated from the somewhat similar mountain mass of Mount Calvaire, lying to the north of the Lake of Two Mountains but no other rocks are seen in the vicinity of the St. Andrews mass as the covering of clay extends on all sides. Great numbers of anorthosite boulders are found around the flanks of the ridge and across its summit.

Overlaid by Potsdam sandstone.

Lachute.

St. Andrews mountain.

Jones island.

Rigaud mountain.

THE DISTRICT BETWEEN THE ROUGE AND NORTH RIVERS.

The rocks of this area are of special interest from the fact that the first attempts to work out the structure of the Laurentian system was made here nearly fifty years ago, when the area was largely a wilderness. Since that time the country has been opened up by the construction

General character of rocks between the Rouge and North rivers.

of numerous roads, so that the study of the district has been greatly facilitated. The rocks are of very different physical aspects, and presumably of very different ages. Thus in addition to the several varieties of gneiss, which are so conspicuous a feature in all the Archæan country, and which may be regarded as forming the greater portion of the system, there are limestones, both white and crystalline as well as serpentinous and dolomitic quartzites, anorthosites, granites, syenites, porphyries, diabases, augen-gneiss, etc., all of which differ in many respects from the grayish gneiss and the limestone with which they are associated, and most of which, from their field relations, are clearly of more recent date, and of igneous origin as evidenced by their action upon the adjacent strata.

Relations of limestone and underlying gneiss.

In the townships of Chatham, and Chatham Gore, Wentworth, Morin and the Augmentation of Mille Isles, the relations of the limestone and the gneiss can be well studied, as well as the action of these igneous rocks upon both of the former divisions. Starting from Lachute and going northward, along what is known as the West Gore road, the strike is crossed obliquely for some miles. On the north side of the North river, directly opposite the village, the whitish-gray limestone of the series is prominently displayed in a quarry. The outcrop is not large, and consists of two principal bands, the larger of which is exposed for about one mile and a quarter in length, with a breadth on the Gore road of about twenty chains; but the more northerly outcrop is much smaller and is separated from the former by a narrow band of gneiss.

Outcrops north of Lachute.

The general strike of these outcrops is nearly east and west or nearly parallel to the course of the road leading up the North river. The dip on the northern side of the exposure is to the south at an angle of 70°, while on the southern margin, near the forks of the roads it is to the north-west at about the same angle, thus presenting the appearance of a somewhat crumpled synclinal, and the limestone is underlaid by the gneiss on either side. The width of the band diminishes as it is followed to the east and apparently thins out till it entirely disappears before the East Gore road is reached.

Limestones with rusty gneiss inclusions.

In its lower portion the calcareous rock becomes interstratified with grayish rusty gneiss in thin bands, which when they first appear present the aspect of inclusions, some of which are several feet in length and often twisted into serpent-like forms, as if the mass had been subjected to violent disturbing agencies. There is moreover a gradual thickening of the gneissic bands as the lower members of the limestone portion are reached, till the latter entirely disappears, the lower bands of the limestone ranging from ten feet to a foot in thickness.

North of this on the west Gore road, successive exposures of well foliated gneiss occur, reddish and reddish-gray in colour, in places holding disseminated garnets, and with occasional bands of grayish quartzose, micaceous and sometimes hornblendic gneiss, for four miles; in which distance a well defined anticlinal is seen, the rocks on the northern slope dipping to the north west $<50°$-$70°$. A mile further on this is changed to a synclinal, in which, on the property of Mr. Evans, another band of limestone occurs about 150 yards east of the Gore road. The width of the band here exposed is about fifty feet, and the dip is to the south-east $<70°$. This band can be traced northerly on the strike, by occasional outcrops, for several miles, and is probably continuous to the band seen on the road to Lakefield Corner, between concessions III. and IV., Chatham Gore, beyond which to the north, it terminates or is concealed shortly after reaching the next concession. South of Evans' place no trace of this band can be seen, and it cannot be connected directly with that near Lachute, unless on the supposition that it represents that band reproduced in the succeeding synclinal. Scales of graphite occur sparingly throughout a great part of the limestone. but not in quantity to be economically important. Near Lachute this rock has been quite extensively used for lime-burning.

Rocks along the west Gore road.

Graphitic limestone.

The continuation of the West Gore road through Chatham Gore into Morin, reveals the presence of several other bands of limestone. The first of these, north of those just described, is about twenty chains south of the road between concessions III. and IV. of the Gore, where it also presents the aspect of a narrow synclinal band, underlaid by the usual rusty gneiss and quartzite. On the southern edge of this band the dip is N. 10° W. $<65°$ and on the northern edge it is S. 10° E. $<75°$. Further, north on concession V., a band, having an exposed breadth on the road of about ten feet, shows near a brook in the valley to the north of the church at this place, but a short distance east of the church, on the road between concessions IV. and V., it can be traced continuously for more than half a mile, several small bands of rusty gneiss appearing in the mass. The limestones of this area are much distorted, and they seem to terminate abruptly just beyond this point, the country to the east being occupied by foliated granite-gneiss for several miles. Abrupt changes in dip are frequent between the gneiss and the limestone, much of the latter being not far from horizontal while the foliation of the gneiss is often steeply inclined.

Rocks of Morin.

From this last outcrop to the corner of the road through the range Ste. Angelique, Augmentation of Mille Isles, no rocks other than the

Distribution in range Ste. Angelique.

reddish-gray gneiss are visible, the surface being rough and hilly. Just east of the corner indicated, a small exposure of very graphitic limestone, twenty-five feet in breadth, occurs which, however, is terminated directly to the south by a ridge of reddish-granite-gneiss, and the outcrop is concealed to the north by an alluvial flat. At the next fork of the road, three-fourths of a mile further east, a much broader band of the limestone is seen, underlaid on either side by gneiss, the converging dips on the north and south being well defined. The exposed breadth of this band is six chains, the dip of the underlying gneiss on the south being N. 20° W. $<50°$. This band is apparently continuous through Ste. Angelique into range Ste. Marguerite, in an eastward direction along a well defined valley, for a distance of three miles and a half.

Rock formations in Morin township.

Continuing northward into Morin, the country is generally very rugged, but in the valleys of the streams flowing north into Lac des Cedres, two well defined bands of limestone appear, which are traceable northward to the road south-east from Morin post-office towards St. Sauveur, being separated by a prominent ridge of reddish gneiss. Here they turn round the north end of the gneiss ridge and uniting, constitute a broad belt, lying to the east of the Morin Flats road, and the band extends thence in the direction of St. Sauveur for about five miles. In the area to the north of Morin Flats post-office the limestone is penetrated by dykes and masses of anorthosite, already described, and a prominent ridge of this rock also bounds the limestone and associated gneiss to the north and north-east, extending thence to the vicinity of St. Sauveur, whence its outline curves to the north through Abercrombie into the county of Montcalm. The limestone for the most part follows the depressions between the mountains of this district; and, leaving the township of Morin, continues in a band nearly a mile in width, eastward to the village of St. Sauveur, where its outcrop bends abruptly to the north and abuts directly against the mass of anorthosite just described.

Limestone of St. Sauveur.

Of the several limestone areas in this vicinity, that of Morin and St. Sauveur is the most extensive. The bands all run in a direction approximately east-north-east, and from the strikes and dips of the calcareous portion as well as of the underlying associated gneiss and quartzite, together with the great similarity of the rocks throughout the entire area, it would appear that they all represent portions of the same mass repeated by successive foldings so that the several outcrops of limestone may be parts of one and the same band.

Irregular outcrops.

Many of these outcrops are quite limited, presenting the aspect of narrow bands, which extend for a few hundred yards, or in places for

only a few feet and then disappear, while others can be followed on their strike along the valleys of the streams for several miles with only occasional gaps in the exposures where they are concealed by the drift.

Lachute to St. Jérôme.

East of Lachute, on the road leading to St. Jérôme, along the north side of the North river, the limestone of the Lachute area can be traced nearly to the East Gore road which leads to Lakefield, when it apparently ends; but on the river road, about one mile and a half east of this corner, a narrow band of only a few feet in thickness appears in a cliff of granite-gneiss. This can be traced north-eastward for about twenty chains as a band in the gneiss, when it also ends and no further indication of it is seen. Thence to the vicinity of St. Jérôme the gneiss is strongly granitic in character, but about half a mile west of the bridge at this place a narrow band comes in which is traceable in occasional outcrops for a little more than a mile northward. Between St. Jérôme and St. Sauveur the rocks are mostly gneissic granites, with a well marked foliation, but two well defined bands of limestone appear in Mille Isles which are the eastward extension of those noticed to the north of Chatham Gore.

Lachute to Lakefield.

On the road from Lachute to Lakefield, East Gore road, a very narrow band appears about one mile and a half to the south of the latter village and is exposed at intervals for two hundred yards, when it disappears; but further south, about one mile south of Sir Johns lake, on the Belslamb farm, along the stream flowing thence to the North river, another small and irregular outcrop, flanked by reddish granite is seen. The limestone here is very impure with many inclusions of rusty gneiss and quartzite, giving it the aspect of a coarse conglomerate. It is here exposed for about 300 yards, the western margin being concealed by clay. No trace of this limestone was observed at Sir Johns lake to the north, the rocks there being reddish and yellowish-gray gneiss. It is certainly not continuous with that noted on the road to Lakefield. Still further south another small outcrop is seen about half a mile east of the East Gore road and the same distance north of the point where it joins the river road. This is also associated with reddish-gray gneiss. Throughout the greater part of this area the gneiss and limestone dip at angles of 50 to 90 degrees, and opposing dips are frequent, showing that the whole series is thrown into a number of folds, while in places the rocks appear to be overturned. In most of the limestone, scales of graphite are common, but no other minerals of importance were recognized.

East Gore road.

Graphitic limestones.

Foliated gneiss.

The greater part of the gneiss in this area belongs to the foliated variety, and may possibly represent what has been designated as the Fundamental Gneiss. In parts, however, masses of granite are seen.

Limestones of Chatham, Wentworth and Grenville.

In the townships of Chatham, Wentworth and Grenville several important bands of the limestone occur. Of these probably the most easterly is that of which the southern extremity is seen near Dalesville, on lot 11, range IX. of Chatham. From this point the band can be traced northward along the valley of Big creek, entering the township of Wentworth on lot 9, range I., and thence bending north-east, reaches the line of Chatham Gore in range V. The breadth of this band in Wentworth is 700 yards. On the road west of Dalesville two other bands of limestone occur in synclinals in the grayish and reddish-gray gneiss, east of the great mass of syenite which occupies the western part of the township, but these are of limited extent. Another band comes in on the southern end of Lake Louisa and occupies the end of a point. On its extension to the north-east it is seen in two small islands in the lake, but was not recognized at the north end, while from the south end it can be traced for one mile, when it disappears. On the west shore of the lake the underlying gneiss is seen, and on the road from this place to the village of St. Jean two other bands occur. The most easterly of these is of small extent, but the other continues along the valley of the creek at this place to the mass of syenite on range X., Chatham, by which it is cut off. At the northern outcrop this band divides into two parts, one curving north-westerly along the road to St. Jean church but soon ending in this direction. A repetition of this band is seen several hundred yards to the west, separated from the former by a ridge of gneiss, the outcrop being only local; while half a mile further west another small exposure is seen in a road cutting, but this cannot be traced in either direction. The strike in this area changes from north-east to north-west, being apparently diverted by the intrusive mass of syenite. Beyond this, however, it gradually swings round, near the line between Wentworth and Harrington, to its usual north-east direction. Here a small band of limestone, beginning near Spectacle lake, can be traced almost continuously for more than ten miles and probably reaches Lake Sapin in the township of Montcalm. It is crossed by the new road from Lost river to Morin, and has a strike at that point of nearly north and south. The band is of no great breadth and is partially concealed along a chain of lakes in this direction. One mile west of this band the limestone of Sixteen Island lake is seen and this can be traced for nearly twenty miles. This band forms a sigmoid curve. Its southern end abuts against the mass of the Grenville syenite, whence it appears in frequent outcrops along the road leading from Dalesville to Lost river. At this point it crosses the road and continues easward along the chain of lakes comprising Gate, Fraser, Long, Silver and Sixteen Island where the band

Lake Louisa.

Village of St. Jean.

The Spectacle lake band.

Sixteen Island lake.

Lost river Lands.

rapidly narrows, appearing in two small islands in the lake, and the underlying quartzite band has a considerable development. At the northern end a very narrow band can be traced at intervals into Proctors lake, where it has an exposed thickness of not more than twenty feet, and here it apparently ends. At Lost river, Long and Gate lakes, this band is divided into two parts by a ridge of reddish gneiss, the northern portion terminating westward a short distance west of the road leading to Arundel, near the south end of Big lake. A well defined synclinal structure is visible in the main band at several points in its course. It is underlain by the usual grayish quartzose and rusty gneiss, and its lower portion contains twisted inclusions and small bands of the latter. On the south side of Silver lake, a portion of the band is serpentinous and a small development of asbestus (chrysotile) in veins up to half an inch in thickness is seen. The quantity, however, is too small to be of much economic importance. This is on lot 20, range IX., Wentworth. The limestone at this place dips N. 55° W. < 50°. Masses of white weathering rock, composed of quartz and felspar, a binary granite or pegmatite, occur in the vicinity. Near Sixteen Island lake pyroxenic rocks come in and small crystals of mica occur on the south margin of the band where the dykes of white granite are found in place, and on the west half lot 23, range VII., Wentworth, also in the same rock, scattered crystals of mica and apatite are found with idocrase. On lot 22 of the same range, small quantities of graphite occur in vein form as well as in disseminated scales in the limestone, but the quantity of the mineral is not such as to be of economic value. The northern margin of this band has a regular dip to the south, showing its synclinal character

Synclinal structure.

Chrysotile.

Pyroxene, mica and Idocrase.

The road from Grenville northward, after traversing the townships of Grenville, Harrington and Arundel, reaches the Rouge river in De Salaberry, near the crossing of the county line between Ottawa and Argenteuil. Thence it closely follows the valley of the stream for nearly sixty miles to the head of the settlement on the river. For a large part of this distance the road crosses obliquely the strike of the rocks which present a succession of outcrops of gneiss of various kinds, with occasional bands of limestone. That portion of the road between Grenville and Lost river, a distance of twenty miles, passes over no less than seven distinct bands of the calcareous rocks, which, however, are possibly repetitions of the same one.

Grenville to Lost river.

In some of these, converging dips indicating a synclinal structure, are well seen, but at certain points the series presents the aspect of an overturned anticlinal. The gneiss and limestone are for the most part

Synclinal structures in limestones.

inclined at high angles, and the structure is complicated by the presence of the western portion of the Grenville and Chatham syenite mass. The usual strike of the rocks is from N. 10° to 30° E. On a road approximately parallel to this, leading north from a point on the shore road three-fourths of a mile east of Calumet station, and which meets the Grenville road in the northern part of range VII., similar bands of limestone occur, some of which are probably the equivalents of those noted on the road from Grenville to Lost river. Some of these outcrops are, however, very local, and can be traced for only a short distance, having an exposed surface of but a few feet; while others have a breadth of several yards across the strike. Considerable areas are covered by sand and clay, so that the entire extent of the deposits is not, in all cases, visible. On the road north from Calumet, four bands are crossed, separated by areas of generally grayish and rusty gneiss.

Road north of Calumet.

Calumet station and vicinity.

On the southern face of the hill at Calumet station, on the Canadian Pacific railway, there is also an exposure of the limestone which has a north-easterly course and which extends westward to the railway at the crossing of the Calumet river. It dips to the south-east and is underlaid by heavy beds of white quartzite, which in turn rest upon reddish-gray quartzose gneiss. The north-east strike of this limestone band would carry it to an outcrop on the road just mentioned, where on the south side of the exposure the dip is to the north-west, thus showing a synclinal structure in this area. An interesting outcrop of the limestone is also seen on the Mountain road and on a cross road leading thence easterly to Glen road. Here the rock forms a pronounced ridge of twenty feet in height, and contains, in addition to the usual inclusions of rusty gneiss, common to most of the calcareous rocks of the Grenville area, numerous well-rounded pebbles of gneiss and quartz-rock, thickly scattered through the mass. The lines of stratification are also well defined, so that the whole presents much of the aspect of a conglomerate. It is underlaid to the north and west by quartzose and rusty gneiss, which in turn rests upon the reddish-gray gneiss of the usual type.

Conglomerate near Calumet.

It will thus be seen that of the several limestone bands exposed along the roads north from Grenville and Calumet, synclinal structures are visible in most cases, though the lack of good exposures interferes with the attempt to establish this fact in every outcrop. Of the most important band, or that which crosses near Lost river, and continues easterly to Sixteen Island lake, the synclinal character is clearly evident at several points. The limestone at this lake on its southern margin, rests upon grayish quartzite, having a dip to the north-west of 45 degrees, but on a small island one mile to the north, a similar rock

Rocks of Sixteen Island lake.

LIMESTONE CONGLOMERATE (?), ON CROSS ROAD, LOT 17, RANGE IV., GRENVILLE TOWNSHIP, ARGENTEUIL CO., P.Q.

in continuation of this band has a reverse dip to the south-east at an angle of 50 degrees, while a similar structure is seen near the Lost river road crossing. A high ridge of reddish gneiss extends along the east side of this lake and separates it from the band already described as passing parallel to this about a mile to the east.

Lost river.

The name of Lost river is given to this stream from the fact that it passes beneath a ledge of limestone which divides the waters of Gate lake from Fraser lake, about two miles east of the road that extends to Arundel. The stream is here concealed for about one hundred feet. Several other cases of these underground streams are known in the limestone areas north of the Ottawa.

Lost river to Arundel.

From Lost river northward, to Arundel, following the main road, two principal bands are crossed, of which the first has a somewhat extensive development along the east shore of Big lake or Johnson lake, into the upper end of which the Lost river flows. This Big lake band apparently terminates a short distance south of the lake, but to the northward continues along the valley of the stream to Bevan lake. The breadth of this band on ranges VII. and VIII., Harrington, is nearly one mile, and it includes a large part of lots 7, 8 and 9. At the termination on Bevan lake the band becomes very much smaller and is underlaid by the usual series of gray and rusty gneiss with converging dips on either side of the outcrop. On the east side of the band the dip is west at an angle of 85 degrees. A repetition of this band is seen on the south-west side of this lake, separated from that just described by the usual ridge of reddish gneiss. In this second band, which extends to the south of the lake for over two miles, where it ends, the converging dips to the centre are also seen. The band has a breadth of three-fourths of a mile, where it meets the lake, and what may be its continuation appears on the eastern margin and extends for several miles north-easterly till it also disappears to the south of the great foliated granite gneiss area of Bark lake.

Bevan lake.

Bark lake.

Big lake band of limestone.

The Big lake band, while apparently terminated not far from the upper end of the lake by a great mass of reddish granitic gneiss, is on the direct strike southward of another important band which crosses from Harrington into Grenville on lots 14 and 15 of Harrington. From this point its breadth diminishes, but is apparently indicated by an outcrop on the Rouge river, about one mile below the Bell chute portage or about on lot 26, range IX., Grenville, from which its continuation can be traced by very good exposures to the Canadian Pacific railway near Pointe au Chêne station. If these several outcrops are parts of one band, which seems probable, it would have a total length

of over twenty miles and be probably the most extensive in the whole area. To the west of this band another comes into view on the Rouge river, on lot 17, range V., Harrington, which continues south-west for four miles to the north line of the township of Grenville. It appears on the Rouge in an irregular and impure outcrop, much mixed with irregular pieces of the rusty gneiss at the foot of the portage past the Bell chute, with a breadth of only a few feet, whence it extends south-west into the augmentation of Grenville for several miles, terminating apparently on range VII. Still further west at the distance of a mile, a smaller band parallel to the last, begins on range V., of Harrington, and crosses the lower part of the Maskinongé river, a short distance above its junction with the Rouge. This is well seen on the latter stream at the Marble falls, as well as in small exposures along the road leading down to Lake Commandant, a short distance below the bridge over the Rouge at the south line of the township. This portion of the band is small and chiefly of importance as serving to indicate the structure of this part of the area.

Limestones of Harrington township.

Marble falls.

Country north of Arundel to Trembling lake.

North of the township of Arundel and east of the Rouge, the calcareous members of the system are but sparingly seen. At St. Jovite, in the township of DeSalaberry, a band occurs which has an exposed breadth of 250 yards, inclosed between nearly vertical walls of gray quartzite and gneiss, the latter presenting the usual rusty characters at the contact with the limestone. The outcrop can be traced for several hundred yards till it is concealed by a mantle of clay and sand; but a thin irregular band appears at intervals along the valley of the Devils river, and on its branch which issues from Trembling lake, which may indicate its extension in this direction, though its regular strike is deflected by some of the masses of intrusive granite-gneiss which are seen in the vicinity. At the outlet of the lake this band has a breadth of not more than fifty feet, but northward it can be traced on several of the small islands near the centre and northern end where the strike changes from its usual north course and bends to the west. Here it apparently terminates against a great mass of granite-gneiss which rises boldly on the west side of the lake. This band of limestone also has a synclinal structure with converging dips on either side towards the centre of the lake. This is the celebrated Trembling lake band, which in the Geology of Canada, 1863, was regarded as the lowest of the limestone series in the Laurentian system, and which by some error in delineation was made to extend northward into Lac les Grues. A careful examination of the district, however, shows that it does not follow this course, since all the rocks about the northern end of this lake are of the gneissic and granitic variety,

The Trembling lake limestone.

Granite of Trembling lake.

similar to those seen in the mass of Trembling mountain. The only depression in this direction is along the valley of Caché creek, which discharges the waters of Lac les Grues on which the gneiss appears and no trace of the limestone was here observed.

Trembling mountain.

Trembling mountain rises above the east shore of the lake to an elevation of 1,720 feet by aneroid and consists, for the most part, of moderately fine-grained reddish-gray gneiss with bands of black hornblendic gneiss, the strike of the foliation being N. 20° W. with a dip to the west. From a calculation of several measurements the elevation of the summit of Trembling mountain is not far from 2,500 feet above sea-level. To the north and north-east of this mountain the rocks are all granite-gneiss and this rock extends to the east as far as the Devils river, where it meets the great mass of the gabbro and anorthosite described by Dr. Adams in the Report for 1895, vol. VIII.

Route from Trembling lake to Labelle on the Rouge.

Between Trembling lake and the Iroquois chute (now Labelle) on the Rouge, three lakes are crossed, there being four portages on the route. On the first, Great Beaver lake, the rocks are all granite and gneiss, most of which is foliated, but large portions massive and syenitic in character, which form great hills to the east and extend across to the west shore of Trembling lake. Crossing a short portage, Long lake is reached, where the rock shows a more decided banding and is in places well stratified with hornblendic and garnetiferous bands, but as a whole is of the reddish variety. Here a small band of grayish binary granite comes in, and a thin outcrop of calcareous rock occurs near the north end of the lake, but no well defined limestone is visible. A portage of a few rods in length connects with Lac Vert, on which the rock is all reddish and reddish-gray gneiss, and similar rock continues thence to Iroquois chute, about one mile distant.

Labelle north to the Macaza river.

At this place reddish-gray gneiss appears at the bridge with a strike of nearly north and a vertical foliation. Just above the village, well banded grayish and garnetiferous and sometimes rusty gneiss strikes north and south and dips west $<85°$ and this can also be seen on the north side of the river, whence a succession of gneisses red, gray, black, sometimes garnetiferous, can be traced to the forks of the Rouge and the Three Arms river, the latter stream soon dividing into the Macaza, the Ruisseau Froid and the Chaud.

Rapid des Pins.

In order to determine the limits, if possible of the limestones in this direction, an examination of these upper waters of the Rouge was made. The only outcrop of the calcareous member on the Rouge between the Labelle and the forks was seen at the Rapid des Pins about

five miles above the village, where a band from three to five feet in breadth is exposed. This is underlain by quartzite, and what is probably the continuation of the same band, with a width of only two feet of limestone, appears just below the mouth of the Macaza associated with twisted gneiss and quartzite. The rocks along this stream strike north and several reverse dips both to the east and west are seen, generally at high angles.

The Macaza and its branches.

The ascent of these branches of the Rouge showed that the prevailing rock in this direction was reddish gneiss, chiefly of the granitic type. The limestone bands seem to disappear almost entirely, as well as the associated grayish gneiss and quartzite. On a small island near the head of Lac Chaud a small outcrop of very impure limestone was noted, which was filled with inclusions and pebbles of rusty gneiss and a small outcrop of two feet in thickness appears on the eastern shore of the lake which apparently marks the northern limit of the calcareous member in this direction, the rocks thence northward being all of the gneissic variety. The elevation of this lake is not far from 1,000 feet above the sea. From these observations it would appear that the calcareous portion of this system occupies a central position in a broad basin-shaped area with a depression to the south, and the extent of the limestone bands which have a very considerable development near the Ottawa, gradually diminishes to the northward, till at a certain elevation they disappear entirely.

Limestones die out.

Outcrops near St. Jovite.

The only other observed outcrops of limestone to the east of the Rouge, were in DeSalaberry township. About two miles to the south of St. Jovite, near the forks of the road to the ferry over Devils river a small ledge is exposed resting upon reddish gneiss, and this can be traced northward to Maskinongé (Pike) lake where it shows on the main road to St. Jovite and also on the road along the north side of the lake. The limestone contains scattered crystals of pyroxene and apatite and was reported to carry asbestus, but a careful search failed to discover any of this mineral.

St. Jovite to St. Faustin.

East of St. Jovite, on the road to St. Faustin, a small outcrop of the limestone is indicated presumably by the presence of scattered blocks of the rock, but the band is seen in place both to the north and south of the road. The quantity, however, is small and it is probably a repetition of that near St. Jovite.

Annunciation village.

The most northerly outcrop in this area near the Rouge was noted in an old quarry, about one mile south of the village of Annunciation, in the western part of the township of Marchand. This place is 600

yards north-west of the road leading from that village to the east side of the Big Nominingue lake. Portions of the rock are serpentinous, but the greater part is of excellent quality for lime-burning. In the serpentinous portion Eozoon structure was observed near the contact with a mass of reddish syenite-gneiss. Eozoon structure.

The rocks along the upper part of the Rouge to the Nominingue creek, as also around the shores of the Nominingue lakes, are all gneissic granites. No trace of the limestone formation, other than those mentioned was observed. The strike of the gneiss is for the most part north-east, the dip sometimes to the east and at places to the west, showing a folded structure. From these lakes a road extends southward along the course of the Nation river to the Ottawa river, and settlements are beginning to form in this direction. Nominingue lakes.

A traverse was made of the several lakes and portages which extend from the Big Nominingue lake to the Rouge river, the geological features of which will be given in the next chapter.

The Rouge river takes its rise near the height of land, separating its waters from those of the west branch of the St. Maurice, and after a course of about 150 miles joins the Ottawa two miles west of Calumet station on the Canadian Pacific railway. The principal branches from the east are the river of Three Arms, which divides into the Macaza and the Ruisseaux Chaud and Froid, already referred to, and which enters the Rouge about eight miles above the village of Labelle in the township of Marchand. The next considerable stream from the east is the Devils river, which rises near one of the branches of the Mattawin, after draining numerous lakes among which the most important is a large lake south-west of Lac des Baies at the head of the west branch and unnamed. Continuing southward, several miles to the east of Trembling mountain, it receives the waters of Trembling lake and others of that chain by a short creek and empties into the Rouge in the north-west corner of Arundel. Further to the south the Lost river enters the main stream near the middle of the same township, and discharges the water of a number of lakes often of good size, among which are Bark, Bevans, Big and Sixteen island, with others of the chain. The Rouge river and its tributaries. The Devils river. The Lost river.

From the west the principal tributaries are Nominingue creek, discharging Big and Little Nominingue lakes and the extensive chain in connection with these, and the Maskinongé river which takes its rise near the Nominingue lake, and after a long course on which a number of large lakes are found, enters the Rouge in the south-west part Nominingue creek.

Maskinongé river and lake.

of Harrington. On this stream is Maskinongé lake, nearly ten miles long. Numerous smaller streams abound, but those mentioned are the principal and the only ones traversable by canoes.

The Rouge below Labelle

As already mentioned, good wagon-roads now exist on either side of the river, and extend northward for nearly a hundred miles from its mouth, the most inland village being Charbonneau, which is about thirteen miles above the mouth of Nominingue creek. Descending the river from Labelle, (formerly Iroquois chute) which is the present terminus of the railway, 101 miles north-west of Montreal, and one of the most important villages in this section of the country, the banks are largely composed of sand and clay, principally the former, which extends to within twenty-five miles of the mouth, where the sand is replaced by clay in the river valley.

Limestones of Three Mountains lake.

At the mouth of George creek, which enters the Rouge about seven miles below Labelle and discharges the waters of the Lake of the Three Mountains, a band of limestone comes in which follows the valley of this creek and which is probably an extension of a small band seen at the outlet of a small lake to the north of the Three Mountains lake. From the mouth of George creek the lime stone can be traced down the river in a series of exposures to Conception village, and thence, though sometimes concealed by drift, to the road at the ferry turning off to the Devils river in the west part of range III., de Salaberry. On this cross road it continues for about a mile, when the exposures disappear. Another small band occurs on the road leading across to the Rouge river from St. Jovite along the south shore of a narrow lake which has a strike nearly east-and-west, but which, after passing the west end of the lake, turns northward again in the direction of Crescent lake to the east of Conception village. This band does not continue very far in this direction and the deflection in its strike is apparently due to the presence of a large mass of augen-gneiss which extends thence northward to Lake Sam on the road from St. Jovite to Labelle.

St. Jovite to Rouge river.

The Green lake band.

Continuing down the Rouge, about one mile north of Huckleberry chute, a small band appears on the west bank of the river and strikes north-west in the direction of Green lake, which lies to the south of Three Mountain lake and is probably the southern end of the Green lake band. This does not appear on the shore of Three Mountain lake, but keeps to the south of it. A band seen on Muskrat lake, which lies between the latter and Lake Maskinongé, and on several small lakes to the south, may be the extension northward of this outcrop, though it cannot be traced continuously, owing to the difficult character of the country to be traversed.

At Huckleberry chute, two bands are exposed, separated by a seven foot band of gneiss. The limestones have a breadth of six feet and twenty feet respectively, and there appears to be an anticlinal structure at this place. A third band, with a thickness of forty yards comes in on the west, mixed with gneiss, but these bands can not be traced to any distance below the chute, as the only exposures in this direction are of reddish-gray gneiss. Huckleberry chute.

From this point down to the bridge over the river at the Jesuit settlement in Arundel, no calcareous rocks appear along the stream. Occasional outcrops of the gneiss are seen, but the banks are frequently occupied by sands which overlie the clay. At the Arundel bridge masses of reddish hornblendic syenite rock are exposed, but a short distance above this, a band of limestone, associated with grayish and rusty gneiss is seen in the river. Drift conceals the rocks for a mile or so below, but what is apparently a continuation of the same band is seen on the road down the east side in a small outcrop on the line between ranges I. and II., Arundel, below which nothing is visible above the drift till the head of Mountain chute is reached. A small band appears, however, at Dog chute, one mile below Dog rapid, in the northern part of Harrington, which has a strike of N. 50° W. The dip is vertical and may represent the northern extension of the band seen at Mountain chute. The associated rock is a grayish rusty gneiss. Dog chute.

The bands of limestone in the area adjoining the lower portion of the Rouge have already been described. For the last seven miles of its course, the river flows over reddish and reddish-gray gneiss, which forms a high range of hills along the east bank and along which a good section can be observed. The strike is, for the most part, N. 30° E. and the dip is to the north-west $<70°$. The last three miles of the stream, from the head of the Nigger rapids, are impassable for canoes on account of falls and broken water, and the road thence, passes over a ridge of gneissic granite. There is a narrow band of limestone near the summit. Further to south another band is seen along the road across the crest of the hill overlooking the Ottawa, and a third narrow band appears on the slope descending to the railway and about three-eighths of a mile north of the track. The last is associated with granitic rocks. Rocks along the lower Rouge river.

It will be seen therefore from the descriptions given, which have been stated in detail on account of their importance in elucidating the structure of this area, on which the characters of the Laurentian were originally based, that the outcrops of limestone are quite numerous,

Irregular distribution of the several outcrops.

but for the most part of no great extent. It was found impossible to trace many of them continuously to any great distance, for though some of the largest deposits could be followed for several miles by occasional outcrops and by the character of the soil, even these often showed great irregularity, rapidly changing their character by decreasing in breadth or by abrupt ending. In many places the exposures are concealed by drift so that it is impossible to trace them; at others the areas were clearly very limited and their extent could be easily ascertained. While the general strike of the gneiss and associated limestone is from ten to twenty degrees east of north, this sometimes rapidly changes in direction. In such cases masses of granite, anorthosite or augen-gneiss are usually found in the immediate vicinity. Good illustrations of this divergence are found in Grenville and Chatham near the syenite of that district, as well as on the upper Rouge near Three Mountain lake. In Morin also sudden changes in the strike are noticed, due to the anorthosite, as also in Grandison and Clyde townships, where great masses of syenitic gneiss and augen-gneiss are present. In these cases the limestone bands, after passing the intrusive masses gradually tend to resume their normal strike, unless they are entirely cut off as is sometimes the case.

THE AREA BETWEEN THE ROUGE AND NATION RIVERS.

Area between the Rouge and Nation rivers.

This area differs from the preceding in that the surface is more largely occupied by lakes, some of which are of considerable size. While a great part of it is as yet unopened to settlement, it is readily traversed by canoes. The western part of the seigneury of Petite Nation and the townships of Ponsonby and Suffolk on the north, are intersected by roads; while along the valley of the North Nation, a colonization road, already referred to, extends to Nomininguе lake on the waters of the upper Rouge, a distance in a straight line of nearly sixty miles.

Colonization roads.

Two colonization roads extend west from the Rouge into this area, the most northerly of which turns off from that stream about three miles above the village of Labelle and continues west to the Big Nomininguе, meeting that from Annunciation, on the shore of the lake; the other starting near the same point trends south to the lower end of Maskinongé lake, and then continues to Desert lake and on to the new settlement of Chapleau, where areas of good land exist, underlain by crystalline limestone. Around the shores of Big Nomininguе lake the only rocks observed were grayish, reddish-gray and

Big Nomininguе lake.

hornblende gneiss, striking ten to sixty degrees north of east and showing by reverse dips, at several points, the presence of anticlinal structure. The eastern shore shows no ledges, the beach being boulder-strewn; but hills of reddish-gray gneiss and granite rise a short distance from the water. The road from Annunciation, past the east shore of this lake, crosses at the Narrows which connects with Little Nomininingue lake, and extends to the Jesuit settlement, which is half a mile from the south-west angle of Big lake. Along this road outcrops of gneissic rocks are frequent. The west shore of the lake shows similar rocky ledges at several places, which strike generally north and south and dip to the west. The southern end is sandy as is also the northern shore for some distance back, being probably the extension of the drift plains of the upper Rouge. No trace of limestone appears on the shores of this lake. The north shore of Little Nomininingue lake, about one mile to the south, is also low and sandy to the mouth of Sauge creek which discharges the waters of a chain of lakes from the north. A road extends along the south shore of this lake connecting with that leading to the Nation, and several settlers have already located there. The land both to the south and west appears to be of good quality and comparatively free from stones. On the east side of Sauge creek a high cliff of grayish hornblende gneiss occurs, with a dip S. E. $<25°$ and extends along the north side of Big lake to the east end. Here several small islands are found, on one of which a small irregular band of limestone, very impure with inclusions of rusty gneiss, is seen. The structure of the limestone band is a crumpled synclinal, the underlying rocks on either side being rusty gray gneiss and quartzite.

Little Nomininingue lake.

Impure limestones.

From Little Nomininingue lake a portage of sixty chains leads to Blanche lake, which is the head of the east branch of the Nomininingue river. The shores are low and no ledges visible. From this a portage of about the same length leads to Black lake, at the head of the east branch of the Nation river, around which also the country is low, but gneiss hills rise at a short distance on either side. A portage of a mile leads thence to Little Black lake, where reddish gneiss appears, but no limestone is seen in this direction. Thence by a portage of a mile and a half, a small lake is reached which is half a mile west of Désert lake, the head of the west branch of the Maskinongé river. Reddish-gray and hornblendic gneiss occurs about these lakes, but on a point on Désert lake, separating the two bays at the north end, limestone is seen, underlain by quartzite and rusty gneiss. The dip is S. 55° E. $<50°$. At the outlet of this lake, which is to the south grayish garnetiferous hornblende gneiss strikes S. 20° to 75° E. The

Portage route from Little Nomininingue to Maskinongé lake.

Désert lake.

shores of most of these lakes are densely wooded with spruce and cedar, and rock outcrops are few, while most of the surrounding country is also a thick forest.

From Désert lake south, a chain of lakes including Long Point, Mauve and Trout, is traversed before reaching Maskinongé lake. On the first of these only is the limestone well seen, large outcrops appearing on lots 4 to 7, range VI. and VII., township of Minerve, occupying a synclinal on the west shore of the lake and this is probably continuous southward to Lac Vert (Green lake). Several folds are seen along this part of the lake, while the rest of the shore shows ledges of reddish gray and garnetiferous gneiss. Similar gneisses are seen around the shores of Lake Mauve. In a large bay on the east side of this lake the gneiss shows several low undulations, with dips of five to fifteen degrees, and no limestone is visible. Trout lake is surrounded by hills of reddish-gray and hornblende gneiss, and below this the stream is navigable for about half a mile, whence a portage leads to the west shore of Maskinongé lake.

Trout lake

The strike of the gneiss on this lake is generally a few degrees east of north, and the dip changes from east to west several times, showing the presence of well-defined anticlinal folds. The portage from Trout lake reaches Maskinongé lake in a small bay near the south end. Here a small band of limestone occurs at the entrance of the bay, underlaid by grayish and rusty gneiss, which dips S. 70° E., $<50°$. This limestone extends south along the west shore of the lake and is separated from another band, seen on an island in the south-east corner of the lake, by a mass of hornblende rock which has the same strike. Dykes of pyroxene cut these and masses of white binary granite, or pegmatite, intersect the limestone.

Maskinongé river.

Descending the Maskinongé river grayish quartzose rusty gneiss appears at the elbow, a short distance below the foot of the lake, dipping E $<75°$ overlaid by limestone, to the east of which the gneiss again appears with a west dip $< 70°$, showing a synclinal in which the limestone occurs. Below this for about four miles to Cameron lake the rocks are gneiss, considerable distances along the stream, however, being drift-covered.

Cameron lake.

On Cameron lake, which is in the south-west part of the township of Clyde, a well-defined limestone band is seen at the south-west angle. The strike of this, as well as of the underlying gneiss, is N. 40° E., dip S. 50° E., $<75°$, on the north side of the bay at the outlet, but on the south side of the bay the dip is reversed to the north-

west $< 80°$. This limestone strikes directly along the south side of the lake, and can be traced north-east into another lake for several miles, when it disappears. To the south-west, its strike is along the course of the stream, but the area is drift covered.

Long and Kidney lakes.

To the south-east of Cameron lake a portage of half a mile reaches Long and Kidney lakes. The rocks in this direction are all reddish-gray gneissés, with bands of hornblende rock, and some of the bands are filled with small garnets. To the east of Kidney lake the country is very hilly and densely wooded, and evidently occupied by granitic and gneissic rocks.

Maskinongé lake.

Returning to Maskinongé lake, which has a length of about ten miles with a breadth of one mile to a mile and a half, the limestone appears in three parallel synclinals along the west shore, from the end of the portage mentioned to the north end of the lake. About the middle of the west shore an overturn in the strata is plainly seen, which makes the gneiss overlie the limestone for a short distance. These synclinals extend to the bay near the north-west angle, where the calcareous members apparently terminate. Ridges of intrusive white binary granite, weathering a grayish-white, occur in this area, as well as dykes of a coarse black hornblende diorite, which cut the limestone. The most northerly exposure of the limestone on this lake is on the north-west shore, between the large west bay and the north-west angle. It is underlaid by gneiss of the usual grayish type, but this band could not be traced inland, the rock in this direction being gray gneiss and quartzite. An attempt to burn lime was made at this place some years ago by a settler, but the rock used was a whitish quartzite instead of a limestone, and the attempt was, of necessity, a failure. Excellent limestone for burning, however, exists in the vicinity within a couple of miles of the Rouge and five miles from Labelle, so that lime could easily be obtained, instead of hauling from St. Jovite, nearly seventeen miles distant.

Lake east of Maskinongé lake.

Along the east side of Maskinongé lake a ridge of reddish gneiss and granite extends along its whole length and separates it from the waters of Muskrat lake (Lac des Frères) and several others which flow into the Lake of Three Mountains. A narrow band of limestone is seen about a fourth of a mile west of Lac des Frères on the portage; and a second band on the east side of the lake, occupying a synclinal and underlain by gray gneiss and quartzite. Crossing by a chain of lakes to Three Mountain lake, two other bands are recognized in synclinals, the anticlinal structure of the gneiss which separates them being quite clear. On Lac Brulé, to the west of Three Mountain

lake, hills of gneiss are seen on the north side which show a folded structure. No limestone appears on any of these lakes, but on Green lake, to the south-east of Three Mountain lake, a narrow band is seen, which may be the extension of one of those just noted.

Road from Montebello to Ponsonby.

In the townships of Amherst, Ponsonby and Suffolk, several new roads have been constructed by means of which sections across this part of the crystalline rocks have been made. One of the most recent of these extends northward from the village of Montebello, on the Ottawa, across the central portion of the seigneury of Petite Nation to the third range of Ponsonby, a distance of twenty-three miles, which will presently be described.

Crystalline rocks of Alfred township opposite Montebello.

Before giving the distribution of the limestone bands on the north of the river for this section, it may be well to point out the occurrence of the older rocks on the south side as seen at Alfred and Rockland. Of these the most important and instructive is that opposite Montebello where a beautiful display of gneiss, quartzite and limestone is presented, in a knoll near the ferry and to the south of the road about half a mile to the east. The rocks in the knoll have been smoothed by glacial action and disclose one of the finest examples of twisted structure to be found in the district. This has been photographed for the Geological Survey by Mr. H. N. Topley. The structure here is apparently an overturned anticlinal in the gneiss and the crumpled strata can be traced along the strike for nearly half a mile nearly east and west. The gneiss is flanked by well bedded quartzite which is in turn overlain to the east by the limestone with rusty gneiss inclusions. A similar quartzite is seen between the gneiss knoll and the river. The eastern extremity of the exposure is concealed by Potsdam sandstone and this also appears on the shore of the river a short distance west of the knoll. The development half a mile east of the ferry shows the usual series of grayish quartzose gneiss with a strike N. 50° E., dip. S. 40° E. 25°., < This is directly overlain by a band of whitish quartzite with the same dip and strike, and this in turn by limestone with rusty gneiss inclusions and thin bands, conformably with the other members of the section. The thickness of this band of quartzite is about 450 feet; that of the limestone could not be definitely ascertained owing to the covering of clay in this area; but the whole series including the gneiss presents all the aspects of a conformably sedimentary deposit. The lower red gneiss does not appear in this section.

Photographs.

Thickness of the quartzite.

Outcrops at Rockland.

A second small outcrop of the (Grenville series) on the south side of the Ottawa is at Rockland, near the mills of Mr. W. C.

CONTORTED GNEISS, NEAR FERRY LANDING, OPPOSITE MONTEBELLO, ALFRED TOWNSHIP, PRESCOTT CO., ONT.

Edwards, and represents the southward extension of the rocks seen at Rockland station on the Canadian Pacific railway on the north side of the river, where gneiss, quartzite and limestone are well exposed. At Rockland the exposure consists of a small mass of gneiss and limestone overlain directly by the Potsdam, the lowest beds of which are a very coarse conglomerate, succeeded by the sandstone of that formation, which forms a prominent escarpment directly to the south. This outcrop is too small to represent on our maps being mostly concealed by the Potsdam formation.

Pointe au Chêne.

Rensselaerite.

Limestone north of Pointe au Chêne.

Returning to the north side of the Ottawa, on the road west from Calumet, a small band of limestone associated with soapstone occurs about a mile east of Pointe au Chêne station. The exposure of steatitic mineral (rensselaerite) extends for nearly sixty yards and has been mined. It is associated with the ordinary gray gneiss. On the road north from Pointe au Chêne to Lake Commandant a well-defined band of limestone occurs which can be traced continuously for six miles and is probably continuous with slight breaks to the Rouge. It is also underlaid by grayish and rusty gneiss in which a synclinal structure is apparent. On the road from Avoca to Lake Commandant another band is seen with an exposed breadth of a fourth of a mile. This is on lots 2 and 3, ranges VI. and VII., of the Augmentation of Grenville. It can be traced for a short distance only to the south, but northward is probably continuous with the band which crosses the Rouge at the Bell chute, already noted.

Lake Commandant.

Kinongé (Salmon) river.

On Lake Commandant two bands are seen, one of which begins at the small bay near the south end of the lake and extends along the south-west shore to the north-east corner of the large island near the centre of the western end (Indian island). The other band follows the course of the south-west bay to the outlet of the Kinongé (Salmon) river. The two areas are separated by a ridge of reddish gneiss. They can also be traced on their strike at intervals to the northern extremity of the lake, where they also appear in two distinct but narrow bands, separated by a long point which divides the east bay from the main portion of the lake. The structure of both bands is synclinal and there are small irregular outcrops of a third band on the north-east shore of the lake. Here a prominent ridge of white-weathering quartzite occurs, but the greater part of the rock exposures around this lake are of grayish and reddish gneiss. The band from the south-west end of the lake has been traced at intervals along the course of the Kinongé river almost to its junction with the Ottawa. About one mile north-east of the lake several small outcrops

of limestone are seen on the Maskinongé river, indicating a broken band which extends for some distance along its course. It appears also near the Catholic church on range III. of Ponsonby, and may continue further north, since the valley of the river, up to Amherst corner, about five miles distant, is largely occupied by drift, and bounded on either side by high ridges of reddish gneiss. This valley of drift is in places nearly a mile wide. On the road from Amherst to Huckleberry chute on the Rouge, the only rocks seen were granitoid gneiss.

Amherst.

Ponsonby.

Throughout the township of Ponsonby, with the exception of the outcrops just noted, calcareous beds appear to be absent. Great masses of reddish and reddish-gray gneiss are seen, for the most part well foliated, which extend into Suffolk, to the forks of the road at Ste. Emilie. On the road from this place into Addington gneissic rocks show at intervals; but at Round lake, which is in ranges I. and II., Addington, a narrow band of the limestone occurs on the road up the east side, and a band of the rusty gneiss is also seen at the extreme north end of the lake. The limestone is also exposed on a small point at the south end. Along the west side the hills of gneiss extend, and some of these are twisted in a wonderful manner.

Round lake.

Lac Vert to Lac des Sucreries.

The road northward ends at this lake but a traverse across the northern part of the township was made from Lac Vert on the Nation, to Lac des Sucreries, in which several detached outcrops of the limestone were observed. It was found impossible, however, to connect these scattered outcrops with those further to the south as the surface was very rough and densely wooded. Synclinals were recognized in the gneiss at several points and it was observed that in most cases the limestones occupied these, while the different areas of the calcareous rocks were separated by anticlinals in the gneiss.

Ponsonby to Hartwell.

Continuing westward, the road from Ponsonby crosses the township of Suffolk, by way of Ste. Emilie and Namur, and thence extends on to Hartwell, at which point roads diverge northward to Lac Simon and thence past the chain of lakes along the Nation river to Lake Nominingue, already mentioned, and southward to the villages of St. André Avelin and Papineauville, on the Ottawa river. Roads also extend westward from Hartwell into Ripon and north-westerly into Lathbury, where the settlements in this direction end. In the western part of the seigneury of La Petite Nation, roads are numerous and settlements are prosperous, owing apparently to the greater prevalence of the calcareous formation. On the new road north of Montebello into Ponsonby several outcrops of limestone are seen which are evidently the northward prolongation of those which occur along the road north

Road north of Montebello.

CONTORTED LIMESTONE, WITH INCLUSIONS OF RUSTY GNEISS, SHORE OF OTTAWA RIVER, PAPINEAUVILLE, OTTAWA CO., QUE.

from Papineauville to St. André Avelin. These bands have been traced to the north-east for some miles and are bounded on both sides by grayish and rusty gneiss. The greater part of this area along the road to Ponsonby is however occupied by the underlying reddish and reddish-gray gneiss.

Papineauville

At Papineauville the limestone is well displayed on the shore of the Ottawa as well as along the railway near the station and on the road through the village. It is here much broken up by masses of white binary granite and the limestone along the shore is twisted in a very complicated series of folds, the included bands of rusty gneiss being well represented. This locality has also been photographed by Mr. H. N. Topley for the Geological Survey. The western edge of this limestone is seen near the corner of the road turning off to St. André Avelin, and it closely follows this road northward for several miles. Three miles north of the village, on a road east to the Montebello road a second calcareous band is noted, separated from that just described by an anticlinal in reddish and gray gneiss. Both these bands continue in a north-easterly course to the big bend in the Nation river at the place called the Portage. Their crumpled synclinal character is well seen at a number of points.

St. André Avelin.

The strike of the Papineauville bands, would, if continuous, carry them into Ponsonby, and on the road north of the Nation river and east of St. André Avelin three bands appear, separated by ridges of reddish and gray gneiss. Two of these terminate apparently a short distance north of the road from Montebello to Ponsonby, while the most westerly appears in a narrow band on that road several miles to the north, beyond which, however, it also soon dies out. These three bands should be, from the structure of the section, repetitions of the same, appearing in repeated synclinals. On the Little Rouge, a branch of the Nation from the north, a small band is seen which cannot be connected with any of those to the north or south, and which has a breadth of only a few feet. It is however on the strike of the Round Lake band in Addington but it is impossible to connect these in the fourteen miles which separate them.

Eozoon Côte St. Pierre.

About the village of St. André Avelin and for two miles west, as well as along the road thence south towards the mouth of the Nation river, outcrops of the limestone are frequent. In the village the strike is north-and-south, dip W. $<45°$ associated with gray and rusty gneiss. North of the village towards Hartwell the road passes over nearly level country for several miles, and at Côte St. Pierre about four miles from the village, several large masses of greenstone and granite are

seen which cut the limestone, and an Eozoon structure is found at the junction of the two series. Occasional masses of red granite-gneiss rise from the generally level plain, but just what area is occupied by the limestone in this drift portion is hard to say. Along the road from St. André Avelin to North Nation Mills outcrops of both limestone and gneiss are frequent and the structure is well seen. The gray and rusty gneiss is well exposed and the presence of three anticlinals in the separating areas of the reddish gneiss is recognized, the limestone and gray gneiss occupying the synclinals. From the forks of the road near the crossing of the Nation river, which is about three miles north of the station of North Nation Mills, a road extends east to the Papineauville road, but on this the rocks are all reddish and reddish-gray gneiss with the exception of a small band of limestone about midway. Several anticlines are seen along this road, as also on a road parallel to this along the south side of the river. North of North Nation Mills station the surface for some distance is covered with sand and clay terraces.

St. André to North Nation Mills.

North Nation Mills to Thurso.

Between this place and the Blanche river, which enters the Ottawa near the village of Thurso, large areas are also drift-covered. Several well-defined bands of limestone occur along the roads which traverse the area between these streams in the eastern part of the township of Lochaber and the Gore adjacent. Some of these are apparently on the line of strike of the bands recognized to the north of St. André and they are also seen in the northern part of the seigneury of La Petite Nation. The two western bands which are seen near Thurso village, can be traced on their strike, north-easterly into the adjacent township of Ripon, and thence into Hartwell, where several important bands are seen on the shores of Big lake or Lac Simon.

Lac Simon.

On the several roads traversed in this area, the strike of the rocks is not far from N. 20° to 40° E., varying occasionally through the action of intrusive masses, while the opposing dips at a number of points indicate the presence of the usual anticlinal structure. On the east shore of Lac Simon, where a continuous series of exposures of gneiss and limestone is seen for several miles, a series of anticlinals is visible in which the resulting synclinals in the limestone are beautifully seen. The limestone and associated gray gneiss are penetrated by masses of grayish binary granite or pegmatite, the composition of which is principally quartz and white felspar.

Limestone quarry.

On the large island in this lake and also on several of the smaller ones off the west shore, outcrops of limestone are well exposed, and near the west shore, for half a mile above the bridge at the Narrows. A quarry has here been opened for lime burning

in a mass of white crystalline rock well suited for that purpose. The study of the rocks around this lake is very interesting, the well stratified character of the several members being well displayed.

The country between the Rouge and Nation rivers north of the township of Suffolk and Ponsonby, is practically unoccupied by settlers. The only information obtainable, therefore, is from the several chains of lakes which abound in the area and along the connecting streams. From a careful examination of all the places that are thus accessible it is evident that the calcareous members of the system are much less extensively developed in this direction. This would tend to confirm the view expressed for the Rouge district, that the limestones and associate gray gneiss were a more recent development in the basin-shaped depression of the Ottawa.

Country north of lac Simon.

North from Lac Simon, which has a length of not far from nine miles from north to south, with a maximum breadth of two and a half, and occupies the northern portion of the township of Hartwell, the Nation consists of two branches. On the east branch are Little and Big Whitefish, au Sable, Vert and Cache lakes; on the west branch are Long, Crooked, Zigzag, and des Iles lakes, while Big Bay lake, Lac des Sucreries, and several others are on the tributaries of this branch. The country around these lakes is generally rough and in places elevations from 400 to 600 feet above the lake levels are found, the rocks being for the most part a reddish foliated granite gneiss. Along the shores of these lakes small outcrops of limestones are occasionally seen which, however, are not traceable to any considerable distance on the line of their strike, while from the generally folded character of the rocks it would be extremely difficult to connect the exposures seen at the various points into a continuous extension of any one band, although they may and possibly do, represent the same band, reappearing from place to place through the agency of folds which are everywhere apparent.

Folded structure.

It has been usual to describe the structure of the crystalline rocks, north of the Ottawa, as having a general easterly dip. This view cannot now be maintained, since the examination of the entire area between the Rouge and Black rivers, shows a regular succession of folds, with well defined anticlinal and synclinal structure. The enormous thickness assigned to the gneiss of this area, in the report of H. G. Vennor,* is therefore misleading, since it was based on the assumption that these rocks over a long distance maintained a regular easterly dip.

*Report of Progress Geol. Surv., Can., 1876-77, pp. 299-300.

Big Whitefish lake, Nation chain.

On the Big Whitefish lake (Nation river)—(for it may here be remarked that in this district there are a number of lakes known locally by this name),—as well as on Little Whitefish lake, the only rocks seen were reddish and gray gneiss. The general strike of these is north. In places the rock is hornblendic and black. Two anticlinals are seen in the rocks around the shores of these lakes, and a short distance west of the big bay on the west side of the former, a large dyke of coarse black dioritic rock cuts across the gneiss. In places this has the aspect of a brecciated rock with angular pieces of black hornblende rock disseminated. The dyke extends for nearly half a mile, and is flanked on the north-west by black hornblende and gray gneiss, which continues up to the head of the lake.

Lake Doré.

A chain of smaller lakes extends for several miles north-and-south, following the strike of the rocks. This chain lies to the east of Little Whitefish lake, and to the north-east of Lac Simon, and from a mile to a mile and a half distant from the former. Through the centre of the chain, on several islands in Lake Doré, a narrow band of the limestone is seen underlain by rusty quartzose rock, which has a strike nearly north-and-south.

Green lake.

From the north end of Big Whitefish lake a portage along Green creek leads to Green lake, about one mile and a half distant. On this route three small lakes are crossed, on the second of which limestone occurs at the south-west angle, with rusty gneiss, dipping to the south-east, while on the small creek connecting this with the third lake, similar limestones are exposed, dipping nearly west $< 50°$. Thence to Green lake the rock is the underlying gneiss. At the entrance to this lake the dip is again reversed to S. 55° E. $< 15°$. The limestone in its lower portion holds the usual inclusions of twisted, rusty gneiss, so common in the Grenville series.

On the west shore of Green lake the limestone occurs in three well-defined bands separated by anticlinals in the quartzose dark-gray gneiss. The strike of the rocks varies from N.E. to N., the angle of the dip either way being from 20° to 50°. On the south end and east side of the lake two other synclinals were observed, with limestone separated in the same way by beds of gneiss. These limestone and gneiss bands could not be traced very far in either direction, owing to the nature of the country, but similar bands appear further north on a small chain of lakes lying to the east of Lac au Sable, and it is possible that the outcrops noted on the west side of Long Point lake in Minerve township, already described in the Rouge system, may repre-

sent their northward extension, as the strike of the several bands would carry them in this direction.

Lac des Sucreries.

By means of a chain of small lakes to the east of Green lake, we reach Lac des Sucreries, on which the section can be extended nearly to Cameron lake on the Maskinongé river. On one small lake midway, a small band of limestone was seen underlain by black and gray gneiss, in the vicinity of which was a large dyke of black or dark-gray diorite. On the several portages the rock, where exposed, was the usual black, reddish and gray gneiss. On the north side of Lac des Sucreries, quartzose gneiss underlies bands of black or very dark-gray siliceous limestone, the latter in bands from six to eight feet thick; the dip on the west side of the exposure being to the east at an angle of 40°, but on the eastern margin, this is reversed to S.E. $<30°$, where the rock becomes grayer in colour. The underlying rock here is a red orthoclase foliated gneiss. Going eastward the dip of the gneiss soon changes to E. $<20°$, beyond which, to the eastern end of the lake, the shores are drift-covered. Similar dark-coloured limestones are seen in two small islands near the centre of the lake on the northern side, and here the rocks are cut by dykes of hornblende and pyroxene.

Bands of crystalline limestone also appear on the south shore of this lake about midway, associated with the usual rusty quartzose gneiss. The nearest calcareous rocks to the south are the outcrops noted on Round lake in Addington, while to the north the nearest are those seen on the west shore of Maskinongé lake, in the township of Labelle.

East branch of the Nation river.

Ascending the east branch of the Nation, a portage leads to Lac au Sable. The shores are mostly occupied by gneiss of the usual varieties, but on the east side, north of the point near the mouth of a small creek which discharges the waters of a small chain of lakes from the east, dark-gray siliceous limestones occur along with black hornblendic gneiss. West of the inlet or Narrows, at the north end of the lake, limestone also occurs, associated with grayish quartzose gneiss, dip W. $<60°$. The upper end of Lac au Sable is in the western part of the township of Minerve. At the north-east angle of the lake low-lying ledges of limestone dip S. 70° W. $<35°$. But few ledges show along the shores of this lake, and where seen, with the above exception, are of grayish limestone, with rusty and black gneiss, the general strike being from N. to N. 10° W.

Lac au Sable

The stream entering the head of Lac au Sable is for the most part sluggish to Lac Croche, where it takes its rise. Several small lake-

expansions occur, but ledges are few, and such as are seen, with one exception, consist of gray or dark hornblende gneiss. On the second lake-expansion below Lac Croche, a small band of white crystalline limestone is associated with hornblende gneiss, but the outcrop is very limited.

Lac Croche. Around Lac Croche the only rocks seen are gneisses, red, grayish and quartzose. The strike is generally north and the dip is east $<40°$ to 80°.

Lac des Iles. From this lake a portage of about a mile in length, leads westward to Lac des Iles, which is at the head of the east fork of the west branch of the Nation. A small band of the limestone is seen on an island near the north-east corner of this lake, overlying fine-grained quartzose gneiss. The strike at this place is N. 25° W., the dip is west. An anticlinal in the dark-gray hornblende and garnetiferous gneiss is seen a short distance west of this outcrop. On the west side of the lake, half a mile below its northern end, is a deep bay in which the rocks are mostly fine-grained and quartzose. A heavy dyke of gray binary granite cuts the gneiss at this place but no limestone was observed, though a synclinal occurs in the gneiss. The islands with which the lake is dotted, are with the exception noted, all composed of gneiss. In places this is rusty and quartzose, but certain bands are garnetiferous. The strike is generally N. to N. 10° W. In the lake to the south, between this and Zigzag lake, a small band of limestone appears on the east shore, underlain by rusty gneiss and quartzite, and a second band occurs towards the south end of the lake near the portage to Zigzag lake, which occupies a well-defined synclinal. The limestone here is very rusty and disintegrates readily, forming a coarse calcareous sand.

Zigzag lake. Around the shore of Zigzag lake the only rocks seen are grayish and dark hornblende gneiss, in places much twisted and crumpled, presumably from the presence of intrusive dykes; but at the outlet of the lake, a short distance above Crooked lake a small band of limestone appears on the point. Similar calcareous rocks, in two bands, also show on the east shore of Crooked lake, south of the inlet of the Nation river, separated by well-defined anticlinals in grayish and rusty hornblende gneiss. The general strike of the rocks is north. Around the north shore of this lake, west of the inlet, several bands of the limestone occur in layers of four to five inches thick. The gneiss with which they are associated, is much disturbed and dykes of white binary granite, largely composed of felspar, are seen in the vicinity. The south shore of the lake shows occasional ledges of black, rusty and grayish gneiss.

Crooked lake.

Two branches of the west fork of the Nation are found in the vicinity of Crooked and Zigzag lakes. The most easterly discharges a lake several miles long containing numerous islands, and named Big Bay lake. It is situated on the western line of the township of Loranger, while on the westerly branch are lakes Sugar Bush, Long and several others, unnamed. On Big Bay lake, outcrops of limestone are seen both on the shores of the lake itself, and on several of the many islands near the centre and southern end. Several of these bands are coarse-grained, yellowish and dolomitic. They are associated with bands of black hornblende and quartzose gneiss, and dip uniformly to the north-west $< 45°$ to $50°$, but show at several points evidence of great disturbance and overturning of the strata. The gneiss bands are frequently garnetiferous, and masses of intrusive white granite are common. On several of the islands in the northern part of the lake a distinct anticlinal structure is seen in the gneiss; and occasionally the rocks are thrown into a series of crumplings and folds in which overturn dips are clearly visible. The east side of this lake is generally low, but ledges of grayish gneiss are seen at intervals, as also along the shores of a deep bay which extends to the eastward. Hills of reddish and gray orthoclase gneiss rise around the lake. From the south-west angle a series of portages and small lakes leads across to Long lake, the intervening rocks, where exposed, being all gneiss. Long lake is about five miles in length from north to south. The shores show numerous ledges of reddish-gray foliated gneiss, often coarse; but near the outlet at the southern end, leading to Sugar Bush lake a small band of yellowish dolomitic limestone appears, containing lumps of dark gneiss and pebbles of quartzite. A synclinal occurs at this place, the underlying rocks being rusty and hornblende gneiss.

Big Bay lake.

Long lake.

On Sugar Bush lake, which is reached by the creek from Long lake, the rocks are mostly gneiss. Indications of limestone are present in the rusty bands on the east shore, but no well-defined ledges are visible, except at the south end where the portage leads across to Crooked lake. On the north shore a heavy dyke of black rock (diorite) is exposed, which holds pieces of slaty-looking gray gneiss in the mass of the rock. The west shore of the lake shows occasional ledges of reddish quartzose gneiss and the usual folded aspect is seen at several points. At the south end the limestone is underlain by white quartzite. The general strike of the rocks on this lake is N. to N. 10° E. On the portage to Crooked lake, half a mile distant, the only rocks seen are red and gray gneiss. No limestone shows in this direction, but on the east side of Crooked lake two well defined areas are exposed along with the characteristic rusty gneiss.

Sugar Bush lake.

Lower Long lake.

Going south to the Lower Long lake on the Nation river, much drift is found along the connecting creek, but, in the northern narrow prolongation of the lake, the calcareous bands are infolded with the gneiss in such a manner as to clearly indicate an overturn of the strata. A well-defined anticlinal is seen on the west shore of the lake a short distance to the south of this place with a corresponding synclinal still further to the south, in which is a second band of limestone. Lower Long lake is about eight miles long from north to south. A considerable portion of the west shore is low and sandy, with occasional outcrops of the gneiss. At the point on the west side of the narrows at the south end, ledges of serpentinous and tremolitic limestone appear much twisted and broken up, owing doubtless to the intrusion of dykes in the vicinity. From this point a depression extends southward to the north-west angle of Lac Simon and occasional outcrops of limestone lead to the inference that the limestone outcrops seen at the upper end of that lake near Edward's dépôt, are continuous with those on Long lake.

Folded character of rocks.

On the east shore of Long lake limestone appears in three bands, so removed from each other, and separated by areas of reddish gneiss, as to make them three distinct bands or repetitions of the same by folding. The dips of the underlying gneiss would indicate the latter structure, although the strata are in places in a nearly horizontal attitude. Reverse dips are, however, readily seen in the underlying rocks, showing a folded structure at several points.

Extent of limestone bands.

In all this area between the Rouge and the Nation, though limestone bands are frequent, the endeavour to trace any of them to any distance continuously, was found to be impossible except in the area, near the Ottawa. In some cases this has been done for several miles where depressions would indicate that these have been caused by the decay of the softer calcareous rocks; but, under the most favourable conditions, little reliance could be placed on the finding of areas, separated by tracts of unbroken forest, and apparently upon the same strike in their presumed place on parallel lines of section. Even on the lake shore so many gaps occur in the rock outcrops, owing to sand deposits, that continuous sections can rarely be obtained; while in other places, through the presence of intrusive masses of granite and diorite, or the agency of faults, the continuity of strata over any considerable area is rarely found. From the frequently recurring changes of dip in the gneissic and calcareous strata, however, it is plainly seen that the entire series of rocks in this area is thrown into a number of recurring folds and that the successive bands of gneiss and limestone are repeated, sometimes at very frequent intervals.

NATION AND LIÈVRE RIVERS.

A great portion of the country between the Nation and the Lièvre rivers is much more inaccessible than that just described. Roads are confined almost entirely to the townships near the Ottawa, very rarely extending north more than twenty miles from that river, while it is not so readily accessible by canoes. The route traversed extended from near the centre of the west shore of Long lake by a portage of three miles along the south side of Simon creek in which distance two small bands of limestone were crossed about midway on the trail, and thence by following a small chain of lakes with several portages to Lac des Ours (Bear lake), which was reached at its southern angle. With the exception of the bands noted on the first portage no limestones were seen on this route. Around the shores of Bear lake the prevailing rock-masses were hornblendic reddish and gray gneisses. Large dykes and masses of white binary granite (pegmatite) show at intervals, more especially along the south-east portion of the lake. The general strike of the foliated gneiss is N. to N. 15° E. and the dip changes from east to west, several anticlinal folds being easily recognized.

Character of country.

Bear lake.

From Bear lake to the Lièvre river a canoe-route exists, either by descending Bear creek to its junction with the Lièvre river, in the southern part of the township of Wells, or by making a portage of a mile and a half near the intersection of the stream with the eastern line of the township into a chain of lakes, in which are included lakes Brochet, L'Aigle, Serpent, Corbeau, St. Germain and du Cerf (Stag lake), from the latter of which Stag creek reaches the Lièvre in the township of Dudley, about ten miles south of the Kiamika river, an important tributary from the east.

Along the course of Bear creek no ledges other than gneiss were seen with the exception of certain intrusive masses of whitish binary granite. At several points loose pieces of limestone were noticed and ledges of the same may exist, which are concealed along the stream by drift-sand and gravel. Shortly before reaching the township of Wells great ledges of gneiss cross the stream producing rapids and falls, the rock being almost as well bedded as the ordinary Potsdam sandstone, and these have the aspect of an altered quartzose sandstone, rather than of a quartzite, though a gneissic structure is apparent. Near the beginning of the portage to Brochet lake greenish pyroxenic rocks cross the stream. The general strike of the gneiss and quartzose rocks is N. 10° E. to N. In this part of the stream three well-defined anticlinals are seen.

Bear creek.

Brochet lake. On the portage to Brochet lake the surface is sandy and flat, only one outcrop of gneiss being observed near the crossing of the North branch. At the north end of the lake, near the outlet, grayish hornblende gneiss occurs with a band of limestone, the strike being north and the dip west. The shores of this lake are generally low and sandy.

Lac à l'Aigle. A portage of a third of a mile leads to Lac à L'Aigle on the east shore of which no ledges are seen, but on the west side reddish-gray and black gneiss comes to the shore with blocks of limestone on the beach, so that it is probable the band noted on Brochet lake continues northward under the water. Along either side, ranges of low gneissic hills rise to a height of 100 to 150 feet and extend in a north-easterly direction. A creek flows from this to Serpent lake, through generally low land, showing no ledges, but from scattered blocks of the limestone it is probable that this band continues along its course. The waters of Serpent lake are discharged into the Lièvre by Serpent creek. This stream was traversed by Mr. L. R. Ord, in 1877. It leaves the lake about midway on the west side, is about ten miles long and very crooked. The valley through which it flows is densely wooded and rock exposures are few. Mr. Ord in his notes says of it 'for the first three miles from the lake the rock consists of small exposures and fragments of limestone and dark-weathering gneiss, strike N. 35° E. and dip N. 55° W. $<40°$. Then the creek runs west of south for a mile and a half on the strike of dark gneiss, to a marshy lake; thence it curves north-west and for a mile crosses gneiss, when it again turns to the south of west and as far as McCabe's mill on the town line of McGill, a distance of about two miles, the rock is limestone with a north-west dip. For sixty chains below the mill the limestone appears at intervals and from this to its junction with the Lièvre the country is flat and sandy.'

Serpent lake and creek.

Notes by L. R. Ord.

Serpent lake. Returning to Serpent lake, the west shore from the southern end to the outlet, shows occasional ledges of reddish and gray gneiss with interstratified bands of quartzite, the strike of which is nearly north and south. These form low hills; but on the east side of the lake great hills of the red gneiss appear, and similar high hills rise to the west about one mile inland. A small band of limestone shows near the north end of the lake which is underlain by the usual gray and dark gneiss.

Lake Corbeau. A creek, half a mile long, leads thence into Lake Corbeau to the north. Here ledges of hornblende gneiss and limestone are seen in the small bay near the south-east end, dipping east at a low angle. Fifty yards further north red gneiss appears, underlying the limestone

dipping W. < 20°. Limestone also shows at the north end of the lake with the same dip and strike, and half a mile further north another exposure shows a dip to the east, <78°. This is underlain by the usual rusty gray gneiss.

The west side of the lake shows the presence of limestone associated with the gray gneiss the strike being N. 10° E. < 50° to 80°. On a small lake to the north-west of this, on the route to Stag lake, several small outcrops of limestone appear which may represent the extension of the bands seen on the west side of Lac Corbeau. Thence to Stag lake, crossing lake St. Germain, on which ledges of white granite cutting the red gneiss occur, the country in the immediate vicinity is low.

Stag lake (lac du Cerf) is about four miles in length from north to south, with a breadth of a mile to a mile and a half. Near the centre a small group of islands, not shown on the map occurs. Two long bays extend from the upper end of the lake to the north-east and north-west, and ranges of high hills of gneiss and granite rise both to the east and west. Stag lake.

The rocks on the south-east part of this lake are reddish and quartzose gneiss. These are cut by large masses of grayish granite. The red rocks extend along the east shore in a series of folds, the strike in this area being nearly east and west with dips to the north and south. About half a mile from the south east angle of the lake these are overlain by white crystalline limestone, containing scales of mica, and underlain by the usual rusty gneiss and quartzite. Thence rusty gneiss with a band of limestone extends eastward into a bay, the shores of which are composed of sand, often calcareous. On the islands near the centre of the lake the rocks are a mixture of garnetiferous gneiss, limestone and white granite, and similar rocks occupy the western shore of the lake as well. Rusty gneiss generally accompanies the limestone, and garnetiferous bands are common. Along the east shore similar rocks are seen, the strike changing to north, but the beds are often minutely crumpled as in those at Papineauville on the Ottawa, showing the disturbing action of the white granite, the series at the two places being identical. On the north side of the north-east arm, which is apparently underlain by the limestone, an anticlinal is seen in the rusty gneiss ; and between this and the outlet, which is on the north-west arm, the anticlinal structure is repeated and another band of limestone appears.

At the eastern entrance to this last bay, calcareous bands with quartzite strike north and dip east <70°. A small dyke of pyroxene is seen

Stag lake to the Lièvre river.

along with the granite, and bunches of limestone occur in the latter as if caught in the intrusive mass. From Stag lake a passage of 250 yards connects with Little Stag lake, the shores of the latter being almost entirely of limestone. An island towards the middle of the lake in the direction of the outlet is also formed of limestone. Gneiss however comes in at the south-west angle. The shores are generally low, and undulations in the gneiss and limestone are visible at several points. The country to the north and west becomes much less hilly indicating presumably the presence of much more extended areas of the calcareous rocks in this direction, though a somewhat extensive covering of sand and clay conceals the outcrops except at scattered intervals. This predominance of the limestone probably marks the eastern limit of the Lièvre basin, which has a breadth to the west of some miles and will be presently described. From Little Stag lake a stream empties into the Lièvre opposite a long island in the township of Dudley, and just below the junction with the Lièvre, ledges of yellowish dolomitic limestone are seen holding scales of graphite with bands of rusty gneiss which dip W. $<75°$. Near the lower end of this island garnetiferous gneiss dips E. $<80°$. A considerable ridge extends along the west bank of the river about 250 yards distant, but the immediate vicinity of the stream is low and occupied with drift-sand.

Little Stag lake.

The Lièvre river.

Before describing the distribution of the rocks along the course of the Lièvre, near the lower part of which some of the most important mineral deposits in the province of Quebec are situated, including apatite, mica and graphite, we may consider the structure as seen between the Nation and the Lièvre near the Ottawa.

Area between Nation and Lièvre rivers.

The district between the Nation and the Lièvre, near the Ottawa, embraces the townships of Buckingham, in part, Lochaber, Derry, near the Ottawa, Mulgrave and Lathberry, Ripon and Hartwell, and a portion of the seigneury of La Petite Nation and the Gore of Lochaber. The principal stream traversing the district is the Blanche, which enters the Ottawa about half a mile west of the village of Thurso. The three branches of this stream in the townships of Villeneuve, Lathbury and Mulgrave have chains of lakes, none of which are of large size, but by means of which the area in question can be readily traversed by canoes, while the portion near the Ottawa is intersected by numerous roads, so that the geological features can be readily ascertained.

Blanche river.

Roads north of Thurso.

Roads from Buckingham village and Thurso meet at St. Malachi and continue north to Blanche lake, a short distance north of the outlet of which it forks, the eastern route continuing across Mulgrave into

Ripon, where it joins the road from North Nation Mills to St. André Avelin, and thus affords a good section across the strike of the gneiss and limestone. The left-hand road continues north to Long lake, in the north-west part of Mulgrave township. A road also extends north-east from Thurso village, crossing the Sinsic river, and thence into the north-east portion of Lochaber. Thence dividing, the west fork reaches Heart lake on the east branch of the Blanche, while the other continues on to the road leading to St. André Avelin. Along these roads and around the shores of some of the lakes, bands of limestone are seen, some of which can be traced for short distances only, while others are continuous for some miles.

Limestone bands.

Among the most important of these is probably that which is recognized in the eastern part of Lochaber, appearing first on ranges V. and VI. This band, with a north-east direction, crosses the Gore of Lochaber and the western part of La Petite Nation to the Nation river, west of St. André Avelin, beyond which it is largely concealed by drift, through which, however, an occasional outcrop appears, by which its extension into the township of Suffolk can be recognized. Several well defined anticlinals are seen in connection with this area.

Thurso to Hartwell.

A second and still more extensive band can be traced almost continuously from Thurso village, where its southern terminus is concealed by the drift of the Ottawa valley, through the eastern part of Lochaber and Ripon, till it reaches the valley of the Nation river, to the south of Lac Simon, in Hartwell township; thence its distribution northward has already been described. The entire length of this band from Thurso to its northern extremity in Long lake of the Nation chain is not far from forty miles.

Lochaber township.

The roads which intersect the township of Lochaber show numerous outcrops of limestone. A somewhat extensive band appears near the Ottawa river at Rockland station, on the Canadian Pacific railway, interstratified with gray gneiss. This band on the road north of the station has a breadth of nearly a mile, its eastern margin being concealed by a mantle of clay. While continuous to the north the calcareous portion gradually decreases, and the underlying gray gneiss appears. Generally, however, the bands of limestone in Lochaber are of no great breadth but are repeated at frequent intervals in a series of folds, with many changes of dip, and anticlinals in the rusty and gray gneiss are seen. A somewhat important band emerges from beneath the clay covering near the line between Buckingham and Lochaber on range IV., and can be traced northeasterly to the village of St. Malachi, where, east of the post office, it has a breadth of nearly half a mile,

beyond which, to the north, it is probably continuous to Green lake on the east branch of the Blanche. Thence it passes to Heart lake and up the valley of the Sinsic brook, the course gradually changing more northerly, till it passes into the eastern part of the township of Lathbury. This band is well defined and has a breadth in eastern Mulgrave of nearly a mile.

Mulgrave band.

Branches of Blanche river.

Another important area is continuous from Buckingham village, where it is well exposed at the falls below the mills, with slight interruptions north-east, past St. Malachi, to the shores of Blanche lake. Here it divides, one arm crossing by the eastern shore of the lake where it becomes serpentinous and is associated with dykes of pyroxene and from this point extends up the middle branch; the other continues up the west branch through Gull, Hawk and Lady lakes, beyond which it has not been traced. This band is also associated with serpentine on Gull and Hawk lakes and attempts have been made to mine the small strings of asbestus (chrysotile) which occur in the serpentine both here and on Blanche lake. The quantity of the mineral is however too small to be of much economic importance. West of the bands just described, others occur to the north of Buckingham village, but these have not been traced to any considerable distance, owing to the difficulty of traversing the rough and comparatively unsettled township of Derry. A small band was also noted at the outlet of the chain of lakes from Echo Beach lake on the western branch of the Blanche, which also could not be traced owing to the drift.

Portland east.

Furthur west in the township of Portland East, a band of limestone is visible between Lake Tamo and Clay creek, which is exposed for a couple of miles. It extends north and south in the direction of the lake valley and may pass beneath its waters. The shores of Lake Tamo however are frequently sandy and rock exposures are few. The band continues northward into Clay lake.

The intermediate areas separating these calcareous bands, are for the most part occupied by grayish gneiss which, near the limestone, assumes the usual rusty character and becomes interstratified in thin bands. This gray gneiss, which is also quartzose, is associated in its lower part with dark hornblendic layers and these pass downward or rest upon the reddish members of the system. Intrusive masses of the white granite are frequent and among other places can be well seen on the road east of St. Malachi. Dykes of pyroxene rock are also more numerous than in the areas to the east, and mines of apatite and graphite have been opened at a number of places. On the whole

Pyroxene and apatite.

however it may be said, that the conditions favourable to the occurrence of apatite and mica over the greater part of the area just described are not so favorable as in that more closely bordering on the Lièvre where important mines of apatite are situated.

The gray and black gneiss of this area has a well marked stratified aspect, and there is apparently a regular passage upward into the calcareous portion. Other parts of the gneiss, notably the reddish members, are generally foliated only; but sometimes this is absent and the rock is a massive granite. Several dykes of a blackish green, generally fine-grained diabase rock traverse both the gneiss and the limestone in a generally east-and-west direction. These dykes are mostly narrow, often only a few inches in thickness while in places they have a breadth of several feet. They do not appear to be connected with any special mineral development where they cut the ordinary gneiss, but sometimes when found with the phosphate-bearing pyroxene, they are associated with developments of apatite. Diabase dykes.

THE LIÈVRE RIVER.

The Lièvre is a much larger and more important stream than those already described to the east. It has a length of not far from 250 miles from the chain of lakes at its source to its junction with the Ottawa river near Buckingham station on the Canadian Pacific railway, about twenty miles east of Ottawa city. It has been carefully examined for over one hundred miles north from its mouth or to the junction of the Tapanee, a branch from the west, from the head of which a portage connects with the Piscatosin lakes and river on the Gatineau waters. The upper part of the stream from Stag creek was examined by Mr. Ord in 1877. The lower portion of the river, in the townships of Buckingham and Portland, is especially well known since it traverses the great apatite-bearing district north of the Ottawa; and on its banks, or in close proximity, are situated the most productive mines of this mineral in the province. The Lièvre river.

The stream is generally easy to traverse, the current for long stretches being slow. Heavy rapids occur at intervals, but the principal descent in the stream is at the High falls, twenty-five miles from the mouth. This fall has a descent of about 130 feet. High falls.

In the lower part of the river, between the railway and Buckingham village, falls and rapids occur, the descent in the three miles being not far from 250 feet. The surface along this area is largely covered with Buckingham to High falls.

sand, the underlying rocks being mostly gneiss, with which, however, are associated small bands of limestone. Limestone also appears along the road down the west side of the river, about one mile below the bridge at the village, but owing to the covering of sand, its relations can not be readily seen. From the landing at the village the current is sluggish, and steamboats ascend to near the foot of the High falls, just above the northern line of the township of Portland. The Little rapid, which formerly interfered with the navigation of this part of the stream, is now overcome by a dam and lock. By the former the stretch of broken water about three miles below the Falls, known as the Long rapid, has also been obliterated.

Mining district east of the lower Lièvre river.

The country east of this portion of the Lièvre is very hilly and broken. About eight miles above the landing at the village of Buckingham, the celebrated mines known as the Emerald, the Squaw Hill and the Ætna are situated, while in the immediate vicinity of the Little rapids, are the London and the Little Rapids mines. About seven miles further up the river, the wharfs of the North Star mines are placed. The mines themselves are situated on lot 18, range VII., Portland east, on the summit of a high ridge, overlooking Lake Tamo, about three and a half miles east of the river. In this direction also are the Philadelphia Company's mines on lot 26, range VIII., the Chapleau mine, on lot 7, range VI., with several others of less importance, judging from the amount of development work performed. Near the landing of the North Star, in a bluff overlooking the village of Notre-Dame de la Salette, are the Salette mines, while two miles, further north is the landing from the Villeneuve mica mine. This mine is on lot 31, range I., Villeneuve, the distance by road from the landing being nearly five miles.

Mining areas west of the Lièvre.

On the west side the surface is much less rugged as far as Chalifoux's landing, opposite the wharfs of the North Star mine. At this place the succession of hills, on which are situated the Ross Mountain, High Rock, Crown Hill, Star Hill and Central Lake mines, and further north, the High Falls mine, come to the river. The distance of these from the river is from half a mile to a mile and a half. These hills rise from the stream to elevations of 500 to 700 feet, and in this range of hills are included the most productive apatite mines of the district.

The country-rock throughout this area is mostly a gray gneiss, the limestone rarely appearing. Along the river small outcrops mixed with rusty gray gneiss, show at the Narrows, about five miles north of the village of Buckingham. Limestone also occurs with the rusty gneiss in the village itself, and a band extends thence north-east,

which has already been referred to. Much of the river course in this part lies between clay banks, and rock exposures are few. North of the Little Rapids a small outcrop is seen on the bank near Salette village, the extension of which cannot be traced owing to the deposits of clay.

Pyroxenes and intrusive rocks.

In addition to the gneiss which is so largely developed throughout this area, great masses of pyroxene appear in the vicinity of all the mines. These, with binary granite (pegmatite) and diorite, form a great part of the hill on which the Emerald and Ætna mines are located, the gneiss in contact being generally rusty and having a shattered aspect as if from the action of intrusive masses.

The same may be said of the hill ranges at the other mines, the intricate admixture of the granite, pyroxene and gray gneiss being everywhere apparent throughout the entire mining area.

Rocks about High falls.

The gneiss at the head of the High falls strikes N. 15° E., but at the great bend above the falls this changes to N. 10° W. the dip being E. $<70°$. Intrusions of pyroxene and white granite are seen in the vicinity and on the hills to the south-west, and small deposits of mica and apatite occur. At the brook flowing from Bowman lake a fourth of a mile above the fall, a considerable band of limestone is seen with a breadth across the strike of nearly half a mile, or to near the shore of the lake, where it is underlain by gray and rusty gneiss. A little further west, on the west side of Bowman lake, the High Falls mine is situated on the east side of a ridge of gneiss and pyroxene.

The Lièvre above High falls.

The band of limestone just mentioned probably extends southward along a depression to Central lake about one mile distant, where it shows in a narrow outcrop. But northward it appears along the river on both sides and is much mixed with the gneiss especially in the lower part of the band. At the mouth of the stream from Scalier lake two miles further north, a similar band appears, but the strike is here nearly east-and-west and just at the mouth of the stream the usual rusty gneiss shows in underlying ledges on the south side of the river. The deflection in the strike at this place is doubtless due to the intrusions of granite in the vicinity, since similar variations are seen in connection with the rocks at all the mines in the pyroxene belt.

Steamboat route.

From the mouth of Scalier creek to Bear creek in the township of Wells, the banks are often of clay and sand; the current is sluggish and a steamboat traverses the river to the foot of Pine rapid, nearly fifteen miles from the High falls. Hills of grayish and reddish gneiss rise on either side. Several thin bands of limestone are seen in this

distance, associated with rusty gneiss the thickness of the calcareous members ranging from eight to twelve feet where exposed. About two miles below the Ox Bow, which is near the north line of Villeneuve township, a twelve foot band of the limestone in gray gneiss is twisted and overturned in a wonderful manner, showing well the enormous disturbance to which these rocks have been subjected, but no calcareous areas of any considerable extent are seen along this portion of the river.

Terraces.

Between Bear creek and Pine rapid, limestone outcrops are seen at two points, the most conspicuous being about one mile below the latter place, where on the east bank of the stream nine bands, in thickness from five to ten feet, are separated by bands of grayish rusty gneiss, the gneiss being in about the same proportion. Beautiful examples of terraces in the sand and gravel are seen along this part of the river, as many as three being easily recognized.

Rapide des Pins.

The Rapide des Pins (Pine rapid) is near the center of the west boundary of Wells, and consists of a heavy rapid ending in a fall of eight to ten feet, over limestone interstratified with and underlaid by gray rusty gneiss. The dip at the lower end is N. 50° E. $<40°$. A short distance above this is the Rapide Croche, also over limestone in which are large inclusions of black gneiss, the strike being north and the dip east and west in a syncline. Between this and Lac des Sables two other rapids are passed, viz., the Cedars and the Iroquois. Calcareous strata are frequently associated with the usual gray gneiss which also underlies the limestone, and from the diverging dips shows an anticline in the lower beds. It is evident along this portion of the Lièvre that these calcareous bands are in part at least repeated by folding having a general strike of N. 10° W. to N. 10° E.

Lac des Sables.

About three-fourths of a mile below Lac des Sables a band of limestone thirty-five feet wide crosses the stream, dipping S. 10° E. 70°. Near the junction of the creek from Big Whitefish lake the calcareous strata are greatly crumpled and a large dyke of black hornblende diorite comes to the river from the south. This is in the south-west angle of the township of McGill. The limestone here has a breadth of several hundred yards and is probably the extension northward of a large area seen on the lake to the south. Furthur north similar limestones again come in, and are separated from the last by an anticline in the gneiss, and these extend in a series of outcrops to near the Iroquois rapid a fourth of a mile below the mouth of Serpent creek.

Just below the lake expansion in the northern part of Bigelow, micaceous limestone and rusty gneiss again appear, the latter forming an anticline with the limestone on either side.

Lac des Sables is about three miles long from north to south and one to two miles wide. The eastern side is bounded a short distance back from the shore by high ridges of reddish gneiss. The shore shows one small exposure of impure limestone, the rocks being mostly hornblendic, quartzose and garnetiferous gneiss. The strike is N. W. the dip S. W. $<80°$. On the west-side there are two bays of which the most southerly as well as the point between the two, is composed of garnetiferous and dark gneiss with a strike N. 60° E. At the head of the south bay this is overlain by a band of limestone with an exposed thickness of fifty yards, and having a strike nearly at right angles to that on the east side of the lake. A lofty ridge of granite-gneiss extends along the south-west side of the lake, and no limestone appears in this direction. Lac des Sables.

The north shore of the lake is mostly sand, and from the extremity of the north-west bay a portage extends westward to Thirty-one Mile lake on the Gatineau waters, by way of Lac au Foin.

Above Lake des Sables the banks of the Lièvre show no ledges for several miles, but about three-fourths of a mile below Babiche rapid, which is half a mile north of the line between the townships of Wabassee and McGill, occasional ledges of black and gray gneiss appear, and at the rapids themselves bands of twisted gneiss and limestone occupy the bed of the stream. An opening has been made along the portage in grayish gneiss for graphite, scales of which are thickly disseminated through the rock. A dam has been built across the river at this place with the object of making the upper part of the river navigable for steamboats, but the force of the current has cut away the east bank so as to render the work at present useless. The strike of the rock at this place is north. Graphite of Babiche rapid.

From Babiche rapid to the foot of Long island or to the mouth of Stag creek where our section from the Nation reached this river, the rocks seen are mostly limestone. The strike is generally north-and-south but this is sometimes deflected by the presence of masses of granite. In the lake-expansion in the southern part of the township of Dudley, alternations of limestone and rusty gneiss occur along with masses of white granite, and at the foot of Long island a ridge of garnetiferous gneiss, with rusty and quartzose bands, rises on the east bank and has a dip of S. 80° E. $< 80°$. Babiche rapid to Long island.

Mr. L. R. Ord on the upper Lièvre.

The upper part of the Lièvre was traversed in 1877 by Mr. L. R. Ord, and from his notes it would appear that along the upper portion of this section the same alternations of gneiss and limestone extend for many miles. Mr. Ord says: 'the main channel is on the west side of Long island which is flat and sandy. From one mile above the foot to the head of the west channel, a band of limestone runs along the shore and on the east shore a band of dark-weathering gneiss dips south-east. From the head of Long island to the Wabassee farm about three and a half miles, all the visible exposures are small bands of limestone on the west bank which appear to strike with the river course, and a band of white-weathering gneiss leaves the river at the head of the island and keeps off to the east to the Wabassee farm, where it strikes N. 15° E. and dips east. A mile to the east of this at Big Wabassee rapid, limestone and gneiss occur in fragments, and from this to the mouth of the Kiamika, where the river bends north again, the country is level and largely drift-covered with occasional outcrops of dark-weathering massive gneiss. For a mile above the Kiamika, small outcrops of gneiss are seen along the Lièvre, and thence to the Red farm the river is broad, shallow and full of sand bars, the country flat and without exposures, presenting a considerable area of good farming land. One mile above the Red farm a small exposure of limestone is seen at the Devils rapid. This is nearly vertical and filled with lumps of rusty gneiss and with scattered grains of graphite and chondrodite, and has a general strike of N. 20° W.

'From this place to the L'Orignal rapid, about eleven miles, the land is low, flat and sandy, with good soil and covered with hardwood timber. This belt of good land apparently extends for a considerable distance on either side of the river, and the rocks seen are small exposures of limestone and dark-weathering gneiss.

L'Orignal rapid.

'At L'Orignal rapid a band of rusty gneiss and limestone, with pyroxene and mica, strikes N. E. and dips N. W. 50°, and from this to Mountain farm, fifteen miles above, the rocks are dark-weathering gneiss and limestone, nearly always occurring together in small exposures, with a general strike of N. 20° E. and a dip to the west. The country in the vicinity of the river is nearly all flat, and the land is good and well timbered with hardwood.

Mountain farm to Rapide des Cèdres.

'From Mountain farm to Rapide des Cèdres, fourteen miles further north, the river is broken by frequent rapids, the rocks seen being principally gneiss boulders. At this point a band of limestone, about forty to fifty chains wide, strikes across the river and dips S. W. $<45°$ to 90°, holding mica, pyroxene and graphite and scattered lumps

of orthoclase and pyroxenic rock. The band is covered over largely by sand and the full extent cannot be seen. North of this to the Chaudière rapid, two miles distant, sand drift prevails. At this place ledges of red massive granite-gneiss, showing but small trace of foliation, appear, but with a general strike of north-west and a south-west dip $<45°$. One mile and a half north of this at the mouth of the Tapanee, a branch from the west, a small band of limestone is exposed.' This point marks the northern limit of Mr. Ord's exploration on this stream.

Although this portion of the river is beyond the limit of the map-sheet in question, the information concerning it is of importance as helping to explain the structure of the crystalline rocks in this northern area, and it has therefore been included in the scope of this report. From Mr. Ord's notes it is clear that the great stretch of comparatively level and drift-covered country, recognized on the upper portion of the Rouge and the Nation, extends westward to this area and that the development of limestone, so well seen nearer the Ottawa here almost disappears.

THE AREA BETWEEN THE LIÈVRE AND THE GATINEAU.

Route between the Lièvre and Gatineau rivers.

Between the Lièvre and the Gatineau several routes exist, along which the structure of the limestones and underlying associated gneises can be well studied. Of these the most southerly, north of the area intersected by roads, is by way of the Big Whitefish, Pemichangan and Thirty-one Mile lakes. This route presents, probably the best opportunity for the study of the rocks owing to the great extent of shore-line and rock sections exposed. The portages are mostly short and easy.

Portage routes to Whitefish lake.

From the Lièvre, Big Whitefish lake is reached either by Whitefish creek, half a mile long to the lower end of the lake, in the south-west corner of the township of McGill, or by a chain of lakes, connected by portages, the first of which leaves the river just below the sharp bend on lot 30, range II., Bowman, about five miles above High falls. The extension of the Portland apatite belt is seen in this direction, the mineral occurring on lots 30 and 31, range II., and 32 and 33, range III. The rocks seen on this portage to Rat lake and thence to Rouge lake, the next in the chain, are all gneiss and granite, with the exception of a small outcrop of limestone, coarse and crumbling, on the east shore of Rat lake. Masses of white granite, composed largely of felspar, are seen both on this and on Rouge lake, and on the latter two

Rat and Rouge lakes.

small exposures of the limestone appear along with quartzose rusty gray gneiss. On the north side of the lake the rocks are all gray and quartzose and dip S. 70° W. <75°. Indications of limestone are visible also in a belt of twisted calcareous gneiss which flanks the granite-gneiss of the hills to the north of this lake, from which and from the general synclinal structure it would appear that a calcareous band enters through the depression at the south-east angle.

Lac Croche.

A portage of a fourth of a mile leads to Lac Croche. Here two small bands of limestone are seen along with the usual rusty beds, and on the west shore the rock is gray and quartzose and strikes north with a dip to the east. On a small island the limestone and gneiss are cut by dykes of pyroxene and granite, and occasional pieces of the former are found in the pyroxene.

The north and east shores of this lake show several bands of limestone, separated by areas of gneiss, and dykes of white granite are frequent. No minerals of economic importance were noted in their vicinity, though small crystals of mica and scales of graphite were observed. Hills of gneiss surround the lake, but are thickly wooded. The portage from this to Whitefish lake is by a route from the south-west angle to a small lake, whence a carry of a mile over a ridge of red gneiss leads to the south-east corner of the lake.

Whitefish lake.

Whitefish lake has a length of about twelve miles from south to north, with a maximum breadth of nearly three. Near the centre of the lake a narrow neck of sand, underlain by limestone, extends from the east side and connects with a prominent ridge of gneiss and limestone which nearly divides the lake into two parts. The southern and larger portion contains a number of islands, the largest of which is two miles in length and is high and rocky. The northern part of the lake is narrow, but widens out near the lower end and there holds a number of islands. It discharges into the Lièvre river by a creek half a mile in length, flowing over limestone.

Road from Poltimore.

This lake is also reached from the south by a rough road leading from the village of Poltimore, through the southern part of the township of Bowman by way of Priests creek, to its southern end. Along this part of the lake the rocks are a mixture of grayish gneiss and limestone which have been cut by large masses of white granite and pyroxene. Near the south-west angle of the lake a deposit of mica in one of these pyroxene masses has been opened by a company from Ottawa, and a small quantity of the mineral extracted and shipped by way of the Lièvre to Buckingham. A portage leads from the west

Mica mine of Whitefish lake.

shore from a point opposite the Big island on lot 20, range XI., Hincks township, through a chain of lakes to the south-east corner of Pemichangan lake.

The eastern shore of Whitefish lake, at the south-east angle, is occupied by gneissic and calcareous rocks, the former often very quartzose, and the whole is penetrated by masses of white granite. Limestone and grayish gneiss, with occasional garnetiferous and reddish areas, show all along the eastern shore of the lake, similar in character to the rocks described along the course of the Lièvre. These are often much broken up, and intrusive masses of white granite are numerous. There are several series of opposing dips to the east and west, showing a folded structure, and the areas of limestone are much more numerous than in the portion between the Nation and the Lièvre rivers. Of the islands situated in this portion of the lake, the greater part are of reddish and gray gneiss, in places highly garnetiferous. Occasionally limestone bands occur, flanking anticlinals in the underlying rocks, and dyke-like masses of the white granite are common. The limestone bands are not traceable to any considerable distance, owing to sudden changes in the strike due to the numerous intrusions which divert the strata from their usual strike of N. 10° E., either through the agency of faults of greater or less extent, or through the thinning out of the beds in either direction.

Folded structure.

The west side of the lake along the southern half is for the most part occupied by limestone, from the northern line of the township of Hincks. These developments of the calcareous members of the system, on either side of the lake, appear to occupy synclinals, separated by the broad area of reddish gneiss which extends through the central portion. In these synclinals however, several subordinate folds are seen.

North of the bar and headland which divides the waters of the lake into two portions, the breadth is much less, the shores being from a half mile to a mile apart. The west shore, for several miles, is composed of highly garnetiferous gneiss often quartzose, in which a well-defined anticlinal structure is apparent, and the strike is nearly north-and-south. The northern extension of the limestone bands from the east side appears on the west shore resting on the east flank of the gneiss anticlinal to the west bay in the northern portion of the lake, and from this point to the outlet at Whitefish creek calcareous rocks for the most part occupy the west shore, showing however several minor undulations in which the underlying gneiss appears.

North end of Whitefish lake.

The eastern shore of the northern half of the lake is mostly gneiss. The presence at several points in the lake, both at the north and south ends, of intrusive areas of white granite is recognized, but with the exception of the pyroxene mass at the south end in which the mica deposit is situated the extensive mineral belt of the Lièvre district does not appear in this direction.

Portage route to Pemichangan lake.

The portage west from this lake to Pemichangan lake passes through several others, the principal of which are Bangatt and Green lakes. On a small lake just before reaching the latter, on lots 15 and 16 range XI. and XII., Hincks, rusty gneiss is seen on the east side and limestone on the west, as also at the outlet leading to Green lake half a mile distant. The rocks throughout this area are mostly limestone occurring in synclinals with separating areas of gray and rusty gneiss and with numerous masses of the white binary granite. Occasional bands of the reddish-gray underlying gneiss appear but the rocks as a whole represent the upper member of the system, rather than the lower or Fundamental Gneiss. The strike of the rocks throughout this section is north, but this is often changed through the agency of the granite intrusions.

Bangatt lake.

The western shore of Bangatt lake shows but little limestone, the rocks being gray gneiss and granite, but at the north end the limestone appears on both shores and extends northward into the valley of the creek which discharges this lake into Pemichangan. High hills of reddish gneiss rise on either side and an anticlinal structure is visible at several points.

Pemichangan lake.

Pemichangan lake lies to the south of Thirty-one Mile lake or Grand lake as it is also called, and is situated in the township of Blake. It is separated from the latter by a ridge of limestone across which there is a portage of ten chains. The outlines of Pemichangan lake are very irregular, long bays extending in different directions, and several islands occupy the centre, one of which has a length of nearly two miles. This lake discharges into Thirty-one Mile lake by a creek from the north-east angle.

Thirty-one Mile lake.

About the shores of this lake and of Thirty-one Mile lake to the north the usual arrangement of the upper gneiss and limestone is seen. The areas of the latter increase to the west, the Lièvre forming the eastern limit of the great Gatineau basin, but the usual strike of north to N. 10° E. prevails. The strata are thrown into a series of folds, the anticlines in the underlying gneiss being well displayed, and at times there is an intimate infolding of the two series, showing the strata to

be in places overturned. Intrusions of the white granite (pegmatite) are frequent and are especially well seen in connection with the limestone. At the point near the north end of Pemichangan lake on the east side, on lots 16 and 17, range VII., Blake, an intrusive mass of pyroxene and dark diorite is seen in which a small opening has been made for mica and apatite, but the quantity of these minerals seems to be small. Large areas along the shores on either side are occupied by limestone which strikes generally with the course of the lake, and a chain of islands extends at intervals throughout the entire length, showing gneiss on which the limestone rests on either side. The regular succession of the various strata throughout this area is strongly suggestive of their sedimentary origin. Many of the limestone bands in the synclinals are only a few yards in breadth, while others are exposed across their strike for nearly half a mile.

Up to this point, therefore, in our section west, it will be seen that the reddish gneiss is much more prominently developed than in the area to the east, and that the limestone and associated gneiss, where exposed, generally occupies synclinals in the former.

Portage route to Thirty-one Mile lake from Lac des Sables

The second portage from the Lièvre, from Lac des Sables, already referred to, shows a similar structure. This route was traversed by Mr. Ord, who says of it in his notes, 'the track from the north-west angle of the north bay in the latter lake runs in a north-west direction for about 100 chains to Hay lake. The surface is low and drift-covered and only one outcrop of gray gneiss is visible. On Hay lake a small outcrop of limestone is seen on the south side along with a little pyroxene. To the west a portage of half a mile leads to Lake Cochon on which also there is a small band of limestone having the usual north-east strike, and from this lake another portage nearly west for two miles leads to a small bay on the east side of Thirty-one Mile lake, a short distance north of the line of Blake township. On this portage a band of limestone occurs about midway, the debris on either side being reddish and gray gneiss. The lake band of limestone is met with about ten chains before reaching the east shore.'

Portage from Thirty-one Mile lake to Gatineau river.

From the west side of Thirty-one Mile lake a portage of three-fourths of a mile leads to Round lake at about lot 30, range VII., Cameron township, and passes over limestone with two small bands of reddish gneiss. Limestone occupies the greater part of this lake, as well as the islands in the centre, separated by outcrops of gneiss. The outlet from this lake is a creek about fifty yards in length, connecting with Rat lake, and the limestone extends all along and also occupies the eastern portion of the latter lake, which is divided into two parts con-

nected by a small narrow passage; but the west shore of the second portion is nearly all reddish granite-gneiss. Thence, to the creek discharging into the Gatineau, gneiss is seen all the way, and forms a broad area, but limestone again comes in on the lower part of the creek and continues to the Gatineau, a distance of half a mile. A belt of coarsely crystalline limestone shows on the Gatineau at the point where the creek from this chain of lakes joins it, and a rapid renders a short carry necessary. This point is about ten miles below the village of Désert, which is at the mouth of the Désert river.

The Gatineau river.

Descending the Gatineau much of the shore on either side is occupied by sand and clay deposits. The country is much more level than to the east, due to the greater superficial extent of the calcareous rocks, but occasional ridges of gneiss rise to elevations of several hundred feet. The soil in this direction seems to be well suited for agriculture, and the crops of wheat, oats and potatoes are excellent. A good carriage road, with a line of telegraph, extends along the river from the Ottawa to the Désert, and settlements continue northward for some miles further.

Six Portages.

At the bend of the river half a mile below the outcrop at the mouth of the creek just noted, rusty gneiss and quartzite show on the east bank. These are overlain a short distance down by limestones which dip east 55°. At the Six Portages post-office the gneiss also underlies the limestone on the west bank of the river, the strike varying from N. 40° W. to north, while the dip is east. Limestone also appears at the village of St. Gabriel, one mile further down, on the west bank of the stream, and from this down to the mouth of Bittobee creek occassional exposures of gneiss and limestone appear above the usual covering of sand and clay.

Portage routes from Bittobee creek.

At the mouth of the Bittobee which enters from the south, the Gatineau turns sharply to the west for about six miles, when it again bends to the south and flows through the townships of Wright and Aylwin. There is a road to Thirty-one Mile lake from the mouth of the creek and also a canoe route south by way of the creek and lakes Bittobee, Victoria and Little Whitefish and thence by a creek south to the Gatineau by which the great bend to the west can be avoided. The principal rocks on this route are limestone with separating anticlinals in the underlying gneiss.

Bittobee lake.

On the first of these lakes (Bittobee) the limestone appears on both the east and west shores, separated by an anticlinal in the gneiss, the opposing dips being east and west at angles of 65° and 75°. A second

anticline is seen on the west side of the lake in red and gray gneiss and masses of white granite and dykes of pyroxene occur in the limestone. A small deposit of mica has been opened at this place in connection with one of the dykes. Mica deposits.

Passing by a narrow channel into Victoria or Bass lake the shores are of reddish garnetiferous gneiss, strike, N. 10° E. dip E. $<70°$. No limestone is seen on this lake. From the south end a portage of a third of a mile reaches Little Whitefish lake over a low ridge of limestone which forms the height of land at this point. Around the shores of this lake especially at the north end and on the west side outcrops of limestone are frequent in several bands separated by anticlines in the gneiss. The strike is constant, a little east of north, except where this is broken through the agency of granite intrusions. The rocks on the east shore are mostly rusty grayish gneiss. The discharge from this lake is south to the Gatineau by a creek along which the rocks are mostly limestone with granite. Victoria lake.

About midway on the east side a portage leads across to the Pemichangan about one mile and a half distant, passing over a high ridge of rusty gray gneiss and along a lake on the shores of which limestone is again exposed in a syncline. From the south-east angle of Bass or Victoria lake a portage also leads to Rat lake about twenty chains distant, over gneiss but meets the limestone before reaching the lake, whence the calcareous band continues along its south shore and crosses the lake in lot 30, range IV., Northfield. The strike of the gneiss and limestone here is N. 30° E. These bands are apparently the continuation of those seen on the lakes to the south. The gneiss of Victoria lake extends across and occupies the greater portion of the north-west shore of Rat lake or to the extension of the limestone bands on the south side. Portage route to Pemichangan lake.

From the frequency with which these limestone bands are repeated along the shores of the numerous lakes to the east of the Gatineau, and from the prevailing gray and rusty character of the gneiss throughout the area, it would appear that the upper or Grenville portion is most largely represented in this direction. The massive development of the underlying foliated gneiss, seen along the Rouge and the country to the west of that stream, does not so largely appear in this direction, and there is a greater development of the newer intrusives such as white granite, pyroxene, &c., but there are also areas of red gneissic-granite which are undoubtedly newer than the Grenville series, and which present certain features common to the Fundamental Gneiss. Numerous limestone bands.

The Gatineau below Bittobee creek.

From the forks of the Bittobee west, the Gatineau flows between drift-covered banks, and exposures of rock along the stream are few. About two miles below the forks, a heavy rapid, necessitating a portage of 10 chains occurs, over limestone and rusty gneiss, and a syncline is seen in the latter a short distance below the rapid. The underlying rocks on either side are of the same gray gneiss. To the north of this place on lots 14, 15, range D, Wright, several deposits of mica occur, one of which on lot 15, is of interest. It is in a vein of calcite associated with dark-green pyroxene and granite, the sides of the vein near the contact being thickly studded with mica crystals, some of which are of good size and of fine quality, though many of the crystals are affected by cracks and grains of calcite. The quantity of the crystals is however very great. The country rock in the vicinity is a grayish quartzose gneiss which forms a considerable ridge at this place. This mine has been recently worked extensively.

The St. Antoine mica mine.

Outcrops of limestone and granite with rusty gneiss also occur near the village of Gracefield in the township of Wright, at the point where the river bends again to the south, the dip being east $<40°$. These continue down the river to Aylwin while masses of reddish granite occur at intervals. Below Aylwin a small opening for mica has been made in a band of limestone, cut by a mass of white granite, but the crystals are small. On lot 22, range II., Hincks, about two miles east of Aylwin village, an important mica mine is situated. This is located in a pyroxene dyke which cuts the great belt of limestone and which is in turn cut by a dyke of granite. The mica here is very dark-coloured but the crystals are of large size and comparatively free from fracture. A large quantity of the mineral has been removed from this place.

Hincks mica mine.

Gatineau river, Aylwin to Paugan falls.

Below Aylwin for some miles the river is very rough, being broken by numerous heavy rapids and falls which necessitate frequent portages. The rocks along either side of the river are mostly limestone, though bands of gneiss occur at intervals, and masses of white weathering granite are frequent. No minerals of economic importance were observed on this part of the stream, but occasionally the rock is serpentinized and small veins of chrysotile were noticed. The stretch of broken water continues down to Paugan falls near the village of Low, and from this point down to the village of Wakefield (La Pêche) the current is smooth and the passage easy. Occasional ledges of limestone show along the stream and hills of reddish gneiss and granite rise on either side, but are more conspicuous to the east.

From Low station south, the section was continued along the line of the Gatineau Valley railway. North of this point, while many cuttings have been made the greater part of these are in blue clay and rock exposures are few. Southward the limestone is seen both along the river and the railway as well as in numerous ledges to the west, the strike generally being north, the dip varying from east to west. Hills of gneiss and granite rise at intervals, but a well-defined area in which limestone is abundant extends all along the valley of the Gatineau from about a mile above the village of Wakefield, having a breadth of several miles in the townships of Low, Aylwin and Cawood. This area will be again referred to. Low to Wakefield.

The red granite comes in about a mile north of Wakefield village, and forms a large area to the south and west. Thence to the vicinity of Chelsea this is the principal rock seen along the railway. Much of this rock is clearly more recent than the limestone and associated gray gneiss with which it is associated, since it cuts both these in every direction. Both at the Cascades and between there, and Kirks Ferry, the pyroxenic rocks have a large development and important mines of mica have been worked for years. A short distance below Kirks Ferry a heavy band of limestone extends to the Gatineau from the direction of Old Chelsea, which lies in a syncline in the gray gneiss. Most of the cuttings on the railway north of Chelsea station are in sand, clay and gravel in one of which, about half a mile north of the station there is a deposit of marine shells. Thence to the junction with the Canadian Pacific railway near Hull, the country is occupied by heavy deposits of marine clay and no ledges are visible on the railway section. Mica mine below Wakefield. Marine shells near Chelsea.

THE UPPER GATINEAU.

The upper part of the Gatineau and several of its principal tributaries to the west, among which are the Désert and the Eagle with their connecting chains of lakes, as well as the Gens de Terre, further north, were examined by Mr. Ord in 1877. On the east side of the river he also examined the Baskatong creek and lake and thence continuing northward ascended the Piscatosin river and lake, whence by a portage, the Tapanee river, a branch of the Lièvre was reached, and a traverse made to the junction with the latter already mentioned. The upper Gatineau. Mr. L.R. Ord, explorations.

As a result of Mr. Ord's work we have now a very good knowledge of the character of the country in this direction, and as having a bearing on the structure to the south it is thought desirable to incorporate

the information thus obtained, though the greater part of the area lies beyond the limit of the map-sheet.

Désert and Eagle rivers.

Of the Désert, and its branch the Eagle, and of the country drained by these streams, Mr. Ord in his notes says: 'The Eagle empties into the Désert about fifteen miles from the junction with the Gatineau on lot 24 range VII., township of Egan. It flows from the west of south, draining several lakes in the townships of Church and adjacent townships in the county of Pontiac, and is narrow, shallow and swift. The country through which it flows appears to consist chiefly of sandy plains with occasional outcrops of dark-weathering gneiss. But few exposures of limestone are seen and these are of small extent. Of these the first is a fourth of a mile from the forks with the Désert, where, it is associated with rusty gray gneiss. A second band occurs a couple of miles furthur up stream having the same associations. The limestone here has a pink tinge and contains mica and pyroxene. For the next three miles the river is rough, flowing over boulders and occasional ledges of dark-gray gneiss, and with one small band of limestone at the end of that distance, beyond which to the junction of Hibou creek, the country is occupied mostly by drift with occasional outcrops of gneiss. One mile south of the Hibou and a fourth of a mile east of the Eagle a small band of pinkish limestone with pyroxene was seen.

Hibou creek.

'Hibou creek flows into the Eagle from the north-west. It is a small stream and for the first mile and a half is almost a continuous rapid, the river flowing across the strike of dark-weathering reddish gneiss. At this point known as the Eagle farm and about thirty chains south of the Hibou and twenty chains west of the township line of Church, there is a band of flesh-coloured limestone with crystals of apatite, mica and pyroxene, which has a north strike and dips east. The outcrop is small and the band is associated with a small exposure of gneiss, most of the country being drift-covered. From this to Pytongo lake, the river is a succession of small ponds with indications of gneiss, the adjoining country showing but few ledges.

Pytongo lake.

'Pytongo lake is a triangular-shaped sheet of water about four miles in length. It lies in a flat sandy plain with occasional mountains of dark-weathering gneiss. From this a portage route is followed through small lakes with short carries, over a sandy plain with gneiss hills to Désert lake. The rocks around Désert and Round lakes to the north appear to be all gneiss which underlies the sandy plain in this direction. In the Narrows between the two lakes a single fragment of limestone with scales of graphite was seen. Round lake discharges into the Désert which thence flows in a north-easterly

Désert and Round lakes.

direction over gneiss, till it takes its long course to the south. The country then becomes drift-covered with small exposures of limestone and occasional outcrops of gneiss to within a mile and a half of the Eagle, where on lot 35, range IV., township of Egan, a band of limestone dips east < 45° and rests upon white, red and black-weathering gneiss.

'Below this to Désert village on the Gatineau, the rock outcrops consist of small exposures of limestone only. The large band of gneiss seen at the Désert church, crosses the Gatineau to the east bank, along which it continues to the Oiseau rapids, two miles and a half above the Désert, the west shore being occupied by the limestone. At this point the gneiss recrosses the stream. It strikes north and dips east < 45°, and continues along the river to Joseph creek and portage, about lot 25, range A, and lots 23 to 28, range B, township of Aumond, where it turns off to the westward and the river flows over limestone as far as the Big Eddy portage on lot 7, range I., Sicotte. At this place the limestone also leaves the river and bends off to the west, and thence up to the Brulé portage on lot 19, Sicotte, the rocks along the river are red and gray-weathering gneiss. The Gatineau above Désert village.

Continuing up the Gatineau river, Mr. Ord further states, that at 'Mountain portage, lot 21, range I., township of Sicotte or two miles further north, a band of gneiss, which is presumably the same as that last noted, appears between two bands of limestone; the rocks are much crumpled and contorted with a local strike of W., dip S. < 30°. From this to lot 29, range I., Sicotte, one mile and a half distant, the river flows through drift banks, and just below the latter a band of dark and rusty-weathering gneiss occurs on the east shore striking N. 10° E. and dipping E. < 45°. This is associated on the west with a band of pink and white limestone, containing pyroxene and mica, with lumps of orthoclase, like the limestone at Mountain portage. Mountain portage.

'This band of gneiss is overlain by another band of limestone and crosses the river to the left bank again at the Reculon portage, about fifteen chains north. It again recrosses at the sharp bend of the stream about lot 48, range I., Sicotte, at the Bittobee chute, with a strike a few degrees east of north. From this the river continues on gneiss for two miles, when the gneiss is overlain by a band of limestone which dips S. E. < 35°, whence to the Elbow, about lot 10, range A, Baskatong, the river crosses the strike of the gneiss. About thirty chains east of the Elbow, a narrow band of the limestone overlies the gneiss with a strike of N. 20° E. Reculon portage.

'From the Elbow to the Gens de Terre, the river flows through a flat, sandy country, with but few small rock-exposures. Above this

stream the same character of country continues, a small band of limestone being exposed in a small rapid, close to the forks of Baskatong creek, which enters from the east.

The Gens de Terre river.

'The Gens de Terre is a small stream emptying a chain of lakes to the north-west. It falls into the Gatineau at the line between concessions IV. and V., Baskatong. For a distance of twenty miles up this stream, to the Lépine farm, the country is flat and sandy. Four small rapids over gneiss occur in the first eleven miles from the Gatineau. At the Lépine farm the hills of gneiss begin to rise, and from this point the country is said to be very rocky.

Baskatong creek.

'Baskatong creek empties into the Gatineau from the east at lot 41, range VI., Baskatong, about one mile north of the Gens de Terre. It flows through a flat, sandy plain, and at a high stage of water in the Gatineau the current sets up stream into Baskatong lake, three miles distant. This lake has a length from north-east to south-west of four miles and a half by about three miles in breadth. At the south-east corner a bay extends for two miles further. There are but two islands in the lake, both of dark-weathering gneiss, and gneissic rocks occupy the shores of the lake on the west side with the exception of a point on lots 1 and 2, range IX., Baskatong, where a band of limestone occurs, holding black mica and green pyroxene.

Piscatosin river.

'The Piscatosin river enters this lake at its north-east angle. From this point southward the shore shows occasional ledges of dark-weathering gneiss, though considerable areas are flat, sandy and heavily timbered.

'The Piscatosin river is very crooked, flowing through a generally flat and sandy country, which shows but few ledges. Three bands of limestone occur between Baskatong and Piscatosin lakes, separated by bands of gneiss, the first of which is about one mile and a half from Baskatong lake, the second two miles further up stream, and the third one mile from the exit of the stream from Piscatosin lake. This latter sheet of water is five and a half miles in length, with an average breadth of about sixty chains. It has two bays running east, separated by a narrow point of land. The first exposures seen on this lake are on an island about forty chains north-east of the outlet, and consist of limestone with mica and pyroxene dipping N. $< 60°$. The associated rock is a dark hornblende gneiss. The limestone also appears on the west end of the point between the two bays, as also at the west end of the lake opposite. The shores of the long bay in the north-west corner of the lake, show dark-weathering gneiss, having a north-east strike, nearly vertical.

'From this lake, going northward, a stream fifty chains long, expands into Cocknagog lake, the prevailing rock being gneiss, with a small exposure of limestone near the outlet. Thence to the north-east the route continues along a chain of small lakes, expansions of the creek, with short connecting streams, for some miles. The country is generally level and sandy, with occasional outcrops of dark-weathering gneiss. Small areas of limestone are seen at two places, but owing to the topography of the country not being depicted correctly on any map, it is impossible to lay these down with any approach to accuracy. The limited areas exposed, however, as compared with that of the gneiss, tend to show that the calcareous rocks have very considerably decreased in volume in this section of the province, which is just north of the line between the counties of Ottawa and Montcalm. Cocknagog lake.

'From the head waters of this stream a portage of about 100 chains over the height of land, leads to Lake Tapanee. The rocks along the portage consist of gneiss, like that just described. This lake is five miles in length from north to south, with a bay extending to the east. Ledges of gneiss show at intervals around its shores with a general strike of east and west and a north dip $<70°$, and from its south end the Tapanee river flows through a generally flat country, with but few exposures, for nine miles, till it joins the Lièvre at the point indicated in the sketch of that river. The rocks seen on the lower part of the Tapanee are reddish and dark-gray gneiss, which dips N.W. Route to Lièvre by Tapanee river.

From the above description of this area by Mr. Ord, it would appear that the pyroxenic-bearing belt is but slightly developed in this direction, and that there is a very considerable extent of arable land, possessing, however, much of the sandy character seen about the upper portions of the Rouge and all the rivers westward. In ordinarily moist seasons these sandy soils produce excellent crops, both of cereals and roots, and the long established farms in connection with the several lumbering companies which operate in this district, have shown conclusively its productive character. The country, as a whole, is much less rugged than that within the first forty miles north of the Ottawa. Along the Gatineau, however, with the exception of the range of townships on either side, the surveys of the lakes and rivers with which the whole area is intersected are of the rudest kind, and of great portions of the country, it may be said, that there is nothing absolutely known as to the mineral conditions there present, except what may be inferred from the geological structure of the portions adjacent, which have already been examined and described. Character of country.

HULL, BUCKINGHAM AND WAKEFIELD DISTRICT.

Hull, Buckingham and Wakefield area.

The townships bordering upon the north side of the Ottawa, between the Lièvre and the Gatineau rivers, have, from their convenience of access, and from their great mineral wealth, been more thoroughly studied than any others throughout the area. Of these, Templeton, Buckingham, the eastern part of Hull, Wakefield and Portland West, are particularly worthy of mention in this respect. In this area are situated the most important mines of apatite, graphite and mica yet discovered in Canada. Throughout their extent the same general development of limestone and gneiss of the Grenville series is seen, the latter predominating. Very considerable masses of clearly intrusive rocks occur, in the form of pyroxene, granite and greenstone, while several dykes of diabase rocks are also found. The settlements are, for the most part, confined to the river ranges near the Ottawa, though along the Gatineau and the Lièvre, these extend further north.

Important mines.

While outcrops of calcareous rocks are comparatively frequent it has been found very difficult at many points in this area to trace most of these to any great distance owing to various causes. Considerable areas are largely drift-covered, and throughout this portion of the Ottawa district there is a greater predominance of the igneous rocks which have exercised a marked influence on the regular distribution of the gneiss and limestone. It is doubtless to this development of the intrusives that the district owes much of its mineral importance.

Limestone bands.

In the eastern part of the township of Wakefield a well-defined band of limestone occurs, having its southern exposed limit in the township of Hull, where it is concealed by the clay covering. It can be traced north-easterly through the Wakefield lakes and the western part of Portland West, into the township of Bowman. It reaches the Lièvre at the High falls and thence extends for some miles up the course of that stream as already noted. Near the south-west angle of Bowman the band divides, the western arm following up the valley of Priest creek and lake, and thence by a chain of small lakes, on each of which it can be recognized, to the western side of the Big Whitefish lake in Hincks township. The separation of this band and its many deflections appear to be due to a large area of reddish granite, and large masses of pyroxene and greenstone occur in the vicinity near Priests lake and creek, where also important deposits of apatite are situated.

Anticlines.

A similar structure as regards anticlines in the gneiss is seen in this area to that which has been described throughout the districts to the

east and north. The limestone in its lower portion is interstratified with thin bands of rusty quartzose gneiss which gradually increase in thickness.

Buckingham and Templeton.

In the southern part of the townships of Buckingham and Templeton adjacent, the roads extend east and west along the concession lines and thus afford sections across the strike. Large deposits of clay and sand cover much of the surface to a distance of three to four miles north of the Ottawa river. Alternations of limestone and gneiss show along the road west from Buckingham to Donaldson lake on ranges IV. and V., as well as around the shores of the latter, but west of this to the road from Templeton village to Perkins Mill the calcareous rocks are rarely exposed and stratified gneiss with masses of reddish newer granite, often foliated, appears to be the prevailing rock. In this direction also, dykes of pyroxene rock, often of large size, cut the stratified gneiss at all angles to its strike and several valuable deposits of apatite are found associated with these, as at the MacIntosh and McRae mines. Along the valley of the Little Blanche, more particularly in the vicinity of Perkins Mill, limestone bands are seen. These are associated with serpentine which appears to be an altered condition of the pyroxene, rather than of the limestone, as the line of separation between the limestone and serpentine is strongly marked, and in the latter numerous small veins of chrysotile are developed. This area has been quite extensively worked, but most of the mineral is too short in fibre to be available for spinning, and the quantity too small, as compared with the great deposits in the Eastern Townships, to be worked with profit. The principal area operated in this direction is on lot 11, range VII., Templeton, about a fourth of a mile east of the main road near Perkins Mill. Similar serpentinous deposits occur a short distance south of the road west of Perkins Mill toward Letourneau lake.

Asbestus mine near Perkins Mill.

Templeton and Portlan townships.

Around the shores of McGregor lake and along the chain of lakes to the north, comprising Big, Mountain, Portage, McArthur, Wakefield and several others in their immediate vicinity, the limestone bands are well exposed, but are often irregular, being frequently broken up by granite and diorite masses. They are however repeated at various points, both to the north and east, and several important mines of both apatite and mica are located around the shores of these lakes. In the township of Hull, however, there is a marked deflection in the strike of the gneiss and limestone along the east side of the Gatineau, due it would seem to the pyroxene and granite masses to the east, in which the Hull apatite and mica deposits are situated. Beyond these mines, however the strike of the strata in the south part of the town-

ship of Wakefield, along the river, resumes to a large extent, except where affected by local causes, its regular course of a few degrees east of north.

Hull and Wakefield.

In the townships of Hull and Wakefield, several well-defined bands of limestone can be recognized. The southern portion of the former township is largely clay-covered, and the first outcrop of the calcareous rocks is seen near the crossing of the Gatineau river at Wrights bridge. This band, which has a breadth of half a mile, can be traced north-easterly into Templeton township where it is interstratified with bands of rusty gneiss in its lower portion. A second band crosses the road to Wilsons Corner near the forks of the road on lot 6, range X., and pursues a course parallel to that just described. This is probably the continuation of that seen at the Forsythe iron mines on the west side of the Gatineau about two miles north-west of Ironsides. Yet another band crosses the river south of Kirks Ferry whence it continues south-westerly through Old Chelsea to the back road leading from Hull to Kingsmere, beyond which to the west the country towards the Ottawa river is covered by clay or by the rocks of the Palæozoic formations.

Cantley.

Northward from Kirks Ferry this band, after crossing the Gatineau continues north-easterly and crosses the road to Wilsons Corner near the Cantley post-office. Half a mile north of this another band comes in, and continues along the valley of Blackburn creek. This band is largely drift-covered.

Wakefield Cove, near Wilsons Corner.

Approaching Wilsons Corner large outcrops of crystalline limestone appear just to the north of the road along the line between the townships of Hull and Wakefield. This area is apparently split up into several bands, one of which with a north-east course follows the road to Pélissier's post-office and thence to Wakefield lake whence its extension to the north-west part of Portland West has already been indicated. In the northern part of this band the celebrated Wakefield cave is situated on lot 20, range II., Wakefield. From Wilsons Corner another band continues up the valley of the creek for more than a mile and then is cut off.

Limestone bands in Wakefield.

On the road west from Wilsons Corner to the Gatineau, a considerable band is exposed on lots 14 and 15, range I., Wakefield. It has a course to the west of north and has been followed south into range XV., Hull, beyond which its extension in that direction is doubtful. To the north-west it appears to continue along the course of Wilson creek and has a breadth of over one mile on lots 6, 7, 8 and 9, range

III., Wakefield, whence it continues to the north as far as range X., on Daly creek, beyond which it has not been followed. A band from the west of the Gatineau, crossing the river near Copelands Ferry, about two miles below La Pêche village, meets this area on lots 6 and 7, range III., the separating mass of rock being principally a red granite-gneiss; and another band enters the township of Wakefield from the south on lot 6, range I., which probably is also continuous to the band first described.

The St. Germain lakes.

Much of the interior of Wakefield township is practically unexplored except along the chains of lakes. Very few roads exist and with the exception of the St. Germain lakes at the head of the west branch of the Little Blanche river, access is very difficult. This chain which includes St. Germain, Marble, Dam, Clear and Newcombe lakes was carefully examined. A small band of limestone was observed at the south-east extremity of the first of these and at several points along the shore, but on all the others the principal rocks seen were reddish granite-gneiss and this rock apparently occupies a large portion of the township. Further north along the valley of the Gatineau river on the east side, exposures of limestone are very frequent, representing the eastern margin of the great Gatineau basin, and the exposed breadth in this area is not far from six miles. A northward prolongation of this area extends up the valley of Whitefish creek past Lake St. Mary to the Little Whitefish lake already described, while other portions are probably continuous north-easterly to the southern part of Lake Pemichangan. The portion of the township of Hincks and Denholm, lying between this area and Priests creek is apparently for the most part occupied by granite rocks.

The preceding descriptions refer principally to the distribution of the various bands of limestone and associated gneiss throughout the area pertaining to map-sheet, No. 121, and to that portion directly adjacent to the north. The structure of this portion is of especial interest, since it was upon the study of the rocks in the counties of Argenteuil and eastern Ottawa that the original views as to the structure and relations of the several members of the Laurentian were based. The area is also of special interest from the fact that we have here displayed not only the several divisions of the Grenville series, including the crystalline limestone and associated gray and rusty gneiss and quartzite, but also what was formerly regarded as the typical red dish and reddish-gray and hornblendic divisions included in the Fundamental or Ottawa gneiss. From the facts as to the structure of the two series just presented, it is evident that the rocks of the Grenville

Grenville series newer than the Fundamental gneiss.

series are decidedly newer than those of the Fundamental division. As for the numerous and often large areas of red granite-gneiss, many of these undoubtedly are of more recent date than either of the others, since they clearly cut both the gneiss and limestone. While in some points the newer granite-gneiss presents features similar to the Fundamental division, as in the foliation of certain portions, there is, over large areas, a marked difference in their aspects in the field. As regards the relative ages of the other intrusive or igneous rocks, such as the pyroxenes, greenstones and diabases it may be said that the first-named often cut the crystalline limestone, and is in turn cut by the binary-granites, which are generally light-coloured and composed largely of quartz and white felspar; while certain dykes, generally of small size but continuous for long distances, of dark-green diabase or trap are still more recent and cut all the preceding members.

Intrusive rocks.

Work of Prof. A. Osann.

Of these igneous rocks it may be said that they include many varieties, the details of which have recently been worked out under the microscope by Professor A. Osann, of Mülhausen, who spent several weeks in the area north of the Ottawa in 1899, and whose report is appended.

SEDIMENTARY DEPOSITS IN THE OTTAWA VALLEY.

Palæozoic formations of the Ottawa valley.

Between the limestones and associated gneisses of the Grenville series which, along the lower Ottawa at least we may regard as representing the newest members of the crystalline rocks, with the exception of the later eruptives, and the lowest member of the Palæozoic formations there appears to be a great geological break. Thus, if we regard the rocks of the Grenville series, and its equivalent, the Hastings series, which is found largely developed in the country south and west of the Ottawa river, as representing the lowest portion of the Huronian system, we find that the upper portion of that system, as seen in western Ontario, and also all the divisions of the great Cambrian system, have not been deposited in the Ottawa basin.

Potsdam sandstone the lowest.

Throughout the whole of the basin of the Ottawa and upper St. Lawrence rivers, the lowest member of the fossiliferous sediments yet seen is the Potsdam sandstone, which is now regarded in Canada as forming the lowest division of the Cambro-Silurian system. This division forms the base of the series along the lower Ottawa, as far west as the foot of the Chats falls, but has not yet been fully recognized at points further west. Above this place the lowest rocks of this series yet recognized belong to the Calciferous formation.

At a number of points throughout this district the basal beds of the Potsdam sandstone formation consist of a conglomerate, sometimes very coarse, and made up of pieces of the underlying gneiss and sandstone in a sandy and sometimes slightly calcareous paste. This rock fills up the inequalities in the old Archæan floor. As we reach the upper Ottawa, the lowest beds resting upon the gneiss belong to yet higher portions of the series, so that on the islands in the northern portion of Lake Temiscaming, the basal fossiliferous strata belong to the horizon of the Niagara formation. Arkose beds.

In many portions along the lower part of the Ottawa river the succession of strata from the base of the Potsdam sandstone to the Medina is unbroken, and the several formations succeed each other in regular order. At several points, however, the whole series has been broken by faults, so that the geological structure is occasionally very complicated. Succession of formations.

As a rule, however, the Palæozoic strata lie in a nearly horizontal attitude, or are disposed in somewhat shallow basins. Well-defined anticlines are seen throughout the area between the Ottawa and St. Lawrence rivers, but the inclination of the beds rarely exceeds five degrees, though occasionally this reaches an angle of nearly twenty. Near the faults, however, the inclination of the strata is sometimes as high as eighty degrees. Horizontal character.

The fossiliferous sediments along the lower Ottawa have evidently been deposited in an estuary of the old valley of that river, which must have been well-defined at an early date and shortly after the deposition of the Grenville series. The northern limit of the Palæozoic sea is defined by the bold series of hills, which extend along the north side of the Ottawa from Ottawa city to St. Jérôme, situated to the north-west of Montreal, whilst the southern and western limit is indicated roughly by the areas of crystalline rocks, the eastern boundary of which can be followed from Arnprior to the city of Brockville, on the St. Lawrence river. These newer formations must, however, at one time have had a much wider extension than we find at the present time, since over a large area of the crystalline rocks to the west, scattered outliers of fossiliferous sediments occur as limestones of Black River and Trenton age, and also of Utica shales, throughout the upper part of the Ottawa basin reaching an elevation of nearly 800 feet above present sea-level. Boundaries of the Palæozoic rocks.

Formations described.

The formations south of the Ottawa which are found in the accompanying map-sheet may be thus enumerated.

Utica shale.

Trenton limestone.

Black River limestone.

Chazy limestone and shale.

Calciferous dolomite.

Potsdam sandstone.

Lorraine and Medina.

In addition to these the Lorraine shale and sandstone are found in the area a little south of the present map limit, and certain outliers of red shales which rest upon the latter have been located and are assigned to the Medina formation.

Faults.

While as a rule these formations are in a nearly horizontal attitude or lie in shallow basins with low converging dips, at certain points they are intersected by heavy faults which have affected the strata over considerable distances. As these have exercised an important bearing on the distribution of several of the formations a short description of some of the more important may first be given.

Of these probably the most extensive is that recognized to the west of Rigaud mountain, which is an eruptive mass on the south side of Lake of Two Mountains already referred to.

Rigaud and Gloucester fault.

A reference to this fault and anticlinal will be found in the Geology of Canada, 1863, page 116, in which it is said to traverse the country south of the Ottawa river to a point some distance above Ottawa city. In places the dislocation of the strata is considerable, but sometimes the disturbance assumes rather the form of an anticline. This fault has quite recently been traced out in more detail and in the area immediately west of the mountain mass has affected the strata from the the Potsdam to the Trenton limestone in a marked degree.

Fault west of Ste. Anne de Prescott.

In the southern part of the township of Hawkesbury east, and a short distance west of the village of Ste. Anne de Prescott, limestones of Black River age are seen in the bed of the Rivière à la Graisse. They here dip to the south-west at an angle of about 10 degrees. Along the roads south of this place the Potsdam sandstone appears in nearly horizontal strata, so that the position of the line of dislocation is fairly well located. Much of the surface is covered with heavy beds of clay or sand and exact contacts are rarely seen.

To the south of this the Potsdam forms a prominent feature and is overlain southward by the Calciferous in regular order. Approaching the line of the Canada Atlantic railway at Glen Robertson the latter is seen at Glen Sandfield with a low dip to the south-west, beyond which there is an interval of clay with some Chazy drift which presumably indicates the presence of this formation beneath, since a short distance north of Glen Robertson heavy beds, representing the upper portion of the Black River formation are well exposed and in this outcrop several large quarries are located. Formations north of Glen Robertson.

The fault thus indicated has a direction nearly north-west, and the strata of the Trenton, Black River and Chazy on either side appears to have been displaced by a horizontal thrust in that direction for nearly nine miles. Displacement.

The extension of this line of disturbance into Russell, does not pertain to this area, but another line of fracture is seen a short distance east of the village of Rockland which has a direction to the south-east and probably meets that just referred to in the eastern part of Clarence township. By this, the formations from the Calciferous to the Trenton are broken across and displaced horizontally for nearly four miles. Furthur east along the lower part of the South Nation river there is also a sharp anticlinal fold in the Chazy and Black River formations and possibly a fault also, by which the limestones of the latter formation are thrown back to the north-west for about two miles. Rockland fault. Nation river anticline.

Nearer Ottawa and about two miles west of Greens creek another line of fracture is recognized which throws the strata of several formations from the Chazy to the Utica to the south for nearly forty chains. West of this again numerous breaks are seen but these pertain to the geology of the adjoining sheet to the south. Greens creek fault.

POTSDAM SANDSTONE.

Reference has already been made to the occurrence of the rocks of this formation in the area north of the Ottawa in a preceding chapter. In this direction the sandstones are the continuation of those which have been described in the south-west sheet (Montreal sheet) of the Eastern Townships series. They form a continuous belt to the south of the Archæan between the line of the Canadian Pacific railway from Grenville to Lachute, or rather from the line of the North river which flows between St. Jérôme and Lachute along the south flank of a ridge of crystalline rocks. They are well seen in a ridge and escarpment Potsdam sandstone. Lachute to St. Jérôme.

east of Lachute where they have a dip to the south of about four degrees, and are soon capped conformably by dolomites of Calciferous age.

St. Andrews mountain.

South of this between the Potsdam ridge and the Ottawa the surface is largely drift-covered, but is probably occupied by Calciferous sediments. The prominent ridge of granite east of St. Andrews possibly cuts, as in the case at Rigaud mountain, the Calciferous dolomites in which case it may be regarded as a recent intrusion.

Lake of Two Mountains.

On the north shore of the Ottawa below the mouth of the North river the sandstone again appears, but is here inclined towards the river away from the slope of the mountain at angles of 10° to 20°. Below this on the north shore the rocks are concealed by drift, but on the south side of the Lake of Two Mountains beginning above the mouth of the Rivière à la Graisse, and extending eastward towards Hudson, Potsdam sandstones are well exposed at intervals, and probably occupy most of this area near the river.

Rigaud village.

Their contact with the overlying Calciferous is seen near the railway bridge in Rigaud village where the dip of the latter is south-east at an angle of nearly 5° or directly towards the mountain which rises on the east bank of this river.

Outcrops in Alfred township.

West of this place along the Ottawa the Potsdam sandstone is recognized at but few points. It is seen near Lefaivre's wharf and on the road south of this place overlying the crystalline limestone of the Alfred outlier, and west of this place, it comes in on the shore a short distance above the ferry road opposite Montebello, where it is exposed for several hundred yards with a north-west dip at a low angle and is overlain by the Calciferous further west. On the north side of the river it is seen on a point about two miles east of Papineauville where there is a quarry in the sandstone and the strata here dip south at an angle of 4°. The sandstones at this place show the presence of the peculiar tracks which have been described from the sandstones of Beauharnois in the Geology of Canada, 1863, pages 103-106.

Quarry east of Papineauville.

Rockland mills.

Still further west, at Rockland mills, the lowest beds of this formation consist of coarse arkose or conglomerates made up of the debris of the underlying gneiss and limestone. This soon passes up into the characteristic sandstone which forms a low escarpment a short distance from the shore on the road leading from the wharf to the village, the dip being to the south-east at an angle of about 4°. This is in turn capped by or passes directly into the dolomites of Calciferous age.

These rocks do not again show on the south side of the Ottawa river within the limits of the map-sheet, but on the north side they rest upon the southern edge of the crystalline rocks at several points, notably on the Lièvre river near the railway crossing near Buckingham station and thence westward to the mouth of Wabassee creek which is about three miles east of Gatineau Point. At Buckingham the lowest beds are also conglomerate which fills hollows in the Archæan floor, but west of this, between the Lièvre and L'Ange Gardien station, the white sandstones are seen to the north of the railway in broad ledges till they are capped by the clay terrace. Buckingham.

West of Templeton station these rocks show on the branch line of railway leading down to Templeton wharf where they rest upon the gneiss about 700 yards south of the Canadian Pacific railway with a dip to the south and south-east of four degrees. They here form part of the escarpment which keeps to the south of the Canadian Pacific as far as the mouth of Wabassee creek when they disappear beneath the clay flat. Templeton.

The characters of the sandstone are well given in a section contained in the Geology of Canada, 1863, page 112, near Rigaud village. The section comprises a thickness of forty feet which represents the upper portion of the formation and the transition beds to the Calciferous dolomite. In this the lower thirty-three feet consist of interstratified beds of sandstone, sometimes calcareous but occasionally hard and vitreous with Scolithus markings, the upper member holding *Helicotoma* and *Murchisonia*. The upper seven feet consist of reddish gray magnesian limestone of the type common to the Calciferous over large areas. Rigaud section.

Fossils are rarely found in the Potsdam sandstone. With the exception of the markings styled *Protichnites* and other allied forms the only other form yet recognized is the peculiar fossil known as *Scolithus*. At the contact with the Calciferous, in what are known as the transition beds, a number of shells have been found which have been described in different reports. These occur in a rock which is partly siliceous and partly calcareous. The fossils are often silicified and by the weathering out of the calcareous portion are made prominent on the surface of the strata. Fossils.

CALCIFEROUS FORMATION.

The rocks of this formation are largely dolomitic in character. The upper beds as they approach the Chazy become shaly and the limestones are in thin beds. As a rule the strata are in a nearly horizontal Calciferous formation.

attitude but are thrown into low anticlines. The outlines of the formation closely follow those given for the Potsdam sandstone, but occasionally the latter are wanting and the Calciferous then rests upon the crystalline rocks.

In their distribution these rocks lie for the most part in close proximity to the Ottawa river. The most extensive development appears to be in the area south of the North river and between that stream and the Ottawa, where they have a breadth of several miles. They are well seen at Lachute near Wilson's paper mills in the west part of the village, in broad ledges, and also to the south of the Potsdam escarpment east of that place. In the direction of Grenville they are rarely exposed owing to the great extent of sand in this direction, but along the Ottawa between Grenville and Carillon they appear at intervals from beneath the Chazy shale.

Lachute.

Pointe au Chêne.

Further west they are exposed along the road west of Pointe au Chêne station on the Canadian Pacific railway. They here rest directly upon the rocks of the Grenville series, so that the Potsdam sandstone has not been deposited or has been cut out by a fault, no indications of which are visible.

Papineauville.

The country along the shore of the river west of this place is composed of clay. Between Montebello and Papineauville the dolomites are exposed on a small island about two miles east of the latter place where they dip south at an angle of 4°, and rest upon the Potsdam sandstone which is seen in the quarry near this place.

Black bay.

Above the mouth of the Nation river, along the shores of Black bay they occur in broad ledges with a low dip of 4° to 5° towards the river, and extend from this place to the village of Thurso where they are seen in a low escarpment on the road from the village to the wharf. They also show along the road east of Thurso where the road turns north along the line of the Gore of Lochaber, forming a narrow margin on the crystalline rocks north of the Ottawa for several miles.

East Templeton.

The most westerly outcrops of this formation in the map-sheet under discussion are about three miles east of Gatineau Point on the road from Wabassee creek to East Templeton where they show in broad ledges dipping with a low inclination towards the river and resting on the Potsdam of the Templeton escarpment. They are also seen on the road west of the Lièvre on the brow of the hill, but are soon concealed by sand at this place, but it would appear that the formation extends in a somewhat broad belt from the Lièvre to the mouth of the Gatineau river.

On the south side of the Ottawa they are exposed on the shore at Cumberland wharf, and extend inland for about 200 paces till they are overlapped by the Chazy shales. East of this they again come into view in the west part of the village of Rockland, near the road which turns south to Stewart's quarry. They occupy a large portion of the village, and are well exposed at intervals to the east limit where they are terminated by a fault which cuts all the formations upward to the Trenton. They here rest upon the Potsdam escarpment seen near the mills and are overlaid by the Chazy shales to the south. Cumberland and Rockland.

Their next appearance eastward is a short distance east of the South Nation river, where they appear along the road leading to Brown's wharf, and also on the shore overlying the Potsdam, already referred to near the Montebello ferry. They next come into view a short distance east of Hawkesbury, along the river, where they form the base of the Chazy, the area being traversed by several small faults. Near the mouth of the Little Rideau river, they have a breadth of about 200 yards and form the south side of the Ottawa here for some distance. Alternations of Calciferous and Chazy strata show along both shores of the river, thence east to Point Fortune and Carillon, the outlines of the formation being somewhat sinuous and the strata affected by faults of small extent. At the last-named place the dolomites are exposed along the shore at low water and dip south at low angles. Road west of Brown's wharf. Hawkesbury to Point Fortune.

Near Rigaud mountain their presence has already been referred to. Above the village they show in the Rivière à la Graisse in low ledges for a fourth of a mile till they are concealed by clay, but on this stream, about three miles west, they appear in large ledges with a dip to the south-west at an angle of 5°, showing the extension of the formation over a considerable area west of Rigaud mountain. Rivière à la Graisse.

It is probable that the Calciferous constitutes the greater part of the area to the south of Rigaud mountain, extending to the St. Lawrence and occupying the north side of that river from the Cèdres west to River Beaudette. The dolomites form a belt several miles in breadth lying to the west of Rigaud mountain, bounded on the north by the line of the great fault which brings against its outcrop on the north the Chazy, Black River and Trenton limestones successively across the southern part of the township of Hawkesbury east. West of this these rocks have not been recognized till the eastern extension of the great mass of the Rideau area is reached in the townships of Osgoode and Winchester. Country south of Rigaud mountain.

CHAZY FORMATION.

The Chazy formation.

This formation has been divided into two parts, the lower embracing the shales and sandstones, the upper the limestones. There are about twenty feet of transition beds in the middle of the formation, where the limestones become interstratified with the shaly portion.

Grenville canal.

The shales have not yet been recognized on the north side of the Ottawa, east of the Gatineau, except along the portion between Grenville and Carillon. In this area the Grenville canal is cut in the sandy and shaly beds for its entire distance, and at Greeces Point, a short distance below the lower entrance to the canal, the contact between the Chazy and the underlying Calciferous can be well seen. Here the dolomitic usually buff-weathering limestones of the latter, are overlain by several feet of a fine conglomerate or coarse grit, resembling in some respects certain beds of the Sillery sandstone. These coarse grits soon graduate upward into greenish shales and sandstone, with thin partings of dark limestone, which represent the lowest division of the Chazy. On the south side of the Ottawa, these shales south of the Little Rideau pass up into the limestones in which several quarries are located, notably that owned by Mr. Robert Ross. Nearer Carillon the contact between the Chazy and Calciferous is seen on the road along the north side of the Ottawa, about one mile west of the village, where there is an abrupt fold in the measures and a fault is also indicated.

Little Rideau.

Hawkesbury.

The shales of the lower part of the formation are well exposed about Hawkesbury and on the roads east and south. Cuttings are seen on the line of the railway to Glen Robertson near the small pond about half a mile south of the former village; and on the southern part of lot 10, near the line between ranges II. and III., outcrops of Chazy limestone occur to the west of the road leading to Vankleek Hill which are filled with the shells of *Rhynconella plena*. The country thence south to the road between St. Eugène and Vankleek Hill is largely drift-covered and outcrops are rare.

L'Orignal.

On the shore of the river between Hawkesbury and L'Orignal the shales are well exposed for several miles. South of the latter village they are also seen along the road to Cassburn, but a fault with a direction to the north-west crosses this road about one mile and a half south of L'Orignal and cuts out the Chazy limestone and a large part of the Black River formation, the upper beds of the latter being tilted to the south-west at an angle of 65° to 80° while the Trenton to the south has a dip of only 5°.

The Chazy limestones also appear along the road in East Hawkesbury between ranges IV. and V., and are well seen on a road south west from Barb post-office between lots 22 and 23. They here contain fossils and have a low southerly dip. Similar rocks show along the road to St. Eugène. East of Vankleek Hill.

West of L'Orignal the country is largely clay-covered for several miles. About three miles from the village several rock outcrops appear along the south side of the river road and in these a number of quarries are located. Some of these are in rocks of Black River and Trenton age, and the presence of the fault which was noted on the road south of L'Orignal is recognized in the tilted attitude of some of the strata. Outcrops of Chazy shales overlain by limestones of the same formation however appear, and these are highly fossiliferous. The rocks are nearly horizontal or with a low dip to the south and on a road leading from the village of Alfred to L'Orignal, known as the L'Ange Gardien road, Black River and Trenton limestones appear with low undulations. Outcrops west of L'Orignal.

Furthur west beneath the escarpment of Black River and Trenton limestones south of Brown's wharf, strata of Chazy age are recognized at its base dipping beneath the escarpment. The country in the direction south of the Ottawa is, however, mostly clay-covered, so that rock outcrops are rarely seen. Ridge south of Brown's Wharf.

Continuing west the Chazy shales come into view a short distance east of Clarence wharf and thence extend along the shore to the vicinity of Foxe creek below Rockland. They are here cut off by a heavy fault with a direction to the south which throws the strata horizontally for nearly four miles in the direction of Clarence creek. Between Clarence creek post-office and Rockland several faults occur, some of which have tilted the strata at high angles and the area is a good deal disturbed. The Chazy shales show along the road south of Rockland in the direction of Stewart's quarry and here pass beneath the Black River and Trenton escarpment to the south. Clarence and Rockland. Faults.

On the road along the south side of the Ottawa in the direction of Cumberland similar strata are seen at intervals at the base of the ridge a short distance to the south. At the latter place they form a somewhat bold escarpment to the south of the village and are succeeded upward by the limestones of the upper part of the formation and these in turn by the Black River and Trenton rocks. Thence westward the shales appear along the road as far as Greens creek, the limestones occurring in the escarpments south of the road, the whole having a low dip to the south or south-west. Cumberland escarpment.

Thickness of the formation.

Good opportunities for measuring the thickness of these two divisions of the Chazy are not afforded east of Ottawa. From observations made along the river west of the city, however it would appear that a thickness of not far from 100 feet must be assigned to the shales and sandstones, and about the same for the limestones with possibly about twenty feet for the middle or transition portion.

BLACK RIVER LIMESTONE.

Black River limestones.

The rocks of this formation appear in a belt varying in breadth from a few yards to over a mile. They overlie the Chazy limestones throughout their entire development, except where they have been removed by faults. One of the most important of these breaks is that situated a short distance east of Rockland where the band of the Black River on the west of the fracture is about four miles south of the continuation of the formation seen to the east in the direction of Clarence post-office.

Great displacement of the Rigaud fault.

In the eastern portion of the area the Black River outcrop seen in the northern portion of the township of Lochiel is separated from what appears to be its extension around the Calciferous and Chazy basin of Hawkesbury east, by a distance of about nine miles, the direction of the throw apparently being to the north-west. The formation southward underlies, throughout the entire Ottawa and St. Lawrence basin, the great development of the Trenton limestone, except in the township of Russell where it is affected by the line of the Rigaud and Gloucester fault along the Castor river, but this area lies to the south of the present map-sheet.

Outcrops of Black River limestones.

The Black River limestones can be well studied at several points. Among these may be mentioned the area east of Greens creek in an escarpment south of the Montreal road; several escarpments to the south of Cumberland village; Clarence creek, about four miles south of Rockland; outcrops along the road half a mile west of Clarence post-office on the Montreal road where they are affected by faults; the strata in the escarpment at A. Stewart's quarry south of Rockland; the South Nation river at Jessup falls about one mile from its junction with the Ottawa river; the north side of the escarpment from Brown's wharf to near the village of Alfred; Murray's quarry about one and a half mile south of L'Orignal, and se
the south of this in East Hawkesbury. The formation is important as furnishing some of the best building stones of the Palæozoic series. These are well seen near Glen Robertson on the line of the Canada

Atlantic railway, but the quarries at this place are a short distance south of the southern limit of the map-sheet.

The limestones are fossiliferous throughout. A large quarry in the upper portion of the formation is found at the crossing of a road over the Rivière à la Graisse on lot 15, range VII., Hawkesbury East. These strata contain *Tetradium fibratum* and other fossils characteristic of the formation, and have a dip to the south-west at an angle of 8° to 10°, apparently in contact with the Potsdam sandstone which shows along the roads a short distance to the south. Fossils.

TRENTON LIMESTONE.

The Trenton is an upward extension of the former division, the limestones passing into each other without stratigraphical break. The fossils are, as a whole, distinct, though in the Black River formation several forms occur which are common to both, but certain of the Black River forms are not found in the upper series. Trenton limestone.

The Trenton limestones have an extensive development in the area between the Ottawa and the St. Lawrence. They are thrown into low undulations which can be recognized at different places generally with low dips which rarely exceed 6° and are often much less. The thickness of the formation is probably not far from 700 feet, that of the Black River being probably not more than 100 feet. Undulations in the strata.

The Trenton limestones are extensively developed throughout the townships of Cumberland, Clarence, Plantagenet, Alfred, Caledonia, and Hawkesbury west and east. In the southern portion of most of these they are overlain conformably by the Utica shales which form the central part of the great Palæozoic basin. In the eastern part of the area the strata are affected in the same manner as those of Black River and Chazy age by the great Rigaud fault. They are well seen along the road from L'Orignal to Vankleek Hill, and south-west from the contact with the Black River formation at the fault near Murray's quarry they have a surface breadth till they are overlapped by the Utica of not far from eight miles. Relation to the Utica shale.

West of L'Orignal they are well exposed along the L'Ange Gardien road towards Alfred for about a mile, in low undulations. They occupy the upper part of the big escarpment south of Brown's wharf and thence are seen along the Nation river in the direction of Plantagenet village in large exposures, the rocks are filled with characteristic fossils of the formation, and the dip is to the south at angles of Alfred escarpment.

3° to 5°. Unless the formation is repeated by faults or by anticlines the dip thus recorded would give a thickness much greater than that already stated.

Anticlines and faults.

The presence of such anticlinal structure is however obvious at several points in this part of the basin. One of these apparently follows a course south-east from the mouth of the South Nation river indicated by the underlying Black River formation at Jessup falls already mentioned. A second is indicated by the presence of an intermediate basin of Utica shales extending across the western portion of Plantagenet north which probably is connected with the run of the Rockland and Clarence fault. Still another anticline from the eastern portion of Cumberland township extends into Clarence township near its central part and separates two other basins of the Utica, while yet others have been recognized in the district further to the south.

Outcrops of the limestone are not however numerous, owing to the great extent of clay and sand in this area, and the exact delimitation of boundaries must on this account be considered as sometimes conjectural.

The area about Ottawa and Hull, where the rocks of this formation are well exposed pertain to the map-sheet adjacent to the south.

UTICA SHALE.

Utica shale.

In the notes of Mr. James Richardson for 1853 the presence of several small outliers of the Utica shale was recognized in the area south of the Ottawa river in addition to the broad area of these rocks which form a large basin to the south of the Trenton just described. As the work at that early date consisted merely of the survey of several roads which traversed the district, much of which was then not open for settlement, the exact distribution of these outliers was not ascertained. Quite recently, however, detailed surveys have been made and their outlines have been determined as closely as the drift-covered character of much of the surface permitted.

Several basins.

In addition to the broad area of these rocks, which occupy a large portion of the townships of Gloucester, Russell, Cumberland, Clarence, Plantagenet and Caledonia, and extend southward to the Nation river and to its west branch, the Castor, two other well-defined basins, bounded on either side by Trenton limestones, were found.

These would appear to be side basins from the main area, extending to the north-west. The most easterly apparently comes to the South Nation river at the line between ranges IX. and X., of the township of Alfred, though as this area is largely clay-covered, its precise limit is not fixed. From the crossing of the Nation it extends in a narrow basin, indicated by a low flat through the eastern portion of Plantagenet North, with a breadth of rather more than a fourth of a mile. It should occupy a narrow strip between the villages of Curran and Plantagenet Springs and continue to the north-west, almost to the line between ranges II. and III., of the township, terminating on lot 14, where the shales are conformably underlain by the Trenton limestone. The black shales are well exposed on lots 12, 13 and 14 of ranges III. and IV., and represent the lower portion of the Utica formation. Plantagenet North basin.

The second and more westerly basin apparently extends north-west from the angle of the Nation river near the village of Pendleton to a distance of about fourteen miles into the township of Cumberland, the last outcrops in this direction being seen on lot 4, range II. This basin is separated from that just described by an anticline in the Trenton limestone in which also occurs the Rockland and Clarence fault. The Utica shales are well exposed in ranges I. and II., Cumberland, and in X. and XI., of Clarence, adjacent. The breadth of this basin is in places a little over a mile and it rests conformably upon the underlying Trenton. Cumberland and Clarence basin.

The portion of the main Utica basin found in the limits of the map-sheet is confined to the townships of Alfred, Caledonia and Hawkesbury West. The determination of the presence of the formation in Alfred is made from several bore-holes which have been sunk through the clay to a depth, in places of nearly 200 feet, the black shales being the underlying rock. In Caledonia the shales underlie the southern half of the bog or Caledonia flats, while the Trenton limestone is found in the vicinity of Caledonia Springs. Here there is also in places a great thickness of clay and sand. Bore-holes. Caledonia basin.

In Hawkesbury West, the Utica shales are exposed at several points. They reach to within about three miles of Vankleek Hill and rest apparently conformably upon the Trenton limestone in this direction. The structure of the Utica appears to be basin shaped, but there are probably low anticlines, the extension eastward of those seen in Clarence and Cumberland. Hawkesbury West.

The shales are usually black or dark-coloured. The lower half are strongly bituminous, the upper portion becoming lighter-coloured and Character of shale.

more sandy in character. These pass upward into the Lorraine shales and sandstone, which are more uniformly gray in colour and are not bituminous.

Thickness of the Utica.

The thickness of the Utica shale in this area has never been accurately ascertained. It has usually been supposed to be very thin and probably under 100 feet, but this estimate must be considerably increased. At a low dip of not more than 2° the volume in the western portion of the basin, south of Ottawa would be over 300 feet and though the formation as a whole is affected by low undulations, the thickness in the main basin will probably be not far from 350 to 400 feet, in this respect corresponding closely with the measurements at Montmorency falls below Quebec. The areas of the Lorraine formation south of Ottawa lie beyond the limits of the map.

SURFACE GEOLOGY.

Surface geology.

Large boulders.

Throughout a great part of the district just described, large areas of drift in the form of sand, gravel and clay are common, and over certain portions extensive collections of boulders are found. Some of the latter masses are of large size as evidenced by the occurrence of single blocks from the crystalline rocks north of the Ottawa river, near Vankleek Hill, where in one case on the road thence to L'Orignal a block of granite measures twenty feet by fifteen and is four feet out of the ground. On a road north from Glen Robertson in the north east part of the township of Lochiel, numerous huge masses are scattered over the surface. These comprise granites, anorthosite rocks, quartzites, etc., one block of the first named being thirteen feet by ten, and three feet out of the ground.

Boulders ridges.

Along the flanks of the granite ridge east of St. Andrews village the blocks of anorthosite are numerous and some are of large size. To the south of the Ottawa also these boulders occur frequently in the form of ridges, of which one is conspicuous just north of the village of Ste. Anne de Prescott, and is made up of immense blocks of granite, anorthosite, quartzite, crystalline limestone, etc. They are moreover widely distributed over portions of the area north of the St. Lawrence river.

Marine clays and sands.

The clays and sands were undoubtedly deposited under marine conditions since they both contain at various points an abundance of marine organisms, such as shells, the remains of seals and fishes, sponges, &c. The localities where these fossils are found are widely

scattered, so that while it may be supposed that all the clays in the district at the same general level are of the same origin the evidences of this are only obtained at rare intervals. Thus along the Ottawa river at the mouth of Greens creek, at Besserers wharf about one mile below and at one mile east of Cumberland wharf, an abundance of clay nodules are obtained which contain the skeletons of *Mallotus* as well as shells, leaves and other remains around which the concretions appear to have formed, below this to Hawkesbury, although the clays along the shores were carefully examined, marine remains were rarely found in them. It is therefore conclusive that the absence of these does not necessarily indicate a different origin.

Fossils of Greens creek.

To the north of the Ottawa great deposits of sand and clays are seen along all the streams flowing south from the height of land. These deposits extend north for many miles. The clays occupy the lower levels and are frequently exposed along the river banks by the cutting down of the channels through the great overlying beds of sand which are widely spread over the surface around their upper waters.

Clays and sands north of the Ottawa.

At many points these deposits are now arranged in a series of terraces of which four at least can be readily recognized along the upper part of the Rouge and the Lièvre rivers. The underlying rocks are thus concealed over large areas by the great deposits of drift, but ridges frequently protrude from the otherwise drift covered plain.

Terraces.

Along the lower Ottawa to the south-east of the North river between the villages of Lachute and St. Jérôme, several well-defined terraces are exposed. These consist of clay, sand and gravel, the upper benches frequently composed of the latter, and at a point about four miles south-east of Lachute two artesian wells were sunk several years ago which have yielded a supply of the purest water. These wells were put down near the foot of a sand and gravel terrace the top of which is about fifty feet above the level on which the wells are located. Of these wells one reached a depth of eighty-three feet, while the other was sunk to a depth of 120 feet, the underlying rock not being reached in either case. This would give a thickness for the drift deposits in this area of not far from 200 feet showing a depression which probably represents an old channel of the Ottawa which was some feet below the present river bottom. No rock ledges appear in the area between the ridge east of St. Andrews and the Calciferous beds to the south-east of Lachute village.

Lachute to St. Jérôme.

Artesian wells.

The construction of the Gatineau Valley railway, along the west bank of the Gatineau river, has enabled us to study the clay deposits

Gatineau Valley railway.

of this district. A great number of cuttings in this material are seen along the line for more than forty miles north of the Ottawa, some of which show walls nearly 100 feet in height. These have been carefully examined as far north as Kazubazua station where the country becomes covered largely with sand deposits.

Marine shells near Chelsea.

The greater part of these cuttings show no organic remains whatever. At a point half a mile north of Chelsea station, however, a bed of marine shells is seen at the contact of sand and gravel with the clay, from which several species have been obtained. The elevation of this place is 395 feet above sea-level.

Shells near Cantley and McGregor lake.

To the east of the Gatineau in Hull township on the road from Cantley to Wilsons corner and about half a mile north of the post-office at the former place, clay banks in a small brook showed quantities of marine shells among which were recognized *Saxicava rugosa, Macoma fragilis and Leda arctica*, with some foraminifera. The elevation of this spot is about 350 feet above the Ottawa by aneroid or about 465 feet above sea-level. At the outlet of McGregor lake, two miles north of Perkins Mills, near the road crossing, shells of *Saxicava* are very abundant and *Macoma* are rare. The elevation of this point is given as 458 feet above sea-level.

Drift of the upper Gatineau.

From the elevations along the Gatineau railway it is probable that all the clay deposits there seen have the same origin. It would appear therefore that the estuary of the Ottawa extended over a very wide area at the time when these deposits were laid down. These clays certainly extend northward to an elevation of more than 700 feet where they are covered by great accumulations of sand. Along the upper part of the Gatineau, the observations of Mr. James Richardson, during his trip from the St. Maurice to this river and his descent of the latter stream, shows that this character of drift-sand continues to the height of land between the two streams which he places at an elevation of about 1,500 feet. That this generally level and sand covered country extends over much of the area north of the Ottawa has been stated by all observers who have traversed the district.

Height of land.

This great overlying mass of drift-sand appears to be devoid of organisms, at least in so far as yet ascertained. It would appear to owe its origin however to the agency of water and should represent the decay of the granitic and gneissic rocks which form the chief geological feature of the district.

Good soils.

Many of these deposits are loamy in character and as a consequence furnish valuable lands for agricultural purposes. Of this

DEVIL'S PLAY GROUND, (LA PIÈCE DE GUÉRÊT) RIGAUD MOUNTAIN, QUE.

character are portions of the area along the Gatineau and the rivers both to the east and west. Large farms in connection with the various operations in lumber, for which this district is celebrated, have been successfully worked for many years, and have clearly demonstrated the fact that in ordinary seasons, much of the land, more especially in the valleys, is of great agricultural value. There are however large areas of apparently almost pure granitic sand, forming plains which are comparatively valueless for this purpose.

Clays north of the Ottawa.

Along the north shore of the Ottawa clays are found to an elevation along the hill sides of at least 500 feet. These higher clays have as yet yielded no fossils, but near Grenville in the bank of the river these are found. They have been described in the Geology of Canada, 1863, page 917.

Boulder beach of Rigaud mountain.

One of the most interesting deposits of water worn stones, forming an old beach, is seen on the north-west flank of Rideau mountain. It has been described in the earlier publications of the Geological Survey, and a brief description is given in the volume just mentioned on page 896. They occur at an elevation of about 550 feet above sea-level by aneroid taken by Mr. R. Chalmers* and are seen in a series of bare patches of oval shaped and rounded boulders ranging in size from two inches to fifteen inches in their longest axis. From the fact that no vegetation grows over much of their surface it would seem that they rest at this point on a rocky base. At the present time the deposit consists almost entirely of the water worn stones, all the sandy portion of the deposit having been washed away and deposited nearer the foot of the slope where these sands are conspicuous. The deposit has been excavated to a depth of more than ten feet and maintains the same character throughout. The rocks are for the most part of the porphyry of the west side of the mountain and a few of quartzite are associated. To the south-west this deposit can be traced for a couple of miles, and is crossed by the road leading south to the village of Ste. Marthe on the western spur of the hill, where it is covered with a scanty growth of small trees and bushes. No trace of it is seen on the south side of the mountain, and it appears to indicate the remains of an old beach during the period of submergence of this area. This deposit has been referred to in the report by Mr. R. Chalmers†.

Striæ.

Ice markings are found at several points throughout the area. They indicate a movement in several directions throughout the Ottawa basin, and the direction of the striæ, as given in the lists published by

* Annual Report Geol. Surv. Can. vol. X. (N.S.) 1897, p. 61 J.

† Annual Report Geol. Surv. Can. vol. X. (N.S.) 1897, pp. 60J and 60A.

Mr. R. Chalmers in the report just quoted, ranges from east and west to south. It is not deemed necessary to repeat these lists in this place. It would seem that there were at last two phases or periods of glaciation and a third series of markings were probably produced through the agency of floating ice, which apparently moved westward along the present course of the river in an almost opposite direction to that taken by the first Laurentian glacier which seems to have closely followed the contour of the Ottawa valley. The lists of striæ will be found in Mr. Chalmers' report, vol. X., pp. 29-39 J.

Ice movements.

ECONOMIC MINERALS.

Economic minerals.

Among the minerals of special economic importance which are found in the district just described may be mentioned apatite, mica, graphite, asbestus and iron. Baryta also occurs in veins at several points and the felspar and quartz which make up the greater portion of many of the masses and dykes of white granite have been found to be of sufficient purity in some cases to be economically worked for the manufacture of glass and pottery as well as of porcelain. In this connection may also be mentioned kaolin, of which at least one deposit of very fine quality is known in the township of Amherst.

In addition to these, certain portions of the district are celebrated for yielding a variety of minerals most commonly associated with the crystalline rocks such as pyroxene, tourmaline, zircon, sphene, scapolite, &c., which are of considerable mineralogical importance and often a source of considerable revenue. The crystals are frequently of large size and in considerable quantity, so that this area has in this respect become celebrated. Certain other minerals have also recently been found in this district which possess certain features fitting them for decorative and ornamental purposes and some of these have yielded gem stones of considerable value.

APATITE.

Apatite.

The occurrence of this mineral north of the Ottawa was known for some years before its economic value was ascertained. The first reference to it was made by Lieut. Ingalls, in the Transactions of the Lit. and Hist. Society of Quebec, in 1829. It was subsequently referred to by Dr. T. S. Hunt, in the Geology of Canada, 1863, page 461, as present in certain rocks in the township of Hull, as also its occurrence in the township of Ross ; but its extraction for export did not commence till

the year 1871–72, or nearly ten years after it was first mined in the province of Ontario, in the townships of Burgess and Elmsley.

The history of the industry has already been fully given in a report on 'the Mineral resources of Quebec'* but certain features in regard to its mode of occurrence and distribution having a more direct bearing on the economic aspect of the question may here be stated.

Igneous rocks.

The presence of various kinds of igneous rocks in the gneisses and limestones of the Grenville series has already been referred to in the preceding portion of this report. These are of several kinds and include syenites, granites, anorthosites, porphyries, pyroxene rocks, binary granites or pegmatites, trappean or diabase rocks. That these are of different ages as regards their period of intrusions is manifest from their relations to each other. Thus the syenite mass of Grenville clearly cuts across the diabase dykes which can be traced for a long distance through the townships of Petite Nation, Grenville and Chatham, while these diabase dykes just as clearly intersect masses of pyroxene and binary granite. Of these several intrusive or igneous rocks it may be said that some of them have exercised a manifest influence upon the occurrence of some of the economic minerals, while in the case of others such influence is not apparent. With the pyroxene rocks are associated apatite, mica and sometimes graphite and asbestus, but with the granites the apatites do not appear in so far at least as has been observed, though mica is frequently an associated mineral in pegmatite dykes. The pyroxene is usually of some shade of green but in certain areas, more particularly in the limestone formation, which is occasionally a dolomite, the colour of the pyroxenite becomes whitish or yellowish-white though its dyke-like character is sometimes maintained. In these cases it is often difficult to distinguish in hand specimens between the pyroxenite and the crystalline limestone.

Their associations with economic minerals.

Pyroxene rocks.

Pegmatites.

The white granites or pegmatites appear in places to have a much more widely extended development than the pyroxene rocks. They have been recognized at a number of points throughout a very large area, both to the north and south of the Ottawa. They generally contain a small quantity of mica which however is recognized only on close examination. They frequently appear to intersect the pyroxene and therefore should be of later date as regards their intrusion.

Mineral belt of the Ottawa district.

The pyroxenic rocks with which the deposits of apatite are most closely connected, are, in the country north of the Ottawa, to a large extent, confined to the area between the rivers Lièvre and Gati-

*Annual Report Geol. Surv. Can. vol. IV. (N.S.) 1889.

neau, and for a few miles on either side of these streams. Their principal development does not extend north of the Ottawa in most cases to a greater distance than twenty to thirty miles. They occur not only as masses, often of large size, but as dykes sometimes bedded with the strike of the gneiss or limestone but also sometimes cutting across the stratification of these. From the bedded aspect of some of these rocks the pyroxenes were for many years regarded as sedimentary deposits similar to the limestones, and as constituting an integral portion of the gneiss and limestone formation.

This supposition is supported to some extent by the presence in certain portions of a gneissic structure, developed presumably through the same agencies which produced the foliation of the granite and anorthosite. Masses of pyroxenite also occur in the township of Hull, west of the Gatineau and in Wakefield and Masham. The extension of the pyroxene belt south of the Ottawa is seen in the townships of North Elmsley and Burgess already described in earlier reports. It is, however, impossible to connect these widely separated areas on the north and south, since the valley of the Ottawa which separates them is occupied by the extensive development of the Cambro-Silurian strata already described.

Relations of the pyroxene with the gneiss.

Character of the intrusive in the Lièvre district.

In the study of the pyroxenic rocks north of the Ottawa, several features observed are worthy of notice as having an important bearing upon the occurrence of deposits of apatite. Thus in certain places, such as the area of the phosphate bearing rocks in Portland west, extending from Ross Mountain into the VIIth range immediately west of the Lièvre river and northward for several miles, the intrusive pyroxenic rocks are intimately associated with the gneissic portion of the upper or Grenville series, portions of the gneiss appearing as if caught and held in the mass of the former.

Ross mountain mine.

At the Ross Mountain mine, High Rock, Crown Hill and others in this belt, the relations of the pyroxene rocks with the quartzose gray gneisses and of the apatite to the pyroxene can be well seen. At the former place the gneiss has a strike of N. 5° to 70° W. the dip near the summit of the hill being southerly at an angle of 65° to 70°. Openings for apatite occur at a number of places along the south and east side of the hill which has an elevation above the river of not far from 700 feet, as well as along the summit of the mountain. At all these places dykes of hard dioritic-looking rock are seen, sometimes traversing the gneiss along the planes of stratification, but frequently cutting the gneiss transversely to the strike. The dykes are generally of some shade of greenish-gray, at times with a peculiar bluish or

purple tint, resembling in this respect some of the anorthosites of the area north of St. Jérôme, and as a rule these are devoid of gneissic structure. In these cases the apatite occurs in the mass of the pyroxenic rock, not as a regular vein but generally as small bunches of the mineral. Near the crest of the hill a band of the mineral in a dyke has a course of N. 5° E. across the strike of hornblende gneiss. The apatite masses occasionally give off small spur-like veins from the side of the deposit, the containing gneissic rock having a strike of W., the dip being vertical.

Occurrence of apatite in pyroxene.

A deep pit at the summit of this hill shows the same greenish-gray pyroxene rock from which apparently a large pockety mass of apatite has been extracted. A small included mass of calcite holding crystals occurs in the pyroxene, but no regular calcareous strata are visible in the vicinity. In the banded gneiss no phosphate is seen. Just west of the pits on the summit of this mountain, black hornblende gneiss with quartzose bands strikes north with a dip to the east of 70° and contains small dykes of diorite which run with the lines of stratification.

In places, judging from the character of the excavations which are left after the removal of the mineral, the apatite would appear to occur frequently in chimney-like masses, the sides of the excavation, which is often several yards in diameter, showing little or no trace of the mineral.

The Crown Hill mine.

At the west pit of the Crown Hill mine, which lies to the north-west of Ross mountain and adjacent to it, a dyke of dioritic-looking pyroxene cuts across grayish hornblendic, sometimes garnetiferous gneiss. This gneiss strikes N. 80° W., and is nearly vertical. The course of the dyke is almost north-and-south, with a dip to the east of 60°. The same dyke with the same direction can be seen in the adjacent pit. The apatite here has been taken from the dyke and the remains of the deposit can be seen in the pyroxene near the contact with the gneiss.

Dyke rocks.

Crossing a ridge to the east of this place the main workings of the Crown Hill are reached on the east side of a swampy flat. The gneiss, rusty and quartzose in places, strikes N. 80° W., is nearly vertical and is cut by a dyke of the usual pyroxenic character. The gneiss here overlies the pyroxene in the upper part of the pit, and is much broken up as if thrown out of its regular position by the action of an intrusive mass. In this the apatite occurs as a series of impregnations or irregular masses, extending inward from the contact with the gneiss for eight to ten feet. The bluish-purple felspar is well seen in the

Apatite.

pyroxenite at this place also. The apatite here does not present any of the features of a bed nor of a well-defined vein, there being neither foot or hanging walls in the ordinary use of the term. The mineral occurs in the form of pockety deposits, in the pyroxene, connected apparently by smaller strings near the contact with the gneiss, and some of the pockets have yielded several hundred tons.

Pocket character.

Ascending the railway track (now taken up) to the summit of the ridge, several pits are found along the slope of the hill south of the company's offices. Here the presence of three distinct dykes is seen, viz., the pyroxene cutting the gneiss, the whitish pegmatite granite cutting the pyroxene, and both of these cut by a three foot dyke of dark-green diabase. The apatite deposits here occur apparently as pockets or chimneys, which have been mined to a considerable depth, and are connected by small irregular vein-like deposits. Along the sides of the pyroxene, near the contact with the gneiss, the remains of the apatite can be seen in the shape of small patches or impregnations of the dyke. The gneiss here has a dip to the west at a high angle.

High Rock mine.

On the road leading thence to the High Rock mine interstratified gneiss and quartz rock occur. The strike is generally N. 60° W., and the dip is to the north-east at an angle of 80°. These are frequently cut transversely, and in places almost at right angles to the strike, by dykes both of pyroxene and pegmatite.

At the High Rock mine, the summit on which the principal workings are situated, is about 700 feet above the river at its foot. The pyroxene and granite dykes are visible in all directions, both at the surface of the hill and in frequent exposures along the sides down to the base. Cuttings have been made in the pyroxenic masses at many points, the lowest workings on the south side of the mountain being about 400 feet below the summit. In places the granite intersects the pyroxene and frequently these intrusions are so numerous that the gneiss, which is the country-rock, occurs as narrow bands or irregularly shaped areas, often of very limited extent.

Apatite in pyroxene.

The apatite in all cases occurs in association with the pyroxenic mass, and the lowest workings are apparently quite as productive as any near the summit, though there is no well-defined vein structure apparent. At the mine near the base of the hill, the apatite occurs as great pockety deposits, often of many hundreds of tons in extent, but varying in size in different portions of the pyroxene mass.

Mode of occurrrence.

In the case of the dyke of apatite-bearing rock possessing much breadth, the mineral is found usually in close proximity to the contact

with the associated gneiss, and frequently both margins of the dyke are apatite-bearing in this way, while the central mass of the pyroxene is almost entirely barren. In narrow dykes carrying apatite, the whole mass is usually extracted and the mode of occurrence is then not so easily seen. At the Star Hill mine, about one mile distant from High Rock to the north, a deep pit has been sunk in greenish pyroxene, with a reddish and white felspathic dyke. The apatite here is also in the outer zone of the pyroxene, which is clearly intrusive in the rusty and gray quartzose gneiss, the latter striking N. 60° W. vertical. At this place the gneiss is garnetiferous in the vicinity of the pit, and is also cut by a dyke of pegmatite. The pyroxene dyke is more nearly along the lines of stratification of the gneiss, but both are clearly of later date.

Star Hill mine.

The Central Lake mines are situated about two miles north of the last-named on the north side of Central lake. It is also in the extension northward of the apatite-bearing belt, which begins with Ross mountain. The country-rock is a grayish quartzose gneiss, having a strike nearly north-and-south. Near the pits to the west and below them on the slope of the hill, a band of dark fine-grained hornblende gneiss, with a band of limestone, strikes north and dips east $<75°$. The pits are sunk in a mass of pyroxene, as at High Rock, and the apatite occurs generally along the sides of each pit, with crystals of mica, at the contact with the adjoining gneiss. The deposits of apatite widen out into large pockety masses, which continue at either side of the pit into narrow veins or strings. At the south pit the gneiss is cut across the strike by the cross-dyke of pyroxene with which the apatite is associated, and this presents the aspect of having pushed the gneiss in contact out of its regular course. Dykes of granite intersect the pyroxene at this mine, and indicate from their relation a later period of intrusion.

Central Lake mine.

Character of the apatite deposits.

At the High Falls mine, one mile further north, and the most northerly mine worked in this belt, the gneiss which forms the country-rock is overlain about five chains east by a broad belt of limestone which extends eastward to the Lièvre river and can be traced for several miles north of this place. The apatite here also occurs in irregular pockety masses in a pyroxene rock, which is clearly intrusive, in that it traverses the gneiss nearly at right angles to the lines of stratification. There is no indication either of a bedded or vein-structure at this place, but the mass of the pyroxene appears to be impregnated with the apatite in places, and on the sides of the pit small patches are seen disseminated through the dyke.

High Falls mine.

On the east side of the Lièvre, in the township of Portland East, there are a number of valuable mines of this mineral which have been extensively worked and are of special interest from the depth at which the apatite has been found in profitable quantity. Among these, probably one of the most interesting and important, as illustrating the method of occurrence of the mineral, is the North Star, situated near the west shore of Tamo lake, on lot 18, range VII. This mine presents certain features which render it peculiarly favourable to the study of the apatite deposits, since it has been worked to a reported depth of over 600 feet in the principal shaft. The location is on the crest of a gneiss ridge, 600 feet above the Lièvre river, which is about three miles distant to the west. On the south flank of the ridge or hill on which the mine is situated, dykes of greenish pyroxene rock cross the road. These dykes carry apatite, and they cut reddish-gray gneiss, which has a strike N. 35° W. and a dip N. 55° E. $<60°$. Ascending the hill, a large dyke of pyroxene has a course of nearly north-west and south-east almost vertical.

North Star mine.

The gneiss a short distance to the east is hornblendic and much injected with quartz and felsite veins. It is well banded and strikes N. 5° W. and dips east $<$ 60° to 80°. At the south pit, before reaching the hoisting works, the intrusive character of the pyroxene is well seen. It has the aspect of a chimney-like dome which has thrust up the gneiss in contact, the strata of which bend round the pyroxenic mass. The apatite in this dyke occurs near the contact with the gneiss. The dyke can be followed nearly along the stratification of the containing gneiss for several hundred yards and is opened by a series of pits and cross-cuts in all of which this mode of occurrence of the apatite can be recognized. In the upper part of the main or deep pit, two bands of apatite are seen, one on each side of the dyke, forming an irregular deposit which gives off small branching spurs into the adjacent pyroxene. These two bands have been followed downward to the lowest or 600 feet level, the quantity of apatite apparently being as great in the bottom of the shaft as in the upper levels, but varying as all these deposits do, owing to the irregular nature of this formation.

Contact character of the apatite.

In the north pit the structure is that of a dome-shaped mass of pyroxene, carrying apatite irregularly disseminated, which has been forced upward through the gneiss, a capping of the latter being seen along the edge of the pit on the east side. In some of the pits near the outer margin of the dyke, crystals of dark mica occur. From the continuity of this dyke and its extension downward to such a distance the theory has been put forward by some that it is a true vein forma-

tion. If so neither hanging nor foot-walls are found, but from the fact that the apatite occurs, in most cases at least, within a few feet of the contact with the inclosing gneiss, it has been followed with great regularity along the entire exposed outcrop of the dyke. Where a so-called foot-wall has been seen, examination has shown it to be merely the gneiss formation which has been reached in the excavation.

Among other important mines on the east side of the Lièvre may be mentioned the Little Rapids, the Emerald, the Squaw Hill and the Ætna. Others occur such as the Philadelphia, the Salette and the London mines, but the features already stated as to structure apply to all these.

Little Rapids mine.

At the Little Rapids mine on lots 6 and 7, range I., Portland East, along the tramway which leads down from the mine to the river, about one mile distant, pyroxene and granite rocks occur intimately associated with the reddish and gray gneiss which is the country-rock of the district. Just west of the mine itself gray quartzose gneiss strikes N. 20° E. and dips N. 70° W. $<50°$ and this is cut transversely by great masses of pyroxenic diorite. The course of the dyke in which the apatite occurs forms an angle of 30° with the stratification of the associated gneiss, and the dip of the west side of the dyke is east $<80°$. The excavation for the mineral is on the west side of the dyke next the gneiss, the edges of the gneissic strata being exposed on the west side of the cutting, and forms what has been called the foot-wall of the vein. Mica crystals occur along the line of contact of the two series of rocks as well as occasionally disseminated in the phosphate-bearing portion, which may be said to include from four to eight feet of the pyroxene. The eastern wall is a hard grayish quartzose granite which is a secondary dyke cutting the pyroxene, the latter again coming in and being exposed, for a further distance of seventy-five feet, to the inclosing wall of gneiss on the east side. About 250 yards to the south-east of the principal phosphate pit a deposit of mica has been opened in a dyke of pyroxene by Mr. W. A. Allen. This deposit is on the northern extremity of a large dyke of pyroxenite which extends across the range of gneiss hills to the south and which presents a conspicuous feature in this area.

London mine.

On the adjacent lot to the north of the Little Rapids mine, is the London mine, and the contact of the intrusive pyroxene with the gneiss, which is here the banded variety, can be well seen. The dyke in the opening on the face of the cliff fronting the river is nearly on the strike of the gneiss, but the line of contact is sharply defined. The apatite occurs in pockety masses close to the line of contact in the pyroxene.

Photographs of a number of these contacts were made by Mr. H. N. Topley, and have been coloured to show the relations of the different kinds of rock as well as the mode of occurrence of the apatite deposits. These are now on view in the museum of the Geological Survey and form an instructive series of exhibits on this subject.

Ætna mine.

At the Emerald, Squaw Hill and Ætna mines on lots 17, 18 and 19, range XII., Buckingham township, similar conditions are to be seen. At the Ætna, which is the farthest mine to the north-east, located near the summit of a large hill, the gneiss is cut by a broad dyke of pyroxene which here follows nearly on the strike of the gneiss with a course nearly north-east, in which direction it can be traced from the mines at Squaw Hill near the river. The dip of the gneiss and pyroxene is N. W. $<80°$ and the gneiss is much altered along the contact, being broken and very rusty. Several very large crystals of apatite were found in it near the contact with the pyroxene. At this place the pyroxene is cut by another large dyke of diabase near the contact of which, the principal masses of apatite occur. A considerable deposit of iron-pyrites is found along the face of the second dyke.

Squaw Hill mine.

Emerald mine.

At the Squaw Hill mine on lot 18, the rock is a reddish and gray quartzose gneiss. The mine is situated on the east flank of a prominent hill, while the Emerald mine is on the north slope of the same hill. The gneiss is intersected by numerous pyroxene and granite dykes, which have broken up the country-rock and twisted it in all directions, much of it being very rusty near the contact with the intrusions. The apatite deposits here are all in the pyroxene mass, sometimes in great irregular bunches which have produced hundreds of tons. Masses of the mineral are occasionally associated with pink calcite which is an integral portion of the pyroxene rock. In the vicinity, to the east, hills of similar intrusive rock in gneiss are seen, presenting similar conditions to those which prevail at this group of mines, but no attempt has yet been made to develop this area.

Mines north of Perkins Mills.

In the township of Templeton also a belt of pyroxenic apatite-bearing rocks is found, similar to those just described, and in this some of the largest and most productive mines are located. This area lies principally along the east side of McGregor lake and the principal mines here situated comprise the Jackson Rae, Blackburn, McLaurin and Battle lake, with others to the north of Perkins Mills. At all these mines the same association of apatite with the pyroxene, already described, occurs. The latter is clearly intrusive in the reddish and gray gneiss of the district and there are, in addition to the apatite, deposits of mica sometimes of large extent and commercially valuable.

Near the Blackburn mine an anticlinal structure is visible in the gneiss. At the McRae mine on lot 11, range V., Templeton, the strike of the gneiss and quartzite is quite regular and has a course north-and-south, while the pyroxene dyke in which the apatite occurs is almost east-and-west. Granite dykes also occur at these mines but the apatite is always in the pyroxene. McRae mine.

Near the McIntosh mine on lot 4, range VI., a small outcrop of crystalline limestone is seen a short distance south of the workings. The same relations of the apatite to the inclosing rock also occur here. The pyroxene cuts the gneiss and is in turn cut by a dyke of granite. McIntosh mine.

The most northerly group of apatite mines in this district is that in the vicinity of Priest lake and creek, in the townships of Denholm and Bowman. They are situated near the line between these townships and present the same arrangement of rock masses as has already been described for the other areas. The principal areas lie between lakes Scalier and Priest on the south, and the south end of Whitefish on the north. But little work appears to have been done at these places further than development, the position of the mines not being so convenient for the shipment of the mineral as those which lie nearer to the shores of the Lièvre. Priest creek mines.

In none of these mines are workable deposits of the mineral found in the limestone. At several points further west or in the Gatineau belt, the pyroxene frequently contains masses of calcite generally pink in colour, more particularly on the outer or contact zone of the intrusive rock, and these masses are often of large size. In these, very frequently, crystals of apatite are distributed in quantity sufficient to render their extraction profitable especially when, as is often the case, they are associated with crystals of mica as at the Gemmill mine near Cantley, and at others near Wilsons corner. This mingling of apatite and mica is a frequent occurrence in the mines of the Gatineau district throughout the townships of Wakefield and Hull where the principal mica mines are located. It is doubtless this occurrence of apatite in the calcite, which is usually called limestone by the miners, which has led to the statement that workable mines of the mineral are found in the limestone as well as in the pyroxene. The two calcareous deposits should however not be confounded since they are entirely distinct in character. The calcite is invariably a portion of the pyroxene intrusive mass while the crystalline limestone is a true portion of the stratified rocks of the Grenville series; and in this limestone the apatite, in so far as yet known, has never been found in workable quantities and in fact is rarely seen, except as occasional scattered crystals near to the contact of some pyroxenic intrusion. Association of apatite and mica. Pyroxene and calcite.

Wakefield.

In the areas west of the Gatineau, apatite deposits are rarely found in any economic quantity. Near the village of Wakefield there are several masses of pyroxene, but though a small quantity of the mineral was obtained, it was not sufficiently plentiful to be profitably worked. Near Old Chelsea also small quantities of apatite were found in connection with some of the mica deposits, but the conditions which prevail in the Buckingham district do not seem to occur on the Gatineau. Further west in the township of Ross, apatite deposits have been reported but upon examination the quantity of the mineral was found to be insignificant.

Relations of pyroxene in gneiss and granite.

From the evidence already adduced from the study of these deposits over the entire area in which workable mines exist, it is plain that a very close connection exists between the pyroxene and the apatite and that all the important deposits must be looked for in the former. From the relation also of the pyroxene to the gneiss and limestone wherever these are found in association, it is plain that the former presents many of the features of igneous rocks such as are usually attributed to intrusions of trappean and dioritic dykes, and this leads to the inference that these have had a similar origin. This resemblance is manifested by their cutting the gneisses and other associated rocks at all angles to their strike, by the breaking up and metamorphism of strata in contact, as well as by the formation of crystals of pyroxene, zircon, sphene, mica, &c., and in the presence of various zeolitic minerals. There is also frequently a marked twisting and distortion of the gneissic bands in the immediate vicinity. As for the character of the apatite, crystals are rarely found in the mass of the pyroxene itself, but occur occasionally in the adjacent gneiss or limestone which has been penetrated by the intrusive mass.

In colour the apatite is generally of some shade of green, but reddish and brown tints are also seen, the principal varieties being known as red and green phosphate.

Much has already been written on the subject in previous reports and papers so that further remarks on the commercial aspect of the question, are not considered necessary in this place. The question will be found very fully discussed in the report on the 'Mineral Resources of Quebec.' *

It is to be greatly regretted that all mining of this mineral, both in Quebec and Ontario, has now ceased. The cheapness of the phosphate from the mines in the southern states of America has rendered the

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

mining of it in this country unprofitable, but the existence of great quantities of the mineral in Canada is a well established fact, and the resumption of the industry is only dependent upon a profitable market for the output.

ASBESTUS.

The presence of both asbestus (hornblende) and chrysotile in the crystalline rocks has been known for many years, and attempts have been made from time to time to work these deposits. North of the Ottawa, chrysotile occurs in connection with the serpentinous bands which are apparently a part of the pyroxenite associated with the crystalline limestones, and wherever this serpentine is found traces of chrysotile may be seen. These deposits are generally small. The veins are usually narrow, rarely reaching half an inch in width, and frequently twenty or more small veins of a tenth to a fourth of an inch are seen in a thickness of six to ten inches of serpentine. Occasionally a number of these small veins coalesce and, for a few inches, form a vein of an inch in thickness, but this enlarged vein speedily splits up again into its thin constituents. The short fibre of the Laurentian asbestus is against its successful spinning as compared with the longer output of the Thetford mines. It is, however, very free from the usual impurities, such as grains of iron, usually found in the veins of the latter. The mineral is silky in texture and of a different shade, being usually of a creamy white colour. The areas of the serpentine in the limestone are usually small. They sometimes occur as narrow dykes, and sometimes as masses with a central core of white pyroxenite, and an outer zone of serpentine, as in the Templeton mine, near Perkins Mills, and in the township of Denholm on the Gatineau, near the Paugan falls. In both these places the chrysotile is confined to small veins in the outer zone of the serpentine and not in the limestone which is the country rock at these mines.

Asbestus.

Short fibre.

The principal localities in which attempts have been made to work this mineral in the Ottawa area are in Portland West, lot 16, range V., on land owned by Nicholas Orange; and in Templeton township, lot 11, range VIII. At the former place the chrysotile occurs in two principal bands, one of which is near the brow of a ridge of limestone with a band of serpentine near the contact with the gneiss, and with a dyke of white granite or pegmatite along the contact. The elevation of this ridge is about sixty feet above the road at its base, and in the serpentine band there are from twenty-five to thirty small veins in a space of two to three feet. Most of these are mere threads, but some

Asbestus localities.

Nicholas Orange deposit.

reach a thickness of half an inch or even a little more, where, as in Templeton, several coalesce to form for a short distance a thicker vein.

The band of limestone is here exposed for a breadth of about one hundred and fifty yards. A second narrow band of asbestus-bearing rock occurs near the eastern edge of the area, which terminates against a mass of red granite gneiss. In this area the concretionary looking masses of the pyroxenite are not observed.

Templeton deposit.

The Templeton band differs somewhat from that just described. The country-rock is also crystalline limestone, but the serpentinized pyroxenite here frequently assumes the shape of concretionary masses, sometimes like rounded boulders, but also in irregular shaped areas extending downward to a considerable distance. The exposed surface of these masses has often an irregularly oval outline. The masses themselves consist of a core of white pyroxenite, at first sight resembling certain of the limestones but generally slightly harder and finer grained, surrounded by a zone of serpentine, and near the contact with the limestone the small veins of chrysotile occur. In one pit a section is made across one of these pyroxenite masses, which here has the aspect of a dyke showing it to descend through the limestone for at least twenty feet, with a thickness of a little over two feet, along the margin of which the small chrysotile veins are arranged parallel to the walls. Some of the rounder masses of the pyroxenite are detachable from the limestone, and this mode of occurrence presents several interesting features. That the pyroxenite is clearly a distinct rock from the limestone is quite clearly seen at a number of points, and that the chrysotile is confined to the pyroxenite is also manifest. When the limestone is serpentinized the mineral appears in the form of small irregularly distributed spots forming an ophicalcite, but this is distinct from the serpentinized pyroxenite.

Denholm.

The deposit in Denholm near the Gatineau is similar to that in Templeton in the mode of occurrence of the pyroxenite. A sharply defined line can be recognized between these masses and the associated limestone and the small veins of asbestus occur in the same way.

Côte St. Pierre.

Eozoon.

Several other areas of serpentine with small quantities of chrysotile have been found at various points. Thus in the seigneury of La Petite Nation at Côté St. Pierre, about three miles north of St. André Avelin, on the road to Hartwell, a band of limestone occurs between two dykes of greenstone or pyroxenic diorite. The contact between the limestone and the diorite is marked by a zone of serpentine in which small veins of chrysotile are seen as well as an eozoonal struc-

ture. The lower portion of the limestone has small grains of serpentine distributed through it. The locality was at one time worked for asbestus and most of the specimens described under the name of Eozoon Canadense have been obtained at this place.

In the township of Wentworth, on lot 20, range IX., south of Silver lake, the belt of crystalline limestone which extends eastward from Lost river to Sixteen Island lake, contains in its lowest part near an intrusive pyroxene, a narrow band of serpentine with several small veins of chrysotile on which an attempt at mining was made some years ago. Some of these veins have a thickness of half an inch. White granite dykes also occur in the immediate vicinity. Sixteen Island lake.

On Blanche lake also, in the township of Mulgrave, similar serpentine deposits occur with small quantities of this mineral, as also on the east side of Gull lake on the same stream, but it may be said that of all those yet examined in this district the quantity of chrysotile is too small to render its extraction profitable. From the mine at Denholm a considerable amount of the serpentine rock has been shipped. Blanche lake.

In this connection in may be remarked that while the small size of the veins prevents their successful separation by the usual process of hand cobbing, a trial of a number of tons through the phosphate mill at Buckingham showed that the smallest veins could be successfully extracted by machinery, the fibre coming from the mill in a clean condition and in good order for shipment.

Serpentine also occurs similarly at several points along the Ottawa in the rear of Pointe au Chêne, and a mill was erected at this place several years ago to separate the chrysotile. The amount of fibre was however found to be too small for successful treatment and the works have been closed. Pointe au Chêne.

GRAPHITE.

The graphite deposits of the Ottawa district have already been very fully discussed in the 'Report on the Mineral Resources of Quebec,'* but some recent developments in the industry require a brief mention. Graphite.

Generally speaking all the workable graphite in the district north of the Ottawa is obtained from the grayish gneiss through which the mineral is disseminated in flakes or scales. In places however it occurs in the columnar form in veins of various width and of great purity. The flakes are found both in the gneiss and limestone, but the workable mineral is for the most part confined to the gray gneiss.

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

The Walker mine.

This is often rusty, especially where it has been acted upon by intrusive dykes or masses which appear to have developed pyrites in the vicinity of the intrusion. Thus at the Walker mine on lot 19, range VIII., of the township of Buckingham, the rock of the tunnel is a gray gneiss with a band of limestone. Both these rocks carry graphite but the workable portion of the deposit is apparently confined to the former. Along the slope of the hill to the north-east a number of prospecting pits also show the disseminated mineral in this part of the formation in such quantity as to render the property most valuable if properly developed. The limestone at the tunnel is an interstratified bed, and contains numerous inclusions of gray gneiss through the calcareous mass. The strike of the graphite-bearing gneiss is N. 50° E. with a dip to the north-west $< 75°$, but an eighth of a mile north the strike changes to N. 50° W. and the dip is to the north-east $< 80°$. An eighth of a mile east of the mouth of the tunnel the strike of the gneiss is north and the dip east $< 75°$. Vein plumbago is found on the adjoining lot to the south on range VII. A large amount of work has been done on this property in former years and large buildings, fitted with all the necessary machinery for crushing, separating and cleaning for the market, have been erected. The deposit at this place is probably one of the most valuable in the crystalline rocks of Canada.

Pugh and Weart's mine.

On the north side of Donaldson lake, on lot 26, range VI., of Buckingham, another large deposit is located. This is known as Pugh and Weart's mine. It has been worked at intervals for a number of years with apparently indifferent success, and a large sum has been spent in the erection of a crushing and separating plant. The gneiss in which the graphite principally occurs is here also associated with limestone bands and the strike of the strata in the principal cutting is N. 30° W. with a dip to the south-west. The graphite is well disseminated in the gneiss and the percentage in places appears to be quite as high as in much of that at Walker's. Furnaces for roasting the ore, prior to crushing, were erected in 1892, but the process does not appear to be very satisfactory.

McNaughton and Donaldson.

Excellent deposits of graphite are also found on lots 23 and 24 of the same range as the last on the property of Mr. MacNaughton, of Buckingham, and also on that owned by Mr. Donaldson. These were prospected by the late Mr. J. Fraser Torrence some years ago, who reported the mineral quite equal to that at the other mines in the district. No attempt has recently been made to develop these properties.

Several years ago the North American Graphite Company commenced mining on what is known as the old Dixon area on lot 28, range VI., Buckingham, where a large and valuable deposit of this mineral is found. Mills for the preparation of the graphite for the market were erected, roads made and a considerable quantity shipped. No details as to the working of this place have lately been received. The mineral at this mine also occurs in a gray and sometimes rusty gneiss which is cut by heavy dykes of granite and other intrusive rocks. In fact at all the graphite localities the presence of these intrusive masses is easily recognized. North American Graphite Co.

On the east side of the Lièvre an attempt was made several years ago to develop a deposit of disseminated graphite on lot 13, range X., Buckingham. The locality is near the summit of a high ridge of gray and rusty gneiss along the top of which the mineral is disseminated. The percentage of graphite at this place does not appear to be quite as great as at some of the places west of the river. About 200 tons of the rock with the mineral unseparated were mined and shipped to England, but the transaction appears to have been a failure financially. Area east of Lièvre river.

The graphite in the township of Lochaber has already been described in the report for 1888–89, vol. IV., page 135K. An examination of these deposits shows the mineral to occur, for the most part in a rusty quartzose gneiss with which crystalline limestone is interstratified, rather than in the limestone itself. This is the case with the deposits on lot 20, range XII., and on lots 23 and 24, range VIII., as also on lot 24, range VII., which comprise the principal deposits in this district. Lochaber.

In the township of Grenville on the south half of lot 10, range V., on a property worked more than fifty years ago, a new company, known as the Keystone Graphite Company, of Wilkesbarre, Penn., has commenced operations. The rocks at this place are largely crystalline limestone, with bands of grayish and rusty gneiss. These are cut by dykes of granite, and diabase, and the graphite is found in irregular veins near the dykes. Various minerals, including scapolite, sphene, pyroxene, apatite, pyrite, &c., are found in the rocks at this place. The results of the mining operations have not been made known, but a large amount of money has been spent in development work. On the lot adjacent to the east, the National Graphite Company, of Scranton, has also commenced mining the graphite, the conditions at both places being somewhat similar. Graphite of Grenville.

Another deposit which was worked to a limited extent some years ago is situated on the south shore of Lake Terror, on lot 12, range III., Lake Terror.

Portland west. The mineral here occurs as veins of the columnar variety in a hard felspathic rock, but they are not of sufficient size to render their extraction profitable, and work has been abandoned.

IRON.

Iron

But little development in the iron industry has taken place in this area since the publication of the 'Report on the Mineral Resources of Quebec,' in 1888-89.

The principal deposits are those known as the Baldwin and Forsythe mines in the township of Hull, about two miles north-west of Ironsides station, on the Ottawa, Northern and Western railway, (Gatineau Valley) and the Haycock mines in the township of Templeton.

The former occur in somewhat extensive pockety or lense-shaped masses in crystalline limestones, which have been cut by dykes of several kinds of intrusive rocks, and the mass of ore, which is somewhat irregular, has been traced westward over three lots.

Forsyth mine.

Of these mines, that known as the Forsythe is situated on lot 11, range VII., of Hull township, and is the one from which the great bulk of the ore was extracted during the several periods in which these deposits were worked. The ore fills an irregular fissure in the limestone, running in a direction a little north of west. The main cutting in the ore-body extends for about twelve chains west of the road to Old Chelsea. In places, the excavation reached a depth of over one hundred feet, but the ore-body proved to be irregular, being sometimes quite wide but diminishing as the depth increased. At the bottom of the workings, it is said to have a thickness of about eighteen feet.

A large quantity of excellent ore was taken from this mine, much of which was shipped to the United States, but a portion was smelted in a blast furnace at Ironsides village, near the bank of the Gatineau river, the fuel used being charcoal. This old furnace was removed nearly twenty years ago, and no mining has been done at this locality for a long time. The ore contained small quantities of sulphur and phosphorus, but not sufficient to be injurious. There is also a small percentage of disseminated graphite. The ore is largely a magnetite, but sometimes passes into a hæmatite. The extension of the ore-body is not definitely known, but what is presumably its continuation, has been uncovered on the two lots adjacent to the west.

Haycock mine.

The ore of the Haycock mine is also a mixture of magnetite and hæmatite. The quantity visible is not as great as at the Forsythe

mine. Considerable work was done there from twenty-five to thirty years ago, and a small forge was erected, the ruins of which can still be seen. The country-rock at this mine is a mixture of granite-gneiss and diorite, and the ore is irregularly distributed. This property is situated on lot 1, range XI., of Hull, and lot 28, range VI., Templeton. Iron ore is also reported as occurring on lot 2, range X., of Hull, but its value is as yet unknown.

Grenville iron ores.

In the Report of Progress for 1857, Sir William Logan calls attention to a deposit of magnetic iron ore which may possibly be of economic importance. He says: 'It is on the south half of lot 3 range V., of Grenville, the property of Mr. Thomas Loughran. The bed is from six to eight yards in breadth, and it was traced running westward and then turning south-west, the whole distance being about 150 yards. The rock on each side of it appears to be a micaceous gneiss, interstratified with many bands of quartzite. The iron ore and the strata run parallel with one another.' The analysis of the ore by Dr. Hunt gave 52·23 per cent of pure metallic iron.

This bed of ore is said to be cut off by a mass of syenite. Indications of iron ore were also noticed on lot 3 of range IV., and on lot 5 of range VIII., but the quantity observed in these was small.

MICA.

Mica.

The mining of mica in Canada is of comparatively recent date. The mineral is described in the Geology of Canada, 1863 on pages 493 and 795.

The merchantable micas may be included in two divisions, viz., the muscovites and lepidolite varieties or potash micas, and the phlogopite and biotite micas which are magnesian.

Grenville mines.

In the report alluded to, the presence of the mineral in the township of Grenville is mentioned as occurring at several localities. 'One of these is on lot 9, range VI., from which small quantities have been extracted and sent to market. A crystal from this place was so large as to furnish sheets measuring twenty-four by fourteen inches. Good mica has also been found on lot 10, range V., and on lot 1, range X., of Grenville, as well as further to the westward in the Augmentation of that township.'

Usual mode of occurrence.

The recent greatly increased demand for mica, created largely by the manufacture of electrical appliances, has led to renewed search

and to the discovery of new deposits of this mineral, more especially in the townships of Hull, Buckingham, Wakefield, Templeton and Hincks, and considerable energy has been displayed in this direction. In a recent examination of the greater number of the existing mines it was observed that the same peculiar features noticed in the deposits of apatite were common to many of these, and in fact many of the mines once worked for apatite when the market for that mineral was good are now being worked for mica, which in the early days of the phosphate industry was regarded as a waste product of little or no value.

Masses of granite, often in the form of dykes, and of pyroxenic rocks are observed at all the mines. The country-rock is generally a grayish gneiss, though occasionally the deposits occur with crystalline limestone, but in no case was the presence of mica in workable quantity observed without the presence of some form of the igneous rocks.

Villeneuve mine.

One of the earliest known, and at one time regarded as the most important of the mica deposits, was in the township of Villeneuve, on lot 30, range I. The mineral here occurs in a dyke of white granite composed largely of white felspar and quartz, with a breadth of about 150 feet, which cuts nearly along the strike of reddish and gray quartzose gneiss. In this granite dyke a mineralized belt occurs in the first ten feet on the west side near the contact with the gneiss and, in addition to the mica, fine crystals of tourmaline are also found. The felspar of the dyke is of sufficient purity to be valuable in the manufacture of porcelain and considerable quantities were formerly shipped for this purpose. The great drawback in this direction, however, is its distance from the line of railway and the consequent expense of getting it to market. The mica is in crystals, often of large size, of the muscovite variety, and has yielded a large amount of merchantable material. The strike of the gneiss at this point is N. 10° E., the dip west $< 70°$.

Little Rapids mine.

Further south on lot 6, range I., Buckingham, about 250 yards south of the Little Rapids apatite mine a deposit of mica is found in association with a dyke of pyroxene which cuts obliquely across the stratified gneiss. The mica here is phlogopite and is almost entirely confined to the dyke.

Varieties of mica.

Generally speaking it may be said that the mica which occurs in the white granite is of the muscovite variety, while that in association with the pyroxene is phlogopite. The latter is always amber-coloured, and the darker the containing rock the darker is the shade of the mica.

A purple mica is also found in association with some of the smaller dykes of white granite when these cut the crystalline limestone. This is usually a lepidolite, and a biotite mica is also found in association with some of the very dark-coloured diorite the darker shade apparently depending largely upon the greater proportion of iron in the mineral.

Mica crystals are found in many of the apatite mines so that certain of these yield both minerals in economic quantities. Crystals of mica are also found in connection with some of the serpentines as at Kendall lake, on lot 26, range XI., Buckingham, the crystals occasionally being of quite large size. Dykes of granite and pyroxene also intersect these rocks and the presence of the mica is apparently due to their action on the strata penetrated. Kendall lake.

Similar associations also occur in connection with many of the deposits along the Gatineau in the townships of Hull and Wakefield, the intrusive dykes or masses penetrating both the gneiss and limestone. The details of some of these localities will be given later.

The deposits of mica formerly worked in the township of Grenville occur in a similar way. Though an attempt was made several years ago to reopen and ascertain the value of several of these mines, no actual mining has yet been attempted in this place. Of these apparently the most important is Cameron's mine, on lot 7, range II., augmentation of Grenville, where the mica is light-coloured, in crystals of a foot across, some of them a good deal wrinkled, the rocks at the mine being pyroxene with a second dyke of syenite and with a little pink calcite, the country-rock being a grayish quartzose gneiss, with some reddish gray bands. The course of the vein is about N. 23° E. A small quantity of the mineral was also observed on lot 2, range II., some of the crystals being of a dark wine-colour, the containing rocks being crystalline limestone with white granite. Cameron's mine, Grenville.

On lot 9, range VI., Grenville, a deposit of mica was opened many years ago and several very fine crystals of muscovite were obtained. The rock is gneiss and limestone cut by dykes of very light-coloured pyroxene and white granite. Not much mineral is now visible at this place as the mine is filled with water but a number of light-coloured crystals were scattered about. The course of the dyke is apparently N. 20° W. the dip to the west $<80°$. In view of the recent discoveries in the Buckingham district, some of which are very productive, but little attention has been paid to the Grenville district.

Big lake mine Harrington.

Furthur north on lot 8, range IV., Harrington, on the summit of a ridge to the south-west of Big lake, an opening has been made in the gneiss and limestone belt, which is here intersected by a large dyke of pyroxene carrying crystals of dark mica. The pit was sunk only a few feet, the mica obtained being apparently too small and wrinkled to warrant further expenditure. Crystals of mica and a small deposit of graphite also occur with small granite dykes cutting limestone, about two miles east of the road at Lost river but neither is in sufficient quantity to be economically worked.

Whitefish lake mine.

In the township of Bowman, lot 34, range VII., at the south-west end of Whitefish lake, a small deposit of mica has been already referred to. The rocks around this end of the lake are grayish gneiss with limestone bands cut by pegmatite dykes as well as by pyroxene. The mica is found in a large mass of light-coloured pyroxene which cuts the gneiss, and several dykes of the granite cut the pyroxene. The mica crystals are sometimes a foot across the face, but so far most of these are somewhat crushed and of small value. The mica is of the amber variety, and no pink calcite was seen. The crystals occur in fissures through the mass of the dyke rather than at the contact with the gneiss. The presence of numerous dykes, both of pyroxene and granite, in this area should be favourable for the occurrence of mica in workable quantity, but no other deposits were observed around the shores of this lake. The gneiss at the mine strikes about north and south with a dip to the east, and underlies the limestone formation seen on the shores of the lake. Another large dyke of the pyroxene occurs a few yards west of that in which the mine is situated.

Priest creek mine.

About four miles to the south-west of this lake, an opening has been made near the west end of Long lake, in the Priest creek chain. This is said to be on lot 21, range V., Denholm. The mica crystals are dark amber-coloured, occurring in fissures in a dyke of soft grayish-green pyroxene, which cuts reddish and gray gneiss. Some of the crystals seen were of fair size, but the quantity appeared to be small, and the location is so far removed from a shipping point that the expense of handling the output is at present too great for profitable working.

Gatineau district.

Although mica is found at a number of points in association with the apatite deposits of Portland and Buckingham, and is still somewhat extensively mined in this district, the largest workable deposits yet found are apparently nearer the Gatineau river, in the townships of Hull, Wakefield and Templeton, and in consequence of the great importance

at present attached to this mineral, a careful study of the most important localities was made, in order to determine, if possible, some facts relative to its mode of occurrence which might be of practical benefit in the search for it.

Generally speaking, it was found that the mica of commerce in this district occurred under four conditions. In all cases it was associated with intrusive rocks, either pyroxene or some form of granite, often a pegmatite. To some extent it closely follows the arrangement already described for the deposits of apatite, in that it generally occurs near the contact of the intrusion with the inclosing rock, and very often the mica and apatite occur associated in the same mass. This is more noticeable probably where these minerals occur with masses of pink calcite, which forms masses of irregular shape in the pyroxene, and often of large extent.

The different modes of occurrence of the mica may be thus described : Modes of occurrence of mica.

1st. In pyroxene rock near the contact with the inclosing gneiss, which has been traversed by the dyke. Sometimes these dykes follow along the strike of the gneiss, but at others they cut across the stratification at all angles. In this case, very often the pink calcite is found near the contact, and this frequently carries the mica in the form of more or less perfect crystals of all sizes, interspersed with crystals of pyroxene and apatite. Good illustrations of this mode of occurrence are seen at the Gemmill mine in Cantley, on lot 10, range XII., Hull, and at the Burke mine on lot 1, range XII. Contact deposits.

2. In pyroxene rock where the mica occurs in fissures in the mass of the dyke. In this case the crystals are rarely perfect, calcite is usually absent and the mica appears to follow certain lines of fracture or faults, along which it occurs in pockety bunches which are apt to disappear suddenly, leaving the rock apparently barren, till another mass of the crystals is found. Often the crystals are of large size, instances being reported of specimens six to eight feet across the face, but these are frequently crushed or twisted so that there is often a large amount of waste material. A good illustration of this is seen at Wright's mine, near the Cascades, on the west side of the Gatineau, and at the Cassidy mine, east of that river. Fissure deposits.

3. In pyroxene dykes cut by cross dykes of granite or diabase. In this case the mica is generally found near the contact with the second intrusion and the crystals are often of large size. This is well seen at the Powell and Clemow mine (formerly Quinn's), in Hincks, some of the crystals being at least three feet across the face and exceptionally Cross dykes.

smooth though very dark-coloured. A similar mode of occurrence of apatite due apparently to the intersection of the pyroxene by a dyke of diabase is seen at the Ætna mine, on the Lièvre, in Buckingham township already referred to. In most of these cases the pyroxene intersects the gneiss, but at the Hincks mine the country-rock is crystalline limestone.

Pegmatite deposits.

4. The intersection of gneiss by pegmatite granite. These dykes are sometimes several hundred feet across and the intrusion sometimes extends along the strike of the gneiss in which case spurs are frequently given off into the adjacent strata, or it breaks at various angles across the inclosing strata. The mica in this case is muscovite, and it also occurs near the contact of the granite and the gneiss. The mica in the preceding conditions is always phlogopite or when the rock is very dark a biotite. Good illustrations of the muscovite condition are seen at the Villeneuve mine and at the Venosta mine in the township of Low, a short distance north of Venosta station on the Ottawa, Northern and Western railway. This variety of mica is much less abundant throughout the Ottawa district than the phlogopite, but along the lower St. Lawrence the muscovite appears to be the principal variety.

Purple mica.

The purple variety, though not as yet an article of commerce, is usually found in cases where the limestone is intersected by dykes of white granite. An illustration of this is seen in the township of Wakefield, near Lascelles post-office, and also on the east side of the river, about lot 6, range IV., of the same township. There is not sufficient of the mineral for economic mining in either place, but the localities are interesting as mineral occurrences. Another interesting locality for this variety is near Wilsons corner, on lot 11, range XVI., Hull.

Wilsons corner.

By far the greater number of the producing mines yield the variety known as phlogopite, the muscovite variety being apparently confined to the two localities just mentioned. Of the phlogopite or amber mica one of the most important localities is along the east side of the Gatineau river near Wilsons corner, and for several miles to the south and east including the mines at Cantley and Lake Girard. Wilsons corner is situated on the line between the townships of Hull and Wakefield, about six miles east of the Gatineau, and in this area there are numerous masses of pyroxene some of large size, as well as of granite.

On the road west from the corner the first mine noticed is on lot 16, range I., Wakefield. Here the rock is a grayish and reddish-gray gneiss having a strike of N. 20° to 30° west and a dip to the east <75°

to 90°. This is cut by a dyke-like mass of pyroxene nearly at right angles to the course of the gneiss. The mica is in the pyroxene and shows a band on the east side of the pit of about two feet in width. A small vein of apatite of eight to ten inches in thickness is associated with the mica, and both minerals occur near the edge of the pyroxene.

Hughes and Haldane.

At Hughes and Haldane mines to the south of this road on lot 12, range I., Wakefield, the mica also occurs in the pyroxene with small bunches of apatite near the contact with red orthoclase gneiss on the south. On the west near the summit of the hill the gneiss strikes north. The principal opening is on the brow of a hill of pyroxene, but several other openings have been made in the vicinity. Occasional secondary dykes of pegmatite cut the pyroxene and with these, or along the contact of the two, small quantities of iron-pyrites are found. At the most southerly opening on the crest of the ridge at this place, the mica is very dark-coloured and is found in the pyroxene near the contact with the reddish-gray gneiss which is seen just on the west edge of the pit. Apparently this peculiarity depends largely upon the colour of the containing rock which is here hard and dark, whereas in the lighter-coloured pyroxene the mica assumes a light shade of amber.

On the north side of the road nearly opposite Hughes' mine is Haldane's old mine. This was formerly worked for phosphate which was mostly red in colour. Small quantities of very dark mica occur here also, and the cutting follows along the irregular contact of the pyroxene and gneiss.

Horse-shoe mine.

Another mine in the vicinity is that known as the Horse-shoe, on lot 14, range XVI., Hull. Here also the country-rock is a reddish-gray gneiss cut by a large dyke-like mass of the pyroxene which is soft and grayish-green. The principal deposit of mica yet worked lies near the contact with the gneiss, on the eastern margin of the dyke in which it is associated with irregular masses of pink calcite and the mica crystals are of good size but sometimes wrinkled or crushed. Crystals of pyroxene also occur in the calcite but no apatite was seen at this place. The strike of the gneiss along the east side of the pit is N. 10° E. the dips S. 80° E. <70°.

Mines north of Wilsons corner.

To the north of Wilsons corner several interesting mines are located which will illustrate certain peculiar occurrences in the mica deposits. Thus on lot 14, range II., Wakefield, pyroxene cuts the eastern edge of a gneiss ridge which extends for several miles north-west along the course of Wilsons creek. At the contact of the gneiss with the north

side of the dyke mass, bunches of pink calcite occur which carry well shaped crystals of mica and apatite. The former are light-amber-coloured, but some of the larger have inclusions of calcite near the centre or sometimes small quantities of apatite in small fissures radiating from a central point which of course seriously affect the market value of the mica. The crystals of mica are found in the calcite but in a portion of the mass of the pyroxene near the contact with the gneiss, apatite was found in the massive condition. The run of the dyke is about north-west and the dip north-east $< 80°$. A short distance to the north-east several openings have been made in the south front of the pyroxene which here intersects the gneiss. Mica and occasionally small bunches of apatite occur in the pyroxene which is apparently much shattered and contains small quantities of pink calcite. Masses of the gneiss appear to be caught in the pyroxene, the contact of the two series being well seen on the north flank of the hill. Most of the observed mica crystals are wrinkled and bunches of pyroxene crystals also occur in the mass. The mineral appears for the most part to be distributed in pockets through the mass of the pyroxene rather than to occur as a contact deposit.

Chubbuck and Wilson mine.

A more important deposit is found half a mile to the north-east of this on the east side of the brook on lot 16, range II., Wakefield. The mica occurs in a gully near the contact of a light-greenish-gray pyroxene. A considerable quantity of pink calcite is found along or near the contact in which the amber mica occurs. Some excellent crystals have been obtained here and small quantities of sea-green crystals of apatite are also found in the calcite. The mining is done by following down on the calcite along the junction of the pyroxene and the gneiss which is sharply defined and this mine is therefore a capital illustration of the contact type.

Seybold's mine.

Not far from this to the south-east are the Seybold mines, on lot 18, range II. On the path up the brook from Wilson's, an opening for apatite has been made, the rock being a pyroxene which crosses the strike of the gneiss and the apatite is of the reddish variety. Scattered crystals of very dark mica also occur in the pyroxene.

The dyke at the Seybold mine is a very dark mottled hornblende rock, in places very hard and containing much iron in its composition. This dyke is broken and jointed and contains patches or vugs of the pink calcite which carries fine crystals of apatite, pyroxene, and mica, while considerable quantities of amorphous apatite also occur. A large mass of hornblende, pyroxene, apatite and calcite, ten feet thick, flanks the north side of the main diorite mass. Portions of this are apparently

composed of felspar and hornblende, the former sometimes purple in colour but generally a bluish-gray. The mica is generally very dark, almost black, in crystals of a foot or more across the face, while great masses of smaller ones are scattered through the calcite near the contact with the diorite.

The north pit on this property also shows small quantities of black mica with some phosphate. The dyke is a very hard dark hornblende and felspathic rock, the mineral contents following a fissure which extends irregularly up the side of the hill. Patches of pink calcite also occur with scattered crystals of apatite, and good crystals of pyroxene also are found at this place. The generally dark colour of the mica is due presumably to its association with a very dark-coloured dyke, and the mineral is impregnated with iron.

Between this point and Wilsons corner several other openings have been made, both for apatite and mica. The conditions seen at all these places are similar to those already described. The pyroxene cuts the gneiss and the mineral contents are, as in the former, near the line of contact.

Lake Girard mine.

The most important mine in this area is that known as the Lake Girard. This is situated on the south side of a lake on lot 24, range II., Wakefield, rather more than three miles east of Wilsons corner. The rocks in the vicinity are mostly reddish-gray and gray gneiss, and several bands of limestone occur about the shores of the lake. About 120 paces back from the shore, on the south side, a large dyke-like mass of pyroxene occurs in which the mine is situated. Several other dykes occur in the vicinity to the south and east, in all of which small quantities of mica were observed. The principal workings were in connection with the large dyke first mentioned, and the excavations have followed downward along or near the contact of the two rock masses to a depth of nearly 250 feet. Large quantities of the pink calcite occur in the pyroxene near the contact, and the mica crystals are for the most part distributed through this. In places these are very abundant and the quality of the output is on the whole excellent, both as regards the size and clearness of the crystals. In some places the calcite is quite barren. A very large quantity of mica has been taken from this mine and hauled to Ottawa, where it is cut for shipment. Only a small part of the large dyke has been extracted, however, and it is quite probable that other portions to the west of the present workings may be equally productive. But very little apatite is found at this mine. A few small crystals are seen at an opening in another dyke about 200 paces east of the principal one. Dykes of pegmatite

also cut the gneiss and limestone at the eastern part of the lake. Work was suspended at this locality for several years owing apparently to depression in the market.

Mines at Wakefield lake

Allan's.

An interesting locality both for mica and apatite is found on the north-west arm of Wakefield lake, on lots 26 and 27, range IV., Portland west. At the apatite mine (Allan's) a number of pits are distributed over the surface of a high ridge of gneiss, cut by pyroxene dykes, which are usually light-green in colour and frequently contain small quantities of iron pyrites. Pinkish calcite is frequently found, through which crystals of red and green apatite are scattered. Quantities of massive apatite also, both green and red, are found throughout the pyroxene. The mica crystals are apparently comparatively few in number and of the amber variety. At several points the pyroxene is cut by dyke-like masses of almost pure felspar, which is sometimes white and at others a pink colour. These felspars should be valuable for the manufacture of pottery, provided the cost of transport is not too heavy.

McRae's mine.

To the south of this on the ridge along the east side of the north arm of the lake, several openings have been made for mica by the McRae Company of Ottawa. That on the north face of the ridge shows the presence of a great mass of the white granite mixed with pyroxene, in which is an irregular vein of pink calcite, through which the mica crystals are scattered. This mass can be traced down the slope of the hill for over a hundred yards. The other or more southerly mine is near the summit of the ridge, near the line between ranges III. and IV. The pink calcite here forms a vein having a course north-and-south with pyroxene, and granite intrusions are also frequent. The mica is dark amber and appears to occur in the pyroxene near the contact with a cross dyke of the granite. A few crystals of apatite also occur in the calcite and the mica crystals are sometimes a foot across the face. No apatite was noted in the opening on the north side of the ridge.

Laurin's mine.

On the road from Deziels corner to Perkins Mills, by way of the north side of McGregor lake, several mines, formerly opened for apatite were examined. In every case the association of mica and apatite crystals was observed in calcite near the contact of the pyroxene and the country gneiss. In Laurin's mine, lot 20, range XII., Templeton, the apatite was in the massive as well as in the crystalline form, the latter being quite abundant in the calcite. The mica in this case was brown.

At the mines of the Templeton and North Ottawa Company, lot 21, range XII., the mica and apatite are intimately associated in the pyroxene which cuts a grayish micaceous gneiss having a strike of N. 45° W. <90°. In neither of these places did the mica appear to be in workable quantity. In fact in nearly all the old phosphate pits around McGregor lake brown or amber mica is found more or less abundantly with the apatite in calcite, but not in paying quantity. McGregor lake.

On the road from Wilsons corner through Cantley, several important deposits of mica were observed. Probably the most extensive of these is what is known as the Gemmill mine on lot 10, range XII., Hull, about half a mile from Cantley post-office. A number of openings have been made along the sides of a knoll of reddish and gray gneiss and granite, which is intersected by several dykes of pyroxene. Most of the mica occurs here as true contact deposits along the gneiss and pyroxene, and the mineral is found almost entirely in the pink calcite. The main veins have a course of north-east with a dip to the south-east. The overhanging wall is sometimes gneiss, the underlying rock being a light-coloured pyroxene. The width of the mica-bearing portion in the principal opening, which is in the calcite, is from three to five feet. The crystals are light-amber coloured, of good size and generally smooth. Another opening to the north of the main pit is near the contact of the pyroxene and a cross dyke of white granite which cuts both the pyroxene and the gneiss, the granite being clearly the later. The crystals here are light-coloured but smaller and somewhat wrinkled. In the most westerly pit near the crest of the hill, the gneiss dips to the north <40°. The pyroxene cuts across the gneiss with a south dip, and carries calcite with mica along the contact. The dyke here runs N. 20° E., dipping S. 70° E. <55°. On the north side of the hill the ridge of banded gneiss dips N. 60° E. <30°. The main dyke in which the principal mica deposits are found has been traced on its north-east course for 1,200 feet. Very considerable quantities of apatite occur in some of the openings at this place along with the calcite. This mine has been photographed by Mr. H. N. Topley, and the relations of the different rocks and minerals can be clearly seen. Gemmill mine.

The Webster Company's mine is situated on lot 10, range XII., Hull. A number of pits have been sunk on a knoll of gneiss which is intersected by pyroxene and diorite dykes. Some of the latter are hard and hornblendic. Pink calcite occurs near the contact of the dyke with the gneiss, and the mica and apatite occur mostly in the Webster mine.

calcite though the latter is also found in the massive pyroxene. Several of these dykes are highly felspathic. The gneiss dips S.E. $<60°$.

Mines south of Wilsons corner.

To the south-west of Wilsons corner several interesting mica mines have been worked. Of these the Wilson, Chubbuck and McLelland are the principal. The latter is on lot 12, range XVI., Hull, and is interesting from the presence of serpentine in association with which the mica occurs. The pyroxene cuts the limestone formation at this place and the serpentinizing of the rock may be due to this fact. To the south-east of this opening a cut has been made in a brownish felspathic dyke which also crosses the limestone. The mica crystals seen are small, rarely more than three inches across and of a dark-brown colour. A similar occurrence of mica in a dyke, cutting limestone, is seen on lot 7, range IV., Wakefield, the mica having the same purplish-brown colour.

Wilson mine.

At Wilson mine on lot 13, range XVI., Hull, pyroxene cuts the reddish gneiss. There is here a very considerable development of the pink calcite and a large quantity of apatite, the latter occurring both in the calcite and the pyroxene. The mica is light amber, the crystals sometimes a foot across the face. The dip of the gneiss at the contact is E. $<55°$ and the dyke cuts the gneiss transversely to the strike.

Chubbuck mine.

A short distance to the west of this on lot 12, range XV., an opening in pyroxene shows, on the south side of the dyke, a very considerable deposit of mica and apatite crystals which underlies the limestone on the north. The strike of the dyke is N. 40° W. and the dip is to the south-west $<50°$. The pink calcite is well exposed along the contact and contains most of the crystals which are often of good size, though the property had been but slightly opened up. Red and gray gneiss lie to the north of the dyke. To the north of this another opening on Chubbuck's property shows great ledges of pyroxene cutting the gneiss and the mica and pyroxene crystals occur in fissures in the dyke itself. At another opening to the west, on lot 13, range XVI., Hull, one of these fissures carries calcite and some very large crystals of smooth mica were obtained. The excavation was carried down to twenty-five feet and hugh crystals of pyroxene occur here which are well terminated. The associated gneiss is generally reddish or reddish-gray in colour and the pyroxene is light-grayish-green and soft. These are not contact deposits but appear to resemble segregations along lines of fissure through pyroxene itself. In the pit which produced the largest crystals of mica and pyroxene no apatite was seen,

while in most of the other pits adjacent, it occurs in considerable quantity. In several other openings on the adjoining lot to the south of those just described, similar conditions are seen. The pyroxene cuts the gneiss, sometimes transversely to the strike, at others nearly with it, and mica and apatite occur, though none of these mines are at present being operated.

On the back road, east of Cantley, on lot 3, range XIII., Hull, a pyroxene dyke cuts reddish and gray gneiss and is in turn cut by a dyke of hard felspathic rock. Apatite and mica occur here along with a little pink calcite in the pyroxene near the contact with the cross dyke, which would therefore appear to have had some effect in producing the mineral deposit. A quarter of a mile further north a similar occurrence is seen. The pyroxene here has apparently burst through the gneiss but not reached the surface as there is a capping of the gneiss along one side of the pit overlying the pyroxene. A diorite dyke also cuts the pyroxene, and along the contact iron-pyrites, calcite and mica are scattered; the crystals occur along jointings in the pyroxene and are generally much twisted.

Burke mine.

Another interesting location in this vicinity is at the Burke mine on lot 1, range XIII., Hull. Here a large dyke of pyroxene cuts the gneiss, portions of the latter being seen along the north side of the pit. This place was formerly worked for apatite and yielded a large amount of this mineral as well as large quantities of amber mica which occurred along with the apatite and which was thrown into the dump as useless. These crystals as well as the apatite were distributed through that portion of the pyroxene near the gneiss along with pink calcite, the relations of the several minerals to the containing rocks being well seen. Huge crystals of pyroxene are seen at this place one on the south side of the pit being over a foot in diameter. This mine has also been photographed by Mr. H. N. Topley, for the Geological Survey.

On the road south from Cantley to Wrights Bridge, a succession of gneissic and granite rocks are traversed for several miles. The relations of the pyroxenic and granitic rocks to the stratified gneiss are well exposed at a number of places. Attempts have been made to mine mica on lot 7, range X., Hull, but the crystals are small and generally dark-coloured.

Nellie and Blanche mine.

One of the largest mines worked for mica in this district is the Nellie and Blanche, on lot 9, range X., Hull. This deposit is for the most part in a great mass of pyroxene through which the mica is distributed apparently along lines of fissure and the deposits are therefore not true

contacts like those at the Gemmill mine. Some of the openings here have reached a depth of almost 200 feet, the pink calcite is rarely seen at this place but apatite is occasionally found in small quantity.

The above mines comprise most of those on the east side of the Gatineau in the townships of Hull and Wakefield. Several deposits are found, however, in Templeton in the vicinity of Perkins Mills which will be referred to further on.

Brown, Fleury, Fortin and Gravelle.

On the west side of the Gatineau river deposits of the mineral are found at a number of places at no great distance from the river. The most southerly in this direction are Brown's mine, on the south end of lot 19, range VII., Fortin and Gravelle, on lot 18, and Fleury mine, on lot 20, Hull. Here a band of reddish and gray gneiss separates two broad belts of crystalline limestone and is cut by soft light-green pyroxene, the mica occuring in pink calcite near the contact with the gneiss. The pyroxene here has a dip of S. 40° E.

Scott mine.

To the north of Old Chelsea a short distance west of the road leading to Kirks Ferry, the Scott mine is situated on lot 14 and 15, range IX. At the south opening the country-rock is a reddish and gray gneiss of the usual type which is cut by small irregular dykes of pyroxene carrying small quantities of red apatite and dark amber mica. The gneiss has a dip to the south-east, and the limestone in the valley adjacent dips to the east. In the main pit a fourth of a mile to the north-east the gneiss is well banded and cut by dykes of various kinds such as pyroxene, granite and diorites. These are generally small, cutting at times along the course of the gneiss. Some ten to twelve tons of mica crystals were taken from this place, all amber-coloured and some of good quality. Red apatite also occurs here and a small quantity of bright red jasper is found in one of the dykes. Further to the north-east another opening has been made in pyroxene associated with the crystalline limestone but the mica here is unimportant.

In the hills a fourth of a mile north of Old Chelsea corner, numerous pyroxene masses are found with the gneiss. At one place on Chamberlain's lot a great mass of pyroxene crystals is seen with bunches of red apatite and small crystals of amber mica. East of the Kirks Ferry road in rear of the church, similar occurrences of mica in small quantity are noticed but the crystals yet found are too small to have much economic value.

On lot 15, range X., similar pyroxenes in gneiss, carrying mica, were also noted, as also on lot 17, and several openings have been made. In one of these the pyroxene shows green phosphate in calcite with

small mica crystals. Going west the intrusive mass is a hard black, dioritic-looking rock, and the mica contained is correspondingly dark-coloured as is also the case in a third pit where the country rock is gray and red gneiss having a strike N. 10° W. with a dip west < 50° The mica here is also dark and in small crystals.

Approaching Kirks Ferry on lot 17, range X., several openings have been made by Mr. Haycock, of Ottawa, which present some points of interest. On the west side of the road and about 100 yards from it the gneiss strikes N. 20° W. and dips N. 70° east < 40° to 60°. This is cut by a dyke of pyroxene having a course east and west with a breadth of about four feet. At the west end of the cutting the dyke is capped by the gneiss. The upper part of this dyke for five or six feet carried apatite, but below this the mica came in and yielded some very fine crystals of the amber variety. The dyke is vertical. Further on another cutting in pyroxene with red gneiss shows bunches of pink calcite near the contact, in which are the usual crystals of mica and pyroxene. Cross dykes of white granite cut the pyroxene at this place. Kirks Ferry Haycock mine.

On the east of the post-road near the Gatineau on lot 12, range XI., two dykes, one of pyroxene and the other of granite, cut the gneiss. The former forms the foot wall of a mica deposit, the granite the upper, and the crystals are formed along the contact between the two. The gneiss at this place and also at that first mentioned has a synclinal structure, the intervening space being occupied by limestone.

Going north, on lot 14, range XI., stratified gray and red gneiss dips east and is cut by small dykes of pyroxene from one to three feet wide. At one point two small dykes of pyroxene come together and in the cavity near their intersection many small crystals of apatite occur, mostly red in colour. These dykes are too small to be worked successfully, but 100 yards further north on the slope of the hill, a larger dyke has been opened from which a number of fine crystals from ten to fifteen inches across, were obtained. Many of these are, however, too much crushed to be of economic value. A considerable quantity of apatite was also mined at this place but no pink calcite was noticed. Connor's mine.

Just above the Cascades on the Gatineau and a fourth of a mile back from the river, on lot 23, range XV., is Moore's or Wright's mine. The hill here is apparently largely composed of pyroxene or diorite, and the openings, which are numerous, are apparently situated along lines of fissures in this rock. They extend over the crest of the hill, and though but little pink calcite is seen at any of them, masses Cascades mines Wright's.

of mica crystals are numerous. Most of these are imperfect or irregularly formed, and all are of the amber variety. Small quantities of apatite are seen at some of the openings. Some very large mica crystals were obtained at this place, but most of these were too much crushed to be of much value. This mine presents none of the features of the contact deposits, but is like the Nellie and Blanche.

Cross mine.

To the west of the Cascades mines, on lot 24, range XIV., Hull, on the property of Mr. Cross, a mass of pyroxene with heavy dark hornblende rock cuts the gneiss. The mica crystals in the dark rock are very dark-coloured also, but in the lighter portions are of much lighter shade. At this place there is a very large outcrop of intrusive rocks of various kinds, and it is probable that these continue across to the mine at the Cascades, which is less than a mile to the north-east.

Cassidy's mine.

On the east side of the Gatineau, on lots 15 and 16, range XV., Hull, two interesting mines are located. Of these, the most southerly is Cassidy's, and is like that at the Cascades, in that it is situated in a heavy mass of pyroxene which cuts red and gray gneiss. The pyroxene is greenish-gray with portions mottled with white, and the mica deposit extends across the pyroxene in a fissure and is from one to two feet thick with a course of N. 40° W. A second and smaller vein cuts across the south-east end of the pit. This deposit is entirely in the pyroxene, and there is no pink calcite showing. Cross-dykes of white granite cut the pyroxene. There is no gneiss within fifty yards of the mine. The crystals of mica are amber coloured and of large size, often twenty inches across the face and some reaching a breadth of nearly three feet, but most of these are imperfect. Green apatite occurs in the south-east end of the principal opening. Half a mile to the north of this is Macfarlane's mine, the path in the interval crossing a band of crystalline limestone which overlies the gneiss to the north of Cassidy's. Macfarlane's openings are for the most part along the contact between the pyroxene and the gray gneiss, with the usual deposit of pink calcite, which carries crystals both of mica and apatite. Some of the former are from eight to ten inches across the face, light-coloured and smooth. In the other pits a short distance to the north, the calcite is in very small quantity and the mica much crumpled. Several other openings have been made in a very hard diorite rock, in which small quantities of iron-pyrites are found, but the mica in these is dark and the crystals unimportant, being small and much twisted.

Macfarlane's mine.

Further north, in the townships bordering along the Gatineau, deposits of mica are found at widely separated points. Thus in the township of Low, lot 36, range XIII., a band of reddish and gray

gneiss separates crystalline limestone and is cut by a heavy dyke of grayish granite near the north-east end of a knoll. The mica crystals (muscovite) are found in the mass of the granite. They were of good size and smooth, but few in number. The strike of the gneiss here is N. 40° E., the dip S.E. <70°. This is what is known as the Venosta mine. The pit is only a few feet deep, work having ceased on the disappearance of the mineral some years ago. Venosta mine.

Further north in Hincks, lot 22, range II., a very large surface show of mica crystals was seen. Three openings were made in pyroxene, cutting limestone. The dyke is of a large size and is cut by another of white granite, the mica occurring in proximity to the cross dyke. This mica is dark-coloured but remarkable for the size and smoothness of many of the crystals some of which were more than three feet across the face. The mine was opened in 1893, and about 200 tons of crystals taken out. The strike of the country-rock, mostly crystalline limestone, in the vicinity of the mine is about N. 25° E. and masses of white granite are seen at a number of places. This mine was worked by Clemow and Powell. Hincks, Clemow and Powell mine.

On the bank of the Gatineau a short distance below Aylwin, several openings were made in a granite dyke also cutting limestone but the crystals were mostly too small to be commercially valuable.

Further north in the township of Wright, on lots 14 and 15, range D, on the north side of the Gatineau, several deposits of mica occur. That on lot 14 has been opened up and extensively worked for some years. The country-rock is a gray gneiss, well stratified and cut by a dyke of greenish-gray pyroxene which holds bunches of pink calcite. The sides of the opening which was originally about eight feet wide and twenty to thirty feet deep, are studded with mica crystals ranging in size up to a foot across the face. The number of these is very great, but many of the largest are injured by the presence of small cracks across the centre in which inclusions of calcite or apatite occur. A large quantity, of mica has been taken from this place. Large dykes of white granite are also numerous in the vicinity. The deposit on lot 14 adjacent is near the crystalline limestone, and dykes of pyroxene and granite are also common. A similar occurrence of mica crystals is also seen here but the locality has been but slightly tested. St. Antoine or Guay mine.

South of the Gatineau on the west side of Bittobee lake, small deposits of mica crystals are found in connection with pyroxene and granite, which cut both the gneiss and limestone, but the quantity does not appear to be very extensive. Further north in the township Bouchette.

of Bouchette, on lot 31, range I., another mica mine is located in a mass of pyroxene cutting a gray and sometimes rusty gneiss. The crystals here are mostly distributed through the dyke and are very dark-coloured and often twisted. But little gneiss is visible in the vicinity of the mine.

Several other deposits have been noted in this area but the quantity observed is generally small. It may, however, be stated that where dykes of pyroxene cut the gneiss or when these are cut by the white granite the chances for mica are much better than when these rocks cut the limestone, judging from the localities yet examined.

Mines near Perkins Mills.

It will be seen therefore from the descriptions given of these deposits that certain portions of the townships of Hull and Wakefield contain by far the greater number of workable deposits of this mineral in the Ottawa district, at least in so far as our researches have extended in this direction. As regards the deposits in Buckingham, Templeton and Portland, while the presence of the mineral has already been pointed out in connection with the apatite deposits at the Blackburn, McLaurin, Jackson, Rae and several other mines in the vicinity, comparatively little attention was paid to the presence of the mica for some years, though the crystals were often abundant and of good quality. Several valuable mines however are situated in the vicinity of Perkins Mills, which have been extensively worked, among which may be mentioned lot 16, range VIII., Templeton (Wallingfords), in which the output is also of the amber variety.

In the area included in the map-sheet No. 122, with the exception of the mines already noted in the vicinity of the Gatineau, deposits of this mineral are very rare or at least have not yet been located. The rocks are somewhat different in character over much of the area and there is an absence of the great development of pyroxenic rock so conspicuous in the Lièvre and Gatineau districts.

In the above descriptions of the apatite and mica deposits of the Ottawa district, it may be stated that the greater part of the examinations were made by this department several years ago. Much development work has been carried on in this area since that time and a number of new areas have been located, some of which have been quite extensively worked. A number of the old mines formerly worked for apatite, in which mica was found and at that time regarded as a waste product, have been operated as mica mines for several years and have proved among the most productive in the district. The details of these new workings were not known at the time of our examinations, but as

the information regarding these deposits is of interest to the mining community, and in order to render this portion of the report as complete as possible, additional details have been obtained from the reports of Mr. J. Obalski, mining engineer for the province of Quebec, and are here added.

In the township of Templeton, in addition to the localities already described, the occurrence of mica may be mentioned as follows :—

On lot 21, range IV., indications on the property of Mr. McTierney.

On lot 22, range IV., Taylor and McVeity, an old apatite mine, reopened for mica in 1898, from which a considerable quantity has been extracted.

Lot 20, range V., W. Smith, indications.

Lot 10, range VII., Stevenson mine, worked by several parties at different times, and in 1899, by Mr. J. Asquith, of Ottawa. A large quantity of good mica is reported as taken from this mine from a large surface trench. Distance from East Templeton, 10 miles.

Lot 14, range VII., prospected by the American Mica Co., Boston. No returns available.

East half lot 15, same range, formerly worked, 1891, by Hon. C. A. Dugas, and in 1896–97 by Baumgarten and Manchester, has yielded a considerable quantity of good mica. In the latter year worked by the Webster Co. to a depth of fifty feet. Ten miles from East Templeton.

West half of lot 15. Worked by several parties since 1893. Quite extensive operations in 1897–99, to a depth of 70 feet, and is reported to have yielded a large quantity of excellent mica associated with apatite, some of the mica crystals being of large size.

Lot 16, same range, Wallingford mine, worked regularly since 1892. One of the largest and most productive mines in the district, the output of merchantable mica being very large. The crystals often of large size and excellent quality. The mica occurs in a large dyke of pyroxene, cutting the grayish gneiss, and has been worked to a depth of over 170 feet along an excavation 200 feet in length. The mine is well equipped with machinery for the extraction of the mica. Apatite is also found in large quantities at this place. Mica is also found on the south half of lot 17, same range, twelve miles distant from Templeton station on the Canadian Pacific railway.

Lot 4, range IX. Worked at intervals since 1892, and has yielded a large amount of good merchantable mica. Known as the Sophia mine. Twelve miles from Templeton station.

South half lot 11, range IX. Prospected in 1894, by the North Templeton and Ottawa Mining Co.

Lot 13. Indications of mica.

Lot 14. Worked for apatite twenty years ago, and since 1894 for mica. The mineral occurs with pink calcite in pyroxene and a considerable quantity of mica has been extracted with the apatite. It has recently (1899) been worked by Jurkowsky and Co.

Lots 16–21, also prospected by the same company, no returns.

Lot 7, range X. Prospected in 1900 by McLaurin & McLaren. No returns.

Lot 8, same range. The Marsolais mine, formerly worked for apatite but since 1897 has been worked irregularly for mica, of which a considerable quantity has been extracted. Fourteen miles from Templeton.

East half lot 9. Post mine, Canada Industrial Co., formerly a phosphate mine, has recently yielded a quantity of mica, some of the crystals being of large size.

West half lot 9. Jackson Rae mine, formerly worked for apatite, has since 1892 yielded a considerable quantity of mica.

North half lot 10. Jubilee mine, formerly worked for apatite, also contains mica in considerable quantity.

East half lot 10. Also formerly worked for apatite, contains a small quantity of mica, worked by Mr. A. Murphy.

West half lot 15. Has yielded several tons of apatite and mica in close association.

Lot 16. Victoria mine, opened in 1899, by McLaurin and McLaren. Excavated for 300 feet in length by 60 feet in depth, and has produced a large quantity of excellent mica as well as of apatite.

North half lots 7, 8, 9, 10, 11. The Blackburn mine, formerly worked for apatite, of which it was a large producer, the mica then being regarded as a waste product. Worked at intervals since 1891 for mica, and has produced a large quantity of excellent mineral of large size. It is one of the most important mines in the Templeton district.

Indications of mica are also found on lots 12, 13, 14, 24 and 27, range XII., and on lots 3, 4, 5, 13 and 17, range XIII. Good sized mica, but somewhat broken, is also found on lot 38 of the Gore.

In the township of Hull work has been carried on in recent years by the Brown Bros., of Cantley, on the following lots :—

Lots 19, 20, 22, range VI., and on lots south half 18, the Eva mine, as also on south half 19, the Aberdeen mine. There is a large quantity of mica in several of these pits, much of it of excellent quality and good size. This is hauled to Cantley and there dressed for the market.

North half lot 18, range VII., the Fortin and Gravel mine, opened 1899 in pyroxene, has yielded a large quantity of good mica, some of which is of large size. It has been worked to a reported depth of 90 feet in one place.

South half lot 20, range VII. The Fleury mine, opened in 1900, shows large dyke of pyroxene carrying excellent mica, one crystal of superior quality measuring 24 by 28 inches. The deposit has not been largely developed.

All the above locations are a short distance south of Kingsmere.

The Scott mine on lot 14, range IX., and the Cascades mine on lot 22, range XV., have already been described.

Lot 23, range XV., Ferguson mine, opened in 1899 by Mr. H. Flynn, is with calcite in pyroxene, and has yielded a considerable quantity of medium-sized and small mica.

The Moore mine on lot 24, range XV., and the Gorman mine on lot 27, range XVI., have been but little worked. The latter was opened in 1898 by Mr. Bishop, of the Cascades.

These are all situated to the west of the Gatineau river.

In Hull township, east of the Gatineau, the following may be noted :—

Lot 7, range X., the Foley mine (Big Crystal mine) had a fair showing of mica, from which it is reported twenty-five tons were taken, but work has apparently ceased since 1898.

Lot 5 and south half lot 6, range XI., the Kearney mine, worked in 1892, by Messrs. Rae and Allan, has yielded considerable mica. The Eureka mine, on lot 6, same range, was also worked in 1893 by Mr Perkins, and about eight tons were extracted.

North half lot 10, range XI., Nellie and Blanche mine, has already been described. It was at one time one of the largest producers in the Gatineau district, but no work has been done here for several years.

Lot 10, range XII., the Gemmill or Nellis mine, already referred to, and has been a steady producer for about ten years.

South half lot 1, range XIII., the Burke mine, formerly worked as an apatite mine, was opened in 1894 for mica, which had formerly been regarded as a waste product. It has yielded a considerable quantity of good mica, some of the crystals being of large size. Already referred to.

North half lot 12, range XV., the Dacey mine, worked in 1898-99 by Webster & Co. Mine excavated to a depth of about 50 feet, and has produced a quantity of generally small sized mica.

South half lot 13, same range, originally worked as an apatite mine, was opened in 1898 by Clemow and Powell for mica, the mineral occurring with calcite in pyroxene. Produced some good mica, but not of large size.

North half lot 13. James Connors, worked by Webster & Co. in 1892, and in 1899 by the owner. Small quantity only reported.

East half lot 15, same range. Jameson mine, worked for several years to a reported depth of 75 feet, and has yielded some mica of large size.

In the township of Wakefield the principal mica mines have already been referred to. They lie to the north and east of Wilsons corner. Work has, however, been carried on within the last four years at several of these, more particularly at those known as the Comet mine, south half lot 15, range II., in 1898-99; at the Kodak mine, lot 16, same range, which was worked to a reported depth of 110 feet along a distance of 200 feet, yielding a large quantity of good mica, and more recently in 1900 by Jurkowsky & Co., and in 1900 by Webster & Co. The mica occurs in pyroxene with a heavy band of pink calcite.

East half lot 17, range II., the Morris mine opened in 1892 has produced several tons of large mica some crystals measuring 12 by 24 inches.

The lake Girard mine on lot 33, range II., has already been referred to and has been for years a very large producer of excellent mica. It is well equipped with modern mining machinery. The works for the last three years have been under a new management.

In Portland west, on Lake Terror, is the Lake Terror mine from which several tons of good amber mica were obtained several years ago. This is on lots 12 and 13, range III. On lot 15, same range, a mine opened in 1900 has produced a small quantity of good mica and on the north-half lot 24 the Lila Mining Co., of Ottawa, employed a number of men in 1899 on a property formerly worked for apatite and extracted several tons of good sized crystals.

On lots 26, 27, 28, range IV., the old apatite mines of Fleming and Allan were opened in 1891 for mica, and for several years produced a large quantity of that mineral. The old apatite mine on lots 5 and 6, range IX., formerly the McIntosh mine, has also been a producer of mica to a considerable extent. Work was carried on at this place in 1899-1900.

In Portland east, on east half lot 1, range I., the Judge mine, opened first in 1893, was reopened in 1900, results unknown, and on the west half lots 1 and 2 same range the Glen Almond Mica and Mining Co. has done a large amount of surface working from which a considerable quantity of generally small sized mica has been obtained. This company has also operated on lot 23, range II., Derry, but no returns of this development are to hand. Work has also been done on lots 3, 4 and 6, range III. This place was formerly worked for apatite.

On lot 9, range I., Derry, Mr. W. A. Allan in 1900 opened a mine. Operations chiefly confined to the surface workings, and several tons were extracted.

In Buckingham, on north half lot 25, range IV., some work was done in 1899 by Mr. Tétreau, and in 1900 by Mr. D. Richard. Several tons of generally small mica were obtained.

In the township of Hincks, in addition to the mines of Clemow and Powell already described, some exploratory work was done in 1897–98 on lots 3–6, range IV., generally small mica was found in pyroxene with calcite, and in several areas near lake St. Mary also, but the mica of this district in so far as yet developed is usually of small size and in limited quantity.

In the township of Northfield, on lot 1, range A, a mine was opened in 1895, and subsequently worked in 1896-98, by the Toronto Mica Manufacturing Co. Several excavations reaching a depth of 30 feet were made, the mica occurring with calcite in pyroxene. The mica obtained was usually of small size though some good crystals were found, and work here has ceased. Some work was also done on lot 2 adjoining, and on lot 8, from which a small quantity of mica was obtained.

On lot 19, range B, a mine was opened in 1898, by Syneck and others. Several openings were made and some tons of somewhat imperfect mica were obtained. The exact results have not come to hand.

In Wright township on lot 6, range A, a mine was opened in 1898 by Mr. Watters. The pyroxene here contains some pink calcite but the rock is generally hard and dark coloured and the mica is also dark. The excavations reached a depth of 15 to 20 feet. The mica is for the most part of small size, though a considerable quantity was obtained. Work was carried on at this place in 1900 by Webster & Co.

At the St. Antoine mine on lot 15, range D, a large amount of work has been done in recent years, the mine being the most productive in the Gatineau district. The mica occurs in crystals sometimes of large size and in great abundance in a pinkish or gray calcite in a large dyke of pyroxene cutting a grayish gneiss. In 1900 the depth of the excavation was over 90 feet and for several years the daily output of rough mica was about three tons. It has recently been worked by the Sills Co., of Chicago. The mine is near the north bank of the Gatineau, about seven miles east of Gracefield.

On lot 12, range V., near the road one mile south of the Pickanock river is the Moore mine. It is in a knoll of pyroxene, and has been opened only by surface workings. The output so far has been generally of small size though crystals of large size are also reported. It was worked at intervals in 1898-99.

The above descriptions, taken in large part from the recent reports of Mr. Obalski, embrace most of the locations in which mica has been worked or known to occur in economic quantity. Indications of the mineral are, however, found at many other points, some of which may yet develop into productive mines, but owing to lack of development nothing can now be said as to their actual value. In an area so traversed by masses and dykes of pyroxenic rocks and granites, mica deposits will undoubtedly continue to be found at many other points throughout the district north of the Ottawa, since over a large portion of the area between the Gatineau and Lièvre rivers and in the country adjacent to these streams the conditions are highly favourable to the occurrence of both mica and apatite.

BARITE.

Barite in Foley mine.

Only two deposits of this mineral are known in the area north of the Ottawa. One of these, formerly the Foley mine, is on lot 7, range

X., township of Hull, near the road to Cantley, and occurs in connection with the granite dyke which cuts the crystalline limestone. The mineral is in small irregular veins along the course of the dyke, ranging from one to two feet in width, and associated with masses of purple fluor. This deposit has within the last two years been worked to some extent by a Montreal paint company and a quantity of the barite has been shipped to that place. Another similar deposit is seen along the back road towards the Templeton line, on lot 3, range XI., of Hull, but has not yet been developed to any extent. The actual value is therefore unknown.

FELSPAR.

Felspar.

Some of the pegmatite dykes are largely made up of felspar, either white or red in colour, and in some of these the mineral is sufficiently pure to be economically available for the manufacture of certain kinds of porcelain or pottery. The presence of iron in the rock is highly injurious, but the red colouring of the felspar disappears in the process of manufacture, and the resulting silica is snow white.

There are large masses of this rock throughout the area occupied by the crystalline rocks, but much of it is too remote from convenient shipment to be economically valuable. The pegmatite dykes are numerous in the areas of crystalline limestone though they cut the gneiss formation also.

Papineauville.

Villeneuve mine.

Large areas are seen near the village of Papineauville where the mass is nearly white, but these are said to contain too great a proportion of quartz and small quantities of mica, which is also injurious, and prevents these deposits from being utilized. A large quantity was at one time shipped from the great dyke at the Villeneuve mine, the quality of the felspar being excellent, but in this case the distance from the Lièvre river and the subsequent transfers from boat to rail rendered the handling unprofitable. The freight rate to the United States where the felspar was shipped, and the low price obtainable, combined to render the industry almost unprofitable. Several quarries were operated a few years ago, one of which was near Templeton station, about twenty tons a day having been shipped for several months, but the work is now suspended.

Kaolin of Amherst.

The Kaolin deposit in the township of Amherst has not yet been developed though the quality is said to be excellent. This could now be shipped by the railway from St. Jérôme into Arundel. The extent of the deposit is, however, unknown.

BUILDING STONES.

Building stones.

The limestones of the Chazy, Black River and Trenton formations have long been noted for the excellence of their material for building purposes, and large and valuable quarries exist in the areas occupied by these rocks. Among these may be mentioned the Ross quarry, in the township of East Hawkesbury, in limestones of Chazy age, and from which a very large amount of excellent stone was taken for construction work on the Grenville and Carillon canals. Near L'Orignal also quarries are found in the Black River and Trenton formations, (Murrays) the stone from which has been used for the same purpose. Butler's quarry in the Chazy limestone about three miles west of L'Orignal near the river road, and several others in the Black River or Trenton limestones in adjoining lots are well known and the quality of stone is excellent. These are in the western part of the township of Longueuil.

Ross quarry.

L'Orignal quarries.

Quarry in Potsdam sandstone.

Further west on the north side of the Ottawa, between Papineauville and Montebello, a quarry is located in the Potsdam sandstone which has yielded a large amount of stone. To the south of Rockland the large quarry of Mr. A. Stewart, from which much of the stone for the Soulanges canal was obtained, is situated in a bold escarpment of Black River and Trenton limestone, the latter forming the upper portion of the cliff. The great quarries of Hull near Ottawa are also in the Trenton limestone.

Lachute.

Quarries in the crystalline limestone are rarely seen in the area north of the Ottawa. The rock is occasionally used for lime-burning, and there is a quarry opposite the village of Lachute from which a large amount of good stone has been taken. On the east spur of Rigaud mountain also there is a quarry in the granite from which large blocks for monumental work have been obtained.

Some of the crystalline limestones of the Grenville series are dolomitic and in certain bands should be sufficiently magnesian to be suited for the manufacture of wood pulp by the chemical process. No efforts to utilize these have as yet been made.

OCHRES.

Ochres of Grenville.

On the eastern part of lot 17, range VII., township of Grenville, a hill of serpentine is seen along the east side of a ridge in which a mica mine, already referred to, is located. In this rock are pockety masses

of a brown ochre which has been worked in former years by a Montreal company for paint, but nothing has been done in connection with this locality for some time. The serpentine rock is in places a beautiful stone, but the rock is apparently too much shattered to furnish blocks for decorative purposes, except of small size.

PEAT.

Along the south side of the Ottawa, deposits of peat are numerous and extensive. Most of these are beyond the limits of the map-sheet. In the Geology of Canada, 1863, several areas are mentioned where peat occurs, some of the deposits being of sufficient size to be economically important. Peat.

On the north side of the Ottawa, in the township of Grenville, three of these peat bogs have been observed. One of these on lots 4 and 5, of range V., covers about thirty-six acres, and has a depth of ten feet. It has been used in the neighbourhood and is pronounced of excellent quality. Another deposit of about the same extent occurs on lot 1, of the same range and is in parts more than fifteen feet in thickness. A third of about thirty acres occurs on lot 4, of range VII. A fourth deposit was seen in a tamarack swamp extending over about forty acres of lots 4 and 5 of range I., of Harrington. All these areas should be easily drained. The depth of the Harrington deposit is from ten to twenty-five feet. Deposits n Grenville.

PEAT AND MARL.

In Argenteuil, on lot 3, range I., an ancient lake basin is filled with peat, the extent of the deposit being about twenty-two acres. The peat has a thickness of nine feet and is underlain by shell marl ranging in depth from five feet to thirteen feet. On the same lot is another peat bog with a length of half a mile from east to west and a breadth of one hundred to one hundred and fifty yards, also underlain by marl with a reported depth of twelve feet. Shell marl Argenteuil.

Marl is found in Eagle Nest lake, on lot 28 of range VIII., of Wentworth; and also in a pond on the lot 5 of range IV., of Harrington. Along the lower Ottawa in the seigneury of Vaudreuil at Pointe à Cavagnol is a bed of marl extending over twenty acres, with a thickness of from twelve to eighteen inches. Wentworth

Low.

Deposits of marl are also found in several of the lakes along the Gatineau river. No examination of these has been made, but one was noticed a short distance west of the road along the river in the bottom of a lake in the township of Low.

Rensselaerite.

Rensselaerite, a hydrous silicate of magnesia, is found on lot 13 of range V., of Grenville. It seems to cross into the same numbered lot on range VI., and appears to be in considerable quantity. It is also found at Old Chelsea village, on the road near the forks to Kingsmere and on the property of Mr. Chamberlain, at this place.

GRANITES.

Granite quarry of Grenville.

In connection with the granite masses of Grenville, large quarries have been opened quite recently for building stone. One of the most important of these is on lot 14 and east half of lot 15, range VII., Grenville, owned by Mr. Joseph Brunet, under the name of the Maritime Granite Company, Montreal. The rock breaks readily into large angular blocks suitable for building purposes, is coarsely crystalline, reddish in colour, and is used in Montreal both for building and paving stone. The deposit is extensive, on the south slope of a steep ridge, and is hauled to St. Philippe station on the Canadian Pacific railway for shipment.

APPENDIX

LISTS OF FOSSILS OBTAINED FROM THE SEVERAL FORMATIONS ALONG THE OTTAWA RIVER PERTAINING TO THE REPORT ON SHEET No. 121, QUEBEC AND ONTARIO (GRENVILLE SHEET).

By HENRY M. AMI, M.A., D.Sc., F.R.S.

POTSDAM SANDSTONE.

From quarry in Potsdam sandstone, between Papineauville and Montebello, Ottawa river.

Protichnites lineatus, Owen, or a closely allied form.
Protichnites septem-notatus, Owen.

CALCIFEROUS.

From Lachute, Quebec. Collected by H. M. Ami and Mr. W. McOuat, 1890.

Ophileta complanata, Vanuxem.
Pleurotomaria Canadensis, Billings.
Murchisonia Anna, Billings.

From point near Carillon, Que. Collected by Mr. George Wanless.

Lituites Apollo, Billings.

CHAZY.

From Chazy beds, north of Stewart's quarry, near Rockland. Collected by H. M. Ami, 1893.

Orthis imperator, Billings.
Orthis borealis, Billings.
Orthis platys, Billings.
Rhynchonella (*Camarotœchia*) *plena*, Hall.
Pleurotomaria (*Raphistoma*) *stamineum*, Conrad.
Modiolopsis parviuscula, Billings.
Orthoceras Antenor ? Billings.

From Grenville, collected by G. J. Hinde, 1879.

Prioniodus radicans, Hinde, 1879.

From Butler's quarry, three miles west of L'Orignal. Collected by L. M. Lambe, 1891.

Rhynchonella (*Camarotœchia*) *plena*, Hall.
Pleurotomaria (*Raphistoma*) *docens*, Billings.
Illaenus, sp.

From same locality, collected by W. E. Deeks, 1891.

Malocystites Murchisoni, Billings.
Leptœna fasciata, Hall.
Pleurotomaria (*Raphistoma*) *docens*, Billings.
Orthoceras, sp.
Bathyurus, sp.
Leperditia Canadensis, Jones.
Ostracoda, other species.

From road between L'Orignal and Murray's quarry.

Orthis (*Hebertella*) *imperator*, Billings.
" *borealis*, Billings.
" sp., very minute.
Rhynchonella (*Camarotœchia*) *plena*, Hall.
? *Helicotoma*, sp.

From Ross's quarry, Little Rideau, six miles east of Hawkesbury. Collected by L. M. Lambe, 1891.

Glyptocystites, sp.
Malocystites Murchisoni, Billings.
Palæocystites tenuiradiatus, Hall.
Bolboporites Americanus, Billings.
Orthis (*Hebertella*) *borealis*, Billings.
Orthis " *imperator*, Billings.
Rhynchonella (*Camarotœchia*) *plena*, Hall.
Asaphus canalis, Conrad.

From same quarry. Collected by W. E. Deeks, 1891.

Cryptozoon, sp.
Bolboporites Americanus, Billings.
Palæocystites tenuiradiatus, Hall.
?*Coscinium proavium*, Eichwald.

Stictopora, sp.
Ptilodictya, sp.
Branching monticuliporoidea.
Orthis (*Hebertella*) *borealis*, Billings.
" " *imperator*, Billings.
" " *perveta*, Conrad.
" *platys*, Billings.
Rhynchonella (*Camarotœchia*) *plena*, Hall.
" sp.
Zygospira, sp, nov.
Atrypa acutirostra (=*Zygospira acutirostra*, Hall, sp).
Pleurotomaria calyx, Billings.
? *Trochonema umbilicatum*, Hall.
Hyolithes, sp.
Asaphus canalis ? Conrad.
Asaphus, sp. indt.
Bathyurus, cf. *B. Angelini*, Billings.
Harpes, sp.
Leperditia Canadensis, Jones.

BLACK RIVER LIMESTONE.

Stewart's quarry, near Rockland, lower portion. H. M. Ami, and Archibald Stewart, Esq.

Columnaria Halli, Nicholson.
Tetradium fibratum, Safford.

TRENTON LIMESTONE.

Stewart's quarry, near Rockland, Ont. Collected by H. M. Ami

Crinoidal fragments.
Streptelasma corniculum, Hall.
Prasopora Selwyni, Nicholson.
? *Homotrypa similis*, Foord.
Stictopora (*Pachydictya*) *acuta*, Hall.
Rafinesquina alternata (Conrad) Emmons.
Orthis (*Dalmanella*) *testudinaria*, Dalman.
" *tricenaria*, Conrad.
Ctenodonta, sp. indt., cf. *C. abrupta*, Billings.
Serpulites dissolutus, Billings.
Orthoceras, sp.

Asaphus platycephalus, Stokes.
Endoceras proteiforme, Hall.
Calymene senaria, Conrad.

From Murray's quarry, near L'Orignal, Ont. Collected by W. E. Deeks and R. Hugh Ells, 1891.

Crinoidal fragments.
Prasopora Selwyni, Nicholson.
? *Diplotrypa Whiteavesii*, Nicholson.
Branching forms of Monticuliporoidea.
Trematis terminalis, *Emmons*.
Strophomena incurvata, Shepard (=*Streptorhynchus filitextum*, (Hall.)
Plectambonites sericea, Sowerby.
Rafinesquina alternata (Conrad) Emmons.
Platystrophia lynx, Eichwald.
Rhynchotrema inæquivalvis (Castelnau).
Conularia Trentonensis, Hall.
Calymene senaria, Conrad.
Asaphus megistos, Locke.
" *platycephalus*, Stokes.
Dalmanites callicephalus, Green.
Ostracoda. Several species.

From same locality. Collected by L. M. Lambe, 1891

Pachydictya acuta, Hall.
Rafinesquina alternata (Conrad) Emmons.
Trematis terminalis, Emmons.
Strophomena, resembling *S. Philomela*, Billings.
Orthis (*Dalmanella*) *testudinaria*, Dalman.
Platystrophia biforata, var. *lynx*, Eichwald.
Rhynchotrema inæquivalvis (Castelnau).
Parastrophia hemiplicata, Hall.
Trochonema umbilicatum, Hall.
Cyrtodonta, sp.
Endoceras proteiforme, Hall.
Dalmanites callicephalus, Green.
Lichas Trentonensis, Conrad.
Ceraurus pleurexanthemus, Green.

From Foxes Creek, Clarence township, Ont. Collected by R W Ells, 1893.

Crinoidal fragments.
Pachydictya acuta Hall

Prasopora Selwyni, Nicholson.
? *Monotrypella Trentonensis*, Nicholson
Discina, or *Trematis*, sp.
Crania, sp.
Lingula quadrata, Eichwald.
Plectambonites sericea, Sowerby.
Strophomena (*Rafinesquina*) *alternata*, Conrad (Emmons).
Strophomena incurvata, Shepard.
Orthis (*Dalmanella*) *testudinaria*, Dalman.
" (*Dinorthis*) *pectinella*, Conrad.
" (?) n. sp.
" or *Anazyga* or *Zygospira*, sp.
Platystrophia biforata, *Schloth-im*, var. *lynx*. Eichwald.
Rhynchotrema inæquivalvis (Castelnau.)
Bellerophon sulcatinus, Emmons.
Calymene senaria, Conrad.
Ceraurus pleurexanthemus, Green.
Illaenus sp., cf., *I. Trentonensis*, Billings.
Asaphus platycephalus, Stokes.
" *megistos*, Locke.
Dalmanites callicephalus, Green.
Trinucleus concentricus, Eaton.

Ridge south of Cumberland village. Collected by Dr. F. Slater Jackson, 1890.

Streptelasma corniculum, Hall, or an allied form.
Crinoidal fragments.
Plectambonites sericea, Sowerby.
Rafinesquina alternata (Conrad) Emmons.
Strophomena fluctuosa, Billings.
" cf. *S. tenuistriata*, Sowerby.
Platystrophia biforata, var. *lynx*, Eichwald.
Rhynchotrema inequivalvis (Castelnau).
Zygospira recurvirostra, Hall.
Liospira Progne, Billings.
Trochonema umbilicatum, Hall.
Hormotoma gracilis (Hall).
? *Omospira Alexandra* (Billings).
Asaphus, sp., apparently *A. platycephalus*, Stokes.
Calymene senaria, Conrad.
? *Lichas*, sp., cf. *L. Trentonensis*, Hall.