CANADA

DEPARTMENT OF MINES

HON. MARTIN BURRELL, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER.

GEOLOGICAL SURVEY

WILLIAM MCINNES, DIRECTING GEOLOGIST.

MEMOIR 103

No. 86, GEOLOGICAL SERIES

Timiskaming County, Quebec

BY

M. E. Wilson

OTTAWA
GOVERNMENT PRINTING BUREAU
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PLATE I.

Concretionary, stratified, post-Glacial, lacustrine clay, Simon lake, Quebec. (Page 141.)

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CHAPTER I.

INTRODUCTION.

GENERAL STATEMENT AND ACKNOWLEDGMENTS.

This memoir is a general statement of the results of geological work carried on for several years in the northwestern part of the province of Quebec. It has special reference to a number of local areas studied by the writer in that region, all of which are included in the recently created county of Timiskaming (Figure 1).

The discovery of important mineral deposits at Cobalt, Porcupine, Kirkland Lake, and other localities in northwestern Ontario, in recent years, seemed to indicate that similar deposits might possibly be present across the interprovincial boundary in the province of Quebec and it was for this reason that the geological explorations in Timiskaming county described in this report were undertaken. Unfortunately, throughout a large part of the county and especially in the northern part where the geological conditions are most favourable for the development of mineral deposits the bedrock surface is largely hidden beneath post-glacial lacustrine clay so that prospecting is necessarily confined to the scattered knobs and ridges of rock, the total areal extent of which in many localities is less than one per cent of the total area of the bedrock surface actually present. Since the construction of the Timiskaming and Northern Ontario railway and the discovery of the silver-bearing veins at Cobalt, however, a few prospecting parties have visited the district during the summer months of each year and occurrences of gold have been found at several points, also pegmatite dykes and quartz veins carrying molybdenite; but mining operations up to the present have not been carried beyond the opening up of prospect pits.

It does not follow from this that extensive deposits of valuable ore are not present in the district or may not eventually be discovered. The geological succession of formations in the northern part of the county, as far as has been determined, is similar in every respect to that found in the Kirkland Lake and Porcupine districts in Ontario, so that geologically there is no apparent reason other than the presence of the overlying cover of lacustrine clay, why similar deposits should not be discovered in Quebec.

The district included in Timiskaming county lies wholly within the Laurentian plateau and forms a part of the great Pre-Cambrian shield of northeastern North America. The rocks of the region, thus, belong for the most part to those ancient Pre-Cambrian terranes which have suffered so many vicissitudes that their original character and relationships to one another have not yet been wholly determined.

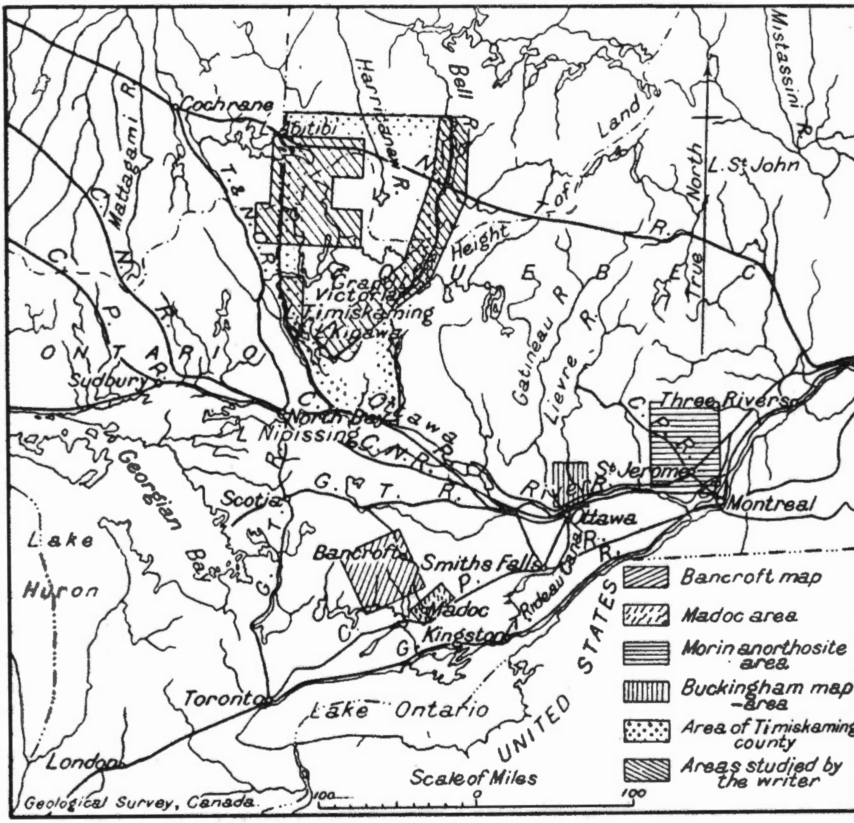

Figure 1. Location of Timiskaming county and other areas mentioned in this memoir.

In the discussion of the geology of Timiskaming county contained in the following chapters, an attempt has been made to separate the sections that are largely descriptive from those that are more or less theoretical. This method of treatment was deemed advisable in that, even though it involves some repetition, it renders the material contained in the report more accessible and at the same time draws a definite line between the description of the geological features observed and the hypotheses based on these observations.

The writer desires to acknowledge his indebtedness to the residents of the district and others for many courtesies received during the course of field work, and to his field assistants whose efficient service contributed much to the progress of the work. The thanks of the Geological Survey are especially due to Mr. J. O. Tremblay, agent for the Department of Mines, Quebec, at Ville Marie; to Mr. Albert McKegg; to Mr. John Alger; to Mr. John Hough, mining recorder for Larder Lake mining division; to Mr. Chas. Richmond; to the officials of the National Transcontinental Railway survey; and to the officers of the Hudson's Bay Company at its various posts in the district.

GEOGRAPHICAL POSITION OF AREA.

The region described is situated in the northwestern part of the province of Quebec and lies adjacent to lake Timiskaming and the interprovincial boundary between Ontario and Quebec. It is limited on the north, approximately, by latitude 49, on the east by Bell river, Grand lake Victoria, and Dumoine river, and on the south and west by the interprovincial boundary. Its total length from north to south is approximately 200 miles, its width from east to west 100 miles, and its area approximately 20,000 square miles. In Figure 1 the outlines of Timiskaming county and the areas in the county studied by the writer, are indicated.

MEANS OF ACCESS.

For many years the sole means of access to this region was by way of the Kipawa branch of the Canadian Pacific railway from Mattawa, Ontario; but with the construction of the Timiskaming and Northern Ontario and the National Transcontinental railways, a number of alternative routes to the district became available, so that most of the region is now easily accessible.

Since the National Transcontinental railway crosses the northern part of Timiskaming county, that portion of the region can be easily reached by train from Cochrane, Ontario—the junction point of the Timiskaming and Northern Ontario and the National Transcontinental railways. Points at a distance from the railway may be reached by canoe along the numerous waterways in its vicinity, the particular route to be taken depending on the destination desired.

For the western part of the district, La Sarre river affords an uninterrupted waterway to lake Abitibi from which the Abitibi-Timiskaming canoe route may be followed southward. Kinojevis river can also be reached from the La Sarre by way of lake Abitibi and a canoe route which leads across the height of land from the eastern extremity of lake Duparquet through Bellefeuille and Dufresnoy lakes. This route, however, requires considerable portaging and follows small streams, the headwaters of which become impassable in time of drought.

Farther eastward there are two main routes of communication transverse to the National Transcontinental railway, one along Bell or upper Nottaway river and the other along Harricanaw river. Bell river although interrupted by numerous rapids and waterfalls, affords a tolerably good canoe route and is the principal waterway used in reaching Mattagami lake and the lower Nottaway on the north and the height of land and Grand lake Victoria on the south. On Harricanaw river, north of the railway, there are numerous portages, but south of the railway there is a continuous waterway navigable without interruption to Mourier lake, a distance of about 60 miles.

In addition to these larger water courses there are numbers of smaller streams such as the Villemontel which is used as a canoe route from the mouth of Fork creek to Kinojevis and Kewagama rivers, and the Natagagan which flows into Bell river at Kanikawinika island a point about 60 miles north of the railway. This stream is said to be a better canoe route from the railway to the lower part of the Bell than the Bell river.

The usual means of communication for the central part of Timiskaming county is by steamboat on lake Timiskaming, either from Haileybury on the Ontario side of the lake, or from Timiskaming station at the foot of the lake to Ville Marie or North Timiskaming and thence by wagon to lac des Quinze and from that lake by canoe along one of its tributary streams. The wagon road from Ville Marie leads to Gillies farm at the south end of lac des Quinze, while that from North Timiskaming leads to Klock's farm, 15 miles farther north. The region in the vicinity of the interprovincial boundary and north of lac des Quinze is easily accessible from lac des Quinze along the Abitibi canoe route of which the lakes in that district form a part; but it can also be reached from the Timiskaming and Northern Ontario railway by road from Dane to Larder lake and thence by the canoe route which leads from Larder lake through Raven lake to lake Opasatika. The country adjacent to Kinojevis river may be reached from lac des Quinze either by way of the upper Ottawa and lake Expanse, through Roger and Caron, or through Barrière, Albee, and Kekeko lakes. Access to the region directly east of lac des Quinze or lake Expanse may be had along either Mackenzie creek, Winawiash river, or the upper Ottawa, but points 10 miles beyond these lakes are more easily accessible from the canoe route which leads from lake Kipawa to Grand lake Victoria.

The southern and southeastern part of Timiskaming coun is easily reached from Kipawa station, the terminus of the Kipawa branch of the Canadian Pacific railway. Beyond this point there are numerous waterways, most of which are excellent canoe routes. Of these routes the best known and most travelled is that which follows a series of lakes to Grand lake Victoria.

AGRICULTURAL POSSIBILITIES.

In the southeastern part of Timiskaming county where the glaciated surface of the Pre-Cambrian bedrock is almost continuously exposed, there is little or no soil suitable for agriculture except in a few very limited areas; but in the northern and western parts of the county extensive areas of post-Glacial, lacustrine clay occur, forming what is generally known as the clay belt. This belt is not continuous or uniform throughout the region, however, for here and there hills and knobs of rock and ridges of gravel and sand protrude through the clay, forming conspicuous landmarks in an otherwise plain-like surface. Within the clay belt proper, there are also numerous large, undrained muskegs in the interstream areas, where the surface of the clay is covered with peat to a depth of several feet.[1] In addition to these rocky, sandy, and swampy districts in the clay belt, there are many well drained areas of clay and these afford a good soil for the growth of potatoes, vegetables, hay, and the hardier cereals. The southern extension of the clay belt situated to the north and east of lake Timiskaming has been settled for a number of years and supports a large farming community; and at the post of the Hudson's Bay Company on lake Abitibi, potatoes, hay, and oats have been grown successfully for a number of years. Potatoes have also been grown for a number of years by the Indians living along Bell river. The thick growth of vegetation, which everywhere covers the surface of the clay belt at present, keeps the soil at a lower temperature than would otherwise be the case and with the clearing of the land the summer frosts will probably be less frequent and harmful. The provincial government of Quebec has begun the building of roads in the section of the clay belt adjoining the National Transcontinental railway and a number of settlers have already taken up land in that district.

CLIMATE.

Climatic records have been kept for the Canadian Meteorological Service for a number of years at a post of the Hudson's Bay Company on lake Abitibi, in the northern part of Timiskaming county. There are no records available from points in the central or southern parts of the county, but meteorological observations have been recorded at Haileybury which lies just outside its western boundary. The average

[1] The maximum thickness of peat observed in the cuts along the National Transcontinental railway was [illegible] feet.

monthly temperatures and precipitation at Abitibi post and at Haileybury are contained in the following tables prepared by Mr. R. F. Stupart, director of the Dominion Meteorological Service.

Meteorological Observations Taken at Abitibi, Quebec, 1897-1910.

	Temperature.				Absolute.		No. days R.or S.	Rain-fall.	Snow-fall.	Total pre-cip.
	Mean high.	Mean low.	Mean	Daily range.	Max.	Min.				
January.....	12·5	−11·3	0·6	23·8	42	−46	9	0.05	18·0	1·85
February....	14·2	−11·0	1·6	25·2	46	−44	7	0.00	14·5	1·45
March.......	28·2	1·6	14·9	26·6	62	−42	7	0.09	21·6	2·25
April........	40·3	21·0	30·6	19·3	70	−20	6	1.00	4·3	1·43
May.........	54·6	36·4	45·5	18·2	94	8	9	2·64	2·2	2·86
June.........	67·9	49·3	58·6	18·6	94	28	8	2·67	......	2·67
July.........	72·6	55·5	64·0	17·1	94	35	10	2·77	......	2·77
August......	68·9	52·3	60·6	16·6	86	34	12	2·85	......	2·85
September...	60·2	44·7	52·5	15·5	87	26	12	2.60	......	2·60
October.....	47·2	32·1	39·6	15·1	76	15	12	2·55	4·1	2·96
November...	31·1	18·2	24·6	12·9	68	−16	11	0·77	12·8	2·05
December...	16·6	−1·4	7·6	18·0	48	−45	9	0·09	21·3	2·22
	......	......	33·4	......	......	......	......	18·08	98·8	27·96

Average date of last frost, June 8.
Average date of first frost, September 14.

Summer temperature 57·2°
" 3 mo. 61·1°

Meteorological Observations Taken at Haileybury, Ontario.

	Temperature.				Absolute.		No. days R.or S.	Rain-fall.	Snow-fall.	Total pre-cip.
	Mean high.	Mean low.	Mean.	Daily range.	Max.	Min.				
January.....	17·7	−4·3	6·7	22·0	48	−40	16	0·32	17·2	2·04
February....	19·8	−2·9	8·5	22·7	47	−38	12	0·24	17·4	1·98
March.......	32·1	8·3	11·9	23·8	71	−34	13	0·51	17·2	2·23
April........	48·3	26·3	37·3	22·0	79	− 3	16	1·26	5·8	1·84
May.........	61·6	39·0	50·3	22·6	93	17	14	3·14	0·8	3·22
June.........	73·7	50·2	62·0	23·5	100	28	12	3·03	......	3·03
July.........	76·7	55·4	66·0	21·3	99	36	14	3·91	......	3·91
August......	73·0	51·8	62·4	21·2	93	27	13	2·63	......	2·63
September...	65·1	44·4	54·7	20·7	91	24	15	3·52	......	3·52
October.....	51·2	33·9	42·5	17·3	80	13	14	2·43	2·8	2·71
November...	35·3	20·9	28·1	14·4	63	−25	15	0·94	13·1	2·25
December...	21·0	3·2	12·1	18·2	47	−35	17	0·42	19·8	2·40
								22·36	94·0	31·77

Average date last frost, June 5.
Average date first frost, September 11.

NATIVE INHABITANTS.

As is stated in the section of the report in which the agricultural possibilities of the region are discussed, the district north and east of lake Timiskaming is occupied by settlers and settlers are also taking up land in the district adjoining the National Transcontinental railway. In the remaining parts of the region, the only permanent inhabitants are the Indians and the employees at the posts of the Hudson's Bay Company.

The Indians who inhabit the region belong to the once powerful Algonquin tribe and speak Ojibway (Chippewa)—the common language spoken by the Indians throughout the whole of the wide territory lying along the northern border of the St. Lawrence basin. The larger part of the Indians of the region have organized themselves into bands, the members of which all assemble in the early summer of each year at one of the Hudson's Bay Company posts. With the exception of the Timiskaming band all the Indians of the region live by trapping and have the territory of each band apportioned among the various families as hunting grounds. The native population of Timiskaming county is distributed as follows:[1]

	Population.
Lake Abitibi	285
Lake Timiskaming	245
Grand lake Victoria	227
Kipawa and Grassy lake	135
Lac des Quinze (Long Point)	105
Lake Opasatika	30
Hunters Point (lake Kipawa)	11
Unorganized	37
Total	1,074

FORESTS.

The forest of Timiskaming county belongs to a belt intermediate between the Canadian and Hudsonian floral zones or to the subarctic zone in the classification of Professor Macoun of the Geological Survey. It is distinguished from that of the more southerly parts of Canada chiefly by the presence of a greater abundance of conifers and a correspondingly smaller proportion of deciduous trees. The variations in the type of forest in different parts of the region are of two classes, those that are regional and those that are local. The regional variations are chiefly related to the climatic difference between the northern and southern parts of the district while the local variations are related to local environmental conditions such as the character of the soil and drainage.

[1] Report of the Department of Indian Affairs, 1914.

The regional variations in the forest are indicated by the relative abundance of numerous deciduous trees in the southern part of the region, which are absent or poorly developed in the north and by the gradual disappearance of white and red pine (*Pinus strobus* and *Pinus resinosa*) from south to north. Thus, in the southern districts, basswood (*Tilia Americana*), hard maple (*Acer saccharum*), ironwood (*Ostrya Virginica*), beech (*Fagus ferruginea*), oak (*Quercus macrocarpa*, *Quercus alba*, and *Quercus rubra*), and white elm (*Ulmus Americana*), are locally common but, with the exception of the elm, are entirely absent in the north. Red and white pine occur in abundance only in the southern part of the county, although scattered groves occur here and there almost to its northern boundary. Groves of pine were seen on the shore of Christopherson lake, in the vicinity of Kewagama lake, near Dufault lake, on Ogaskanan lake (Plate IIIB) and on the islands in Duparquet lake. The most northerly pine seen in the whole region were a few scattered trees on some of the islands in lake Abitibi.

The local variations in forest types repeat themselves throughout the region according as the conditions most favourable for the growth of particular trees are present. Thus, in the partially drained portions of the clay belt, the forest generally consists of black spruce (*Picea nigra*), and constitutes what is known as a black spruce swamp (Plate IIA). Exceptionally wet areas, on the other hand, are commonly occupied by tamarack (*Larix americana*) and these are known as tamarack swamps. Along the margins of lakes and rivers, there is a belt, several hundred feet in width, where the drainage is good and, in these zones, poplar (*Populus tremuloides*), balm of gilead (*Populus balsamifera*), and birch (*Betula papyrifera*), grow large in size and in great abundance. In districts where the soil is sandy or gravelly, as in some of the areas underlain by glacial outwash materials, a forest of Banksian pine (*Pinus Banksiana*) occurs. These are known locally as jack-pine sand-plains (Plate IIB). If, however, a forest fire has swept over an area in recent years, a thick growth of small poplar and birch is generally present. In some localities, generally the more rocky areas, a mixed forest occurs and there the white pine, the red pine, and the jack-pine, the poplar, the birch, the balsam (*Abies balsamea*), and the cedar (*Thuya occidentalis*) grow side by side.

Commercially, the most valuable trees in the region are the red and white pine and the spruce, the latter being used in the manufacture of pulpwood. Much of the original pine has been removed from the southern part of Timiskaming county by lumber companies and by forest fires, although here and there some large areas of virgin pine forest still remain, notably along the headwaters of Kipawa river. In the vicinity of the upper Ottawa, little of the pine has yet been cut, but in this district the trees are smaller and more scattered. Spruce occurs everywhere throughout the county in great abundance. It reaches its best development in the clay areas where the drainage is good and in these localities some of the trees have diameters of 2 to 3 feet.

The other timber found in the district is not of much value at present. In some localities, especially in sand-plain areas (Plate IIB) banksian pine grows straight and tall with a diameter as great as 18 inches. This is useful for rough lumber or pulpwood wherever the cost of transportation is not prohibitive. There is also considerable canoe birch in the area from which logs 2 feet or more in diameter might be cut. The difficulties of transportation, however, render this valueless except where it occurs in close proximity to the railways. Tamarack was at one time abundant in the muskegs (Plate III A) of the district, but the trees were all killed by the larch sawfly about twenty-five years ago. Cedar, balm of gilead, poplar, and balsam—the remaining trees found abundantly in the region—do not grow to sufficient size to be of importance commercially.

FAUNA.

The fauna of Timiskaming county includes the usual species found in the rocky wooded districts of eastern Canada. Of the larger varieties, moose (*Alce americanus*) are the most abundant and form one of the principal sources of food supply for the Indians of the region. Red deer (*Virgianus cariacus*) though not so abundant as the moose, are common and would be much more abundant were it not for the large numbers killed by the wolves. These animals follow the deer in their migrations and are always abundant wherever the deer are found. Caribou are also present according to the Indians, although none was seen by the writer during the several field seasons spent in the county.

The most valuable animals found in the region are the fur-bearing varieties. These include the fox (*Vulpus vulgaris*), otter (*Lutus canadensis*), beaver (*Castor fibre*), lynx (*Lynx canadensis*), fisher (*Mustella americana*), black bear (*Ursus americana*), mink (*Putorius vison*), ermine (*Putorius erminea*), and muskrat (*Fiber zibethicus*). Large numbers of these animals are trapped each season by the Indians and, in consequence, some of the varieties whose fur is most valuable, are gradually disappearing.

Other animals common in the region include the porcupine (*Erethizon dorsatus*), groundhog (*Arctomys monax*), chipmunk (*Tamias striatus*), red squirrel (*Sciurus hudsonius*), flying squirrel (*Sciuropterus volucella*), and varying hare (*Lepus americana*).

No attempt was made to study the birds of the region, but a few notes with regard to the principal varieties seen, may be of interest.

Among the most abundant are the gulls (*Larus argentatus smithsonianus* and *Larus delawarensis*). They nest in the numerous rocky reefs which project from the lakes of the region and in some localities make their home by hundreds on a single rock only a few feet in diameter.

During the spring and autumn migrations large numbers of ducks gather in the marshy bays of the larger lakes but at other periods of the year these birds are not abundant. The most common of the family seen in the region during the breeding season is the black duck (*Anas obscura*). The old bird with her young is often met on the small lakes and in other secluded spots along the waterways of the region. When approached by a canoe, the old bird endeavours to attract the attention of the intruders while the young hide in the grass and underbrush along the shore. The young birds hidden in this way are often difficult to find, but, once discovered, can be easily killed with a stick and are thus secured by the Indians during the months of July and August.

The loon or great northern diver (*Gavia immer*) is another common inhabitant of the region, usually making its home in rocky clear water lakes. There is generally at least one pair of these birds on each of the small lakes of this type, and generally a pair on each separate expansion or bay in the case of larger bodies of water. To these localities the loons return each summer with great regularity to breed.

The two varieties of Canadian grouse or partridge (*Bonasa umbellus togata* and *Canachites canadensis*) are generally common in the district but vary greatly in relative abundance from season to season. This variation is probably related to climatic conditions and especially to the amount of sleet which falls during the winter; for the birds have the habit of burying themselves in the snow, and, when a heavy fall of sleet occurs, they are not always able to extricate themselves.

Other common birds observed in the region are the following: saw-bill (*Merganser americanus*), pied-billed grebe (*Podilymbus podiceps*), bittern (*Botaurus lentiginosus*), mud hen (*Fulica americana*), spotted sandpiper (*Actitis macularia*), owls (*Syrnium varium* and *Nyctea nyctea*), woodpeckers (*Dryobates pubescens medianus*, *melanerpes erythrocephalus*, and *Ceophloeus pileatus abieticola*), flicker (*Colaptes auratus luteus*), belted kingfisher (*Ceryle alcyon*), sapsucker (*Sphyrapicus varius*), whip-poor-will (*Antrostomus vociferus*), night hawk (*Chordeiles virginianus*), and raven (*Corvus corax principalis*).

The lakes and rivers of the region abound in fish, the species present in different localities varying according to the environmental conditions which prevail. Thus in the clay belt nearly all the lakes and streams contain large amounts of suspended material during the greater part of the year and for this reason afford an unsuitable environment for either trout (*Salvelinus namaycush*) or bass (*Micropterus salmoides* and *M.*

bolomieu). In the clear water lakes of the rocky portions of the country, on the other hand, these fish are generally common.

The large deep-water lakes of the district contain whitefish (*Coregonus clupeiformis*), sturgeon (*Acipenser rubicundus*), freshwater herring (*Gyosomus artedi*), and the common eel (*Anguilla rostrata*). Whitefish are especially abundant in lake Timiskaming and in the connected series of lakes forming Bell river. Sturgeon are most numerous in Grand lake Victoria. Brook trout (*Salvelinas fontinalis*) although comparatively uncommon are found here and there in the clear, cold-water brooks occurring in the rocky headwaters areas.

There are certain fish such as the pike (*Esox lusius*), maskinonge (*Esox nobilios*), and doré (*Stizostedion vitreum*), which seem to be capable of living through a great range of environment and these are found nearly everywhere in the region. Pike and maskinonge, however, are most abundant and largest in the shallow grassy lakes of the clay belt.

The other fish found in the region are of little or no value although many are very abundant. They include the sucker (*Calostomus teris*), rock bass (*Ambloplites rupestris*), perch (*Percea americana*), sunfish (*Lepomis pallidus*), and several varieties of chub.

EARLY EXPLORATIONS AND SURVEYS.

That the principal geographical features of the Timiskaming region were known to the French at a very early date is shown by the maps of Canada or New France, published in France during the early years of the French regime. This information was largely obtained from the fur traders who, even at that early period, penetrated far into these northern wilds in quest of furs. It was no doubt for the protection of this traffic that forts were established by the French, about the close of the seventeenth century, on lake Timiskaming and lake Abitibi.

It is probable that in going from lake Timiskaming to lake Abitibi the early French voyageurs did not follow the present route by way of lac des Quinze and lake Opasatika, but went by way of the east or Abitibi branch of Blanche river and Labyrinth lake, for on De l'Isle's map of Canada published in 1703 and on Bellin's map of Canada published in 1744, the route by way of Blanche river and Labyrinth (Labirinthe) lake is indicated.

The principal surveys used in the compilation of the published maps of Timiskaming county are: surveys of lakes and rivers made by the members of the staff of the Geological Survey who have examined portions of the region from time to time; surveys of waterways, base, meridian, and township lines by the Crown Lands department of Quebec; the survey of the interprovincial boundary between Ontario and Quebec; and the railway surveys of the Canadian Pacific Kipawa branch and the National Transcontinental line.

PREVIOUS WORK.

Geological descriptions of a few local areas and of some of the canoe routes in Timiskaming county have appeared from time to time in the publications of the Geological Survey, and, more recently, in the reports of the Department of Colonization, Mines, and Fisheries, for the province of Quebec.

The earliest geological work carried on in the Timiskaming region was an examination of the Ottawa river from Bytown (now Ottawa) to the head of lake Timiskaming by Sir William Logan in 1845. This investigation included a study of the geology along the east shore of lake Timiskaming and Quinze river up to the first chute.[1]

In 1872, Walter McOuat made a geological examination of "a portion of the country on the Ottawa to the northward and eastward of lake Timiskaming," an account of which appeared in the Report of Progress of the Geological Survey for 1872–73. This report includes a detailed description of the rocks occurring along the canoe route from lake Timiskaming to lake Abitibi and along the shores of lake Abitibi.

In 1887, Robert Bell and his assistant A. S. Cochrane ascended from lake Timiskaming to Grand lake Victoria by way of lakes Kipawa, Birch, Sassaganaga, Wolf, Grassy, and Dumoine. From Grand lake Victoria, Bell continued his explorations to the headwaters of the Ottawa and thence down Gatineau river, while Mr. Cochrane proceeded northward across the height of land and descended Bell river to a point 10 miles north of Shabogama lake. He then retraced his course to Grand lake Victoria and returned to lake Timiskaming by Ottawa river and lac des Quinze. In 1895 Bell again returned to Grand lake Victoria and continued the exploration of Bell river, begun by Cochrane in 1887, to its outlet into lake Mattagami and then proceeded down the Nottaway to James bay. Descriptions of these reconnaissances were given by Bell in the Summary Reports of the Geological Survey for the years 1887 and 1895.

During the years 1892 to 1895 A. E. Barlow studied the geology along the principal waterways in the southwestern part of Timiskaming county, the description of which was published in 1897, in Barlow's "Report on the geology and natural resources of the area included in the Nipissing and Timiskaming map sheets."

In 1896 Robert Bell assisted by R. W. Brock, spent a portion of the field season of that year in making reconnaissance surveys of the Migis-

[1] Geol. Surv., Can., Rept. of Prog., 1845-46.

kan and other tributaries of Bell river. The details of these excursions are given by Bell in the Summary Report of the Geological Survey for that year.

In the year 1901, a paper was published in the American Geologist by W. G. Miller, on some newly discovered areas of nepheline syenite in central Canada in which the occurrence of nepheline syenite on the Kipawa river was mentioned.

In 1901, J. F. E. Johnston made a reconnaissance examination of the geology along some of the waterways of the region. These included La Sarre river, Makamik lake, Lois lake, Lois river, the canoe route from lake Duparquet to Dufresnoy lake, and Kinojevis river. Johnston's observations were published in the Summary Report of the Geological Survey for 1901.

In 1904, W. A. Parks made a geological examination of the rocks along some of the canoe routes in the country north of lake Timiskaming, including the southern part of the Timiskaming-Abitibi canoe route, Dasserat and Labyrinth lakes. His report was published in the Summary Report of the Geological Survey for that year.

During the summers of 1906 and 1907, W. J. Wilson investigated the geology along the waterways and railway survey lines adjacent to the National Transcontinental railway. The results of Wilson's work were published in the Summary Reports of the Geological Survey for 1906 and 1907, and again in greater detail in Memoir No. 4, "A geological reconnaissance along the line of the National Transcontinental railway in western Quebec."

The reports of the Provincial Department of Mines for Quebec for the years 1906 and 1907, contain accounts of reconnaissance trips through this region made during the summers of those years by J. Obalski.

In 1909, in the course of the preparation of his report on the molybdenum ores of Canada for the Mines Branch of the Department of Mines, T. L. Walker examined the occurrences of molybdenite in the vicinity of Kewagama lake.

In 1911, an examination of the township of Fabre on the east side of lake Timiskaming was made by Robert Harvie for the Department of Colonization, Mines, and Fisheries, of the province of Quebec. An account of this work was published by the Quebec Department of Mines, the following year.

During the field seasons of 1911 and 1912, J. A. Bancroft was engaged in mapping the geology in the vicinity of Kewagama lake, the headwaters of Harricanaw river, and the Nottaway basin adjacent to lake Mattagami. Bancroft's account of the geology of these areas was published in the reports on mining operations in the province of Quebec for 1911 and 1912.

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"The Kewagama Lake map- area, 1911," Geol. Surv., Can., Mem. 39, 1913.
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CHAPTER II.

PHYSIOGRAPHY.

LAURENTIAN PLATEAU.

The district included in Timiskaming county forms a part of the great physiographic province which occupies the greater part of northeastern North America—the Laurentian plateau. This great area over 2,000,000 square miles in extent is characterized by a remarkable uniformity of elevation and similarity of topography and, in all its essential features, must be regarded as physiographically a unit.

It is bounded on the north by the Arctic ocean, on the east by the Atlantic, and on the south and west by the overlapping southward dipping Palæozoic sediments, the successive numbers of which outcrop along its border in alternating lowland belts and cuesta ridges.

In a broad way the Laurentian plateau may be regarded as a great U or V-shaped, amphitheatre-like area rising abruptly along its outer margin and sloping gently towards the great central basin of Hudson bay. That the surface of the plateau has this basin-like form is indicated not only by the elevations determined at various points, but also by the drainage, the larger part of which flows into Hudson bay. The proportion of the drainage discharging in this way would be much greater, however, were it not for the fact that many large rivers such as the Ottawa and the Hamilton escape from the plateau through deep, narrow, gorge-like depressions, the gradients of which have no relationship to the slope of the surrounding uplands.

The outstanding physiographic feature of this great plateau area is its remarkable uniformity of relief in contrast with the detailed irregularity of its surface. The greater part of its immense area has a range in elevation of less than 1,200 feet, the minimun elevation being generally greater than 800 feet, and the maximum less than 2,000 feet above the sea: locally the range in elevation is generally less than 300 feet. Despite this remarkable absence of relief, the plateau surface in detail is exceedingly irregular and rough, in consequence of which the drainage of the plateau is of an extremely juvenile type. Lakes of irregular outline and filled with numerous islands abound everywhere; the water from these spills over the margin at its lowest point and in this way descends by successive rapids and waterfalls from basin to basin. Thus, while, on the one hand, the flat surface of the plateau truncating the structures of its Pre-Cambrian rocks is a feature characteristic of mature topography, the detailed irregularity and juvenile drainage, on the other hand, is a characteristic of the youthful stages of physiographic development.

TOPOGRAPHIC DEVELOPMENT.

Introductory Statement.

The great Canadian shield of which the Laurentian plateau is the physiographic expression constitutes one of the ancient necular land masses or positive elements in the earth's crust and has retained the low relief, so striking in its present topography, continuously from Pre-Cambrian time. The physiographic development of the Laurentian plateau, therefore, goes back to a very early period in the earth's history.

Geological investigation of the rocks which underlie the plateau, except in a few isolated areas, has not proceeded far enough to afford even an approximate record of its Pre-Cambrian physiographic history; and Palæozoic and later rocks deposited since Pre-Cambrian time are so generally limited in extent and range that the topographic record of the plateau during these later geological periods is necessarily fragmentary. For these reasons the following account of the topographic development of the plateau must be regarded as merely an approximate outline based on imperfect knowledge of an incomplete geological record.

Pre-Cambrian History.

Wherever the rocks of the plateau have been studied in detail, evidence has been found that during the Pre-Cambrian, just as in later geological periods, mountain-building movements accompanied by batholithic intrusions occurred from time to time, here and there throughout the plateau, and that between these uplifts, intervals of erosion occurred, with the development in some cases at least, of peneplains; but whether or not the whole plateau was mountainous at any time during the Pre-Cambrian, or whether or not any of the peneplains developed during the Pre-Cambrian extended over its whole surface, is not known.

Owing to later geological processes—uplift, igneous intrusion, denudation, and deposition—the physiographic forms developed during these early Pre-Cambrian erosion intervals, for the most part, have been long since replaced by more recent topography. In certain localities where flat-lying Pre-Cambrian sediments occur, however, the ancient erosion surfaces beneath the sediments are once more being exposed by denudation so that buried peneplains or palæoplains correspond in places with the present surface of the plateau. In this way the palæoplain beneath the Cobalt series in Timiskaming region and that beneath the Keweenawan and Animikie sediments in the region north and west of lake Superior are again being exposed by the stripping away of the overlying series. There are also numerous other localities throughout the plateau—as on the east side of Hudson bay[1], in central Labrador[2], on Hamilton inlet,[3] on Mattagami river,[4] and at a number of points in the region west of Hudson bay[4]—where flat-lying sediments occur in which no fossils have been found and which are probably of Pre-Cambrian age. In these places, likewise, the ancient floor upon which the sediments were deposited is being once more laid bare by the removal of the flat-lying, less resistant cover.

Although, as indicated in the previous paragraph, the present topography of the Laurentian plateau corresponds very closely in places to Pre-Cambrian erosion surfaces, it is probable that those surfaces are merely remnants which have been preserved either (1) because the surface of the Pre-Cambrian peneplain at the points where the remnants are preserved had originally an elevation somewhat below the general elevation of the peneplain; or, (2) because downwarping or downfaulting has occurred in these localities since the late Pre-Cambrian sediments were deposited; or (3) because the late Pre-Cambrian sediments were originally of greater thickness or have been more resistant to erosion in the localities where they are now found.

Pre-Palæozoic Palæoplain.

During the late Pre-Cambrian there was a cessation of orogenic movements throughout a large part of the Laurentian plateau—as shown by the numerous occurrences of approximately horizontal, late Pre-Cambrian rocks—which terminated finally in a prolonged period of base levelling preceding an early Palæozoic marine submergence. While the geological record is too incomplete for positive conclusions with regard to the extent of this Pre-Palæozoic base level, yet the following data and inferences therefrom indicate that the whole plateau was probably reduced to a peneplain condition at that time.

Palæozoic sediments, which overlap the Pre-Cambrian along the margin of the plateau and in the interior basin of Hudson bay, rest on a surface which has all the characteristics of a well-developed pene-

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[1] Bell, R., "The Nastapoka and Manitounuck groups," Geol. Surv., Can., Rept. of Prog., pt. C., 1877-78, pp. 11-18.
Low, A. P., Geol. Surv., Can., Ann. Rept., vol. XIII, pt. DD, 1900, pp. 16-31.
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[2] Low, A. P., Geol. Surv., Can., Ann. Rep., new ser., vol. VIII, 1895, pp. 261-282.

[3] Bell, J. M., Ann. Rept., Ont. Bureau of Mines, vol. 13, 1910, p. 140.
Baker, M. B., Ann. Rept., Ont. Bureau of Mines, vol. 20, 1911, p. 225.

[4] Tyrrell, J. B., Geol. Surv., Can., Ann. Rept., vol. VIII, pt. D, 1895, p. 17; pt. F, 1896, p. 171.

plain.[1] Furthermore, numerous outliers of Palæozoic sediments resting on a base-levelled surface occur within the plateau up to points 200 miles from its border. These outliers, however, must obviously lie a long distance within the limit of the Palæozoic marine submergence, for they consist largely of limestone, an easily eroded rock, and, as far as the geological record shows, have undergone denudation continuously from the Palæozoic to the present. The outliers, therefore, represent merely the remnants of a much more widely extended Palæozoic sedimentary cover which prolonged denudation has failed to remove.[2] Since the Palæozoic sediments have not been entirely removed it would seem evident that denudation since the Palæozoic submergence has been largely engaged in stripping off the sedimentary cover and that the present low relief of the Laurentian plateau in its marginal portions at least is pre-Palæozoic in its origin.

One of the striking characteristics of the early Palæozoic strata which overlap the Laurentian plateau is the general paucity of clastic sediments; for limestones[3] and even coral reefs[4] rest directly on the smoothly eroded surface of the Pre-Cambrian. If the surface over which the Palæozoic sea advanced had been deeply weathered, or had possessed a rugged topography, or if the rivers flowing into the sea from the interior of the plateau had possessed steep gradients, great thicknesses of clastic sediments would have been laid down. From the general absence of detrital material it may, therefore, be inferred that not only in the regions where Palæozoic sediments are found but throughout the whole Laurentian plateau, the pre-Palæozoic old land possessed an exceedingly low relief.

In those localities within the Laurentian plateau where folded, late Pre-Cambrian rocks occur, these strata are truncated by the present surface of the plateau, indicating that the plateau has been base-levelled since the late Pre-Cambrian sediments were deposited. Moreover, in some of these localities as in the case of the Cobalt series (Huronian) on lake Timiskaming, the Palæozoic series rest on the truncated edges of the late Pre-Cambrian strata, so that in such places a pre-Palæozoic base level was evidently well developed.

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[1] Lawson, A. C., Bull. Geol. Soc. Am., 1890, p. 169.
Adams, F. D., Jour. of Geol., vol. 1, 1893, p. 238.
Bell, R., Bull. Geol. Soc. Am., vol. 5, 1894, pp. 350-366.
Van Hise, C. E., Science, new ser., vol. 4, 1896, pp. 57-59.
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Cushing, H. P., Fairchild, H. L., Ruedemann, R., Smyth, C. H., N.Y. State Mus., Bull. 145, 1910, pp. 54-60.

[2] Ulrich, E. O., and Schuchert, C., Rept. N.Y. State Palæontologist, 1907, p. 639.

[3] La Flamme, J. O. K., Geol. Surv., Can., Ann. Rept., pt. D, 1882-3-4, p. 15.
Adams, F. D. and Barlow, A. E., Geol. Surv., Can., Mem. 6, 1910, p. 342.
Baker, M. B., Ann. Rept., Ont. Bureau of Mines, pt. I, 1911, p. 226.

[4] Parks, W. A., Ann. Rept., Ont. Bureau of Mines, 1899, p. 188.

From a study of the pre-Palæozoic floor in the central part of southern Ontario, A. W. G. Wilson concluded that following the peneplanation of the Pre-Cambrian old land a period of dissection ensued.[1] Our knowledge of the relationships of the Palæozoic outliers occurring in the interior of the plateau is not sufficiently complete, however, to determine whether this dissection was common to the whole plateau or not. The outliers on lake Timiskaming and lake St. John lie somewhat below the level of the plateau surface in their vicinity, suggesting that these sediments may occupy pre-Palæozoic valleys; but it is also possible that they have been lowered to their present elevation by faulting, or were deposited originally in broad depressions in the pre-Palæozoic peneplain surface.

Post-Palæozoic Uplift.

Since we know from the absence of folding, both in the Palæozoic sediments which overlap the margin of the plateau and in the flat-lying outliers of rocks occurring in its interior, that no orogenic movements have occurred anywhere in the Laurentian plateau since the early Palæozoic, it follows that whatever regional or local relief the plateau has acquired since that time owes its origin primarily either to uplift of the plateau, as a whole, or to faulting, or warping. The first of these diastrophic agencies has apparently played the most important part in the post-Palæozoic history of the plateau.

The Palæozoic strata occurring to the south of Hudson bay, on the Arctic islands, and on the Mackenzie basin, have all widely extended outcrops indicating that they lie in a horizontal position and, therefore, have not suffered differential uplift. Along the southern border of the plateau, on the other hand, the overlapping Palæozoic sediments dip away from the plateau showing that in this locality the uplift *has* been differential. In some places along the southern margin of the plateau, also, the pre-Palæozoic floor descends so rapidly near the Palæozoic contact that it has been suggested that faulting has occurred as well as differential uplift although the actual fault plane has not been discovered.[2] It would thus seem probable that the uplift of the Laurentian plateau since the early Palæozoic submergence, while uniform in the northern and central portions, has been accompanied by marginal warping and possibly faulting on its southern border.

There is little geological or physiographic data from which the history of the plateau during the long interval which elapsed between the Palæozoic emergence and the coming of the continental ice sheet can

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[1] Trans. Can. Inst., vol. 7, 1901, p. 157.

[2] Adams, F. D., Geol. Surv., Can., Guide Book No. 31, 1913, p. 19.
Kindle, E. M., and Burling, L. D., Geol. Surv., Can., Mus. Bull. No. 9, 1915.

be deduced. Sedimentary rocks overlapped its western border during the Cretaceous, but with this local exception it was apparently a land area during the whole period. Probably it stood so close to base level for such a large part of the time that denudation proceeded with exceeding slowness. It has been suggested by J. W. Spencer that the plateau was elevated to a much higher point than at present immediately preceding the Glacial epoch, the evidence cited in support of this hypothesis being: (1) the existence of a river-like depression on the bottom of the gulf of St. Lawrence and (2) the occurrence of fiord-like inlets on the margin of the plateau such as those which characterize the outlets of Saguenay and Hamilton rivers.[1] It is probable, as pointed out in the section on denudation by the continental ice-sheets, that a large part of the detailed dissection so characteristic of the plateau at present was accomplished before the Glacial period and such an uplift might account for the wide extent and depth of this dissection.

Continental Ice-sheets.

The last important modifications in the bedrock physiography of the Laurentian plateau were those effected through the agency of the continental glaciers. These modifications may be regarded as falling into two classes: (1) those produced by denudation and (2) those resulting from deposition. The importance of the first in the physiographic development of the plateau has been generally recognized, but the last has been equally important in its topographic effects.

Denudation. That the continental glaciers were capable of considerable denudation is evident from the general roches moutonées contours of the plateau surface, from the gently sloping curve of the surface of rock exposures on the north as compared with their more abrupt termination on the south, and from the glacial striæ and grooves which are commonly observed wherever a rock exposure has been protected from weathering agencies. Notwithstanding these evidences of the intensity of glacial denudation, however, there is other evidence indicating that the erosive action of the glacial ice sheets was largely of a superficial character and that the surface of the Pre-Cambrian bedrock which underlies the drift corresponds in its major features to the pre-Glacial topography of the plateau.

In numerous localities throughout the Laurentian plateau there are deep, linear, gorge-like valleys, now partially filled with drift, which cut across all varieties of rocks regardless of their structure or age and trend in practically every direction of the compass. We know that these valleys have not been formed since the glacial epoch, because they are

[1] Bull. Geol. Soc. Am., vol. 1, 1890, p. 68.

partially filled with glacial drift and because post-Glacial erosion throughout the plateau has been so insignificant that dissection has scarcely commenced even in the unconsolidated glacial and post-Glacial deposits. Furthermore, if the valleys had been excavated by the erosive action of the continental glaciers it might be assumed that wherever the rock was of a uniform character the valleys would trend parallel to the direction of movement of the glacial ice and that whatever divergence from parallelism occurred in localities where the rocks were not uniform would be closely related to rock structure. But the valleys are wholly unrelated to rock structure, are not parallel, and, in many cases, trend at right angles to the direction of movement of the glacial ice-sheets. It follows, therefore, that the "trench" valleys of the Laurentian plateau are probably not of glacial origin and hence must be remnants of pre-Glacial topography, presumably pre-Glacial river valleys.

Much evidence has been cited in discussing the physiographic history of the plateau, which indicates that its surface has not been greatly denuded during the interval which has elapsed since the Palæozoic submergence, and that the present surface corresponds very closely to the pre-Palæozoic peneplain.[1] This would also indicate that the plateau has not been greatly eroded by the glacial ice-sheets.

The cuesta ridges of Palæozoic sediments which parallel the southern margin of the plateau stand up in places with abrupt northward facing scarps. These pre-Glacial forms could scarcely have survived if the glacial ice-sheets had been capable of general deep denudation.

In the light of the preceding discussion, the topographic effects produced by the erosive action of the continental ice-sheets must be regarded as largely modifications of previously existing forms rather than the production of an entirely new topography. A summarized statement of these modifications follows:

(1). Removal of the pre-Glacial soil cover of the plateau.
(2). Production of "hogback" surfaces on the stoss side of the rock exposures.
(3). Formation of grooves and glacial striæ.
(4). Excavation of undrained rock-rimmed basins.
(5). Development of scarps by glacial plucking.
(6). Overdeepening of pre-Glacial valleys.
(7). Modification of pre-Glacial valleys to U-shaped valleys.
(8). Rejuvenation and partial disorganization of the pre-Glacial drainage ot the plateau.

Deposition. With the final retreat of the continental glaciers from the Laurentian plateau, glacial debris was left scattered irregularly over the plateau surface in the form of moraines, outwash plains, kames,

[1] Lawson, A. C., Bull. Geol. Soc. Am., vol. 1, 1890, pp. 163-173.
Barlow, A. E., Geol. Surv., Can., Ann. Rept., vol. X, pt. I, 1897, p. 25.
Wilson, A. W. G., Jour. Geol., vol. 11, 1903, p. 666; Can. Inst., vol. 7, 1907, p. 181.

eskers, etc., and in this way a new set of topographic forms was superimposed on the bedrock beneath.

The deposition of these materials had, indirectly, another important topographic effect; for it completed the work of glacial denudation in disorganizing the pre-Glacial drainage of the plateau and aided materially in the development of the strikingly youthful system of drainage which characterizes the plateau at present. The deposition of the glacial drift irregularly over an uneven glaciated rock surface resulted in the formation of innumerable undrained, partly rock-rimmed, partly drift-rimmed depressions in which water accumulated to form lakes. As the depressions became filled the water spilled over the margins at their lowest points to tumble downward to basins below and thus an "accidental" drainage of multitudinous lakes and precipitous watercourses was formed.

Post-Glacial Lacustrine Epoch.

In many parts of the Laurentian plateau, the glacial drift is overlain by wide areas of stratified clay and sand which are believed to have been deposited from large lakes which covered these districts during the retreat of the continental glaciers. In order, however, to provide basins for lakes extending over these large areas, it has been necessary to assume that the lakes were hemmed in, in part, by the fronts of the continental ice-sheets, an hypothesis which would also account for the disappearance of the lakes when the ice barrier was withdrawn.

Numerous post-Glacial lakes of this type were formed during the various stages of the glacial retreat from the St. Lawrence, Nelson, and Saskatchewan basins, also, at a later stage in the retreat, in the southern part of James Bay basin.

Marine Epoch.

In the lower part of the St. Lawrence basin and on the shores of Hudson bay[1], marine sediments—chiefly stratified clay and sand—rest on the glacial drift and overlap the plateau up to elevations of approximately 700 feet above sea-level in the St. Lawrence basin and 500 feet above sea-level in the James Bay region. It is believed that these sediments were laid down at the close of or immediately following the glacial epoch.

The deposition of these post-glacial sediments was the last event of importance in the physiographic history of the plateau, denudation since that time consisting merely of a slight amount of stream dissection in unconsolidated glacial and post-Glacial deposits.

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[1] Bell, R., Ann. Jour. Sc., vol. 1, 1896, pp. 219-228.
Low, A. P., Bull. Geol. Soc. Am., vol. 4, 1893, pp. 419-423.

TIMISKAMING REGION.

Timiskaming region lies wholly within the Laurentian plateau and possesses in part the usual rocky-lake topography which characterizes that physiographic province; but, it departs, locally, from the characteristic physiography of the plateau in its flat, plain-like areas of post-Glacial lacustrine clay, forming what is generally known as the "clay belt," and in its numerous, linear, gorge-like valleys, incising its bedrock surface. The physiography of Timiskaming region may thus be described in three sections: (1), rocky uplands; (2), clay belt, and (3), linear valleys.

ROCKY UPLANDS.

Distribution.

The rocky upland country occupies the southern and southeastern parts of the Quebec portion of Timiskaming region, whereas the clay belt covers the larger part of the northern and northwestern part of the district. Within the clay belt, however, there are numerous areas which rise above the highest point at which the lacustrine clay was deposited, and which exhibit all the typical physiographic features of the upland topography. The largest elevations of this type are the Abijevis hills, the Tenendo hills, the Smoky hills, and the group of hills (Kekeko ridge, Swinging hills, etc.), which forms the St. Lawrence-Hudson Bay divide in the region north of lake Opasatika. Since the last-mentioned hills lie across the interprovincial boundary and are all part of a continuous area of Huronian rock, they may be appropriately designated collectively the Boundary hills.

Relief.

The rocky uplands, as their name implies, include most of the higher parts of the region. The dividing line between the rocky uplands and the clay belt is not solely a matter of elevation, however, for portions of the district possessing typical upland topography have a much lower elevation with respect to sea-level than parts of the clay belt.

The large area of upland country which occupies the southern and southeastern part of the district is the most typical example of plateau topography in the whole region. It is underlain throughout nearly its whole extent by the banded gneisses which occupy such a large part of the Laurentian plateau and exhibits the low regional relief, minutely rugged topography, and other physiographic features characteristic of the plateau, to a remarkable degree. The surface of the area has a gentle regional slope towards the southwest, rising from a general elevation of 900 feet above sea-level in the vicinity of lake Timiskaming to

1,150 feet at Grand lake Victoria. Unlike the upland areas in the northern part of the region there are no prominent hills serving as conspicuous landmarks in this belt, the highest elevations nowhere attaining altitudes greater than 300 feet above the surrounding country. The elevations of some of the principal lakes in the southern upland belt are included in the following list:

Lake Elevations.	Feet above sea-level.
Obashing	822[1]
Kipawa	873[2]
Morin	892[1]
Lavallee	974[1]
Ostaboining	928[1]
Sassaganaga	1,025[1]
Ogaskanan	1,040[1]
Wolf	1,025[1]
Grassy	1,027
Trout	1,170[1]
Old Man	1,146[1]
Kawasachuan	1,116[1]
Grand lake Victoria	1,103[1]
Wapusanan	1,080[1]

The upland areas forming the Abijevis, Tenendo, and Smoky hills are alike in that they all consist of the ancient volcanics of the basal complex and are on this account of special interest since they indicate the amount of relief possessed by the ancient erosion surface upon which the Huronian Cobalt series was deposited. They are all situated in the northwestern part of the region, the Tenendo hills in Montbray township southwest of Tenendo lake, the Smoky hills east of the Smoky river in Duprat township, and the Abijevis hills in the northern part of Destor, Aiguebelle, and Manneville townships. The Abijevis hills form an especially definite upland area, extending as a continuous range with a width of 5 to 6 miles for a distance of 20 miles and having an elevation of 1,630 feet above the sea and 700 to 800 feet above the surrounding country.

The Boundary hills include a group of prominent elevations continuous with a similar upland area occurring in the vicinity of Windego and Larder lakes, across the interprovincial boundary, in Ontario; the whole of this belt being a remnant of the Cobalt series which denudation has failed to remove from the surface of the basal complex upon which it rests. All the Boundary hills are, therefore, composed of similar rocks and have had a similar origin and for this reason have been grouped together, although they embrace a number of separate knobs and ridges.

In Ontario, the upland area is divided at the west end of Raven lake into two northeast-southwest trending ranges, one of which parallels the east side of the Windego series of lakes and the other the west

[1] Aneroid determination.

[2] Canadian Pacific Railway survey.

shore of Raven lake. The latter range is terminated abruptly near the interprovincial boundary by a deep depression which cuts it off from a prominent haystack-like knob known as mount Shiminis. From this point the upland belt splits into three extensions, one of which trends northward to Labyrinth lake, forming what might be termed the Labyrinth hills, and the second continues northeastward terminating at the south end of Dasserat lake in the Swinging hills (so-called from the Indian name which translated literally means "the place where the spirit swings"); the third prolongation is much longer than the two northerly extensions and lies eastward, forming the prominent east-west trending ridge to the northwest of Kekeko lake known as the Kekeko hills.

The elevations of some of the most prominent points in the boundary upland area are as follows:

Upland Elevations.

	Feet above sea-level.
Mount Shiminis	1,850[1]
Swinging hills	1,600[1]
Kekeko hills	1,680[1]
Height of land between Ogima and Summit lakes	936[2]

Mount Shiminis, the highest knob of the group, with the possible exception of Maple mountain in the Montreal River district of Ontario,[3] has the greatest elevation yet recorded for any point in the whole Timiskaming region.

The small diameter of the hill compared with its height and its peculiar haystack like form makes it, as its Indian name Shiminis, "big island" implies, a veritable island in the landscape. It is visible for many miles in every direction and is one of the best known landmarks in the whole upper Ottawa basin.

The foregoing account of the upland relief of northwestern Quebec indicates that there is a close relationship between the topography of these areas and the lithological character of the underlying rocks. Thus, the general high relief of the boundary upland area is directly related to the resistant character of the firmly cemented conglomerate, arkose, etc., of which the hills of this district are composed. Likewise, the southern upland belt which is underlain almost entirely by hard granitic gneisses has, on the whole, a considerably higher relief than the northern part of the region where the metamorphosed volcanics of the basal complex predominate. On the other hand, however, owing to the greater uniformity of the gneissic rocks, the local relief is much less in the southern uplands than in the northern districts underlain by the more variable volcanics.

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[1] Aneroid determination.

[2] Ottawa River Regulation Survey, Public Works Department, Canada.

[3] Maple mountain has an elevation of a little over 2,000 feet above sea-level according to R. Bell, Geol. Surv., Can., Ann. Rept., vol. X, pt. I, 1897, p. 22.

Drainage.

The rocky uplands, being generally higher than other portions of the district, are the headwater areas in which the streams of the region originate and form the divides or heights of land between drainage basins. In this way it happens that three of the northern upland areas—the Boundary, the Smoky and the Abijevis hills—are situated on the divide between the St. Lawrence and Hudson Bay basins, dividing their drainage between the Abitibi on the north and the Ottawa on the south. The southern upland belt also forms a height of land between two basins which are wholly separate except for the deep Timiskaming gorge which has been incised across the upland belt, thus connecting the upper and lower Ottawa basins into one system. If this connexion were absent, the waters of the upper Ottawa basin would not find an outlet into the St. Lawrence, as at present, but would flow northward across the present height of land, to Hudson bay.

Rivers of the normal type can scarcely be said to exist anywhere in the upland districts of Timiskaming region, the drainage being effected, for the most part, through innumerable lakes connected by rapids and waterfalls. A few of these so-called rivers occupy marked depressions in the rocky surface of the plateau in parts of their courses, but the majority are of the most fortuitous type occupying such indefinite channels, that, in many parts of their courses an obstruction a few feet in height would deflect the river in an entirely different direction. The northern upland areas are limited in extent and on this account are drained entirely by small headwater brooks; whereas the southern upland belt, being much more extensive and continuous with a still larger area of similar upland territory to the eastward, is traversed by streams of considerable size. On its northern slope, it includes the upper Ottawa from Wapusanan lake and Grand lake Victoria eastward, also, the connected groups of lakes forming the upper portions of the basins of the Winiwiash and Spruce rivers—tributaries of the Ottawa which traverse the clay belt in the lower parts of their courses. On its western slope the principal river is the Kipawa (Plate IV) which includes Kipawa, Ostaboining, and other large lakes in the southwest part of the region. On the south slope, there is Maganasibi, Dumoine, Black, and Coulonge rivers—all important streams flowing southward into the lower Ottawa from the interior uplands.

Of the topographic features which distinguish the Laurentian plateau from other physiographic provinces, probably the most characteristic is the remarkable number of lakes of all shapes and sizes which, everywhere, cover its surface. These are especially abundant, in those districts which like the southern upland belt of the Timiskaming region, are underlain by granitic gneisses. A typical area in this granitic belt is shown in Figure 2. In this area, 535 square miles in extent, there are over one hundred and thirty-five lakes and approximately 27 per cent of the surface is covered by water.

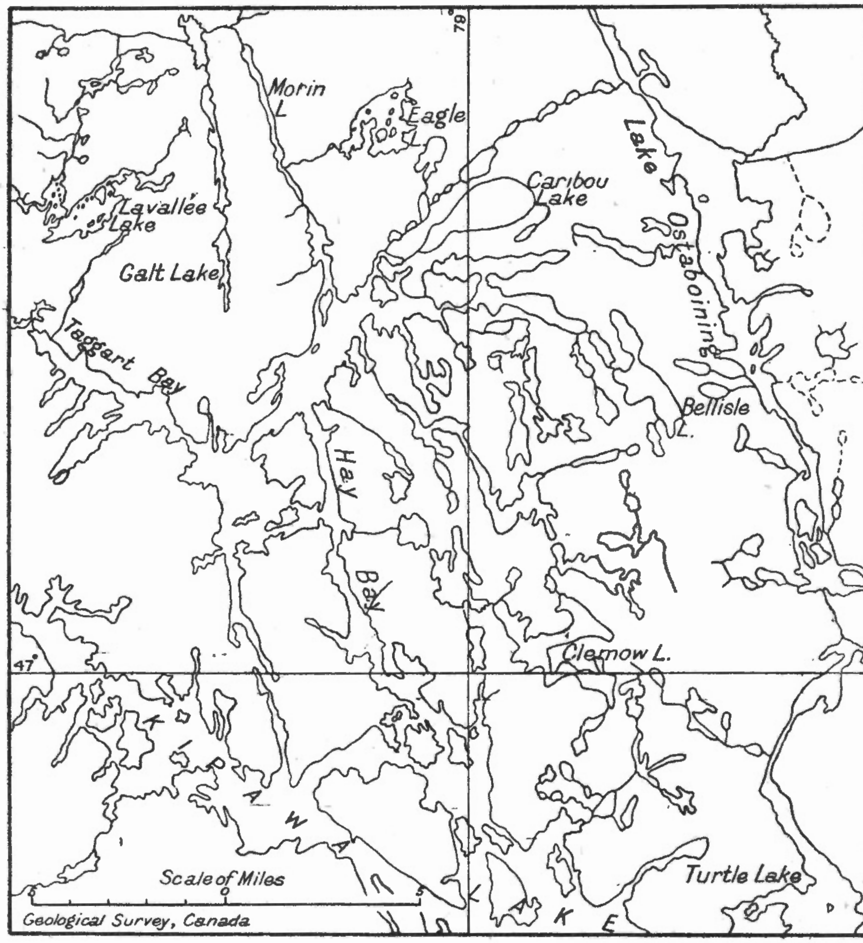

Figure 2. Area in the vicinity of lake Kipawa showing the multitude of lakes; about 27 per cent of the surface area is water.

The lakes of the upland district of Timiskaming region are of three principal types. The most common variety of lake has a form which is not controlled primarily by the underlying bedrock surface, but by the glacial drift deposited on the bedrock surface. Lakes of this class are remarkable both for the detailed irregularity of their shore-line and the enormous number of scattered islands which they contain. The second type of lake occupies structural basins, that is, basins whose form is controlled primarily by the structure—foliation, bedding, etc.—of the underlying rock. The third type of lake includes those bodies of water whose form is controlled primarily by long, narrow, gorge-like depressions which have been incised in the bedrock surface regardless of its structure. These lakes, as a rule, are hemmed in by glacial drift at their ends, although, in the case of some lakes at least, we know that a rock-rimmed basin would remain even though glacial drift were absent. In some localities a lake of the linear type has been filled so full of water that it has overflowed into a larger basin thus expanding a linear basin into a basin of the irregular type. Lake Kipawa and Grand lake Victoria appear to be basins of this sort. Lake Sassaganaga is a typical lake of the irregular, fortuitous type; Lavallee lake is an example of the second variety; and Dumoine lake belongs to the third.

One of the common characteristics of the rocky upland lakes of Timiskaming region, both large and small, is the presence of two or more outlets to the same basin. Thus, Dumoine lake has its principal outlet into the Ottawa down Dumoine river but it also drains northward into Grassy lake and thence to lake Timiskaming by way of Kipawa river. Likewise, the body of water known as Old Man and Old Woman lakes drains into the upper Ottawa partly eastward through Five Portage lake and partly northward by Spruce lake, and Grand lake Victoria has several channels leading to Wapusanan lake, but these unite near the latter lake and for this reason must be regarded as simple portions of a single river, rather than separate outlets.

The approximate areas of some of the principal upland lakes of the Timiskaming region are as follows:

Areas of Lakes in the Upland.

	Square miles.
Kipawa	120
Grand lake Victoria	40
Dumoine	38
Ostaboining	20
Sassaganaga	20
Ogaskanan	14
Wapusanan	13
Obashing	11
Trout	10

CLAY BELT.

The clay belt of northern Ontario and Quebec includes a wide area of country approximately 68,000 square miles in extent, throughout which post-Glacial lacustrine clays have been deposited, thereby forming a depositional or constructional plain. The thickness of clay deposited was only sufficient, however, to fill the minor inequalities of the underlying surface and consequently the surface of the plain is interrupted not only by extensive areas of rocky upland country but also by small protruding outcrops of bedrock and by areas of glacial drift.

With the exception of a small area of country to the north of lake Timiskaming, the clay belt lies wholly to the north of the St. Larwence-Hudson Bay divide in Ontario, but in Quebec it extends southward across the divide and covers nearly the whole of the northern part of the Timiskaming basin, an area of 3,000 square miles.

Relief.

Although the surface of the lacustrine clay of the clay belt is so generally uniform that it appears flat to the eye, yet, in reality, it conforms to the slope of the underlying surface upon which the clay was deposited. At the north end of lake Timiskaming depression, it has an elevation of only 600 feet above sea-level, but 15 miles eastward, on lac des Quinze, the elevation is approximately 900 feet. From lac des Quinze, it rises gently northeastward with an average gradient of one foot per mile, attaining an elevation of over 1,000 feet above sea-level on the height of land. Beyond the height of land as in the south it slopes gently away from the divide northward towards Hudson bay.

The following table of elevations of points within the clay belt has been compiled from the elevations on the National Transcontinental, Canadian Pacific, and Timiskaming and Northern Ontario railways, from the levels on the upper Ottawa determined by the Ottawa River Storage branch of the Public Works Department, and from aneroid measurements by the writer.

Clay Belt Elevations.

	Feet above sea-level.
Lake Timiskaming, low water	578[1]
Lake Timiskaming, high water	592[1]
Haileybury, Ont., T. and N.O. railway depot	766[2]
New Liskeard, Ont., T. and N.O. railway depot	642[2]
Englehardt, Ont., T and N.O. railway depot	677[2]
Lac des Quinze	852[3]
Lake Expanse	854[3]
Barrière lake	867[3]
Lake Opasatika	869[3]
Height of land between Ogima and Summit lakes	936
Kinojevis river at its outlet	876[3]
Caron lake (Crooked lake)	876[3]
Lake Kinojevis	876[3]
Roger lake	902[3]
Kekeko lake	877
Lake Dufault (Lake of Islands)	951
Lake Dufresnoy (Kajakanikamak)	907
Height of land between Mackay and Bellefeuille lakes	950
Lake Kewagama	958[3]
Height of land east of Robertson lake	1,074[4]
Lake Dasserat (Mattawagosik)	913

[1], [2], [3], [4]. See footnote, page 31.

	Feet above sea-level.
Lake Duparquet (Agotawekami)	882
Lake Abitibi, high water level	870[4]
Makamik lake	915
Lois lake	990
La Motte (Seals Home) lake	966[3]
De Montigny (Kienawisik) lake	968
Christopherson lake	1,099
Lake Obaska	1,033
Lake Shabogama	994
Bell river, at Kanikawinika island	852
La Sarre (Whitefish) river, at N.T.R. crossing	870[4]
Lois river, at N.T.R. crossing	915[4]
Harricanaw river, at N.T.R. crossing	971[4]
Peter Brown creek, at N.T.R. crossing	1,003[4]
Natagagan river, at N.T.R. crossing	1,000[4]
Summit on N.T.R., west of Coffee river	1,084[4]
Bell river, at N.T.R. crossing	994[4]
Migiskan river, at west crossing of N.T.R.	1,071[4]

Drainage.

The drainage of the clay belt differs from that of the rocky upland country in the smaller number of lakes which occupy its surface and in the rivers which have incised their channels in the easily transported post-Glacial stratified clay. If the deposition of lacustrine clay had continued for a sufficiently long period, all the irregularities of the underlying surface would eventually have been buried, leaving a flat surface with no undrained depressions. The thickness of clay deposited was only sufficient, however, to carry this change to partial completion, so that the deeper lake basins survived. The drainage systems of the clay belt, like those of the rocky upland belts, are thus composed of both lakes and rivers; but, unlike the upland districts, the rivers are the most important and are of the normal type, having definite and graded channels wherever they traverse the lacustrine clay.

The lakes of the clay belt include all the types of basins which occur in the upland districts and, in addition, a fourth type which occupies wide shallow depressions, and which might be called the clay belt type. Lake Dufault is a typical example of the irregular, accidental class of lake, having a most irregular outline and containing an enormous number of islands; of the linear lakes occupying well defined rocky basins there are also numerous representatives, as for example lakes Opasatika, Caron, and Roger; the structural type of basin is represented by lake Dufresnoy which conforms in its trend to the strike of the folded volcanic flows in which its basin occurs. The most striking lake basin of the clay belt type is lake Abitibi having a total

[1] Canadian Pacific Railway survey.
[2] Timiskaming and Northern Ontario Railway survey.
[3] National Transcontinental Railway survey.
[4] Upper Ottawa Regulation survey.

area of 335 square miles and a depth of 10 feet or less throughout nearly its whole extent.

The areas of some of the most important lakes occurring in the clay belt portion of the region are given in the following table:

Areas of Lakes in the Clay Belt.

	Square miles.
Abitibi	335
Timiskaming	120
Expanse	60
Kewagama	48
Lac des Quinze	40
La Motte and Okikeska	40
Shabogama	25
De Montigny and lake Lemoine	22
Sifton	20
Opasatika	20

The river courses in the clay belt were determined originally by the slope of the surface of the lacustrine clay so that they must be regarded as consequent streams developed on the surface of a constructional plain. They have cut their way through the clay to the underlying bedrock in places, however, and are thus in the initial stages of superposition on the Pre-Cambrian rock surface beneath. At the points where the rivers have been superposed on the bedrock they are interrupted by rapids and waterfalls; but, between these interruptions, where they traverse the clay, there are long sinuous stretches of quiet, almost currentless water.

The rivers of the clay belt are remarkably similar, winding back and forth through the wooded, swampy, clay flats with monotonous regularity. Well developed meanders are not common, although here and there on the small tributary streams both meanders and cut-offs are present. In proportion to the volume of water which they discharge the clay belt rivers have remarkably wide and deep channels, a feature which probably owes its origin to the erosive action of the high water in the spring, on the soft unconsolidated clay in which they have their courses.

Since the lacustrine clay was deposited for the most part in the lowland portions of the region, all the important rivers, with the exception of those draining directly into the lower Ottawa from the southern upland belt, necessarily traverse the clay belt in at least parts of their courses. South of the St. Lawrence-Hudson Bay divide, all the streams are tributary to one trunk drainage channel, the upper Ottawa, which traverses the clay belt in a general east-west direction from Wapusanan lake to lake Timiskaming, a distance of approximately 100 miles. North of the divide, on the other hand, the drainage of the clay belt is divided between three wholly separate river systems: Abitibi, Harricanaw, and

Bell or upper Nottaway. All are important rivers and empty into James bay at its southern extremity.

The upper Ottawa has several tributary streams of considerable size both on the north and on the south. Those entering from the south have their headwaters in the southern upland belt but the northern tributaries, except for a very small part of the Boundary hills, have their drainage basins entirely in the clay belt. The largest of the rivers tributary to the upper Ottawa is the Kinojevis which drains a very marked northerly extension of the Ottawa basin, approximately 2,500 square miles in area, around which the height of land bends sharply to the north for approximately 50 miles.

The territory in Timiskaming county belonging to the Abitibi system occupies the northwestern part of the region extending from the Kinojevis River basin westward to the interprovincial boundary. Its drainage finds its way for the most part either into lake Duparquet on the south or into Makamik lake on the north. Both of these lakes serve as collecting reservoirs for a considerable area of country, Duparquet lake being the outlet of Kanasuta, Magusi, and Smoky rivers and Makamik lake the outlet of Lois, Fly, and Bellefeuille rivers. These lakes in turn drain into a still lower basin, lake Abitibi, the former by way of the upper Abitibi and the latter by way of La Sarre (Whitefish) river.

The section of the Harricanaw basin included in the region under description embraces an elongated, irregular area of country intervening between the Abitibi and Bell River basins and adjoining the height of land directly north and east of the Kinojevis River basin. In its upper portion, it includes a number of large clay-belt lakes, several of which form a part of what is generally regarded as the headwater continuation of the Harricanaw river—although the river is in reality a connected series of lakes. The tributary drainage of the area generally flows directly into the Harricanaw so that all the other streams are small, Launy creek, the outlet of Launy (Atikameg) lake, and the Octave (Shishishi) river, the outlet of Chikobi lake being the only tributary streams of importance in the whole district.

The Bell River drainage basin occupies the northeastern part of Timiskaming county. It resembles the Harricanaw river in its upper portion, consisting for the most part of a series of lakes—Shabogama, Obaska, etc.—connected by short intervals of river; but its basin is wider and its drainage less radially disposed, so that the tributary streams are larger. On the east, the Bell is joined about 6 miles north of the National Transcontinental railway by the Migiskan, a large river having its headwaters in the northeastern continuation of the southern upland belt, which at this point lies east of Bell river. On the west, there is also a large tributary river, the Natagagan, which, from

Natagagan lake about 3 miles south of the National Transcontinental railway, in Fiedmont township, flows northward for 70 miles to its outlet into the Bell, at Kanikawinika island. There are also a number of other tributary drainage channels, including Coffee river—so-named because of the dark brown colour of its water—Shabogama river, Kiask river, and Garden Island river, all streams of considerable size but small as compared with the Migiskan and Natagagan.

LINEAR VALLEYS.

Among the physiographic features which characterize the Laurentian plateau, in the Timiskaming region, probably the most interesting and unique are the numerous deep, linear, trench-like valleys which maintain their direction with remarkable uniformity across all its Pre-Cambrian bedrocks, without regard to their variety, structure, or age. Prior to the Glacial epoch, these rocky depressions were even more conspicuous topographic features than at present; for, many of the valleys were, no doubt, greatly modified by glacial erosion and those which survived the erosive action of the continental glaciers are now partly filled with glacial drift deposited as the ice-sheets withdrew. Their existence in the region at present is indicated chiefly by numerous series of long, narrow lakes, linearly continuous with one another.

Of all the linear trench-valleys of the region the depression occupied by lake Timiskaming and Ottawa river between lake Timiskaming and the village of Mattawa is undoubtedly the most striking, having a length of 100 miles and a depth in places within 100 feet of sea-level. The character of this depression is aptly described by the late A. E. Barlow as follows:[1]

"The greater portion of this valley is a very steep, rocky gorge, fringed on either side by lofty hills or perpendicular cliffs, which rise abruptly to a height of from 400 to 600 feet above the surface of the water, while the average of a large number of soundings indicates that the lake has a depth of over 400 feet. The depression, therefore, occupied by these waters would be about 1,000 feet below the level of the surrounding country, and as the bottom of the lake wherever examined, consisted in the deeper portions of a very fine, grey unctuous clay or silt, this depth may have been much greater before the accumulation of this material. From Mattawa to the mouth of the Montreal river, these abrupt and rocky shore-lines prevail, but about the mouth of this stream the lake undergoes considerable expansion and the shores exhibit a more gradual slope towards the surface of the water. The traveller ascending the Ottawa river is thus usually impressed with the mountainous character

[1] Geol. Surv., Can., Ann. Rept., vol. X, 1897, pt. I, p. 23.

of the district, but an ascent of the hills on either side at once shows that the adjoining country is comparatively level, and that what appeared

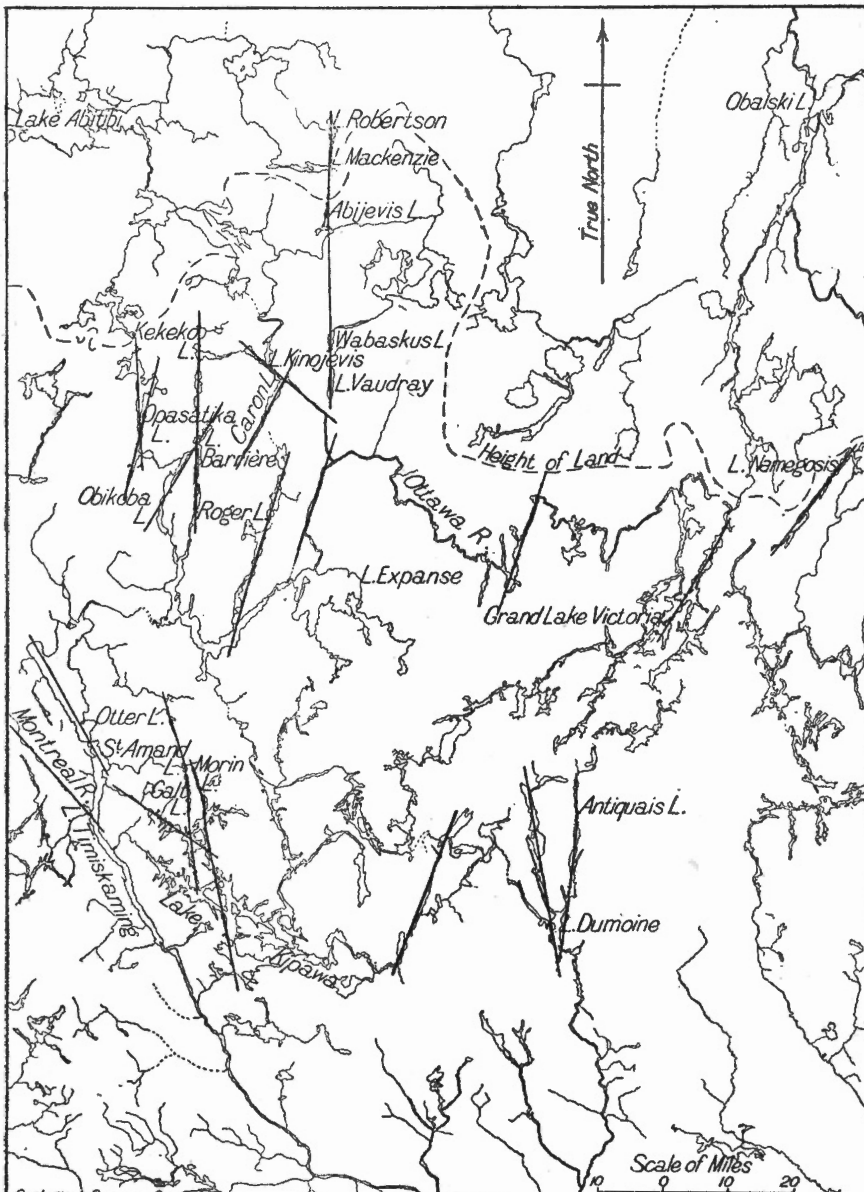

Figure 3. Linear valleys unrelated to rock structure, Timiskaming county.

as ranges of hills are in reality the enclosing walls of this great valley" (Figure 3).

There are a number of other linear valleys in the Quebec portion of the Timiskaming region which, although not so deep or long as the Timiskaming gorge, are nevertheless notable depressions. About 12 miles east of lake Timiskaming, a parallel northwest-southeast trending trench extends from Campbell bay on lake Kipawa to Otter lake, in Laverlochere township; this is directly in line with another depression farther to the northwest occupied by Long lake and the northwest

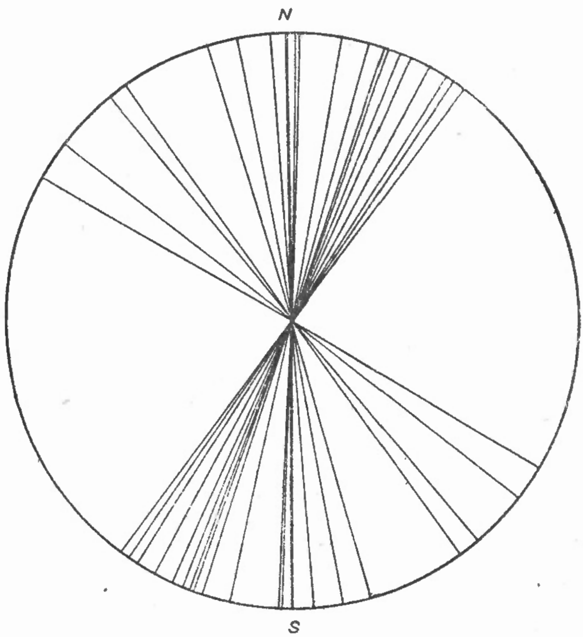

Figure 4. Directions of linear valleys.

trending portion of Rivière des Quinze; and it is probable that these valleys are parts of the same gorge. So much glacial drift has been deposited in the trench that it is not possible to determine its depth. In the district between Otter and St. Amand lakes, however, it is hemmed in on the east by a cliff between 200 and 300 feet high over which the creek from Silver lake descends precipitously to the valley beneath, forming a very picturesque waterfall.

In the northern and central parts of Timiskaming county there is a series of linear depressions extending in a north-south direction from Robertson lake in Privat township to Vaudray (Long) lake in Vaudray township—a distance of 50 miles—which are probably parts of a single valley. This traverses all the important rock members of the basal complex and trends almost at right angles to their structure. Where it crosses the Abijevis hills, it forms a remarkable, narrow, rift-like gorge walled in on either side by vertical scarps which rise to elevations of 200 feet above the surface of Eileen and Abijevis lakes.

Lake Opasatika, Caron lake, the Kekeko-Albee-Barrière chain of lakes, Kinojevis lake and part of Kinojevis river, Grand lake Victoria, Kipawa river between Wolf and Brennan lakes, and the northwest bay of lake Kipawa also lie in important linear depressions which are entirely unrelated to the structure of the rocks in which they occur. The trenches occurring in the area included in the map which accompanies this report are shown in Figure 3. It will be observed that the valleys trend in various directions and intersect one another in places thus forming basins for lakes with arms radiating at various angles.

In order to ascertain whether there is a tendency to parallelism in the trend of the linear valleys, the directions of the lines shown in Figure 3, as tabulated in the following list, were plotted through a single point as shown in Figure 4.

Bearings of Linear Valleys.

Lake Namegosis	N. 38 E.
Grand lake Victoria	N. 34 E.
Ottawa river at lake Nimewaja	N. 24 E.
Dumoine and Antiquois lakes	N. 12 E.
Dumoine lake, Northwest bay	N. 14 W.
Kipawa river between Wolf and Brennan lakes	N. 25 E.
Lakes Robertson, Mackenzie, Abijevis, Wabaskus, and Vaudray	N. 2 E.
Caron lake	N. 30 E.
Lake Kinojevis	N. 50 W.
Barrière-Obikoba lake	N. 35 E.
Barrière and Kekeko lakes	N. 3 W.
Lake Opasatika, south end	N. 17 E.
Lake Opasatika, north end	N. 3 E.
Roger lake	N. 20 E.
Ottawa river, east of Roger lake	N. 20 E.
Morin lake	N. 16 W.
Lake Kipawa, Hay bay	N. 14 W.
Lake Kipawa, Taggarts bay	N. 57 W.
St. Amand, Galt, and Otter lakes	N. 10 W.
Lake Timiskaming, north end	N. 33 W.
Montreal river	N. 37 W.

It can be seen from Figure 4 that these lines appear to occur in three systems and all fall in the north and south quadrants.

Origin.

Faulting. The origin of the linear valleys of Timiskaming region by erosion along fault planes was discussed at some length in a previous report[1] and on that account merely a summarized statement of the data on which the hypothesis is based is included here.

[1] Geol. Surv., Can., Mem. 39, pp. 16-19.

In favour of the faulting hypothesis the following evidence may be cited:

The remarkable linearity of the trench valleys and the manner in which they cut across all varieties of rocks regardless of their character (hardness, etc.), or structure (foliation, bedding, etc.), are features, which while generally characteristic of fault planes, are not normal characteristics of river valleys.

In the case of the Cobalt Lake depression, an actual fault plane has been found to correspond with the longer axis of the basin.

The evidences of deformation in the flat-lying Palæozoic outlier at the north end of lake Timiskaming, at a point in Dymond township directly in line with the west shore of the lake, suggest that the linear scarp which forms the west boundary of the Timiskaming gorge has been developed along a fault plane.

Numerous faults of small displacement have been found in the mine workings at Cobalt indicating that the region in that locality has been subject to faulting on an extensive scale.

The manner in which some of the linear valleys lie on the contact of older and younger formations lends strong support to the hypothesis that the valleys in these cases occur on a fault along which the formation on one side of the valley has been vertically displaced with respect to that on the other.

In opposition to the faulting hypothesis there is the following evidence:

Up to the present time, the actual fault plane has been found along only one of all the linear valleys of the Timiskaming region, namely Cobalt lake.[1]

From an examination of maps of areas in the Timiskaming region on which the geological formations are shown in detail, it seems evident that, as regards the larger part of the linear valleys, there is no apparent difference in the rocks exposed on opposite sides of the valleys, an effect that would be very noticeable, in most localities, if the rocks on one side had suffered considerable vertical displacement with respect to the other.

If the linear valleys of the Timiskaming region have been developed by erosion along planes of faulting, it would seem probable that the Timiskaming gorge, at least, the longest and deepest of all the linear valleys, would occur along a fault of great displacement; yet the pre-Cobalt Series palæoplain occurs at approximately the same elevation, throughout a considerable area, on both sides of the lake, showing that one side of the lake has suffered little or no vertical displacement with respect to the other.

Other Possibilities. If it be assumed for the purpose of investigation that the linear valleys have not developed as a result of faulting, is there any other known way in which such a striking series of linear depressions could be formed? It is pointed out in the section of the report which follows that they are not of glacial origin and, as far as known to the writer, such a system of drainage could only develop normally by the superposition of drainage valleys from an overlying series of rocks which have since been eroded away, presumably, in this case, from Palæozoic sediments, since, as far as known, these are the only overlying rocks which ever occurred in the region.[2] But even if the linear valleys originated on a younger Palæozoic cover we have still to explain how such a system of drainage composed of linear valleys trending in three principal directions could be initiated in flat-lying sedimentary strata except by faulting or deformation.

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[1] Miller, W. G., and Knight, C. W., Eng. and Min. Jour., vol. 92, pp. 648, 1911.
Williams, M. Y., Geol. Surv., Can., Mus. Bull. No. 17.

[2] Pirsson, L. V., Am. Jour. Sc., vol. 30, 1910, p. 30.

Conclusions. Having considered the various ways in which the linear valleys which characterize Timiskaming region might have been formed, can a definite conclusion be inferred from the evidence cited as to the mode of origin of these striking physiographic forms? On the whole the evidence probably favours the hypothesis that the trend of the valleys has been determined by planes of faulting or deformation. The large number of the valleys and the manner in which they intersect one another, are features which are remarkably similar to those characteristic of fault planes in a region which has been subjected to faulting of a block type. Many of the dislocations in a region which had been shattered in this way, would, no doubt have very small displacements and thus the uniformity in the character of the rocks outcropping on either side of many of the linear valleys might be explained. That so few fault planes have been found may be partly accounted for by the fact that the depressions are generally filled with water or glacial drift so that the actual planes of dislocation are not generally exposed.[1]

Age.

It is not possible to fix the time at which the linear valleys of Timiskaming region originated except within wide limits. They cannot possibly be of post-Glacial origin because stream dissection since the Glacial epoch has been almost insignificant and the valleys are themselves occupied by glacial drift deposited by the ice-sheets. It is also very improbable that they are the result of glacial denudation, for they have no relationship to the character of the rocks they traverse, and they trend, in some cases, at right angles to the direction of ice movement. Since the valleys are neither Glacial nor post-Glacial in their origin, it follows, *a priori*, that they are pre-glacial valleys.

It is known that the linear valleys cut across the sills of Nipissing diabase which were probably intruded during the Keweenawan period so that the valleys are at least of post-Keweenawan age. Furthermore, if the linear valleys have been developed along fault planes—and the balance of evidence is probably in favour of this conclusion—the occurrence of a zone of deformation in the Palæozoic rocks on a line continuous with the west boundary of the Timiskaming depression, would indicate almost conclusively that this trench and probably the other linear valleys of the region likewise, are of post-Silurian age.

It would thus seem probable that the linear valleys were formed some time during the long interval which elapsed between the Palæozoic submergence and the coming of the continental glaciers. If a Cretaceous peneplain covered the Laurentian plateau, however, they would neces-

[1] Hobbs, W. H., Trans. Wis., Acad. Sc., vol. 15, 1905, p. 19.
Pirsson, L. V., Am. Jour. Sc., vol. 30, 1910, p. 25.

sarily have to be post-Cretaceous in age. The fact that the valleys have survived to the present probably favours the assumption that they were formed during the period immediately preceding the Pleistocene, possibly, as suggested by Spencer, during a pre-Glacial uplift of the plateau.

Overdeepening of the Timiskaming Trench.

It was concluded in the previous discussion of the age of the linear valleys that they were pre-Glacial in their origin. From this, it would follow presumably that they had been carved out, in the main, by the normal process of stream erosion. Valleys formed in this way, however, have graded bottoms, whereas the Timiskaming trench is apparently cut off by a rock barrier in the lower part of its course.

The Timiskaming trench proper extends from the north end of lake Timiskaming to the village of Mattawa, Ontario, a distance of over 100 miles, and is occupied by lake Timiskaming in only its upper part. Between the lower end of lake Timiskaming and Mattawa there is an interval about 35 miles in length, in which numerous rapids occur, the first of which, known as the Long Sault, is 6 miles in length, and connects lake Timiskaming with a long stretch of almost currentless water, about 16 miles long, called Seven League lake. Between Seven League lake and Mattawa there are three abrupt descents in the water course known as Mountain, Les Erable, and Cave rapids respectively. Of the two lakes occupying the depression, Timiskaming has a surface elevation of approximately 580 feet above sea-level, and a maximum depth of 470 feet,[1] while Seven League lake has a surface elevation of approximately 530 feet and a maximum depth of 397 feet[2]—that is the bottom of lake Timiskaming has an elevation of 110 and the bottom of Seven League lake an elevation of 137 feet above sea-level. These elevations are probably considerably higher than the actual elevation of the rock bottom of the trench, however, for it has been partly filled both by post-Glacial lacustrine clay and by glacial drift. The obstruction which separates lake Timiskaming from Seven League lake and over which the Long Sault rapids[3] descend is composed of glacial drift so that the trench in reality maintains its great depth continuously from lake Timiskaming to Seven League lake. The barrier below Seven League lake, on the other hand, apparently consists of solid rock, the river descending "through a narrow channel, obstructed by rocky reefs and islets."[4] Since the elevation of the bedrock surface at Mountain rapids is about 425 feet

[1] Barlow, A. E., Geol. Surv., Can., Ann. Rept., vol. X, pt. I, 1897, p. 165.
[2] Guerin, Thos., Ann. Rept., Minister of Public Works, Canada, 1884-85, pp. 106-107.
[3] Rep. of Prog., Ottawa River Storage, Dept. of Pub. Works, 1909–10, p. 85.
[4] Barlow, A. E., Geol. Surv., Can., Ann. Rept., vol. X, pt. I, 1897, p. 170.

above sea-level, there is a rock-rimmed basin having a minimum depth of not less than 315 feet in the bottom of the Timiskaming trench.

In a paper entitled "Crustal warping in the Timagimi-Timiskaming district, Ontario," published in the American Journal of Science in 1910, Dr. L. V. Pirsson pointed out that a rock-rimmed basin was present at the bottom of the Timiskaming trench and suggested that the upper portion of the trench had been over-deepened by downwarping, the alternative possibility—glacial overdeepening—being dismissed as untenable, because the trend of the Timiskaming valley (as pointed out by Dr. Barlow[1]) was transverse to the direction of movement of the glacial ice.

The warping hypothesis of Dr. Pirsson presents some physiographic difficulties in that if the northern portion of Timiskaming trench had been lowered 300 feet below the southern portion either by transverse warping or faulting, this would almost certainly be evident in the higher elevation of the region adjacent to the trench from Seven League Lake southward. This is apparently not the case. Furthermore, it might be pointed out with regard to the overdeepening of the trench by glacial denudation, the continental ice-sheets did not move across the valley at right angles but obliquely, so that it is not impossible that a subcurrent of the ice-sheet might have been directed down Timiskaming gorge eroding out its bottom to a depth of several hundred feet.

TOPOGRAPHIC HISTORY.

The most important events in the physiographic history of Timiskaming region have already been described in the section of the report on the topographic history of the Laurentian plateau. In the following account of the physiographic development of a particular area within the plateau, however, the various events are described in greater detail than was possible in the general outline of the development of the whole physiographic province.

The physiographic history of Timiskaming region may be regarded as commencing with the development of the great erosion plain which separates the Huronian Cobalt series from the great basal complex beneath. During geological ages which preceded the development of this ancient Pre-Cambrian erosion surface, numerous plains of denudation may have been formed in the region but these find no expression in the present topography and the evidence of the presence of even the last of them is to be found only in the wide areas of clastic sediments and in a few doubtful remnants of older denuded surfaces.

Although the floor which underlies the Cobalt series has been considerably warped and dislocated in places, during the long period which has

[1] Geol. Surv., Can., Ann. Rept., vol. X, 1897, p. 25.

elapsed since the Cobalt series was deposited on its surface, it is yet possible to discover the degree of relief possessed by this ancient surface, from a study of its contacts with the overlying sediments. In most localities, where the contact is exposed at numerous points or where numerous small scattered remnants of the sedimentary cover occur, it is seen that the surface was generally one of low relief. In a few places, however, there are hills composed of rocks belonging to the basal complex which rise to elevations of several hundred feet above outcrops of the Cobalt series exposed at their base—as for example the Abijevis hills in Destor township; if these hills have not been raised to their present elevation above the Cobalt series by faulting, they must represent monadnocks which stood above the surface of the ancient plain. This ancient erosion surface, moreover, was developed over the territory—at least 50,000 square miles in area—extending from the north shore of lake Huron to lake Mistassini throughout which the Cobalt series is found, so that it was not merely a local base-level but a wide plain of low relief with remnants of erosion rising here and there above the general level of its surface. This Pre-Cambrian surface of denudation, therefore, represents a remnant of a peneplain once buried and later exposed and falls into the class of land form known as a palæoplain.

In Chapter III of this report, it is pointed out that the Pre-Cambrian basal complex of Timiskaming region includes parts of three great lithological belts or zones: a southern zone extending from the east shore of Georgian bay to the lower Ottawa, in which crystalline limestones is a common lithological type; a northern belt extending from lake Superior and the north shore of lake Huron to lake Mistassini, throughout which volcanic lavas are the dominant rocks; and between these two zones, an intermediate belt of banded gneisses stretches from the north shore of Georgian bay to the gulf of St. Lawrence. If an examination be made of the geological maps of the territory in which these belts occur, it is seen that the late Pre-Cambrian Huronian sediments which rest on the truncated surface of the basal complex are limited in their distribution to the northern belt, in which the basal complex is largely composed of volcanic flows—a coincidence which can scarcely be accidental.

On the whole the elevation of the Laurentian plateau in the region where the Huronian sediments occur, is but little higher than the elevation throughout the belt underlain by the banded gneisses; so that these younger Pre-Cambrian sediments must evidently, at present, occupy a depression in the Pre-Huronian peneplain surface, and it is probable that it is chiefly on this account that they have been preserved throughout the northern geosynclinal belt while they have been denuded away elsewhere. To account for the occurrence of the Huronian rocks in a depression coincident with the great northern volcanic belt of the basal complex two possibilities suggest themselves: (1) there may have been a depression in the Pre-Huronian peneplain surface throughout this belt when the Huronian sediments were laid down; or, (2) the Huronian rocks may have been downwarped or downfaulted throughout the region in which they occur, since they were deposited.

The occurrence in the basal complex of a great central igneous belt of granitic gneisses flanked on either side by surface rocks—sediments and volcanic flows—would seem to indicate that the belt of banded gneisses represents the core of a great Pre-Cambrian geanticlinal mountain range and that the folded surface rocks are the remnants of geosynclinal intermontane belts. If this interpretation of the structural relationships of the rocks of the basal complex be correct, then the mountain belt even after numerous cycles of erosion owing both to the original higher elevation and to the superior hardness of the granitic gneisses, would probably lag somewhat behind the intermontane areas in erosion and in consequence a depression might occur in the ancient peneplain surface throughout the geosynclinal areas.

In discussing the origin of the linear valleys of the Timiskaming region, it was pointed out that the Cobalt series had probably been subjected to faulting and it is probable that these rocks have in places been depressed relatively to the other rocks of the region, in this manner; furthermore, it is also possible that the deformation which has occurred in the Huronian rocks has taken place along structural lines which parallel the axial trends of the great geanticlinal and geosynclinal belts in the basal complex beneath, and, in such an event they might be downwarped or downfaulted or both downwarped and downfaulted throughout a region which would correspond to the geosynclinal belt in the basement complex. In order to establish this hypothesis, however, it would be necessary to show that the structural trend of the folds in the Huronian sediments has a northeasterly-southwesterly direction parallel to the axial trend of the folds in the older complex, and this has not yet been determined.

The great erosion interval during which the pre-Huronian peneplain was developed was finally terminated in Timiskaming region by the deposition of the Huronian Cobalt series of sediments which are believed to be in part of glacial origin. Following the deposition of the Cobalt series a second period of denudation ensued which continued into the early Palæozoic when a marine submergence occurred as shown by the presence of Ordovician and Silurian rocks at the north end of lake Timiskaming. It is probable that the larger part of the denudation which has occurred in the region since Pre-Cambrian time, took place during this interval; for the Palæozoic sediments rest, in part, on unroofed and denuded sills of Nipissing diabase, which were intruded into the

Cobalt series in the Keweenawan period, and in part on the pre-Huronian floor from which the Cobalt series has been stripped away. Moreover the discordance in structure which separated the Palæozoic sediments from the Cobalt series indicates that the folding which has occurred in these sediments took place during this period and that after the folding had occurred the region was base-levelled before the Palæozoic marine submergence took place.

It was formerly thought from the fossils contained in the Palæozoic outlier occurring at the north end of lake Timiskaming that the Palæozoic sea had covered the Timiskaming region during the Silurian period only and that these Palæozoic sediments were deposited originally in a depression which lay below the general level of the surface of the Laurentian plateau. Recent investigation has shown, however, that there are also fossils of Ordovician age[1] in the Timiskaming outlier and that the Palæozoic sediments were probably not deposited originally in a depression but occupy their present depressed position as a result of faulting. Both of these conclusions have an important bearing on the history of the Laurentian plateau; since it may be inferred from the first that Timiskaming region was twice submerged beneath the sea during the Palæozoic era and from the second that the Palæozoic sediments originally covered not only the area in which they occur but the whole region in the vicinity of lake Timiskaming to a depth of at least several hundred feet.

During the interval which elapsed between the withdrawal of the Palæozoic sea and the coming of the Pleistocene continental glaciers, Timiskaming region was, as far as known, continually a land area, but it is probable that the agencies of erosion were engaged during a considerable part of this period in removing the Palæozoic cover. At some time during the interval—most probably during a period of uplift near its close—numerous rivers cut their way into the surface of the plateau forming the peculiar trench-like valleys so conspicuous in the topography of the region at the present time.

The effects of glacial denudation and glacial deposition in modifying the topography were practically the same in Timiskaming region as in the Laurentian plateau as a whole (page 22). The abundance of glacial striæ and grooves and the general mammalated character of the bedrock surface bear ample testimony to the effective erosion power of the glacial ice in modifying the detailed topography of the region; on the other hand, the presence of numerous linear valleys, which are probably of pre-Glacial origin, is an indication of the limitations of this power. Owing to the deposits of glacial drift and post-Glacial clay which cover the bedrock surface, it is difficult to determine the amount of glacial

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[1] Williams, M. Y., Geol. Surv., Can., Mus. Bull. No. 17, 1915.

gouging which has actually occurred; but, at the bottom of the Timiskaming trench (page 40), there is a rock-rimmed basin 300 feet deep which probably originated in this manner.

Materials deposited from the continental glaciers, as elsewhere in the Laurentian plateau, are abundant in all the forms—moraines, kames, eskers, outwash plains, etc.—usually assumed by glacial and fluvio-glacial deposits. The control exercised by these materials on the hydrography of the region is also very conspicuous, the linear valleys being practically the only pre-Glacial forms which have survived. Thus, the Timiskaming trench, which was undoubtedly the trunk drainage channel of the region in pre-Glacial time, still serves in that capacity, although the river which occupied the channel originally has been replaced by a series of lakes lying behind barriers of rock or glacial drift.

The concluding event of importance in the physiographic development of Timiskaming region was the deposition of stratified lacustrine clay from large but shallow bodies of water—lakes Barlow and Ojibway—which occupied a wide extent of country in the central and northern parts of the region thereby producing the great constructional plain known as the clay belt. The disappearance of these great lakes, following the withdrawal of the continental glacier from the region, practically concluded the physiographic history of the region; for denudation since that time has consisted for the most part of a small amount of stream dissection in the unconsolidated glacial drift and post-Glacial lacustrine clay.

CHAPTER III.

GEOLOGY OF THE OTTAWA BASIN.

GENERAL STATEMENT.

The rocks occurring in the basin of Ottawa river, subdivided according to their structural and age relationships, fall naturally into four principal groups: (1) the basal complex which, with respect to the later rocks of the region, may be regarded as early Pre-Cambrian in age, (2) the Huronian sediments and certain intrusive dykes, sills, etc., of diabase and other rocks which may be classed as late Pre-Cambrian, (3) marine sediments deposited during the Palæozoic (Upper Cambrian to Silurian) era, and (4) Glacial and post-Glacial deposits belonging to the Quaternary.

BASAL COMPLEX.

Of the four great divisions to which the rocks of the Ottawa basin belong, the most widely exposed is the heterogeneous assemblage of metamorphosed sediments, volcanic flows, granite, granite-gneiss, and other igneous rocks, generally referred to by the early geologists as the basement, metamorphic, or fundamental complex and more recently by geologists in United States, as Archæan. In this particular region, these basement rocks occur in three great southwesterly trending belts which are lithologically different from one another. On the south, extending through southeastern Ontario and along the lower Ottawa, there is a zone in which crystalline limestone, and other altered sediments composing what is generally called the Grenville series, predominate and which for this reason may be designated the Grenville belt; on the north, in the vicinity of lake Timiskaming and extending westward to the north shore of lake Huron and eastward to lake Mistassini, there is a belt consisting chiefly of folded volcanic flows belonging mainly to the Abitibi group which may be referred to as the Abitibi or Timiskaming belt; and intervening between these northern and southern belts there occurs a third belt consisting almost wholly of banded gneisses which may be appropriately called the belt of Ottawa gneisses. The central of these great lithological zones is thus distinguished from those on the north and south in being composed mainly of plutonic igneous rocks, while the latter consist largely of what may be termed surface rocks—sediments and volcanic flows.

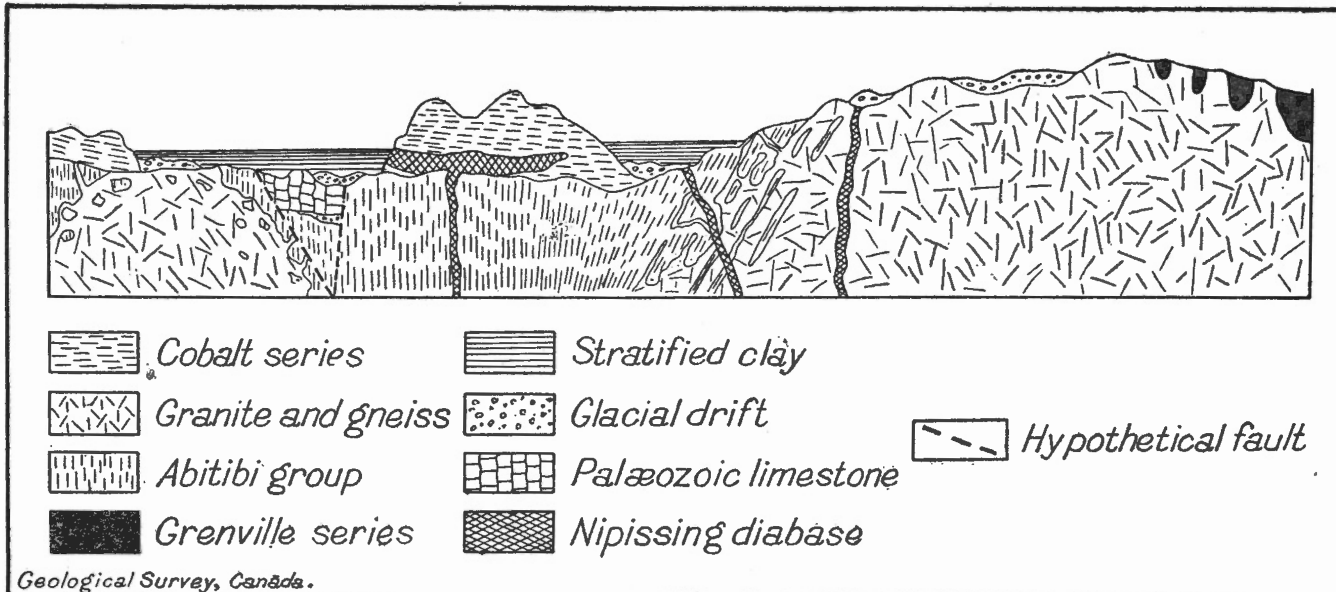

Figure 5. Diagrammatic cross-section of Timiskaming county.

Grenville Belt.

The principal rocks composing the southern or Grenville portion of the Pre-Cambrian basal complex of Ontario and Quebec have long been known from the works of Logan, Murray, Vennor, Ells, Adams, and other geologists employed on the staff of the Geological Survey during the early period of its investigations, but the relationships of these rock types throughout the region as a whole have not yet been worked out except in a few local areas.

Lithologically, the rocks of the Grenville belt belong to three principal groups: (1) metamorphosed sediments consisting of crystalline limestone, garnet gneiss, quartzite and mica schist, amphibolite, pyroxenite, and other products resulting from the contact metamorphism of limestone, and in the Madoc district, Ontario, volcanic lavas. (2) Pyroxenic gneisses, gabbros, diorites, anorthosites, and other rocks of intermediate to basic composition. (3) Granites, syenite, nepheline syenite, pegmatite, aplite, and related rocks.

With the exception of a few areas of limestone, slate, conglomerate, quartzite, and mica schist occurring in the Madoc district of Ontario, which are believed to be infolded synclinal remnants of a younger (Hastings) series,[1] all of the rocks of subdivision 1, as far as known, are conformable with one another and belong to a single group, the Grenville series. Whether or not the pyroxenic rocks of subdivision 2 are all of the same age is not known, although they are all apparently intrusive into the Grenville series. The acidic rocks of the Grenville belt, subdivision 3, as far as has been observed, are all intrusive into the rocks of groups 1 and 2; but whether they were intruded during one or several periods of batholithic invasion has not been generally determined. In the Madoc district, however, according to Miller and Knight, of the Ontario Bureau of Mines, there are two granites, the older of which lies unconformably beneath the Hastings series, while the younger (Moira granite) intrudes these sediments.

Timiskaming Belt.

As has been already pointed out, throughout the region extending from the north shore of lake Huron to lake Mistassini there is a belt in which the basal complex is composed chiefly of folded and metamorphosed volcanic flows. There is associated with these volcanics in places, however, a considerable proportion of clastic sedimentary material, and both these sediments and the volcanics are intruded here and there by batholithic masses of granite and granite gneiss.

[1] Report of the Special International Committee on Pre-Cambrian correlation, Jour. of Geol., vol. 15, 1907, p. 199.

Miller, W. G. and Knight, C. W., Ann. Rept., Ont. Bureau of Mines, vol. 22, pt. 2, 1914.

It has become customary among most geologists engaged in field work in Timiskaming region to regard the sedimentary rocks of this great northern belt as generally younger than its volcanic members, and in accordance with this conception, the sediments are called Sudbury or Timiskaming series, while the volcanics are grouped together as Keewatin. In Chapter IV, it is pointed out, however, that, although in certain localities sediments occur resting unconformably on volcanic rocks, it has not been established that all the volcanic rocks of the district are older in age than the sediments; nor that the complex is composed of two and only two series; nor that the volcanic members of the complex are necessarily equivalent in age to the volcanic complex called Keewatin in the region northwest of lake Superior. It is, therefore, thought to be more in accord with our actual knowledge to use the name Timiskaming group instead of Timiskaming series for all those areas of rocks which are known to be younger in age than other rocks of the Pre-Cobalt series complex with which they are associated, and to include all those rocks of the complex of which the age is in doubt or which are older than any of the series composing the Timiskaming group in a separate subdivision, the Abitibi group.

ABITIBI GROUP.

Igneous Rocks.

Extrusive. The Abitibi group is composed mainly of a complex of lava flows ranging in composition from basalt to rhyolite, which for the purpose of description may be designated the Abitibi volcanics. These lavas are dark green to grey rocks having characteristically a fine-grained aphanitic texture. In the interior of the flows, however, they become porphyritic or even approach the texture of plutonic rocks of similar composition. They commonly exhibit the amygdaloidal, variolitic, pillow, and other structures which usually characterize extrusive rocks.

The Abitibi volcanics have been everywhere more or less metamorphosed but, except in the vicinity of the intrusive granite batholiths or along local zones of deformation, the alterations have been mineralogical rather than mechanical; so that in most localities it is still possible to approximately determine their original composition and texture. The metasomatic changes which have taken place are remarkably uniform everywhere even in rocks of considerable difference in composition, the feldspars being transformed into sericite, epidote, zoisite, and carbonate and the ferromagnesian minerals to chlorite and secondary amphibole—actinolite, tremolite, or hornblende. Except for the presence of quartz, the acid members of the group differ from the basic merely in the proportion of these minerals, the sericite which occurs so abundantly in the acid rocks being replaced by epidote and chlorite in the basic varieties.

Where the volcanics have been subjected to contact metamorphism in the vicinity of the granite batholith, the basic volcanics have been generally recrystallized to hornblende schist or amphibolite. The acid lavas, on the other hand, have been mashed to sericite schist.

In most parts of Timiskaming region owing either to the paucity of exposures, or to the absence of definite and uniform horizons such as occur in sedimentary rocks, it has not been possible to work out the detailed structural or stratigraphical relations of the volcanics; yet, in places, the attitude and trend of the lava flows can be determined from the change in texture from the centre to the margin of the flow, from the presence of amygdaloidal and other flow structures along the surface of the flows, and from the strike and dip of the associated sediments. Wherever it has been possible to apply these criteria, it has been found that the volcanics have generally a vertical or nearly vertical attitude and trend, for the most part, in a direction parallel to the trend of the great Abitibi belt to which they belong.

Intrusive. Here and there, throughout the Abitibi belt, masses and dykes of quartz porphyry, aplite, diorite, andesite porphyry, peridotite, and lamprophyre occur in association with the Abitibi volcanics, which, except for their somewhat coarser texture, differ in no respect from the coarse-grained phases of the volcanics and are probably genetically related to them. Many of the intrusions of quartz porphyry and aplite have been partially replaced by ferruginous dolomite and chrome mica; and, it is possible, as is pointed out in Chapter VI, that the many masses and bands of chrome-mica-bearing ferruginous dolomite, which occur throughout the Abitibi belt have also originated in this way and, on this account, should be regarded as belonging to the intrusive members of the Abitibi group.

Sedimentary Rocks.

The sedimentary rocks belonging to the Abitibi group generally occur as small isolated masses or long narrow bands either surrounded on all sides by the Abitibi volcanics or intervening between the volcanics and batholiths of granite or granite gneiss. They include the following rock types: agglomerate and tuff, slate and phyllite, iron formation, ferruginous dolomite, conglomerate, greywacke, arkose, and quartzite.

Agglomerate and Tuff. Agglomerate and tuff are not extensively developed in the Abitibi group but have been described as present in a few localities. They presumably represent fragmental ejectmenta deposited contemporaneously with the volcanics with which they are associated.[1]

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[1] Rept. of min. oper., Que., 1911, p. 182.
Geol. Surv., Can., Sum. Rept., 1912, p. 303.

Slate and Phyllite. The rocks of this class are generally fissile rocks having in places a well developed slaty cleavage. They have generally a vertical attitude, are interbanded with greywacke, arkose, or iron formation in places, and are very commonly graphitic. Their mode of occurrence and relationships are variable; in some localities they are probably interstratified with the associated Abitibi volcanics but in other districts they are conformable with conglomerate and other sediments which are believed to be separated from, at least, part of the volcanics by an unconformity.

Iron Formation. The iron-bearing rocks, generally designated iron formation, although nowhere occupying an extensive area of country, are exceedingly common nearly everywhere throughout the belt occupied by the rocks of the Abitibi group. They generally occur in small masses or bands usually not more than a few hundred feet in width but continuous, in some cases, for several miles. They consist of interlaminated bands of magnetite or siliceous magnetite and jasper or quartz, and may occur enclosed in the Abitibi volcanics without the other sediments being present, or may be interstratified with slates, greywackes, or mica schists. They have generally a vertical position conforming to the structure of the rocks with which they are associated but do not appear to be limited to any particular horizon or formation of the Abitibi complex, occurring in association with all the rocks of the belt, volcanic and sedimentary alike.

Ferruginous Dolomite. In numerous localities throughout the Abitibi volcanics there are small local outcrops or bands of a rusty weathering rock, consisting of ferruginous dolomite, which is traversed almost everywhere by innumerable intersecting and anastomosing veinlets of quartz or of quartz and dolomite. The rock is generally highly pyritic and contains an abundance of chromiferous mica from which it derives its bright green colour. In a few places, this rock occurs interlaminated with sediments and, on that account, was thought to be of sedimentary origin, but, in other localities there is evidence, as is shown in Chapter VI, that the same rock has been derived from quartz porphyry, rhyolite, and related rocks by thermal replacement, so that it is possible that all these occurrences are in reality not sediments but replacement deposits.

Pontiac Series. In northwestern Quebec there is an east-west trending belt of sediments, about 10 miles in width, extending almost continuously from the interprovincial boundary between Ontario and Quebec to lake Matchimanito, a distance of approximately 110 miles, which has been named the Pontiac series. This group of sediments consists mainly of mica schist, but, near the northern margin of the belt, where the series is most remote from the belt of intrusive gneisses which it adjoins on the south, greywacke, arkose, and local areas of conglomerate occur. The belt also includes two bands of iron formation and one area of staurolite schist. The rocks represented in the pebbles and boulders of the conglomerate include granite, quartz porphyry, rhyolite, and quartz.

The relationship of the Pontiac series to the Abitibi volcanics has not been positively determined, although the occurrence of the series in a long narrow belt 110 miles in length, intervening between the great batholithic belt of gneisses and the volcanics, indicates that they have been folded up into their present position in company with the intrusion of the batholith and that, just as in the vicinity of laccolithic intrusions, the older strata occur adjacent to the laccolith; so the Pontiac series which adjoins the intrusive should underlie the volcanics occurring farther to the north. On the other hand, the presence of pebbles of rhyolite in the conglomerate of the Pontiac series might be taken to indicate that the Pontiac series is younger in age than the Abitibi volcanics. This is not conclusive, however, for the pebbles of rhyolite might have been derived from lavas contemporaneous in age with the Pontiac series or older lavas not now represented in the area.

Larder Lake Series. In a number of localities in Larder Lake district of Ontario, areas and bands of highly metamorphosed sediments occur which are believed to be overlain unconformably by conglomerate belonging to the Timiskaming group, and which, therefore, must be classed as a part of the Abitibi group. They consist of well bedded phyllite and slate interbanded with chrome-mica-bearing ferruginous dolomite, the dolomitic bands having widths ranging from a few yards to several hundred feet.

TIMISKAMING GROUP.

In this group are included all the areas of rock belonging to the Pre-Cobalt series complex which are known to be younger in age than other rocks of the complex with which they are associated. The principal rock areas belonging to this class, so far discovered in the Timiskaming region, are the Kirkland Lake series, with which is included conglomerate on Larder lake, the Timiskaming series, and the Fabre series.

Kirkland Lake Series. In the Kirkland Lake district a belt of sediments about 3 miles in width and 30 miles in length extends almost continuously from the village of Swastika on the Timiskaming and Northern Ontario railway to the Larder Lake district. These sediments include highly deformed conglomerate, greywacke, quartzite, and related rocks having generally a vertical or nearly vertical attitude and east-west strike. The conglomerate member of the series contains a large variety of pebbles including various greenstones, diabase, quartz porphyry, iron formations, jasper quartz, and granite, and has been found to rest unconformably on greenstone and quartz porphyry.[1]

An area of conglomerate belonging to this series, occurring on claim L.M.78, in the district north of Larder lake was observed to contain pebbles of the chrome-mica-bearing dolomite which occurs interbanded with the slate and phyllite found on the north shore of Larder lake. This seems to indicate that the Kirkland Lake series rests unconformably on the Larder Lake series.

Timiskaming Series. In the region adjoining the north end of lake Timiskaming (chiefly to the northwest of the town of Haileybury) highly metamorphosed sediments, conglomerate, greywacke, and slate, occur, for which the name Timiskaming series has been proposed. The conglomerate member of this series contains pebbles of granite, syenite, iron formation, diabase, basalt, and other rocks resembling the Abitibi volcanics. The series is, therefore, regarded as younger than both the Abitibi volcanics (Keewatin) and the Laurentian—the name Laurentian, in the nomenclature of the Ontario Bureau of Mines, being reserved for the hitherto undiscovered granite from which the pebbles of granite contained in the conglomerate of the Timiskaming series were derived. The Timiskaming series is intruded by a mass of granite which has been named the Lorrain batholith.[2]

Fabre Series. In the township of Fabre, in the region east of lake Timiskaming, some local areas of conglomerate, slate, and other sediments having the same general lithological character and relationships as the sediments already mentioned, were described and designated the Fabre series by Robert Harvie.[3]

Belt of Ottawa Gneisses.

General Statement.

It has been previously explained that throughout both the Grenville belt on the south and the Abitibi belt on the north, numerous intrusions of granite and gneiss, ranging in size from small masses to huge massifs, occur and that between these great belts an intermediate zone extends continuously from Georgian bay to the gulf of St. Lawrence, which has been referred to as the belt of banded gneisses. These granitic rocks, as far as has been observed, are everywhere intrusive into the other members of the basal complex with which they are in contact, although the presence of conglomerate containing granite pebbles, among the

[1] Burrows, A. G., and Hopkins, Percy E., Ann. Rep., Ont. Bureau of Mines, vol. XXIII, pt. 2, 1914, p. 10.

[2] Ann. Rept., Ont. Bureau of Mines, vol. XIX, pt. 2, 1913, p. 62.

[3] "Report on the geology of Fabre township," Dept. of Colonization, Mines, and Fisheries, Quebec, 1911.

intruded rocks, indicates that, at one time, if not at present, granites belonging to a much older period of intrusion occurred in the region.

It has been assumed by some geologists that the central belt of gneisses, because of its banded character, probably represented this ancient granite, but this is merely an hypothesis not yet established by evidence in the field. While it is probable that the granites and gneisses of the Ottawa basin are of varying age, this has not yet been determined to be the case, nor have criteria capable of wide application been discovered by which granites of different age within the basal complex can be distinguished from one another. Therefore, the only practicable course at present is to group all the acidic intrusives of the basal complex, lithologically, into a single Pre-Cobalt series group.

Lithological Character.

The batholithic masses of the Pre-Cambrian basal complex which have been grouped together are all very similar to one another in that they consist of rocks having a granitic texture and acidic composition; yet, within these limits, there is much variability. In the smaller and more massive batholiths this heterogeneity may arise, (1) from the presence of schlieren containing a greater abundance of ferromagnesian minerals than the surrounding matrix, (2) from the intrusion of rocks of slightly different composition through one another, (3) from the intrusion dykes of pegmatite and aplite or, (4) from the presence of included masses of the rocks intruded by the batholith. In the central belt of gneisses, the dominant varieties of rock present are very similar to those observed in the smaller batholiths but these occur chiefly as folded and interlaminated bands intruded by crumpled dykes of pegmatite and aplite.

The principal rocks composing the banded complex included the following varieties: granite, syenite, granodiorite, diorite pegmatite, and aplite. Of these biotite granite is by far the most common. The granites are generally grey to red rock of variable texture, and consist chiefly of quartz, orthoclase, microcline, albite or oligoclase, and biotite, hornblende, or muscovite. The syenites are grey to rusty red rocks consisting essentially of orthoclase, albite, microperthite, and biotite. The granodiorites resemble the granites in appearance, but their mineralogical composition shows them to occupy an intermediate position between granite and diorite, containing less quartz and correspondingly more plagioclase. The diorites are speckled to black rocks containing an abundance of glistening crystals of hornblende. They consist essentially of blue green hornblende, albite, oligoclase, or andesine. In a few localities within the belt of banded gneisses, masses of hornblendic rocks occur, some of which contain such a small proportion of feldspar that they might be more appropriately called amphibolite rather than diorite; but, because of their very limited extent, they have not been regarded as sufficiently important for separate description.

In addition to the various rocks mentioned in the previous paragraph, areas of cyanite and garnet gneiss and mica schist occur here and there throughout the belt of gneisses, the chemical and mineralogical composition of which indicate that they are possibly highly metamorphosed sediments. The relationships and possible mode of origin of these rocks are discussed at greater length in Chapters V and VI.

Foliation and Banding.

Since the Laurentian rocks all belong to the basement complex, they have all been subjected to deformation and in consequence have been generally foliated. This foliation has been brought about, for the most part, by the parallel orientation of biotite plates and hornblende prisms and, in some cases, by the flattening of the feldspar and quartz in the same plane. Very commonly the biotite of the biotite gneiss is seen to "eye" around small lens-shaped fragments of feldspar, giving rise to the characteristic augen structure, which results from deformation.

Not only have the rocks of the Laurentian complex been foliated to gneisses but, throughout the great central belt and in places in the smaller batholiths, which intrude the Grenville series on the south and the Abitibi group on the north, they occur as interlaminated bands. The banding in the gneisses arises either from a variation in the proportion of minerals present in the same rock, or by the alteration of bands of different rock. One of the most common types of banding is that brought about by the alternation of bands of biotite gneiss, containing varying proportions of biotite, so that a light band, in which little biotite is present, alternates with a dark band containing a large proportion of biotite. In a similar manner, variations in the proportions of hornblende in the hornblende granite gneiss, the granodiorite-gneiss, or the diorite-gneiss may result in a banded structure. The second type of banded structure, in which the alternate bands are composed of different rocks, may also be combined with bands of the first types, and in this way an almost infinite variation in the composition of the bands may occur. The width of the bands may vary from a fraction of an inch to several hundred feet. When followed along the strike they usually pinch out as though they were in reality thin lenses. This lenticular form is especially evident in the pegmatite which commonly occurs as a succession of lenses around which the foliation in the surrounding gneiss forms bands in a manner very similar to that which occurs on a small scale around the augen of feldspar in the augen gneiss.

From the study of the structure of the banded gneisses it is apparent that they have folded forms very similar to that assumed by deformed sedimentary strata. While there are no bands which can be traced continuously over wide areas like sedimentary beds, yet, all the various types of folds which characterize folded strata are present on a small scale and, in places, anticlines and synclines nearly half a mile wide in transverse section can be recognized (Plate IX). These anticlines and synclines are generally pitching, but the strike of the beds is northeasterly parallel to the trend of the great belt to which they belong.

In describing the structure of the Laurentian gneisses occurring in eastern Ontario, Adams and Barlow note that the foliation of the gneiss near the border of the batholith corresponds to the strike of the surrounding sedimentary rocks and conclude that the batholiths are anticlinal in their relationship to the Grenville series, the anticlinal axes trending north 30 degrees east. They also point out that the trend of the foliation and banding in the batholiths is commonly oval or elliptical in form, and, while no further statement is made by the authors as to structure of the gneiss, it seems apparent, from the trend of the foliation indicated on their maps, that the gneiss in that locality also has a folded structure similar to the central belt of gneisses of the Laurentian complex.[1]

Structure and Relations of the Three Great Basal-Complex Belts.

It has been pointed out in previous sections of this report that throughout eastern Ontario and southwestern Quebec the basal Pre-Cambrian complex is composed of three great northeasterly trending belts, the northern and southern of these consisting of surface rocks (volcanic flows and sediments) and the central consisting, for the most part, of intrusive banded orthogneisses; also, that the rocks composing these belts are all highly folded and have a structural trend parallel to the trend of the three great zones to which they belong. Furthermore, geological investigation throughout the world has shown that, where folded mountains have been greatly denuded, batholithic masses of acidic rocks are generally found at their centres and, since the Laurentian banded gneisses occur in a central belt intervening between belts of folded surface rocks, it seems probable that the great gneissic complex extending from Georgian bay to the gulf of St. Lawrence originally formed the core of a Pre-Cambrian mountain chain and constitutes a geanticlinal axial belt intervening between geosynclines formed by the rocks of the Abitibi group and the Grenville series.

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[1] Geol. Surv., Can., Mem. 6, 1910.

LATE PRE-CAMBRIAN ROCKS.

Introductory Statement.

Since the geology of only a very small part of the territory included in the Ottawa basin has been mapped in detail, our information with regard to the rocks of late Pre-Cambrian age in this region is necessarily incomplete. The known rocks of this class, however, include the Huronian sediments occurring extensively in the Timiskaming region, and numerous dykes, sills, and other intrusions of diabase, quartz diabase, olivine diabase, and related rocks, believed to be approximately of Keweenawan age.

Huronian.

INTRODUCTORY STATEMENT.

Throughout the region underlain by the Abitibi complex and along the northern border of the central belt of gneisses there are, in places, comparatively undisturbed sediments which rest on the truncated and greatly denuded surface of the basal complex in most striking unconformity. These are believed to be equivalent in age to similar rocks occurring on the north shore of lake Huron which were designated Huronian by Sir William Logan. As represented in Timiskaming region the Huronian consists, as far as known, of a single group of conformable clastic sediments, the Cobalt series.

COBALT SERIES.

Distribution.

The geological investigations of the Geological Survey, the Bureau of Mines of Ontario, and the Department of Mines for Quebec, in recent years, have shown that the Cobalt series probably extended originally all the way from the north shore of lake Huron to lake Chibougamau in Quebec, a distance of nearly 500 miles, and covered an area of at least 40,000 square miles. Throughout the larger part of this territory, however, the series has been eroded away from the surface of the basal complex so that it now remains, for the most part, merely as remnantal hills and ridges or small isolated exposures. In the Timiskaming region, outcrops of the series are known to occur as far north as lake Abitibi and as far south as the southern extremity of lake Timagami. The most easterly exposure observed by the writer occurs in Destor township, Quebec, approximately 25 miles east of the interprovincial boundary between Ontario and Quebec. On the west, the series extends across the whole of the Timiskaming basin and beyond to the Sudbury district and the north shore of lake Huron.

Lithological Character.

General. The Cobalt series in the Timiskaming region includes all the common varieties of clastic sediments and more especially the poorly sorted types, viz., conglomerate, greywacke, and arkose. In those localities in the district where the most complete sections of the series are present, it is generally composed of the following lithological divisions, from the base upward: (1) coarse basal conglomerate, (2) greywacke and argillite, (3) arkose and quartzite, (4) coarse conglomerate similar to (1).

This classification holds only in a general way, however, for each of these subdivisions contains local beds similar to the other members of the series and the contacts between the different members are generally gradational. Nevertheless, except when the upper members have been removed by denudation, two thick beds of massive coarse conglomerate separated by fine-grained stratified sediments are generally present.

A compilation of the published observations of the succession and thickness of the various members of the Cobalt series in different parts of the Timiskaming region is included in the following table. It is evident that many of these sections are only partial, including in some cases the upper and in others the lower members of the series, yet in a general way, the succession is remarkably uniform.

Section of the Cobalt Series in Timiskaming Region, Ontario and Quebec.

Rock.	Thickness feet.	Locality.	Reference.
Quartzite, etc. Argillite and greywacke Conglomerate *Unconformity* Basal complex.	1,100 100 600	General maximum section, Timiskaming region.	Barlow, A. E. Geol. Surv., Can., Ann. Rept., vol. X, 1897, p. 104.
Quartzite Argillite Conglomerate *Unconformity.* Basal complex.	? ? ?	Between Rabbit and Timagami lakes.	Young, G. A., Geol. Surv., Can., Sum. Rept., 1904, p. 198.
Quartzite passing into conglomerate at top Argillite Greywacke Chocolate-coloured argillite ? *Contact not exposed* Basal complex	90 26 10 54 ?	Windigo lake.	Parks, W. A., Geol. Surv., Can., Sum. Rept., 1904, p. 215.

Rock.	Thickness feet.	Locality.	Reference.
Conglomerate............. Quartzite................. Greywacke................ Conglomerate............. *Unconformity* Basal complex	? ? ? ?	Larder lake.	Brock, R. W., Rept. Ont. Bureau of Mines, 1907, p. 211.
Arkose................... Argillite.................. Conglomerate............. *Unconformity* Basal complex.	? ? ?	Trout lake, South Lorrain tp., Ont.	Burrows, A. G., Rept. Ont. Bureau of Mines, pt. II, 1908, p. 25.
Argillite.................. Quartzite................. Conglomerate............. *Unconformity* Basal complex.	? ? ?	Everett lake, Gowganda district.	Burrows, A. G., Rept. Ont. Bureau of Mines, pt. II, 1908, p. 1.
Arkose and quartzite....... Conglomerate, etc......... Conglomerate............. *Unconformity* Basal complex.	? ? 200	Gowganda district.	Collins, W. H., "Prel. Rept. on Gowganda dist.," Geol. Surv., Can., 1909, pp. 26–27.
Conglomerate, greywacke, slate, and quartzite Conglomerate } ?.............. *Contact not exposed* Basal complex	300 ?	Mount Sinclair	McMillan, J. G., Rept. on Geol. along T. and N.O. Railway trail Gowganda to Porcupine, 1912.
Conglomerate............. Quartzite................. Greywacke with beds of argillite and quartzite...... ?.............. *Contact not exposed* Basal complex	30 to 40 15 20 ?	Little Silver Cliff mine, Cobalt, Ont.	Miller, W. G., Rept. Ont. Bureau of Mines, vol. XIX, pt. II, 4th edit., 1913, p. 78.
Arkose and quartzite....... ?................. *Contact not exposed* Basal complex.	900 ?	Maple mountain, Ont.	Miller, W. G., Rept. Ont. Bureau of Mines, vol. XIX, pt. II, 4th edit., 1913, p. 78.
Conglomerate............. Arkose................... Greywacke and argillite..... ?................. *Contact not exposed* Basal complex.	90 150 250 250+	Mount Shiminis.	Wilson, M. E., Geol. Surv., Can., Mem. 39, 1913.

Basal Conglomerate. The basal conglomerate is an exceedingly variable rock consisting largely of coarse rock fragments in some places, and in other places consisting almost entirely of matrix. The included fragments may be angular, subangular, or round in shape and are commonly 2, 3, or even 5 feet in diameter. They include every variety of rock represented in the basal complex, a large number occurring even in a single outcrop. The matrix varies from a coarse arkose to a fine-grained slate-like rock, the latter being the type described by Logan as chlorite slate conglomerate. As a rule, the basal conglomerate is without stratification, but in places a partial alignment of pebbles can be seen. The thickness of this conglomerate member, like that of all the other formations of the Cobalt series, is so variable that it is difficult to determine its original average thickness.

Greywacke and Argillite. The second formation, the Cobalt series, consists of finely cemented ferromagnesian sediments which range in texture from a sand to a fine-grained mud. The coarse-grained phase of these deposits constitutes what has been generally described as greywacke; the fine-grained mud phase has been generally called slate or less frequently shale. The rock to which the latter names have been applied is neither a slate nor a shale as these rocks are usually defined, however, for it does not possess the slaty cleavage of slate and, on the other hand, is much too finely cemented for a shale. Since rocks of this class are very common in the slightly disturbed late Pre-Cambrian sedimentary series of the Canadian shield, the writer has proposed that it be called argillite. Argillite,[1] according to this definition, would then occupy approximately the same position in the shale-slate series of sediments that quartzite occupies in the sand-sandstone group. In places, the greywacke and argillite are unstratified, but, as a rule, they are uniformly bedded, the beds ranging from an eighth of an inch to half an inch in thickness. Like the other members of the Cobalt series, the thickness of the greywacke and argillite is exceedingly variable ranging from 0 to a maximum of 300 feet.

Arkose and Quartzite. The greywacke and argillite gradates upward into beds of quartzite and arkose. The rocks are always stratified, although in places the stratification is not strikingly apparent. The maximum thickness recorded for this member of the Cobalt series is 250 feet.

Upper Conglomerate. The upper conglomerate which overlies the arkose resembles the basal conglomerate in every respect and cannot be distinguished from it except where the stratigraphical succession is known. The maximum thickness observed in the region examined by the writer was 90 feet.

Pebbly Quartzite. On the east and west shores of lake Timiskaming near its north end, a peculiar sericitic green quartzite containing small

[1] Geol. Surv., Can., Mem. 39, 1913, p. 83.

well-rounded pebbles of quartz and jasper in lenticular aggregates, is exposed. Wherever the relationships of this quartzite were observed it either rested directly on granite or passed imperceptibly downward into greywacke; and thus apparently occupied a stratigraphical position similar to the arkose-quartzite member of the Cobalt series occurring in the adjacent districts. Lithologically, this pebbly quartzite differs from the typical arkose and quartzite, however, in its more highly sorted character, in the roundness of its grains, and in the pebbles of quartz and jasper which it contains. Moreover, in the region west of the Timiskaming district, a rock, lithologically similar to this quartzite, is reported to occupy a much higher position in the Cobalt series occurring above the upper conglomerate member. In view of these complications[1] the pebbly quartzite has been described as a possible fifth member of the Cobalt series. The various possible relationships of the rock are discussed in greater detail, however, in Chapters V and VI.

Structure and Origin.

Owing to the absence of continuous and uniform stratification in the conglomerate members of the Cobalt series, it is difficult to determine the attitude of these rocks in many localities; but wherever stratification is present the dips are everywhere small, usually not exceeding 20 degrees, and indicate that the series has been folded into gently pitching anticlines and synclines.

The modes of origin of the various rocks composing the Cobalt series are discussed at length in Chapter VI of this report and merely a summary of the conclusions reached in that discussion need be included in this section of the report. From a consideration of the lithological character and structure of the Cobalt series and the physiographic and climatic conditions of the region at the time the series was laid down, it is concluded in Chapter VI that, on the whole, the evidence preponderates greatly in favour of the hypothesis that both the lower and upper conglomerate members of the series are till sheets deposited from a continental glacier and that the stratified greywacke, arkose, and quartzite which intervene between the upper and lower conglomerate members are interglacial deposits. This conclusion is supported, not only by the fact that the series is strikingly similar both stratigraphically and lithologically to the Pleistocene Glacial and post-Glacial deposits of the same region, but also by the fact that there is no other known process at work on the earth's surface to-day by which such sediments could originate under similar physiographic conditions.

[1] According to W. H. Collins, Geol. Surv., Can., Mus. Bull. No. 8, 1914.

Post-Cobalt Series Intrusives (Keweenawan).

GENERAL.

Wherever detailed geological work has been carried on in the Pre-Cambrian portions of the Ottawa basin, intrusions of diabase and related rocks have been generally found to be present, occurring as dykes in the basal complex and as dykes and sills where the basal complex is overlain by Huronian sediments. It is believed that these rocks were derived from the same magma as the Keweenawan intrusives and extrusives and are of Keweenawan age, for the following reasons: (1) they are lithologically similar to the Keweenawan rocks; (2) they occur throughout the whole region extending from lake Superior to the Ottawa basin and hence are geographically continuous with the Keweenawan intrusions; and (3) they were intruded in late Pre-Cambrian or early Palæozoic time and, therefore, at about the same time as the Keweenawan volcanism occurred.

LITHOLOGICAL CHARACTER.

Throughout the Ottawa basin and westward to lake Superior, the Keweenawan intrusives are represented by a considerable variety of rocks including diabase, olivine diabase, norite,[1] micropegmatite, diabase-aplite, syenite porphyry,[2] and camptonite.[3] Many of these, however, are merely local phases of larger masses formed by differentiation within the magma after their intrusion. In the Timiskaming region the diabase and olivine diabase are the only Keweenawan rocks of common occurrence and of these the diabase is the most common, composing all the sills of the district. The olivine free diabase consists essentially of augite and ophitic labradorite with usually some quartz micrographically intergrown with feldspar. The olivine diabase, on the other hand, contains round grains of olivine in addition to augite and ophitic labradorite, but no quartz. In some localities the olivine diabase has been observed to intrude the olivine free variety, indicating that the latter is the older of the two rocks. This general relationship would seem to indicate that a regional differentiation had occurred in the Keweenawan magma at depths with the result that the more basic rocks were intruded last.

PALÆOZOIC SEDIMENTS.

The third great group of rocks occurring in the Ottawa basin, the Palæozoic sediments, are bedded limestones, shales, and sandstones

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[1] In the Subdury region.
[2] Geol. Surv., Can., Mem. 39, p. 100.
[3] Geol. Surv., Can., Mem. 17, 1912, p. 48.

laid down during two successive early Palæozoic marine invasions over the Pre-Cambrian old land. How far the sea extended during these invasions or whether it covered the whole Laurentian plateau cannot now be positively determined; but a large part of the Ottawa basin was evidently submerged on both occasions, for remnants of both Ordovician and Silurian sediments are found in the limestone outliers at the north end of lake Timiskaming.

To the south of Ottawa river in the lower part of its basin, Palæozoic sediments ranging from the Potsdam to the Queenston in age, extend almost continuously from the outlet of the Ottawa at Montreal to Quyon, a point 25 miles west of Ottawa. Beyond Quyon, numerous outliers continue as far west as Allumette island, a distance of 50 miles. In these remnants, however, an overlap seems to have occurred, for the Potsdam sandstone is absent and the Beekmantown or higher formation rest directly on the surface of the Pre-Cambrian complex.

In the upper part of the Ottawa basin, a few small outliers of sandstone and limestone containing fossils which have been identified as belonging to the Black River and Trenton formations occur in the bed of the river,[1] a few miles east of Mattawa, Ontario. At the north end of lake Timiskaming there are a number of Palæozoic outliers, some of which are several square miles in extent and several hundred feet in thickness. It was formerly supposed that these occurrences contained only Silurian fossils (Clinton and Niagara)[2], but recently it has been discovered that some of these outliers contain fossils characteristic of the Ordovician.[3]

PLEISTOCENE.

The Pleistocene deposits occurring in the Ottawa basin are of two classes: unsorted glacial till, and stratified clay and sand. The latter occurs in two localities: along the lower Ottawa (Champlain), and north of lake Timiskaming (lakes Barlow and Ojibway).

Glacial.

The Pre-Cambrian and later rocks previously described in this chapter, are now largely covered by boulders, gravel, sand, and boulder clay. This unconsolidated material is believed to have been laid down from a huge continental glacier which covered the eastern part of Canada and the adjacent parts of United States during a considerable portion of the

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[1] Geol. Surv., Can., Rept. of Prog., 1845, pp. 64-66.
Geol. Surv., Can., Ann. Rept., vol. X, pt. I, 1897, p. 120.
[2] Geol. Surv., Can., Rept. of Prog., 1845, pp. 69-70.
Geology of Canada, p. 334.
Geol. Surv., Can., Ann. Rept., vol. X, pt. I, 1897, pp. 121-127.
[3] Williams, M. Y., Geol. Surv., Can., Mus. Bull. No. 17, 1915.

Pleistocene epoch. Up to the present time evidence of the presence of only one of these continental glaciers has been found within the Ottawa basin proper; but in the southern part of the territory covered by the Labradorean glacier and along Mattagami river, to the south of James bay in Ontario, glacial till sheets separated by interglacial deposits have been found, indicating that there were in reality several continental ice-sheets. The thickness of the glacial deposits is generally not very great, the average for the whole region being certainly less than 50 feet. They occur in all the common forms assumed by such glacial debris, kames and outwash plains being especially common in the northern part of the region. The direction of movement of the ice-sheet throughout the Ottawa basin indicated by the glacial striæ was generally from north to south.

Post-Glacial.

CHAMPLAIN CLAY AND SAND.

Throughout the lower part of the Ottawa basin and along the lower St. Lawrence, the glacial and older formations are hidden beneath a thick mantle of stratified clay and sand containing marine shells. While these deposits vary somewhat in different localities, on the whole the clay is the dominant member, the sand occurring only in local areas and generally as the topmost beds. In those portions of the region where river dissection has not removed the Champlain clay and sand, the elevation of their surface is generally between 300 and 400 feet above sea-level, but local flats occur above this level up to 700 feet.

LACUSTRINE CLAY AND SAND.

Deposits of this class are found in the Ottawa basin along the inter-provincial boundary north of lake Timiskaming, and northeastward from this point through the province of Quebec to the St. Lawrence-Hudson Bay divide, where it joins a still more extensive area of similar deposits occurring in the James Bay basin to the north of the divide. The larger part of these deposits consists of stratified clay constituting what is generally called the clay belt of northern Ontario and Quebec. They are believed to have been laid down in huge post-glacial lakes which covered this territory following the retreat of the last Labradorean ice-sheet.

CHAPTER IV.

NOMENCLATURE AND CORRELATION.

GENERAL STATEMENT.

The detailed geological work carried on in recent years throughout the southern part of the Canadian Pre-Cambrian shield has shown that the geological succession in the ancient terranes of this territory is regionally less uniform and includes a greater number of rock series than was formerly supposed. Moreover, it has become evident that the widespread correlations implied by the use of the same nomenclature, nearly everywhere throughout this great Pre-Cambrian province, assumes much more with regard to the regional succession in these ancient rocks than is actually known.

Although it is not possible generally to demonstrate with mathematical conclusiveness that geological formations occurring in different localities are equivalent, nevertheless the premature use of the same name for formations, the correlation of which is open to question, or the continued use of the same name for the formations after it has become evident that their correlation is in doubt, is misleading, and an obstacle rather than an aid in geological investigation. Hypothetical correlations of groups of rocks occurring in widely separated districts may serve for comparison or as a stimulus to investigation,[1] but all the advantages of such tentative correlations may be attained by using a general terminology (Proterozoic, Archæozoic, etc.) and thereby avoiding the definite correlations implied in the use of names of local origin.

In the Pre-Cambrian province which occupies the northern part of St. Lawrence River basin, there are four geographically and geologically separate sub-provinces: (1) the region northwest of lake Superior, (2) the region south of lake Superior, (3) the region extending northeastward from lake Superior and lake Huron to lake Timiskaming and lake Mistassini, and (4) eastern Ontario and the lower St. Lawrence, with which might be included the Adirondack region. With the possible exception of the south shore of lake Superior and the lake Huron-lake Timiskaming sub-provinces, the available data upon which the rocks of these separate regions can be correlated, are exceedingly meagre; and, for the present, at least, the only logical course would seem to be to build up a separate nomenclature for each sub-province by using the names originally defined in each sub-province supplemented by such new local names as geological investigation requires.

[1] Lawson, A. C., Univ. of California, Dept. of Geol. Bull., vol. 10, 1916, p. 3.

In the present report and in several previous publications in which the geology of districts occurring in the Timiskaming region is described, a local nomenclature, in accordance with the principle stated in the previous paragraph, has been adopted by the writer, and the following discussion is mainly a re-statement of the reasons why this terminology was found necessary.

OBJECTIONS TO AN INTER-SUB-PROVINCIAL NOMENCLATURE.

The widespread correlations implied in the use of a common nomenclature throughout all the Pre-Cambrian sub-province of the St. Lawrence basin has been based on the assumption that the succession of formations within the various sub-provinces has been worked out to a practical completeness and, on the application of certain principles by which the correlation of the various formations in these widely separated areas are presumed to be established. The purpose of the following discussion is to point out that the assumption that our knowledge of the succession of formations in any of the sub-provinces is complete is open to question, and that the principles by which Pre-Cambrian rocks are generally correlated are in part inapplicable and as a whole quite inadequate for the establishment of a Pre-Cambrian nomenclature embracing all the territory in the St. Lawrence basin in which Pre-Cambrian rocks occur.

Our Knowledge of the Succession of Formations in the Sub-provinces Incomplete.

The numerous regional classifications of the Pre-Cambrian rocks of the St. Lawrence basin, which have appeared from time to time in recent years, and the use of such terms as Keewatin, Laurentian, and Huronian nearly everywhere throughout this great Pre-Cambrian province and at points hundreds of miles from those in which these names were originally defined, would seem to imply that our knowledge of the succession of formations within this vast territory was much more complete than is actually the case. Only a very small part of the territory, in the St. Lawrence basin in which Pre-Cambrian rocks occur, has been actually mapped in detail, and even in those localities which have been mapped in considerable detail and which have been regarded in the past as type areas, the succession of formations formerly supposed to be present has in many cases been considerably modified by more recent investigation.[1]

[1] Lawson, A. C., Geol. Surv., Can., Mem. 28, 1912, and Mem. 40, 1913, p. 4.
Miller, W. G. and Knight, C. W., Ann. Rept. Ont. Bureau of Mines, vol. XXII, pt. 2, 1914.
Allen, R. C., and Barrett, L. P., Jour. Geol., vol. 23, 1915.
Collins, W. H., Geol. Surv., Can., Sum. Rept., 1916, p. 183.

The Principles of Pre-Cambrian Correlation Inapplicable or Inadequate.

Continuity or Approximate Continuity of Outcrop. The principle of continuity or approximate continuity of outcrop is the most conclusive of all the means by which the relationship of rocks can be determined; but it is inapplicable to the correlation of the various rock series occurring in the different Pre-Cambrian sub-provinces for the reason that these are geographically and in part geologically separate from one another. Between the Timiskaming and the Grenville sub-provinces, there intervenes an extended belt of banded gneisses; between the Timiskaming and the western sub-provinces there is the little known wooded Pre-Cambrian highlands on the north and overlapping Palæozoic sediments on the south; and between the northwestern and the southwestern sub-provinces lie the waters of lake Superior. If, therefore, a common nomenclature be employed for all the Pre-Cambrian sub-provinces of the St. Lawrence basin, this nomenclature must be based on other less conclusive principles of correlation.

Lithological Similarity. This criterion has been widely applied in the correlation of Pre-Cambrian formations although it is in reality of very limited application; for the Pre-Cambrian rocks of the Canadian shield, both sedimentary and igneous, are for the most part common types which might be deposited or intruded in any epoch of earth history. It has been largely on the basis of this principle, that the name Keewatin, first applied by Lawson to the metamorphosed basal volcanic complex occurring in the region northwest of lake Superior, was extended, first to the Timiskaming region and later to eastern Ontario, a district nearly 1,000 miles distant from the locality in which the term was originally defined; yet volcanic rocks of this character are among the most common in the earth's crust. They are represented at some point in nearly all the Pre-Cambrian series of the St. Lawrence basin; are, likewise, abundant in later formations throughout the world, as in Great Britain where they occur at numerous horizons ranging in age from the early Palæozoic to the Tertiary; and are in process of formation at one or more points on the earth's surface to-day. As a consequence of this unscientific method of correlation, the name Keewatin while presumed to represent a definite formation, in reality is now applied in the Canadian Pre-Cambrian sub-provinces to any metamorphosed volcanic rock without regard to age.

Similar Stratigraphical Succession of Beds. The larger part of the Pre-Cambrian surface rocks of the region under consideration are volcanic flows or clastic sediments, in which a regular sequence of strata is uncommon, and this criterion is, therefore, inapplicable except to the late Pre-Cambrian rocks. It has been especially useful in the mapping of the Huronian series in Timiskaming sub-province, the Lower Marquette in the region south of lake Superior, and the Animikie sediments in the region northwest of lake Superior.

Similar Serial Succession. The widespread correlations implied in the nomenclature applied to the Pre-Cambrian rocks of the St. Lawrence basin has been based to a considerable extent on this principle, although the apparent similarity in the serial succession may very frequently be explained in other ways. The principal objection to the use of this criterion is that it neglects to consider the possibility of overlap. Sedimentary rock series are not generally deposited continuously or uniformly over wide areas and where they have been deposited they are very commonly swept away in part by later erosion, before succeeding series are laid down. Moreover, the Pre-Cambrian surface rocks are to a large extent volcanic flows or land sediments and on this account are much more discontinuous than sediments of marine origin.

Mode of Origin of Formations. This criterion is of limited application; for, sediments originating in the same way may be deposited during different geological epochs and likewise sediments originating in different ways may be deposited contemporaneously in adjoining localities. It might be of value in the correlation of certain uncommon types as glacial deposits which generally occur only at long intervals in geological time.

Relationship to Batholithic Intrusions. The relationship of the Pre-Cambrian surface rocks to the great epochs of batholithic invasion is of great assistance in correlation and may possibly eventually prove to be the most important of all the criteria used in the classification of the Pre-Cambrian rock series into major groups; for geological investigation throughout the world has shown that batholithic intrusions are an accompaniment of mountain building movements in the earth's crust and are thus directly related to the great regional changes in rock structure, to regional metamorphism, and to the uplifts which give rise to the great erosion intervals which form the dividing lines between the great Pre-Cambrian terranes. Some of the applications and limitations of batholithic invasion in rock correlation are included in the following:

Batholithic massifs are coextensive with the mountains they underlie and since mountains are generally extensive and linear, the massif should also be extensive and linear. The extent of the outcrop of the massif will depend, of course, on the extent to which unroofing has been carried. In the Rocky mountains, for example, unroofing has apparently only begun; in the Coast Range batholith of the Pacific coast, on the other hand, unroofing is almost complete; and in some of the Pre-Cambrian batholiths of the Canadian shield, the unroofing is not only largely completed but the batholith has also been reduced to base level.

If two batholithic massifs have been intruded in a given region, the younger may displace the first. Hence the conspicuous structural features of the region would be those of the younger massif and all evidence of the former presence of the older batholith might be destroyed except for such remnants as happened to remain in association with the roof rocks in the geosynclinal belts.

Mountain building periods and hence also periods of batholithic intrusion occur at long intervals separated by erosion periods and the development of peneplains.

The rocks in the vicinity of an intrusive batholithic mass are generally highly folded and metamorphosed; hence if in a given area in the vicinity of a batholith, flat-lying rocks occur which have not been greatly metamorphosed, it may be inferred that they have not been intruded by the batholith.

Batholiths are composite and their intrusions continue during long intervals of time so that their various parts are only approximately of the same age.

Batholithic rocks are lithologically so similar that it is generally impossible to distinguish between batholiths of different ages except by means of their relationships to other rocks of which the age is known.

Recently A. C. Lawson has contributed an interesting paper to the discussion on the "Correlation of the Pre-Cambrian rocks of the region of the Great Lakes," in which he formulates the hypothesis that throughout the region extending from the Adirondacks to northwestern Ontario there were in Pre-Cambrian time, "two and only two periods in which great granitic batholiths were developed in the earth's crust." On the basis of this hypothesis he correlates all the Pre-Cambrian rocks occurring in the territory to which his hypothesis is applied.[1] This hypothesis, if true, would undoubtedly greatly simplify the problems of Pre-Cambrian nomenclature and correlation in the region under discussion; but, an examination of the hypothesis from either a deductive or inductive standpoint seems to indicate that it is an unwarranted assumption.

The principal fact on which Lawson's hypothesis of two and only two periods of granitic batholithic intrusion was based, was that, at the time the hypothesis was formulated, only two periods of batholithic intrusion had been recognized in most of the Pre-Cambrian sub-provinces of the St. Lawrence basin. There is a very apparent reason, however, why two and only two batholithic intrusions can be recognized in a single locality, namely, that if a third batholith were intruded in a district where two batholiths were already present, the evidence of the former presence of one or other of the older batholiths would probably disappear.[2]

If it be assumed that batholithic intrusions represent the interior portions of mountain chains, it is obvious that the prolonged erosion, which generally follows an orogenic uplift, must inevitably result in the stripping off of the roof rocks from the underlying massif and the replacement of surface rocks by plutonic types in the district where the uplift has occurred; also that successive crustal movements of the orogenic type in the same or adjoining localities must eventually bring about the disappearance of all trace of rocks originally present in such zones of disturbance. It is probable that within the base-levelled Pre-Cambrian complex which underlies the larger part of the Canadian shield evidence of the presence of more than two separate periods of batholithic intrusion would not generally survive in a single locality. If, however, the succession of formations can be determined over an extended area, as where

[1] University of California Publications, vol. 10, 1916, pp. 1-19.

[2] Lane, A. C., Am. Jour. Sc., vol. 43, 1917, p. 43.

less metamorphosed late Pre-Cambrian sediments occur, the number of batholithic intrusions which can be recognized might be increased. Thus, as a result of the more extended areal geological studies of recent years, evidence is accumulating that at least three definite periods of batholithic invasion are represented in several of the Pre-Cambrian sub-provinces of the St. Lawrence basin.

The folded and metamorphosed Pre-Cambrian rocks occurring along the southern margin of the Canadian shield have in the main a north-easterly structural trend; likewise the granitic batholiths, in so far as their areal distribution has been determined, are distributed in north-easterly trending zones; thus the region (approximately 1,000 miles in length) extending from the Adirondacks to lake of the Woods, to which Lawson's hypothesis has been applied, lies almost transverse to the regional trend of Pre-Cambrian folding, mountain building, and batholithic invasion. Moreover, mountain systems throughout the world are generally narrow and linear and where zones of crustal disturbance composed of several mountain systems, such as the cordillera of North America, occur, the systems composing the zone are generally of varying age. Hence, if granitic massifs represent the interior of mountain systems exposed by denudation, it is more probable that the southwesterly trending Pre-Cambrian batholithic zones of the St. Lawrence basin instead of belonging to two and only two periods of batholithic intrusion in reality represent several periods of batholithic development.

Relationship to Igneous Intrusions other than Batholiths. Igneous intrusions other than batholiths, especially if they are composed of unique rock types, can likewise be employed for purposes of correlation, but generally only within a single sub-province. The principle has been used for inter-sub-provincial correlation in the case of the late Pre-Cambrian diabase intrusions, however, all of which have been generally regarded as Keweenawan in age.

Folding and Metamorphism. Since folding and metamorphism are accompaniments of mountain building and batholithic invasion, these criteria are in reality included under the head, "Relationship to Batholithic Intrusions." It can be generally inferred that in the same district those rocks which are most highly folded and metamorphosed are the oldest in age. This does not follow in the case of widely separated regions, however; for it has been found that rocks which are flat-lying and slightly metamorphosed in one district may be highly folded, metamorphosed, and intruded by granite batholiths in another locality.

TIMISKAMING REGION.

The investigations of the Ontario Bureau of Mines and the Geological Survey in recent years throughout the territory extending from the Timiskaming region to the north shore of lake Huron have shown that the rocks known in the Timiskaming region as the Cobalt series are approximately continuous from lake Timiskaming to the north shore of lake Huron, and that this series corresponds to the upper portion of the original Huronian; the lower of the two series present in the original Huronian area apparently disappears when traced northeastward towards Timiskaming region, that is the time during which the lower of the original Huronian series was deposited is represented in the Timiskaming region by an erosion interval.[1] Furthermore, in the vicinity of lake Chibougamau near lake Mistassini, a basal complex similar to that occurring in the Timiskaming region is overlain by a series of flat lying sediments which structurally, lithologically, and in the sequence of its members corresponds in every respect to the Cobalt series, so that it seems evident that the Huronian is represented in the Lake Chibougamau district also. The extent and stratigraphical relationships of the Huronian, as originally defined, has, therefore, been approximately determined throughout the whole of the great Timiskaming belt, more than 40,000 square miles in area, and it is now known that with a few isolated exceptions, all the late Pre-Cambrian (for the most part undisturbed) sediments in this wide territory belong to the Huronian system.

As regards the basal complex which underlies the Huronian, the regional succession of formations has not been fully determined. The succession of formations assumed to be present by the geologists of the Ontario Bureau of Mines is that included in column I of the following table; the classification used by the writer is indicated in column II.

I.	II.
Lorrain granite	Pre-Cobalt series granites and gneisses
Igneous contact	*Igneous contact*
Timiskaming series	Timiskaming group
Unconformity	*Unconformity in part*
Banded gneisses (Laurentian)	
Keewatin	Abitibi group

In the classification outlined in column I, it is assumed that the surface rocks (volcanic flows and sediments) of the Timiskaming region are everywhere divisible stratigraphically into two separate groups of rocks, the Timiskaming series, to which nearly all the sedimentary rocks

[1] Miller, W. G., and Knight, C. W., Ann. Rept., Ont. Bureau of Mines, vol. XXIII, pt. 1, 1914. Collins, W. H., Geol. Surv., Can., Mus. Bull. No. 8, 1914.

belong and the Keewatin series which includes all the volcanics; that the Pre-Huronian batholithic rocks are of two ages, the belt of banded gneisses representing the older of these batholithic intrusives (Laurentian); and that the volcanic rocks of the basal complex in the Timiskaming region are equivalent in age to the rocks classed as Keewatin in the region northwest of lake Superior.

The objection to all these assumptions is that they are hypotheses not yet established by detailed investigation in the field. While the presence of unconformable contacts here and there within the basal complex indicates that at least two series of rocks are probably represented, the actual succession of formations present has nowhere been worked out to sufficient completeness to determine that two and only two series of rocks are present or that all the volcanics are older than the sediments. From an examination of the regional map which accompanies this report it may be observed that the Pontiac series, which has been placed provisionally in the Abitibi group, intervenes between the banded gneisses and the volcanics of the Pre-Huronian complex in a narrow belt almost continuously from the Ontario boundary to lake Matchimanito, a distance of 110 miles. The position of the Pontiac series in this position as a narrow belt extending along the margin of an intrusive massif, suggests that, just as in the case of an intrusive laccolith the older formations adjoin the intrusive, so in this case the Pontiac series is older than the volcanics which adjoin it on the north. On the other hand, if the Pontiac series belongs to the younger group of sediments classed as Timiskaming, the belt of banded gneisses which intrude the Pontiac series must be post-Timiskaming and not pre-Timiskaming in age; so that either the first or second of the assumptions cited is false. Furthermore, in those portions of Timiskaming county studied by the writer it was found that owing to the absence of well-defined beds in the basal complex which could serve as definite horizons in working out the geological structure; to the predominance of volcanic rocks which generally do not occur in such uniform beds as sedimentary rocks; to the highly metamorphosed and deformed condition of the rocks of the complex; and to the paucity of exposures, a large part of the basal complex being hidden from view beneath the overlapping Huronian formation and post-Glacial lacustrine clays; it was not possible to work out the regional, structural, and stratigraphical relationships of the various formations composing the pre-Huronian complex. For these reasons it was deemed advisable to adopt a classification for the rocks of the basal complex which would be, as far as possible, a statement of what was actually known, and the pre-Huronian has accordingly been divided into three divisions: the Abitibi group, the Timiskaming group, and the pre-Huronian batholithic intrusives.

The term Abitibi group includes the same rock formations as are usually called Keewatin in the Timiskaming region. It has been substituted for Keewatin because, as is pointed out in the preceding section of this chapter, the use of the term Keewatin in the Timiskaming region, several hundred miles distant from the locality in which this term was originally defined, is a hypothetical assumption. Theoretically there is a basal Abitibi series represented in the pre-Huronian complex of the Timiskaming region, but, in most localities it is not possible to positively differentiate this series in the field and for this reason the name Abitibi group has been used instead of Abitibi series.

The Timiskaming group includes all those surface rocks included in the pre-Huronian which are known to be younger than other portions of the complex with which they are associated. It has not been established however, that all these rocks are part of a single series and, on that account, the term group has been substituted for series.

Although the presence of pebbles of granite in the conglomerate members of the Timiskaming group and the Pontiac series indicates that there was a granite older than the sediments at one time, if not at present, in the region, the surface rocks of the complex are intruded by the batholithic masses wherever they have been observed in contact with the latter. There is no positive evidence, therefore, that the batholithic rocks of the basal complex found in the Timiskaming region are of different ages and they have accordingly been grouped together in a single group as Pre-Huronian batholithic intrusives.

CORRELATION OF THE GRENVILLE AND TIMISKAMING BELTS.

It has been pointed out in previous sections of this report that the basal complex in the region under description forms parts of three great northeasterly trending belts; the Grenville belt which corresponds to the Grenville Pre-Cambrian sub-province; the Timiskaming belt which corresponds to the Timiskaming sub-province, and the intervening belt of banded gneisses which are mainly igneous in origin forming part of a huge batholithic massif intrusive in the rocks of the other belts.

Since the surface rocks of Grenville and Timiskaming belts are geographically separate from one another and are lithologically unlike, it is obvious that the basis upon which the rocks composing the basal complex in these two sub-provinces can be correlated is necessarily hypothetical. The correlation can, therefore, be best discussed by considering the various possible relationships which might exist between the Grenville series on the one hand and the complex of the Timiskaming region on the other. These possibilities are: that the Grenville series is present in the Timiskaming region, but is older in age than and underlies the rocks exposed at the surface; that rocks equivalent in age to the

Grenville series are not present in the Timiskaming region; and that the Grenville series is equivalent in age to the Abitibi or Timiskaming groups.

Evidence that might be cited in favour of the first of these possibilities is: that the Grenville series is much more highly metamorphosed than any of the rocks of the Timiskaming belt; that the Grenville series is intruded almost everywhere by rocks of intermediate composition which might be equivalent in age to part or all of the volcanics of the northern complex; and that the central massif of banded gneisses, almost to its northern margin, contains bands of garnet gneisses and amphibolite which might represent recrystallized inclusions of Grenville series.

The second possibility, that rocks equivalent in age to the Grenville series are not represented in the Timiskaming region, implies that the Grenville series was never deposited in the Timiskaming region or after its deposition was removed by erosion. This hypothesis is supported by the following observations: the rocks composing the Grenville series originally consisted of interstratified beds of shale, sandstone, and limestone, a typically marine succession of sediments, whereas the rocks of the Abitibi and Timiskaming groups consist mainly of volcanic flows and poorly sorted clastic sediments; since Pre-Cambrian time, the Laurentian plateau has been almost continuously a land area and it is probable that this positive tendency was characteristic of the plateau even in Pre-Cambrian time, and that just as in the Palæozoic so in the Grenville era marine sediments were mainly deposited on the margin of the plateau.

The third possibility, that the Grenville series is equivalent in age to part or all of the Abitibi group or the Timiskaming group, implies that the conditions of deposition in these two sub-provinces were different in the Grenville era; for the abundance of unassorted sediments in the Abitibi and Timiskaming groups indicates that terrestrial conditions probably prevailed in the Timiskaming belt at the time these rock groups were laid down. It may be possible, therefore, that either the Abitibi or the Timiskaming group represents land deposits laid down contemporaneously with marine sediments in the Grenville region.

In recent inter-sub-provincial classifications it has been assumed that the Grenville series was approximately equivalent in age to the Abitibi group (Keewatin). The principal evidence upon which this assumption is based is the apparent presence of two separate series of rocks in the basal complexes of both sub-provinces and the presence of areas of ellipsoidal greenstones in the Madoc district of eastern Ontario which are said to underlie the Grenville series without evidence of unconformity. It is assumed that the greenstones of the Madoc district are of the same age as the Keewatin volcanics of the Timiskaming sub-province and thus it is inferred that the Keewatin (Abitibi group) of the Timiskaming sub-province is older, but directly underlies the Grenville series. The objections that might be raised to this conclusion are: that it has not yet been established that there are two and only two series of rocks present in the basal complex of the Grenville and Timiskaming sub-provinces; that even if there are only two series in each sub-province, these are not necessarily equivalent in age; and that the presence of lava flows in conformable contact with the Grenville sediments has little of age significance since volcanic extravasations are common phenomena in earth history.

It is concluded, therefore, with regard to the relationships of the Grenville series to the surface rocks of the Timiskaming belt, that there are several possible relationships between the rocks represented in these two great sub-provinces. Conclusive evidence in support of any of these possibilities is wanting. All that can be positively stated is that the rocks in both belts are apparently older than the belt of banded gneisses and that typical marine sediments such as characterize the Grenville series are either not represented in the Timiskaming belt or are buried beneath the accumulations of lava which occur so extensively in the northern terrain.

CHAPTER V.

GENERAL GEOLOGY.

GENERAL STATEMENT.

The rocks occurring in Timiskaming county, like those of the Timiskaming region generally, fall into four great divisions: the basal complex, the Cobalt series and associated Keweenawan ? intrusives, the Palæozoic sediments, and the Quaternary Glacial and post-Glacial gravels, sands, and clays. Of the first three groups, the basal complex is geographically by far the most extensive.

TABLE OF FORMATIONS.

The succession of formations arranged with respect to age in descending order, is as follows:

Quaternary	
Post-Glacial	Stratified lacustrine clay and sand.
Glacial	Gravel, sand, boulders, boulder clay.
	Unconformity
Palæozoic	
Silurian	
Niagara	Calcareous sandstone and limestone.
	Unconformity ?
Ordovician	
Black River	Limestone.
	Unconformity
Pre-Cambrian ?	
Keweenawan	Diabase, olivine diabase, olivine gabbro, syenite porphyry.
	Igneous contact
Pre-Cambrian	
Huronian	Cobalt series. Conglomerate. Arkose. Greywacke and argillite. Conglomerate.
	Unconformity
Basal complex	
Pre-Huronian batholithic intrusives	Granite, granite-gneiss. Syenite, syenite-gneiss. Granodiorite, granodiorite-gneiss. Diorite, diorite-gneiss. Aplite, pegmatite. Mica schist.

Igneous contact

Abitibi group	Sedimentary:
	Pontiac series:
	Mica schist, hornblende schist, staurolite schist, etc.
	Amphibolite.
	Iron formation.
	Greywacke, arkose, conglomerate.
	Ferruginous dolomite (?)
	Iron formation.
	Conglomerate and agglomerate.
	Slate and phyllite.
	Igneous:
	Intrusive
	Lamprophyre.
	Ferruginous dolomite (?)
	Quartz porphyry.
	Diorite, andesite porphyry.
	Diabase, gabbro.
	Peridotite, serpentine.
	Extrusive
	Sericite schist.
	Quartz porphyry, rhyolite.
	Chlorite-sericite schist.
	Andesite, andesite porphyry, diorite.
	Amphibolite, hornblende schist, chlorite rock.
	Basalt, gabbro, diabase.
Grenville series	Garnet gneiss.
	Pyroxenite.
	Crystalline limestone.

BASAL COMPLEX.

As was pointed out in the outline of the geology of the Ottawa basin, the surface rocks of the basal complex (volcanic flows and sediments) occurring throughout southwestern Quebec and the adjacent portions of Ontario, may be divided lithologically into two sub-provinces: a southern belt, in which crystalline limestone and other sediments belonging to the Grenville series predominate, and a northern belt in which volcanic flows and clastic sediments are the dominant members. Between the Grenville sub-province and the Timiskaming belt intervenes the central belt of banded gneisses. If a geological section be made, proceeding northward from the region where the rocks of the Grenville series are abundant, across the central belt of gneisses to the northern volcanic belt, it will be observed that along the southern border of the gneissic belt, the gneisses intrude and include masses and bands of crystalline limestone and other metamorphosed sediments belonging to the Grenville series and that these masses and bands gradually decrease in size and numbers towards the north until replaced almost entirely by the banded orthogneisses; and that, likewise, a similar relationship holds on the north, the rocks of the Abitibi group being intruded by the gneisses and gradually disappearing when traced (southward) towards the gneissic belt.

Grenville Series.

Timiskaming county, Quebec, can scarcely be said to include any part of the great Grenville belt, the Grenville series being represented only in the southern part of the country by a few scattered masses or bands of crystalline limestone, by masses of pyroxenite or related ferromagnesian rocks, which have probably resulted from the metamorphism of crystalline limestone, and by bands of garnet gneiss, which may also represent metamorphosed (argillaceous) portions of the Grenville series. The distribution, lithological character, and relationships of these various rock types are described in the following sections.

CRYSTALLINE LIMESTONE.

Distribution.

Crystalline limestone was observed by the writer in only one locality in Timiskaming county, namely, on the northwest shore of Brennan or Sairs lake—one of the series of lakes which together constitute the upper Kipawa river—at the point where the southern east-west trending portion of the lake bends northward. In the region east of Brennan lake, which was not examined, limestone was reported to be present by the local inhabitants, but, throughout the territory north of Brennan lake, no limestone was seen and it is probable that the Brennan Lake occurrence marks the approximate northern limit of the Grenville limestone in Timiskaming county.

Lithological Character.

The Grenville limestone occurring on the shore of Brennan lake is a coarse, white variety, consisting of calcium carbonate traversed by numerous seams or zones of tremolite. Along the contact of the limestone and the gneiss, a lime silicate zone has developed which, when examined under the microscope, was found to consist of tremolite and diopside.

Structural Relations.

The Brennan Lake limestone occurs in two lenticular masses about 10 feet long and from 2 to 3 feet in thickness. These have almost a horizontal attitude conforming to the foliation of the enclosing gneiss, which, at this point, lies almost flat. From the contorted and lenticular forms of the limestone masses and the conformity of the lenses to the foliation of the gneiss, it is evident that the limestone has been subjected to intense deformation, and from the occurrence of lime silicates on their margin, it is also evident that considerable contact action between the gneiss and the limestone has taken place.

PYROXENITE.

Distribution.

Pyroxenite was seen at several points on the southwest shore of Sassaganaga lake, outcropping in elongated masses, about 10 feet in width and trending in a southeasterly direction parallel to the strike of the adjacent gneiss. At the southeast end of Birch lake a small island occurs which is composed of a rock, consisting of a carbonate, anthophyllite, and a green mica. The similarity in composition and mode of occurrence of this rock to the pyroxenite indicates that the two rock types are related in origin and for this reason they have been described together.

Lithological Character.

The pyroxenite occurring on Sassaganaga lake is a massive greenish grey to resinous-looking rock which, under the microscope, was found to consist of a colourless pyroxene, partly altered to yellow green serpentine, carbonate, and pale green lamellar talc.

The mass of rock composing the island in Birch lake, in the hand specimen, is a rusty yellow to white, fibrous rock containing scattered flakes of a dark green lamellar mineral. In thin section under the microscope, the rock is seen to consist of anthophyllite, partly massive and partly fibrous, carbonate, and a colourless lamellar hydromica.

CYANITE AND GARNET GNEISS.

General Character and Distribution.

In numerous localities throughout the belt of banded gneisses, especially in its southern part, bands of biotite and hornblende gneiss were observed which contained garnet, also in two localities—on the north shore of Birch lake and on the north shore of Hunters bay, lake Kipawa—these beds of garnet gneiss were observed to contain cyanite. The relationships of these bands differed in no apparent way from those of the other portions of the gneissic complex; but the peculiar mineralogical composition of the bands points to the possibility that they may represent metamorphosed remnants of Grenville sediments, and for that reason they have been included, for the purpose of discussion, in this section of the report.

Lithological Character.

The rocks belonging to this group are so variable in character that it is scarcely possible to adequately describe all the different types collectively. The hornblendic varieties are generally dark uniform rocks having the appearance of a diorite or amphibolite. The biotitic varieties, on the other hand, are light coloured and variegated in appearance, the minerals occurring in aggregates, biotite in one portion of the rock and quartz and feldspar in another. Throughout the whole rock scattered red garnets occur, some of which have a diameter as great as ¾ of an inch. In one band of this type occurring on Brulé lake, a few flakes of molybdenite were observed. The cyanitic garnet gneiss occurring on Turtle lake, except for the pale blue cyanite which it contains, resembles the ordinary garnet gneiss, but that on Hunters bay, lake Kipawa, also contains muscovite.

The hornblende-garnet gneiss, when examined under the microscope, except for the presence of the garnet differed in no respect from the ordinary dioritic bands of the gneissic complex, the usual minerals present being oligoclase, blue green hornblende, biotite in variable quantities, and magnetite. The biotite types are granular rocks with a considerable variation in the size of the mineral grains and consist chiefly of quartz, orthoclase, acid plagioclase (largely oligoclase), garnet, and apatite. A muscovite variety occurring on lake Kipawa, when examined under the microscope, was found to consist essentially of quartz in irregular grains showing undulatory extinction, garnet, deep brown biotite, and muscovite.

AGE AND CORRELATION.

The Grenville series, as has been already stated, is the name applied to highly deformed and crumpled masses of crystalline limestone, garnet gneiss, vitreous quartzites, and related ancient metamorphosed sediments occurring along the southern border of the Laurentian highlands. These rocks are lithologically similar wherever they occur and, as far as known, are in conformable succession and hence are assumed to constitute a single series. The crystalline limestone occurring on Brennan lake has been correlated with the Grenville series because it is lithologically similar to a characteristic member of the series, it is located in the same geological province, and like the rocks of the Grenville series, it is a part of the basal complex. The cyanite and garnet gneisses have also been placed provisionally in the Grenville series because their mineralogical and chemical composition suggests that they are possibly metamorphosed sediments and in that case are similar in origin and relationships to the sillimanite-garnet gneisses of the original Grenville area. The mode of origin of these rocks is discussed at greater length in the section on the banded gneisses in Chapter VI.

Abitibi Group.

GENERAL STATEMENT.

It has been previously explained (Chapter IV) that the surface rocks of the basal complex occurring in the Timiskaming region have been classified for the purpose of description into two divisions: the Timiskaming group, which includes all the rocks which are known to be younger in age than other rocks of the complex with which they are associated; and the Abitibi group which includes those rocks which are known to be older than the Timiskaming group or of which the age is in doubt. Rocks of the first class, while present in the region directly to the west of the district, are not positively known to be present in Timiskaming county, the relationships of the Pontiac series which constitutes the largest single belt of sediments in the pre-Huronian complex of the Timiskaming region, being in doubt. The surface rocks of the basal complex as represented in the northern part of Timiskaming county are, therefore, all classified as belonging to the Abitibi group.

DISTRIBUTION.

Local intrusive masses of granite are so common throughout the region in which the rocks of the Abitibi group occur, that it is impracticable to outline the areal extent of the group in detail. Except, however, for the areas underlain by granite and the narrow east-west trending belt of Cobalt series which overlaps the basal complex in Dasserat and Boischatel townships, all the rocks occurring in the northern part of the region belong to the Abitibi group. The contact with the belt of gneisses, which limits the Abitibi group on the south in Timiskaming county, trends in an east-west direction from the north end of Grand lake Victoria to lake Opasatika; but at the interprovincial boundary it turns abruptly to the south and continues in this direction to a point about 16 miles below the upper end of lake Timiskaming where it again trends westerly to the north shore of lake Huron.

EXTRUSIVE ROCKS (ABITIBI VOLCANICS).

General Character.

The larger part of the Abitibi group is composed of a series of more or less metamorphosed volcanic flows ranging in composition from basalt to rhyolite. These are on the whole fine-grained aphanitic rocks, but locally in the interior of the flows they become coarse-grained and possess the textures of intrusive rocks. Their structure is exceedingly complex and unlike normal series of stratified sediments they contain no sharply defined, uniform, and easily recognized beds which might be used as horizon markers; furthermore the bedrock surface throughout the region in which they occur is, for the most part, hidden beneath the post-Glacial stratified clay deposited from lake Barlow. For these reasons, it has not been possible to work out the structural relationships of the various rocks to one another. They are all lava flows, however, and on this account have been grouped together as the Abitibi volcanics, although they may possibly represent rocks of widely different ages.

The distribution given for the rocks of the Aibtibi group in general applies equally well to the Abitibi volcanics except that along the southern border of the territory occupied by the Abitibi group and adjoining the belt of gneisses, the Abitibi volcanics are replaced by the belt of sediments composing the Pontiac series.

In the description which follows, the Abitibi volcanics have been divided into three principal classes: (1) (a) basalt, diabase, and gabbro, (b) amphibolite, hornblende schist, and chlorite rocks; (2) (a) andesite and diorite, (b) chlorite-sericite schist; (3) (a) rhyolite and quartz porphyry, (b) sericite schist.

Basalt, Diabase, and Gabbro.

Distribution. Although the rocks of this class are widely distributed throughout the Quebec portion of Timiskaming region, they are on the whole much less common than the lavas of intermediate composition. They are most extensively developed in the vicinity of lake Abitibi, in Baby township adjacent to Rivière des Quinze, and in the Kamak ridge which parallels lake Dufresnoy on the southwest.

Lithological Character. The basic lavas belonging to the Abitibi group are dark green rocks of approximately the same mineralogical and chemical composition, but of variable texture, the basalt being aphanitic, the diabase ophitic, and the gabbro allotriomorphic. These various types are commonly developed in the same lava flows, the coarse-grained gabbro or diabase occurring in the interior and the basalt on the margin. The basalts commonly exhibit amygdaloidal pillow and other structures which characterize extrusive rocks.

The examination of the basic volcanics under the microscope reveals much more information with regard to the character of the metasomatic changes to which they have been subjected than with regard to their original composition, only the outlines of the original minerals remaining even in the least altered types. In the diabase and gabbro, the feldspars are largely, if not entirely, replaced by carbonate, zoisite, epidote, and sericite; and the original pyroxene has disappeared entirely or remains merely as a residual core in the midst of secondary hornblende. Tremolite, chlorite, or actinolite are also commonly present filling the interstices between the hornblende or feldspar. Other constituents commonly observed are titanite, sphene, pyrite, and magnetite. The basalt is not generally porphyritic as observed in the hand specimen, although under the microscope small phenocrysts of plagioclase or of plagioclase and augite can be observed in some sections. The groundmass of the basalt consists chiefly of minute crystals or long branching fibres of feldspar. They generally contain considerable iron oxide, chlorite, zoisite, and other alteration products from which the rock derives its dark green appearance. In some sections a eutaxitic or banded structure is present, features evidently developed by flowage in the basalt during consolidation.

Chemical analyses of the basic member of the volcanic complex occurring in Timiskaming county, Quebec, are not available, but two analyses of similar rocks occurring in the adjacent portions of Ontario are included in columns 1 and 2 of the following table:

Analyses of Abitibi Volcanics.

	1	2	3	4
Si_2O	48·70	53·90	49·68	66·96
Al_2O_3	15·21	19·67	15·35	19·01
Fe_2O_3	4·28	0·71	4·53	3·70
FeO	8·35	10·21	9·22	1·79
CaO	11·11	8·30	6·92	0·35
MgO	3·76	0·72	4·40	0·59
Na_2O	3·23	2·78	3·84	4·62
K_2O	0·59	0·58	2·25	1·44
CO_2	2·25	0·86	0·65	....
H_2O-	} 0·65	1·80	1·37	0·20
H_2O+			2·14	0·64
MnO	....	0·32	....	....
TiO_2	....	....	1·37	0·27

1 and 2. Basalt, Ann. Rept., Ont. Bureau of Mines, vol. 23, pt. 2, 1914, p. 6.
3. Diorite, from Dufresnoy lake, analyst S. J. Lloyd.
4. Dacite, from Dufresnoy lake, analyst S. J. Lloyd.

Amphibolite, Hornblende Schist, and Chlorite Rocks.

General Character and Distribution. The amphibolite, hornblende schist, and chlorite rocks described in this section of the report have been classed together because their mineralogical composition and field relationships indicate that they all represent the metamorphic product resulting from the alteration of the rocks of the basalt-gabbro family described in the preceding paragraphs. The amphibolite and hornblende schist are found chiefly along the margin of the granite batholiths where the batholith is in contact with the Abitibi greenstones, as, for example, adjoining the Abitibi batholith on Nepawa island in lake Abitibi and adjacent to the great southern batholith at the head of the

Maple rapids on Rivière des Quinze. Chlorite is a very common constituent of the greenstones of the region and chlorite schists are likewise locally abundant; rocks consisting almost wholly of chlorite were not observed anywhere in the region, however, except in the vicinity of Moose bay on lake Opasatika (Plate VII).

Lithological Character. The amphibolite and hornblende schist are usually dark green to almost black rocks varying in texture from a uniform fine-grained type, containing innumerable glistening crystals of hornblende, to a coarse variety containing amphibole crystals half an inch or more in length. The chlorite rocks are generally soft, greyish green rocks without any apparent foliation. The exposures which occur on the north and south shores of the entrance to Moose bay on lake Opasatika are traversed by a network of calcite seams, which give the rock a very peculiar net-like appearance.

On making a microscopic examination of the amphibolite and hornblende schist it is seen that, while these rocks are all alike in that they consist essentially of abundant blue green amphibole, quartz, and feldspar, they vary greatly in the proportions of these minerals, in some places consisting almost entirely of amphibole and in other places containing a large proportion of feldspar or quartz. The feldspars range in composition from orthoclase to andesine, although the plagioclase is, on the whole, the most abundant. Other minerals commonly present, in addition to those already mentioned, are a carbonate, biotite, diopside, epidote, titanite, apatite, pyrite, and garnet. The hornblende schist does not differ from the amphibolite in composition, but has a foliated structure, owing to the parallel alignment of the hornblende and the elongation of the quartz grains. The chlorite rocks, when examined under the microscope, are seen to consist entirely of chlorite, pyrite, and carbonate.

Andesite and Diorite.

Distribution. The volcanics of intermediate composition—andesite and diorite—constitute the prevailing rock throughout the larger part of the territory in which the Abitibi complex occurs. They are most extensively developed in the vicinity of Dasserat lake, in Montbray township, in the vicinity of Duparquet and Dufresnoy lakes, in the Abijevis hills, and in the headwater area of Bell river.

Lithological Character. The typical andesite of the Abitibi group is a light-coloured, greenish-grey aphanitic rock which is very commonly porphyritic. In a few localities, as on Dufresnoy lake, medium-grained grey to pink diorites occur which are probably also extrusive in their origin representing the more coarsely crystallized interior portions of lava flows. These rocks, therefore, are a part of the Abitibi volcanics and are accordingly described in this section of the report.

Examined under the microscope the andesites are seen to be holocrystalline rocks consisting of small phenocrysts of oligoclase-andesine enclosed in a groundmass of minute lath-like crystals of plagioclase (pilotaxitic texture); chlorite, and specks of iron ore are also commonly present. The alteration products usually observed are epidote, sericite, zoisite, chlorite, and carbonate. The feldspar phenocrysts are seen in some thin sections to be broken and strung out linearly, a condition which has evidently been brought about by the flowage of the lava after the feldspar had crystallized.

The diorites as a rule are composed essentially of amphibole and plagioclase. The amphibole may be actinolite, tremolite, or pale green hornblende, and is probably of secondary origin. The plagioclase is usually too much decomposed for microscopic determination. When sufficiently unaltered for the albite twinning to be recognized, the maximum extinction angle is generally found to be about 7 degrees, indicating that the feldspar is an oligoclase-andesine. Other original minerals which commonly occur in the diorite are ilmenite, titanite, and magnetite. The minerals of secondary origin generally present are chlorite, sericite, zoisite, epidote, and carbonate. Of these minerals, the chlorite results from the alteration of the ferromagnesian constituents, while the sericite, epidote, zoisite, and carbonate replace the feldspar. In some localities, the andesites and diorites contain quartz in micrographic intergrowth with feldspar and thus pass into dacites or quartz diorites. The chemical analysis in column 4 of the table of analyses on page 83 is the composition of a rock specimen, from the northeast shore of lake Dufresnoy, collected and analysed by S. J. Lloyd. The composition of the rock would indicate that it is a dacite.

Chlorite-Sericite Schist.

In those localities where the andesite or diorite have been mashed, the resultant rock is generally a greenish-grey chlorite-sericite schist. These schists consist generally of fine granular quartz and feldspar throughout which sericite, chlorite, and carbonate are disseminated. Except for the greater abundance of chlorite, they differ but little from the sericite schist resulting from the mashing of the more acid volcanics.

Quartz Porphyry and Rhyolite.

Distribution. The acid rocks belonging to the Abitibi volcanics were not observed in many localities. There are a number of occurrences of rhyolite porphyry and quartz porphyry on Duparquet lake and several other typical examples were observed on Sifton lake and Bell river near the outlet of Sifton lake. It is possible also that a part of the great area of porphyritic greenstone occurring in Guigues and Baby townships, to the east of lake Timiskaming, should be included in this subdivision of the Abitibi group.

Lithological Character. The rocks of this group have been classified as quartz porphyry or rhyolite according to their difference in coarseness of grain. The quartz porphyry is a fine-grained, granular rock of pink to grey colour containing phenocrysts of quartz and feldspar. The rhyolite is also commonly porphyritic, but the phenocrysts are small and are embedded in an aphanitic matrix.

The microscopic study of these rocks affords some information with regard to their original mineralogical composition and the nature of the metasomatic changes which have taken place in the various minerals. Both the quartz porphyry and the rhyolite consist, essentially, of phenocrysts of quartz and feldspar enclosed in a fine-grained matrix of similar material. The quartz phenocrysts are generally fresh round grains with characteristic inclusions and marginal embayments. The feldspar phenocrysts, on the other hand, are generally considerably altered, even the freshest looking crystals containing an abundance of sericite microlites. Spherulitic intergrowths of quartz and feldspar and phenocrysts consisting of micrographic intergrowths of quartz and feldspar were also observed in some of the thin sections of rhyolite examined. In those specimens of rhyolite and quartz porphyry which have been metasomatically metamorphosed, the original minerals are generally replaced by sericite, carbonate, epidote, and chlorite. The proportion of these minerals present varies greatly in different rocks, however, although on the whole the sericite and carbonate are the dominant secondary products, the epidote and chlorite being comparatively unimportant.

Sericite Schist.

The sericite schists are light grey, or greenish grey, foliated, fine-grained rocks commonly occurring as local mashed zones in the quartz porphyry or rhyolite. From the microscopic examination of these occurrences it is seen that the sericite schist consists of fine granular quartz and feldspar throughout which carbonate and numerous microlites of sericite are disseminated. In some sections partly granulated crystals of quartz and feldspar are present, which are evidently residual portions of phenocrysts. The less common constituents present in the sericite schist are chlorite, magnetite, and pyrite.

Origin.

The Abitibi volcanics, as their name implies, are believed to comprise a great series of lavas extruded during a period or periods of vulcanism which occurred early in Pre-Cambrian time. The reasons for assuming these rocks to be lavas are briefly the following: they are characteristically fine-grained or aphanitic; they are characterized by amygdaloidal structure, pillow structure, and variolitic structure—all features which belong essentially to extrusive rocks; and in some localities the transition from a coarse-grained rock in the interior of a lava flow to the fine-grained aphanitic margin can be recognized (Plate V.) .

Relations to Other Formations.

The relationship of the Abitibi volcanics both to the other rocks of the Abitibi group and to the other formations occurring in the region are discussed at length in other sections of the report. It may, therefore, be merely stated here, that the relationship of the Abitibi volcanics to the Pontiac series has not been positively determined, that the floor upon which they were laid down has not been recognized, that, wherever they have been observed in contact with granite and gneiss, they were intruded by the latter, that they are overlain unconformably by the Cobalt series, and are intruded by dykes of Nipissing diabase.

INTRUSIVE ROCKS.

General Statement.

In addition to the volcanic rocks which compose such a large part of the Abitibi group, dykes and masses of intrusive rocks occur here and there throughout the volcanic complex, which are similar in composition to the extrusive lavas and which are probably genetically related to them. These include the following rock types: peridotite and serpentine, diabase and gabbro, diorite and andesite porphyry, quartz porphyry, and lamprophyre. Each of these rocks is briefly described in the following paragraphs.

Peridotite and Serpentine.

The rocks of this class occur in numerous localities throughout Timiskaming county—in Duhamel and Laverlochère townships, in the region east of lake Timiskaming; in the vicinity of Kewagama lake, in Preissac township; on the west shore of Poirier lake, in La Pause township; in the vicinity of La Motte lake in Malartic and La Motte townships; and on De Montingy lake and upper Harricanaw river in Varsan township.[1]

The rocks of the peridotite-serpentine group are represented in the district east of lake Timiskaming by five outcrops, four of which form a

[1] Bancroft, J. A., "Min. oper. in the prov. of Quebec," 1911, p. 174; 1912, p. 208.

north-south trending series, extending from lot 25 to lot 29 of Duhamel township, and are probably portions of a single rock mass; the fifth outcrop occurs on a small rocky point on the north shore of Rousselet lake in Laverlochère township. In the Duhamel area the rock is a soft, dark green, massive rock traversed by seams of fibrous serpentine, and under the microscope is seen to consist entirely of serpentine and dusty iron ore. The occurrence on the shore of Rousselet lake is a light green, granular rock which, when examined microscopically, is found to consist of serpentine, magnetite, and ilmenite, the whole being traversed by veinlets of calcite.

The other occurrences of peridotite and serpentine in Timiskaming county are all found in the district in the central part of the country adjacent to Kewagama, La Motte, and De Montigny lakes. These were not studied by the writer but are described by Dr. J. A. Bancroft in his report on this district published by the Mines Branch of the Department of Colonization, Mines, and Fisheries of Quebec. The peridotite which occurs in the vicinity of Kewagama lake is described by Bancroft as follows. "Intrusions of peridotite are especially numerous in the vicinity of East Kewagama lake, west of Poirier lake, and on the northwest part of Indian peninsula. In places the peridotites are commonly altered to talc, a light greenish mica, and a carbonate probably rich in magnesia and particles of black iron ore."

The occurrences of peridotite found in the vicinity of De Montigny and La Motte lakes are described by Bancroft in the following quotation. "The most interesting Keewatin rocks within the area, are the peridotites and their serpentinous equivalents. Fine-grained serpentine rocks, the relations of which are obscure, occur at a few points on Kienawisik (De Montigny) lake, and at two of the three outcrops on the river leading from this lake to La Motte lake. On the eastern shore of the latter lake and especially on the long narrow peninsula just to the west of the mouth of the river from Kienawisik lake, and upon the large island northwestward from this peninsula, they are especially well developed. Upon the other shores and upon some of the islands of this lake, partly talcose or serpentinous peridotites are exposed in numerous localities. In the eastern and central portions of La Motte township, some of the low hills are composed of this interesting group of rocks.

"Upon the long peninsula which has been mentioned, the peridotite is fresh and displays a great variety in petrographical character. Upon the end of this point, where it is traversed by two small veins of asbestos, the rock is quite coarsely crystalline and displays beautiful lustre-mottling or poicilitic structure. Under the microscope it was found to be composed of olivine, biotite, hornblende, and augite with particles of black iron ore and pyrite."

Diabase and Gabbro.

Rocks of this class which could be positively identified as intrusive in their relationships were not observed by the writer, but they are stated to occur both in the De Montigny (Kienawisik) Lake and Kewagama Lake areas, by Bancroft. In the Kewagama Lake district, according to Bancroft, diabase of this class intrudes the peridotite previously described.

Diorite and Andesite.

Although diorite belonging to the Abitibi group was not seen anywhere in intrusive contact with the Abitibi volcanics, outcrops of diorite having the coarse texture which usually belongs to intrusive rocks were observed in several localities. The most coarsely crystallized occurrences of diorite observed were those seen on the north shore of the southeastern bay of Labyrinth lake and on the eastern shore of Dufault lake. In both of these outcrops the rock differs only in texture from the ordinary diorite occurring in the lava flows and like the rocks of the lava flows has been subjected to intense metasomatic action. The rocks of these two outcrops consist mainly of secondary hornblende, chlorite, and epidote.

Andesite porphyry was observed in numerous small dykes intruding the mass of ferruginous dolomite occurring to the north of the Cascade rapids on the Kinojevis river. This rock is a fine-grained aphanitic type containing small feldspar phenocrysts embedded in an aphanitic matrix. Under the microscope it is seen that the feldspar phenocrysts are altered to sericite and epidote and are enclosed in a groundmass of small feldspar rods and epidote.

Quartz Porphyry.

Only a few dykes of quartz porphyry were observed which were positively determined to be intrusive in their relationships. Intrusive quartz porphyry is extensively developed, however, in the region adjacent to Kewagama and De Montigny lakes[1] and it is possible that part, at least, of the quartz porphyry occurring in the region east of lake Timiskaming is intrusive in its relationships. Lithologically the intrusive quartz porphyry is similar to the extrusive variety, except that in some localities, as in the case of the porphyry dykes occurring on the shore of Fortune lake to the northeast of lake Opasatika, it contains ferruginous dolomite and chrome mica in addition to the usual metasomatic alteration products. In Chapter VI much evidence is cited which indicates that the various occurrences of chrome mica bearing ferruginous dolomite

[1] Bancroft, J. A., "Min. oper. in the prov. of Quebec," 1912, p. 208; 1911, p. 173.

found in Timiskaming county and the adjacent region have all possibly originated by the replacement of quartz porphyry or related intrusives in a manner similar to that observed in the dykes on Fortune lake; if these dolomite rocks have been formed in this manner, they properly belong to the intrusive rather than the sedimentary members of the Abitibi group and should be described in this section of the report. They have been classed among the sediments, however, for the purpose of description, not because the evidence is more favourable to this mode of origin but because the evidence pointing to their igneous origin is not, in all cases, conclusive.

Lamprophyre.

A dyke of lamprophyre was observed to intrude the Abitibi volcanics occurring on the southwest shore of lake Dufault and a dyke of similar rock was observed by Mr. Stewart J. Lloyd in the interior of the peninsula which projects into Dufresnoy lake. Examined under the microscope, this rock was found to be a minette, consisting essentially of orthoclase, plagioclase, biotite, and carbonate with chlorite, sericite, sphene, and iron oxide as secondary constituents.

The result of a chemical analysis of the minette from lake Dufresnoy, made by Mr. Lloyd, is given in column 1. The analyses of similar rocks from other portions of the Timiskaming region have been inserted in columns 2 and 3 for the purpose of comparison.

Analyses of Minette.

	1	2	3
SiO_2	55·39	48·50	52·29
Al_2O_3	11·90	22·43	19·38
Fe_2O_3	0·90	2·85	4·40
FeO	4·71	4·78	6·00
CaO	7·63	7·62	7·79
MgO	3·67	1·16	3·54
Na_2O	1·99	3·38	2·12
K_2O	4.30	3.56	4.12
TiO_2	1.24		
H_2O-	0·26	2·26 (H₂O− and H₂O+)	0·95 (H₂O− and H₂O+)
H_2O+	6·08		
CO_2	2·12	3·72	
	100·09	100·26	100·59

Nos. 2 and 3. Ann. Rept., Ont. Bur. of Mines, vol. 23, pt. 2, 1914, p. 12.

SEDIMENTARY ROCKS.

General Statement.

The sedimentary rocks of the Abitibi group may be conveniently divided, for the purpose of geological description, into two classes; those which occur as scattered local bands or masses in association with the Abitibi volcanics and those which belong to the great band of sediments known as the Pontiac series. The rocks of these two classes are in part lithologically similar, but their age relationships to one another are unknown and they are, therefore, separately described.

Slate and Phyllite.

Distribution. Slate and phyllite were observed in association with the volcanics of the Abitibi group on the north shore of lake Duparquet and at Clay rapids on Kinojevis river. The last mentioned occurrence is, however, continuous with an area of greywacke similar to that of the Pontiac series, occurring on Clericy lake, and has been included provisionally in that series. Rocks of this class also occur in the township of Fabre[1] and it is possible that the fine-grained fissile sericitic schists occurring on the south shore of Chauvigny lake, on the Lacroix claim to the north of Beauchamp lake, on the south shore of Boundary bay on lake Abitibi, and on the property of the Union Abitibi Mining Company to the north of Renauld lake, are metamorphosed sediments and, in that case, to be classed with the slate and phyllite.

Lithological Character. The slate and phyllite are fine-grained, grey to black, bedded rocks which, on microscopic examination, are seen to consist of chlorite, sericite, carbonate, quartz, feldspar, and pyrite, the proportion of these minerals present varying in the different types. The grey varieties generally contain an abundance of sericite and carbonate, the green an abundance of chlorite, and the black types contain graphite.

Origin. The slate and phyllite wherever they occur have generally a vertical or nearly vertical attitude and are enclosed on all sides by the Abitibi volcanics. Whether they were deposited contemporaneously with the volcanics and folded up into their present position in company with them, or were laid down after the volcanics were extruded and later infolded into their present position was not determined; although their limited thickness, their uniformity of strike and dip, and the absence of evidence of a synclinal structure might be possibly regarded as indicating that they were deposited in conformable succession with the volcanics. They are all uniformly stratified rocks and were evidently deposited from a standing body of water. Their composition is approximately the same as that of the volcanics, so that they might be materials derived from the volcanics by denudation of fine-grained volcanic ejectmenta, the original characteristics of which have been destroyed by metamorphism. These generalizations include all that is positively

[1] Harvie, R. "Geology of a portion of Fabre township," Mines Branch, Dept. of Colonization, Mines, and Fisheries, Que.

known with regard to the origin and relationships of the slate and phyllite.

Conglomerate and Agglomerate.

Several small elongated patches of squeezed conglomerate containing pebbles of greenstone and iron formations were observed in association with the Abitibi volcanics, in Laverlochère township to the south of Lac Clair, and similar squeezed conglomerate is reported to occur in the eastern part of Fabre township.[1] Agglomerate was seen in only one locality in the whole region, namely on the shore and adjacent islands of Duparquet lake, near the outlet of the Magusi river. This rock consisted of fragments of dark amygdaloidal greenstone enclosed in a chloritic matrix which in places contained considerable pyrite.

Iron Formation.

Iron formation was seen in association with the Abitibi volcanics in three localities in Timiskaming county: to the south of Lac Clair in Laverlochère township, on the portage from Rivière des Quinze to Kakake lake, and on Bell river below Kiask rapids.

The iron formation found in the Lac Clair district is included in the belt of Abitibi greenstone which extends from Lac Clair eastward. It occurs as a number of exposures a few feet in length outcropping at intervals for 2 miles, the maximum width of the exposures being 30 feet and their strike 6 degrees south of east. It consists of bands of siliceous magnetite and vitreous quartz having an average width of about half an inch. It contains considerable pyrite in places, has been greatly faulted and brecciated, and is cut by porphyry dykes.

The iron-bearing rock observed on the Kakake portage occurs in a band about 30 feet wide and 100 yards in length and is composed of bands of siliceous magnetite interlaminated with layers of white, red, and grey quartz. The strike of the formation is north 20 degrees east and the dip 70 degrees northwest.

The third occurrence of iron formation observed in association with the volcanics of the basement complex, is merely a small exposure a few feet in diameter outcropping near the north end of the portage at Kiask rapid on Bell river. It consists of siliceous magnetite inter-banded with chlorite.

Ferruginous Dolomite.

In almost all districts in Timiskaming region where the Abitibi volcanics have been mapped in detail, scattered masses and bands of a chrome mica ferruginous dolomite have been found in association with

[1] Harvie, R., "Geology of a portion of Fabre township," Mines Branch, Dept. of Colonization, Mines, and Fisheries, Que.

the volcanics. All the occurrences of this rock in Timiskaming county, Quebec, are of very limited extent; it was observed, however, on the south shore of Boundary bay, lake Abitibi; on the north shore of Chauvigny lake, and on the west shore of Fraser lake, in Privat township; in the vicinity of Fortune and King of the North lakes, in Dasserat township; and north of Cascade rapids on Kinojevis river, in Manneville township.

The ferruginous dolomite, as it is typically developed in Timiskaming county, is a rusty weathering rock traversed by innumerable quartz veinlets. When freshly broken, the rock is seen to have a bright green colour due to the presence of disseminated chromiferous mica. When examined in thin section under the microscope, the rock is seen to consist of pyrite, chrome mica, sericite, quartz, and feldspar, the proportion of these minerals present varying greatly in different localities.

Further details with regard to the character and relationships of this interesting rock are presented in the discussion of the origin of the ferruginous dolomite in Chapter VI.

Pontiac Series.

General Statement and Distribution. The Pontiac series embraces an assemblage of rocks which have been separately designated, not because it has been definitely established that they are of different age to other portions of the Abitibi group, but because they are lithologically different from the Abitibi volcanics and associated rocks, because they occur in a single great belt, and because they were apparently laid down during a continuous period of deposition. The rocks composing the series may be grouped, for the purpose of description, into four classes: greywacke, arkose, and conglomerate; iron formation; amphibolite; and mica schists, hornblende schist, and staurolite schist.

All the rocks occur in an east-west belt averaging about 10 miles in width and extending continuously across the central part of Timiskaming county from the interprovincial boundary and the north end of lake Opasatika to Grand lake Victoria and lake Matchimanito, a distance of 110 miles. The limitations of the belt are sharply defined, on the north, in Dasserat and Boischatel townships, by its contact with the overlying Cobalt series and from these townships eastward by its junction with the Abitibi volcanics. On the south, on the other hand, the boundary is indefinite because of the wide intruded zone which marks its contact with the belt of banded gneiss.

Greywacke, Arkose, and Conglomerate. The belt of sediments composing the Pontiac series has been so greatly metamorphosed by the intrusion of the great belt of gneisses which adjoins it on the south that it is only along the northern border of the belt that the sediments retain any trace of their original clastic character. Throughout the region north of Kekeko, Kinojevis, and Kiekkiek lakes, there is a marginal zone about 2 miles wide, consisting of greywacke and arkose which, here and there, contains aggregates of squeezed granite and rhyolite pebbles. On the northeast shore of Garden Island lake, there are also two small outcrops of mashed conglomerate similar to that on Kinojevis river and Kiekkiek lake. In this locality some of the softer and less resistant pebbles have been so flattened by deformation that they are now represented by thin plates embedded in a mica schist matrix. In thin section under the microscope the greywacke, arkose, and the conglomerate matrix are seen to consist of fragments of feldspar and quartz, generally more or less corroded and granulated on their margin, embedded in a fine-grained matrix of the same minerals along with varying amounts of chlorite, sericite, carbonate, and iron oxide. The arkose differs from the greywacke merely in the smaller porportion of ferromagnesian material which it contains. It is only in a few localities that the original characteristics of the greywacke, arkose, and conglomerate of the Pontiac series have been sufficiently well preserved to afford definite information with regard to the manner in which these rocks originated. Their stratified character and their occurrence in a belt 110 miles in length would indicate that they were laid down from a body of water of large extent: the coarseness, angularity, and unsorted character of the material composing them, on the other hand, point to shallow water deposition. Other features such as cross-bedding and ripple-marks, which might have aided in determining their original character, were not observed, possibly because they had been destroyed by deformation. All that can be said with regard to the mode of origin of the greywacke, arkose, and conglomerate is that these rocks are characterized by features which might belong to sediments deposited on the flood-plain of a river, on a delta, in a large lake, or in a shallow sea.

Iron Formation. Iron formation is known to occur in association with the Pontiac series in Cadillac township to the south of Newagama lake, and on the east shore of lake Matchimanito. The former occurrence is described by Bancroft as consisting of slates rich in magnetite interbanded with foliated, grey quartz, slate, and schists, the whole having a vertical attitude and a strike a few degrees south of east. The zone throughout which the magnetite laminæ are present has a maximum width of 1,300 feet and length along the strike of 2 miles. The iron formation occurring on the east shore of Matchimanito lake is very similar in character to that occurring in Cadillac township, but the Pontiac series in its vicinity is represented by a garnetiferous and staurolitic schist. The iron-bearing rock outcrops throughout a zone 300 yards in width and half a mile in length and consists of a laminated, magnetite-bearing, mica schist having a vertical attitude and a strike of north 60 degrees east. Microscopically, the rock is seen to consist chiefly of granular quartz and magnetite and parallel flakes of mica, with epidote, chlorite, sillimanite, and apatite as accessory constituents. The alternating laminæ all contain the same mineral constituents, but the proportion of the constituents present is variable, some bands containing more magnetite and correspondingly less quartz and biotite than others.

These iron-bearing rocks are stratified deposits and are undoubtedly sedimentary in origin; but, whether they were originally laid down in their present form, or as hematite, or, as in the case of some of the iron-bearing formations to the south of lake Superior, as iron carbonate or iron silicate, cannot now be positively determined. If iron carbonate or iron silicate were ever present, these minerals were long ago destroyed; on the other hand, it is significant that whereas the Pontiac series as a whole is composed of unsorted rocks and in only a few localities, as far as known, consists of slate or staurolitic schist—rocks generally regarded as representing the ultimate products of weathering—it is in association with these rocks that the iron formation is found. Furthermore, the iron formation, except for the magnetite which it contains, is similar in mineralogical composition to the ordinary mica schist of the Pontiac series, a feature which indicates that the iron was deposited originally as iron oxide rather than as a silicate or carbonate.

Amphibolite. At a number of points within the belt in which the Pontiac series occurs, outcrops of amphibolite were observed, which have been included in the Pontiac series because of their geographical association although lithologically they are similar to the Abitibi volcanics. These rocks are exceedingly variable in texture, colour, and structure, but are alike in being composed for the most part of amphibole. When examined under the microscope, the light green varieties are seen to be composed chiefly of tremolite, or actinolite, whereas the dark green varieties contain an abundance of blue green hornblende. Some thin sections of the rock contained considerable magnetite, some contained garnet, and one contained diopside. The most typical amphibolite consisted of hornblende, alkalic feldspar, quartz, biotite, magnetite, titanite, and carbonate.

The amphibolites of the Pontiac series were not observed in direct contact with the other members of the series and neither their mode of origin nor their relationship to the other rocks of the Abitibi group were determined. In some localities, as on Kinojevis river, outcrops of the amphibolite occur which have a botryoidal appearance on the weathered surface somewhat similar to the pillow structure of the Abitibi volcanics—a feature which indicates that in this locality the amphibolite may represent a volcanic flow presumably contemporaneous in age with the Pontiac series. In other localities, the amphibolite is coarse in texture and massive and may possibly be intrusive into the Pontiac series. Whatever the relationships of these occurrences of amphibolite may be, however, they are all highly metamorphosed and undoubtedly belong to the basal complex and hence form a part of the Abitibi group.

Pontiac Schists. The Pontiac schists form the dominant part of the great belt of rocks, 110 miles in length, extending from the interprovincial boundary to Matchimanito lake, to which the name Pontiac series has been applied (Plate VIII). These consist mainly of biotite schist, but locally pass into hornblende schists, and, in one locality on Matchimanito lake, also contain staurolite and garnet. On the weathered surface the Pontiac schists have generally a rusty appearance due to the oxidation of the pyrite which they contain; but on the freshly broken surface, they generally appear grey in the biotitic varieties and green or black in the hornblendic types. The schists have a banded appearance in places, very commonly show marked tendency to break off on the surface in slabs from 3 to 5 inches thick, and, in places, are traversed by minute intersecting seams of quartz and feldspar which stand up on the weathered surface, giving the rock a ridged appearance. Thin crumpled lenses of quartz strung out parallel to the foliation, are very common in the Pontiac schists, notably so in the vicinity of lake Opasatika and on the ridge southeast of Kiekkiek lake. Masses and lenses of pyrite and pyrrhotite were also observed in association with these schists at a number of points in the region adjacent to lake Opasatika and Barrière lake.

Examined in thin section under the microscope the Pontiac schists are seen to consist chiefly of quartz, and usually some feldspar—chiefly orthoclase—with biotite or a blue green hornblende as the ferromagnesian constituents. The staurolitic schist outcropping on Matchimanito lake differs from the ordinary varieties in that it contains no feldspar and consists almost entirely of quartz, biotite, and staurolite, or staurolite and garnet. The common accessory minerals present in the schist are pyrite, magnetite, epidote, sphene, apatite, sillimanite, and garnet. Where alteration has occurred, the feldspar is generally sericitized and the biotite and hornblende are chloritized. The Pontiac schists generally possess the fine-grained and granular texture which commonly characterizes recrystallized sediments, and the quartz and feldspar grains of the schist, like the ferromagnesian minerals, are usually flattened in a direction parallel to the foliation of the rock.

As regards the origin of the Pontiac schists it is believed that their bedded character, their composition, especially where they contain highly aluminous minerals such as staurolite and garnet, their crystalloblastic texture, and the transition from the schist to greywacke, arkose, and conglomerate,[1] on passing northward away from the great belt of intrusive gneisses, indicate that they were originally sediments which have been metamorphosed into schist by the great batholithic massif which adjoins them on the south.

Granites and Gneisses.

GENERAL STATEMENT.

A large part of Timiskaming county, Quebec, in common with the Laurentian plateau generally, is underlain by granites and gneisses which in this report, for reasons explained in Chapter IV, are referred to collectively as the pre-Huronian batholithic intrusives. For the purpose of description these rocks may be conveniently divided according to their distribution into two great classes: the granites and granodiorites occurring as isolated batholiths here and there throughout the belt of sediments and lavas composing the Abitibi group, and the great belt composed largely of banded gneisses which occupies nearly the whole of the southern part of Timiskaming region.

NORTHERN BATHOLITHS.

General Statement.

The rocks composing the northern batholiths are chiefly granite or gneissoid granite passing locally into granodiorite, and occur as irregular masses ranging from a few hundred feet to several miles in diameter. These have intruded their way through the rocks of the Abitibi belt with which they are in contact. It may be observed from an examination of the map which accompanies this report, that only a part of the batholithic masses have been outlined in detail, but all the masses seem to be remarkably similar in character and belong to the class of rocks generally described as subalkalic.

Lithological Character.

The northern batholiths are chiefly composed of medium to coarse-grained, granular rocks, having the mineralogical composition of a hornblende or biotite granite. In the hand specimen the prevailing type is fresh-looking pink, white, or grey rock having a more or less speckled appearance due to the scattered crystals of hornblende or mica

[1] Geol. Surv., Can., Mem. 39, 1913, Plates XVI, XVII, and XVIII.

which it contains. Very commonly the ferromagnesian minerals have a parallel arrangement, but a gneissoid structure in the most of the batholiths is not conspicuous. One of the striking peculiarities of the northern batholiths is the great heterogeneity which prevails nearly everywhere. Very commonly a granite containing very little biotite may be seen to have broken through a granite in which this mineral is more abundant or more finely disseminated, or a hornblende granite may be cut by a biotite granite in a similar manner. In some places long schlieren of granite containing a larger proportion of biotite than the surrounding rock are present, and in other localities masses of hornblendite are common. These, however, are very probably masses of the Abitibi volcanics which have been broken off from the walls of the magma chamber during the intrusion of the batholith. Pegmatite and aplite dykes and quartz veins are abundant in all the batholiths.

The microscopic examination of these batholithic rocks shows them to be largely granites consisting essentially of hornblende or biotite or both of these minerals with orthoclase, microcline, soda plagioclase (albite to oligoclase), and quartz as salic constituents. In a few localities, the hornblende granites pass into granodiorites, quartz diorites, or even diorite, by the loss of potash feldspar and quartz, but these occurrences are of limited extent. In the Kewagama Lake batholith, which in some respects more closely resembles portions of the great southern batholith than the other northern batholiths, muscovite is also an abundant constituent. The less common minerals occurring in these rocks are apatite, titanite, muscovite, epidote, allanite, magnetite, ilmenite, calcite, pyrite, and chlorite, the latter being always of secondary origin after hornblende or biotite. In those places where the feldspars have undergone metasomatic alteration, they are largely transformed into sericite or to sericite, zoisite, and epidote. The aplite and pegmatite when examined microscopically were found to consist chiefly of quartz, orthoclase, and microcline, with muscovite in subordinate quantity. Accessory minerals observed were magnetite, biotite, calcite, and garnet.

BELT OF BANDED GNEISSES.

General Statement and Distribution.

Practically, the whole of the southern part of Timiskaming county, Quebec, is occupied by the belt of banded gneisses, which, as has been previously explained, extends continuously from Georgian bay on the west to the gulf of St. Lawrence on the east. The junction line between the Timiskaming belt and the belt of gneisses crosses lake Timiskaming at a point about 30 miles from its north end, and east of the lake turns almost directly north continuing for 60 miles to lake Opasatika, from which point it continues approximately eastward across the county to the north end of Grand lake Victoria. With the exception of a few local areas occupied by the limestone and pyroxenite of the Grenville series the region south of this line of junction is underlain almost wholly by banded gneisses.

Lithological Character.

The rocks of the belt of gneisses differ from the northern batholiths not only in possessing characteristically a foliated structure but also in the banded and folded appearance which they everywhere present. The rocks of the belt include the following types each of which is described in the sections which follow: granite and granite-gneiss; syenite and syenite-gneiss; granodiorite and granodiorite gneiss; diorite and diorite-gneiss; pegmatite and aplite, and mica schist.

Granite and Granite Gneiss. The granite and granite gneiss of the gneissic complex are light grey coloured rocks possessing the characteristic granitic texture which usually belongs to rocks of this class. They consist essentially of quartz and alkalic feldspar (orthoclase, microcline, albite, and oligoclase) but may be classified as hornblende, biotite, hornblende-biotite, biotite-muscovite, or muscovite granite gneiss according to the minerals present. Of the different varieties the biotite granite gneiss is much the most common. The muscovite granite gneiss in most of its occurrences is probably merely foliated aplite or fine-grained pegmatite, and belongs to the pegmatite and aplite division described below. The common accessory minerals found in these rocks are epidote, titanite, garnet, zircon, and apatite. The minerals arfvedsonite and ægerine are also present in some thin sections of granite gneiss occurring in the district to the north of the upper Kipawa river.

From the microscopic examination of thin sections of the granite and granite gneiss it is seen that, in some places, the constituent minerals are remarkably fresh, whereas in others the feldspars are largely replaced by sericite and the hornblende and biotite by chlorite. Between these two extremes an intermediate rock type is also common in which sericitized feldspar occurs enclosed in a matrix of fresh, granular, quartz and microcline. In some sections, too, the minerals show by their undulatory extinction and granulated character that they have been subjected to intense mechanical deformation. In others, however, all these evidences of deformation are entirely wanting.

Syenite and Syenite Gneiss. The syenite and syenite gneiss are commonly a grey to rusty red rock, which in most localities shows a remarkable tendency to disaggregate into its constituent mineral grains on the weathered surface. Examined under the microscope, the syenite and syenite-gneiss are seen to consist essentially of orthoclase, albite, microperthite, ægerine, and dark brown biotite. The accessory constituents observed are titanite, apatite, zircon, epidote, and magnetite. Under the microscope, it can also be seen that the disaggregation on the weathered surface arises from irregular fractures which traverse the rock along the contacts of the mineral grains. The cause of the fractures is not apparent, but they are possibly related in their origin to the pressure which no doubt accompanied the slight decomposition which has occurred in the ægerine. The syenite and syenite gneiss have their greatest extent in the region adjacent to the upper Kipawa river a few miles east of lake Kipawa.

Granodiorite and Granodiorite Gneiss. The granodiorite and granodiorite gneiss are rocks of similar appearance to the granite and granite gneiss, but their mineralogical composition shows them to occupy an intermediate position between diorite and granite. They contain much less quartz and orthoclase than the granite and correspondingly more plagioclase, and biotite is replaced by hornblende as the dominant ferromagnesian constituent. The accessory mineral constituents, mineral alterations, and evidences of mineral deformation are the same in the granodiorite as in the granite and granite-gneiss.

Diorite and Diorite Gneiss. The diorite and diorite gneiss are dark rocks containing an abundance of glistening crystals of hornblende. Examination under the microscope shows most of the rocks of this class to consist essentially of blue green hornblende and plagioclase (either albite, oligoclase, or andesine), but in some thin sections the proportion of plagioclase becomes so small that the rock might be more appropriately called a hornblendite. The common accessory minerals observed are garnet, magnetite, biotite, titanite, epidote, and zircon. The hornblende and biotite are commonly more or less altered to chlorite and the plagioclase in some sections is entirely replaced by sericite and epidote.

Pegmatite and Aplite. The rocks of this class occur in the gneissic complex partly as parallel bands, partly as included lenses, and partly as crumpled dykes intruded transverse to the banding and foliation. They consist largely of quartz, orthoclase, microcline, and albite, the names pegmatite and aplite being used according as the rock is coarse or fine-grained. In addition to the quartz and feldspars already mentioned, numerous accessory minerals were observed in the pegmatite and aplite, of which the following are the most abundant: muscovite, biotite, apatite, garnet, allanite, graphite, molybdenite, epidote, titanite, and cyanite.

Mica Schist. Within the belt of banded gneisses, there are several occurrences of mica schist which are possibly, in some cases at least, altered sediments; but, because their mode of origin is in doubt and because they are closely associated with the gneisses, they have been included in the belt of banded gneisses. One common type of mica schists occurring in the gneiss is a fine-grained aphanitic rock containing broken and rounded fragments of feldspar which give the rock a porphyritic appearance. This was observed in four widely separated localities; on the south shore of Hunters lake, on lake Ostaboining, at the north end of Trout lake, and near Mink narrows on Twenty-one-mile bay, Grand lake Victoria. Under the microscope, this schist is seen to consist of fragments of biotite, quartz, and feldspar enclosed in a fine-grained matrix of the same minerals. In some of the thin sections examined, the rock has an appearance closely resembling that of an arkose, but the abundant evidence of fragmentation in other sections suggests that it is in reality of igneous origin, and has assumed this clastic appearance as a result of deformation.

Mica schists resembling the Pontiac schist were also observed in several localities within the central belt of gneisses. These are fine-grained rocks consisting of biotite, quartz, orthoclase, and albite, and possess the mosaic-like, crystalloblastic texture so characteristic of the paragneisses. On Grand lake Victoria, there is an area of these rocks several square miles in extent, which contains a very large proportion of pink garnet. The presence of such a large proportion of this highly aluminous mineral indicates that the schist has the chemical composition of a sedimentary rather than an igneous rock and is probably a paragneiss.

In the following table are included the chemical analyses of five rock specimens collected by A. E. Barlow from the belt of banded gneisses.[1]

Analyses of Gneisses.

	1	2	3	4	5
Silica	71·69	69·39	67·74	67·50	44·92
Alumina	14·84	17·46	16·13	18·23	18·88
Ferric oxide	....	....	1·50	....	2·73
Ferrous oxide	1·25	1·38	1·96	2·39	13·76
Manganous oxide	tr.	....	tr.	....	0·26
Lime	1·03	2·14	4·41	1·85	9·07
Magnesia	0·37	0·52	1·36	1·56	5·38
Potassa	7·09	2·77	1·30	4·25	0·53
Soda	3·13	5·18	4·92	3·79	2·94
Water at 100°C	0·10	0·06	0·10	0·08	0·20
" above 100°C	0·49	0·47	0·86	0·90	1·62
Totals	99·99	99·37	100·28	100·55	100·29

1. Granite gneiss from the west shore of Taggarts bay, lake Kipawa.
2. Granite gneiss from the south shore of McLaren bay, lake Kipawa.
3. Granite gneiss from west shore of lake Timiskaming, at north end of Opinaka narrows.
4. Granite gneiss from the northwest shore of Leonard inlet, Wicksteed lake.
5. Quartz-mica diorite gneiss from Ottertail creek, lower end of the second portage above the junction with the north branch.

[1] Geol. Surv., Can., Ann. Rept., pt. I, 1897, p. 53.

Structural Features.

Foliation. Everywhere throughout that portion of the great central belt of gneisses studied by the writer, the rocks, as the term gneiss implies, were all highly foliated. This foliation arises for the most part from the parallel orientation of biotite plates and hornblende prisms, but also, in some cases, from the flattening of the feldspar and quartz in the same plane. Very commonly the biotite of the biotite gneiss is seen to "eye" around small lens-shaped fragments of feldspar, giving rise to the characteristic augen structure, which results from deformation. The trend of the foliation, like that of the banding, indicates that it has the form of anticlines and synclines simulating the structure of folded sedimentary rocks in every respect.

Banding. The most striking and the most characteristic structural feature of the central belt of gneisses is the banding which is everywhere developed (Plate IX). The extreme complexity of the structures exhibited by these bands and the heterogeneity of the rocks which they contain even in a single rock outcrop are scarcely capable of description; yet when examined over broad areas, this complexity and heterogeneity is so uniform that it becomes monotonous. The banding of the gneisses may arise either from a variation in the proportion of minerals present in the same rock or by the alteration of bands of different rock. Thus, one of the most common types of banding is brought about by the alternation of bands of biotite gneiss containing varying proportions of biotite so that a light band, in which little biotite is present, alternated with a dark band containing a large proportion of biotite. In a similar manner, variations in the proportion of hornblende in the hornblende granite gneiss, the granodiorite gneiss, or the diorite gneiss result in a banded structure. The second type of banded structure, in which the alternate bands are composed of different rocks, may also be combined with bands of the first types, and in this way an almost infinite variation in the composition of the bands may occur. The commonest rock of the banded gneiss is the biotite or biotite-hornblende granite gneiss; but pegmatite and aplite are also important, composing not less than 15 per cent of the whole. The proportion of other rocks is small, so that the central belt of gneisses, considered as a whole, is granitic rather than dioritic in composition. The width of the bands may vary from a fraction of an inch to hundreds of feet. When followed along the strike they are commonly found to pinch out as though they were in reality thin lenses. This lenticular character is particularly evident in the case of the pegmatite, which commonly occurs as a succession of lenses (Plate X) around which the foliation in the surrounding gneiss bends in a manner very similar to that which occurs on a small scale around the augen of feldspar in the augen gneiss.

Granulation. That granulation has occurred to a large extent in the banded gneisses is apparent from the abundance of augen gneisses and from the evidence of strain and fragmentation seen in some thin sections. Recrystallization has followed granulation in many cases, however; for in many rocks which have very evidently suffered granulation, the granular quartz and feldspar which surround the lens of the augen contain a large proportion of microcline and are much fresher in appearance than the central core.

Folding and Faulting. The study of the structure of the banded gneisses indicates that they have been folded in a manner very similar to that exhibited by deformed sedimentary rocks. Though the bands are not continuous over wide areas like sedimentary beds, yet all the various types of folds are present on a small scale and, in places, anticlines and synclines, nearly a half-mile in cross section, can be recognized. These folds are generally pitching and, since the strike of the bands is dominantly in a southwesterly direction, it is inferred that the banded gneiss has been folded into pitching anticlines and synclines having a southwesterly trend. In some places the biotite has been smeared out along the contacts of the bands, giving a slickensided appearance which has, evidently, resulted from differential movements accompanying the folding.

On the whole, faulting has been subordinate to folding in the gneisses, but faults of both the overthrust and normal types are present. The pegmatite and aplite dykes which are transverse to the banding of the gneiss have been very commonly intruded along fault planes, for the bands on opposite sides of many of the dykes have been relatively displaced.

HURONIAN.

Cobalt Series.

GENERAL STATEMENT.

The second great division of the Pre-Cambrian in the Timiskaming region is represented by a group of approximately flat-lying clastic sediments (conglomerate, greywacke, argillite, arkose, and quartzite) which, as far as has been determined, are in conformable succession and thus constitute a single series. These rocks are not sharply defined members occurring everywhere in the same definite succession, nor are all the members present in every locality. Nevertheless, as shown in the following table, in those localities where the most complete sections of the series are present, there is commonly a basal and upper conglomerate with greywacke or argillite and arkose or quartzite as intermediate members.

Sections of Cobalt Series.

Locality.	Rock member.	Thickness feet.	Contact	Basal Complex.
Kekeko hills	Cross-bedded, pebbly arkose and conglomerate	550	Not exposed	Pontiac schist
	?............	150		
	Conglomerate..........	50+		
		750+		
North end lake Opasatika	Arkose................	220	Gradational	Pontiac schist
	Conglomerate..........	80		
		300		
Swinging hills	Arkose................	250	Not exposed	Abitibi volcanics
	?	365		
	Conglomerate..........	70		
		685		
Mount Shiminis	Pebbly greywacke	90	Not exposed	Pontiac schists
	Arkose................	150		
	Greywacke and argillite..	250		
	?	?		
		490+		
Labyrinth hills	Coarse conglomerate....	65	Not exposed	Abitibi volcanics
	Arkose................	165		
	?	175		
		405		
Lavallee bay, lake Timiskaming	Arkose...	?	Not exposed	?
	Greywacke and argillite	?		
	Conglomerate..........	?		
		350		
Little river, east shore lake Timiskaming	Arkose................	?	Not exposed	?
	Greywacke............	?		
	Conglomerate..........	?		
Baie des Pères, lake Timiskaming	Quartzite containing pebbles of jasper and quartz..............	?	Gradational	Granite
	Arkose................	?		
	Conglomerate..........	?		
Joanne bay, lake Timiskaming	Quartzite containing pebbles of jasper and quartz..............	?	Not exposed	?
	Conglomerate..........	35		
East shore lake Timiskaming, north of Wright mine	Pebbly quartzite	?	Not exposed	?
	Red argillite and greywacke...............	?		
	Conglomerate..........	30		

LOCALITY.	ROCK MEMBER.	THICKNESS FEET.	CONTACT	BASAL COMPLEX.
West shore of Antler lake	Coarse conglomerate Argillite ?	? ? ?	Not exposed	?
		75		
Lot 40, range IV, Duhamel tp.	Pebbly quartzite Arkose Conglomerate	? ? ?	Gradational	Granite
		250		

In the preceding table it may be observed: that in every locality where the base of the series is exposed, the basal beds consist of coarse unsorted conglomerate; that in most localities the basal conglomerate is overlain by greywacke or argillite followed by arkose or quartzite, or the greywacke and argillite are absent and the arkose or quartzite rests directly on the conglomerate; and that in several localities the arkose-quartzite member is overlain by an upper conglomerate. There are, however, some apparent variations from the usual succession as well as striking changes in the character of the different members in different localities. Thus the Kekeko hills, in the whole of their upper parts are composed of rudely sorted arkose and conglomerate; and, though uniformly stratified greywacke and arkose occur in the vicinity of the base of the hills, these members were not seen in the hills proper and may be entirely absent. If this is the case then the whole Kekeko ridge, 750 feet in height, might be regarded as simply an upward continuation of the basal conglomerate. Another example of a variation from the usual succession of the members occurs in the Antler Lake section where the upper conglomerate rests on argillite, the arkose-quartzite member being absent. The marked variations which occur in the character of the same member even in adjoining localities is illustrated by the upper conglomerate which occurs at the top of the Labyrinth hills and Mount Shiminis. In the first of these localities the conglomerate is an exceedingly coarse variety containing boulders up to 2 feet in diameter; that on mount Shiminis, on the other hand, is a fine-grained greywacke in which small pebbles are disseminated. In the region adjoining the east side of lake Timiskaming, the Huronian is represented by great ridges of pebbly quartzite which differs from the arkose-quartzite members of the Cobalt series found elsewhere in its more highly sorted character and in the pebbles of quartz and jasper which it contains. As far as could be determined, this rock apparently occupies the same stratigraphic position as the arkose member of the Cobalt series, resting on greywacke or argillite in places and in other localities passing gradually downward into arkose-conglomerate developed in situ on the surface of the basal complex. In the region to the west of lake Timiskaming, however, a similar pebbly quartzite (Lorrain) has been found which apparently overlies the upper conglomerate of the Cobalt series. For this reason the pebbly quartzite which is typically developed in the vicinity of Ville Marie on the east shore of lake Timiskaming is described in the section on the lithological character of the Cobalt series as a separate possible fifth member—the Ville Marie quartzite.

DISTRIBUTION.

The Cobalt series occurs extensively in Timiskaming county in three principal areas, namely, in the district east of the north end of lake Timiskaming, in the series of hills occurring adjacent to the inter-provincial boundary near the north end of lake Opasatika, and along the St. Lawrence-Hudson Bay divide, north of Bellefeuille and Dufresnoy lakes. In the first of these localities, the Cobalt series occurs as scattered knobs, ridges, and small outcrops extending along the east side of lake Timiskaming from the outlet of Rivière des Quinze at the north end of the lake southward to beyond Lavallee creek, a distance of about 30 miles. Most of these occurrences lie within 5 miles of lake Timiskaming, but extensive areas in Laverlochère township and numerous smaller outcrops occur up to points 15 miles eastward of the lake; so that the total area throughout which the Huronian occurs on the east side of lake Timiskaming is approximately 450 square miles. The second area of Huronian constitutes the group of elevations described as the Boundary hills in the chapter on the physiography of the district. These include mount Shiminis, Labyrinth hills, Swinging hills, and Kekeko ridge, the total area underlain by Huronian in the district being approximately 80 square miles. The third and most northerly area of Huronian, that lying north of Bellefeuille and Defresnoy lakes, has not been studied in detail and the full extent of the occurrence is unknown; it probably covers a large area, for numerous erratics of conglomerate, some of which are 30 feet in diameter, were observed throughout the country to the southward. Unlike the southern areas, the Huronian is represented in this locality solely by conglomerate which forms very low hills of no topographic prominence.

LITHOLOGICAL CHARACTER.

Basal Conglomerate.

The lowermost member of the Cobalt series, the basal conglomerate, is a massive compact rock with the two common characteristics, namely: it is everywhere exceedingly heterogeneous and, in most localities, is wholly unsorted, stratification being entirely absent or indicated merely by a partial alignment of its pebbles and boulders. If classified according to the character of the matrix the basal conglomerate would fall naturally into two groups: a greywacke conglomerate in which the matrix is composed of greywacke and an arkose variety in which the pebbles and boulders are enclosed in arkose. Of these two varieties, the latter is much more common in Timiskaming county, although the greywacke conglomerate is also extensively developed in some localities notably along the east shore of lake Timiskaming. It was to this rock that the name chlorite slate conglomerate was applied by Sir William Logan in 1847.

The pebbles and boulders of the conglomerate include every variety of rock to be found in the basement complex; and so intimately have these been intermingled, that very commonly the larger part of the rocks represented in the basement complex can be identified in a single outcrop. In those basal beds of the conglomerate which have been formed in situ from the underlying basement, the pebbles and boulders are all from the Pre-Huronian complex directly below, but, on passing upward above these basal beds, there is generally a gradual addition of foreign material until the local conglomerate is entirely replaced by the typical heterogeneous variety. There is a local exception to this succession in the district east of lake Timiskaming, however; for, in the vicinity of Baie des Pères and in the adjoining portions of Duhamel township, there is an arkose-conglomerate developed in situ from the underlying granite which passes upward through arkose into the Ville Marie pebbly quartzite. Of the rocks represented in the pebbles and boulders of the conglomerate, granite is on the whole the most abundant, occurring everywhere, and in places at points several miles from the nearest occurrence of this rock in the underlying complex. Fragments of the various volcanics of the Abitibi group are also generally present. In places, pebbles of quartz and jasper are abundant, the latter being especially conspicuous because of its bright red colour. Material derived from the Pontiac series was observed to be common in the Boundary hills, but elsewhere is not abundant. As might be inferred from the coarsely clastic and unassorted character of the basal conglomerate, the pebbles and boulders are not well rounded, angular to subangular and faceted forms being most common. In one locality, in the Kekeko hills at the north end of Kekeko lake, some of the pebbles of the conglomerate were found to have striated faces.[1]

The heterogeneity which characterizes the pebbles and boulders of the conglomerate is even more in evidence in the matrix which encloses

[1] "Kewagama Lake map-area, Quebec," Geol. Surv., Can., Mem. 39, Plate I.

the pebbles and boulders. In places the pebbles and boulders are closely compacted together and cementing material is almost entirely absent; in other localities, the matrix constitutes the larger part of the rock and the pebbles and boulders occur as sparsely disseminated inclusions. In texture, the matrix ranges from a coarse gravel to fine mud and in composition, from arkose to argillite. Under the microscope, the matrix is seen to consist of varying proportions of quartz, feldspar, and rock fragments enclosed in a groundmass of chlorite usually accompanied by pyrite, epidote, and calcite. In the coarse phase of the matrix the quartz, feldspar, and rock fragments predominate and in the argillite the chlorite becomes the most abundant constituent.

Greywacke and Argillite.

The basal conglomerate of the Cobalt series very commonly passes gradationally upward, by the loss of its pebbles and boulders, into greywacke or argillite. Of these rocks, the greywacke was originally a ferromagnesian sand and the argillite a ferromagnesian mud, but both have long since become firmly cemented into hard resistant rocks. The cemented mud rock has been generally described as a slate in descriptions of the geology of the Timiskaming region; since the rock possesses no slaty cleavage, however, it cannot be properly described as slate and on this account the name argillite has been substituted by the writer.[1] Like all the other members of the Cobalt series the greywacke and argillite vary greatly, here and there containing beds of arkose, quartzite, or conglomerate, and in some localities single isolated boulders. They are characteristicallv grey to green in colour and are generally uniformly bedded, although in a few localities stratification appears to be absent. In two outcrops, one on the east shore of lake Timiskaming, north of the Wright mine, and the other near Lavallee creek on lot 21, range III, Fabre township, greywacke stained red with iron oxide was seen. In thin section under the microscope the greywacke is seen to consist of fragments of quartz, feldspar, basalt, andesite, and other ferromagnesian rocks along with an abundance of chlorite. The argillite is much finer-grained than the greywacke consisting of exceedingly minute fragments of quartz and feldspar embedded in a chloritic cement. Small quantities of sericite, epidote, and carbonate are also commonly present in all of these rocks.

Arkose.

The greywacke and argillite are generally replaced on passing upward by arkose, the transition taking place either by a gradual increase

[1] Idem., p. 82.

in the feldspar and quartz content or by an alternation of beds of the two rocks. This member is a stratified, firmly cemented feldspathic sand which, when examined microscopically, is found to consist of rounded, angular, or subangular fragments of quartz and feldspar with small quantities of calcite, sericite, epidote, and pyrite. In places, as in the arkose occurring along the east shore of lake Timiskaming, ripple-marks can be seen on the surface of the arkose beds.

Upper Conglomerate.

Where an upper conglomerate was seen overlying the greywacke-argillite or arkose members of the Cobalt series, it was found to differ in no respect from the basal member of the series, exhibiting the same heterogeneity, in the variety, size, and angularity of its pebbles and boulders and in the composition and texture of its matrix.

Ville Marie Quartzite.

In portions of the region east of Lake Timiskaming and notably in the vicinity of the village of Ville Marie, a quartzite occurs consisting of well-rounded grains of quartz and minute flakes of green sericite. As has been previously explained, this rock is lithologically similar to a quartzite found in other parts of Timiskaming region occupying a stratigraphical position above the other members of the Cobalt series. On this account it is here separately described as the Ville Marie quartzite.

RELATIONSHIPS OF THE COBALT SERIES TO THE BASEMENT COMPLEX.

It was explained in the discussion of the physiographic history of Timiskaming county, that the Cobalt series was laid down at the termination of a prolonged period of denudation during which the crumpled and metamorphosed rocks of the older complex were worn down to base level; so that the pre-Huronian surface must be regarded as a buried peneplain or palæoplain. At those points in Timiskaming county where the basal conglomerate can be seen resting on the older basement, the contacts are of two strikingly different types; in one, the line of contact is exceedingly well defined, and, in the other, the basal conglomerate passes gradually downward into unbroken rock, no definite line of junction being visible.

Contacts of the first type can be seen on the east shore of lake Timiskaming in lot 18, range I, Fabre township, at a point about one mile south of Kennedy lake, in Dufay township, on the east side of the large island of Dufay (Rest) lake, and on the south shore of Dufay lake. In the lake Timiskaming locality the conglomerate rests on granite with an irregular but definite contact, the conglomerate filling in the inequalities of the granite surface. Where the contact is exposed on the island in Dufay lake the conglomerate lies on a flat surface of Pontiac schist into which dykes of granite have been injected parallel to the schistosity. In both the other localities the conglomerate rests on smoothly eroded granite, the surface exposed on the south shore of Dufay lake having a slope towards the north.

Contacts of the transitional variety were seen in numerous localities: on the shore of lake Timiskaming at Ville Marie, and opposite Drunken island, at several points in Laverlochère township, on lot 5, range IX, Guigues township, in the northern part of range IV, Duhamel township, at the north end of lake Opasatika, on the south shore of Nissaki lake, and at the northwest end of Renauld lake.

The contact between the Huronian and the older granites exposed on the east shore of lake Timiskaming at Baie des Pères exhibits the transitional relationship in a most interesting manner.[1] The first stage in the transition observed is a gradual change in the colour of the underlying granite from pink to pale green—a transformation which is seen under the microscope to be due to the alteration of the feldspar of the granite to sericite. Above this zone of sericitized granite, masses in which the sericitization has been less intense are indicated by faint differences in colour on the weathered surface. These differences become more and more evident at points more remote from the contact until the transition to typical conglomerate with an arkose matrix is complete. Accompanying the change in colour of the rocks there is a gradual increase in evidences of mechanical disintegration and sorting, the arkose-conglomerate finally giving place to arkose and the arkose to pebbly quartzite. In the northern part of range IV, Duhamel township, a similar degradation of the granite surface is shown in a section 200 feet in thickness, consisting of boulders and fragments of granite enclosed in an arkose matrix. In this locality the feldspar of the underlying rock is white in colour, and has not undergone decomposition to sericite to such an extent as that on the lake shore; in consequence, there is so little contrast between the two rocks that the line of junction cannot be fixed within wide limits. The slight mechanical action to which the disintegrated feldspar and quartz have been subjected also makes it exceedingly difficult to distinguish the matrix from the enclosed fragmental masses. Junctions between granite and conglomerate of a transitional type were observed in two other localities in the region, namely, on the shore of lake Timiskaming opposite Drunken island, and at the east end of lot 30, range I, Laverlochère. In the first locality, the granite surface is merely covered by a thin layer of arkose which is followed by

[1] Barlow, A. E., Geol. Surv., Can., Ann. Rept., vol. X, pt. S, 1897, p. 193.

conglomerate containing the usual assortment of pebbles, the whole being enclosed in a red coloured matrix. In the second locality, the rocks are associated in the usual transitional way, the base of the conglomerate consisting of closely compacted pebbles and boulders of the underlying granite porphyry. Since this porphyritic variation in the underlying granite of the basement complex is exceedingly limited in extent, the local origin of the conglomerate is evident. On the point which occurs at the south end of Cameron lake, in Laverlochère township, a small area of conglomerate occurs overlying quartz-porphyry. Pebbles and boulders of the latter are enclosed in a matrix which, in places, can scarcely be distinguished from the included fragments, the whole of the conglomerate having evidently been formed by the disintegration of the rock surface beneath. A very similar association of the two rocks occurs on lot 5, range IX, Guigues township. Here, as on Cameron lake, the base of the conglomerate consists wholly of debris derived from the porphyry; but, on proceeding farther away from the eruptive, fragments of other rock appear, the pebbles and boulders also become better defined and less angular, and the coarse, dark-green cementing material becomes finer-grained and more uniform.

Contacts in which the transitional relationship between conglomerate and the Pontiac series occurred were seen only at the north end of lake Opasatika and on Nissaki lake. In both of these localities there is the usual disintegrated surface with the gradual addition of foreign pebbles and boulders, the transition taking place in an interval of a few feet.

The transitional contact between the basal conglomerate and andesite exposed along the northwest shore of Renauld lake, is the sole point in the whole area in which the conlomerate was observed to overlie the typical ellipsoidal greenstones of the Abitibi volcanic complex.

FOLDING.

Since the conglomerate members of the Cobalt series are generally unstratified and are nowhere uniformly bedded, the structure of the series can be determined only from the strikes and dips of the greywacke, argillite, arkose, and quartzite. From such determinations, however, it is evident that the series has been only very gently folded, the dips usually not exceeding 20 degrees. The prevailing dips indicate that on the whole the folding has been most pronounced in a southwesterly direction.

ORIGIN OF THE COBALT SERIES.

The mode of origin of the various members of the Cobalt series is discussed at length in Chapter VI as well as in previous reports on the district. It may, therefore, be merely stated here that there is much evidence indicating that the whole series is closely related in origin to continental glacial conditions, the conglomerate members having the characteristics of glacial till sheets.

Post-Cobalt Series Intrusives.

INTRODUCTORY STATEMENT.

With the exception of the areas of diabase occurring in Fabre township on the east side of lake Timiskaming, there are no extensive occurrences of post-Cobalt series intrusives in Timiskaming county, although numerous small masses and dykes occur throughout the whole region. Lithologically the post-Cobalt series intrusives include three rock types: diabase, olivine diabase, and syenite porphyry. The first two are common, but the syenite porphyry is found in only one locality.

DIABASE.

Distribution.

The occurrences of diabase in Timiskaming county are too numerous for separate description so that only the most important areas geologically examined are here described.

In the district east of lake Timiskaming, the principal areas of diabase are to be found in the township of Fabre. These, while not all connected at present, were, without doubt, originally portions of a single sheet injected into the Cobalt series near its contact with the underlying basement complex. In addition to the Fabre areas of diabase, several dykes of diabase were noted in the townships east of lake Timiskaming, one northeast of Otter lake in range XII of Laverlochère and the others in the vicinity of Lac des Quinze.

In that portion of the region east of lake Abitibi, seventeen occurrences of the olivine free variety of diabase were seen[1] and in the district adjoining Kewagama, La Motte, and De Montigny lakes in the eastern part of the same region, several other occurrences were encountered by J. A. Bancroft. There are no large masses or dykes in this territory, however, the most extensive being a dyke 400 feet in width and several miles in length which parallels the western margin of the peninsula lying between Kewagama and Poirier lakes.[2]

In the eastern part of Timiskaming county, along Bell river, a number of occurrences of diabase were seen, the longest dyke being that outcropping at intervals along the west shore of Shabogama lake. In the southeastern part of the county along the canoe route from lake

[1] Geol. Surv., Can., Map 93A, 1913.

[2] "Min. oper. in the prov. of Quebec," 1911, p. 181.

Kipawa to the headwaters of Bell river, only a single outcrop of diabase was seen. This occurred as a small mass on the point of the peninsula projecting into Grand lake Victoria between its southwest and southeast bays. The absence of diabase in this territory would seem to indicate that the intrusions of diabase were less common throughout the belt of banded gneisses.

Lithological Character.

The olivine free, or quartz diabase as it is commonly designated through Timiskaming county, is a rock of remarkably uniform composition although somewhat variable in texture and colour according to the conditions under which the rock solidified. In the smaller dykes and along the margins of the larger intrusives the rock is generally black and aphanitic; elsewhere it is generally dark green or grey green or, in a few localities, red in colour. The ophitic texture is usually present and can be generally recognized even in the hand specimen. A porphyritic texture was seen in a single locality, namely, in a mass of diabase outcropping along the National Transcontinental railway on lot 51, range II, La Reine township, where phenocrysts of plagioclase about three-fourths of an inch in length were present.

The microscopic examination of this variety of diabase shows it to consist of laths of labradorite, the interspaces between which are filled with augite, ilmenite, and, in some sections, micropegmatitic intergrowths of quartz and feldspar. The presence of the micropegmatite, like the texture of the rock, is related to the speed of solidification; for it is entirely absent in the fine-grained aphanitic diabase which occurs in the smaller dykes and on the margin of the larger intrusions, and becomes more abundant as the size of the intrusive mass and the coarseness of grain increase. Apatite is also a usual original constituent of the rock and occurs as rod-like crystals disseminated through the other minerals. As a rule, the diabase is more or less altered, the secondary minerals being calcite, epidote, zoisite, sericite, hornblende, and chlorite.

OLIVINE DIABASE.

Distribution.

Although the olivine diabase is not so common in the region as the quartz-bearing variety, it is equally well distributed and forms some of the largest dykes encountered in the whole country. Of these, the most important are the dyke crossing the north end of Blueberry island in lake Kipawa, the dyke projecting into lake Opasatika at its north end, and that traversing the Indian peninsula in lake Kewagama along its eastern margin.

Lithological Character.

Macroscopically the olivine diabase differs very little in appearance from the quartz variety. It is generally fresher and in the Blueberry Island dyke in lake Kipawa contains phenocrysts of dark labradorite up to one inch in length. Microscopically, the olivine diabase is seen to consist of olivine and labradorite enclosed in augite. The olivine generally has a rounded outline when it comes in contact with the augite and in some parts of the section has the same relationship to the plagioclase, but is more commonly cut off sharply by the feldspar laths. A dark brown mica is usually present in the olivine diabase and in some sections is associated with the ilmenite. The accessory constituents of the olivine diabase are similar to those of the ordinary type, but the secondary minerals were entirely absent in all the sections examined, the rock having suffered practically no mineralogical alterations.

STRUCTURAL RELATIONS OF THE QUARTZ AND OLIVINE DIABASE.

With the exception of the areas of diabase in Fabre towsnhip, which are probably remnants of a sill,[1] all the diabase in the region occurs as dykes having vertical or nearly vertical attitudes, or as small isolated bosses. It is possible that some of these isolated masses are also remnants of sills, although the only evidence for this conclusion is their lack of linearity. Wherever the contacts of the dykes with the country rock were observed, the junction was sharp (Plate XI), the effect on the country rock was apparently unimportant, and the dyke itself suffered no apparent change other than the change to a finer texture as the margin was approached. In the dykes occurring in the vicinity of Kewagama lake, however, inclusions of granite were found by J. A. Bancroft along the margin of a dyke. In places also impregnations of pyrite, arsenopyrite, and copper pyrite were seen along the margin and in the wall rock of the dykes.[2] With regard to the relationship of the olivine diabase to the olivine free variety, no positive evidence was found other than the fact that the olivine variety is the fresher of the two rocks. In the region west of Lake Timiskaming, however, dykes of the olivine diabase have been found to penetrate the sills of the quartz diabase.

ORIGIN OF DIABASE.

The mode of origin of the quartz and olivine diabase has already been implied in previous sections of the report, but may be here briefly restated. Both varieties of diabase are believed to have been derived

[1] Harvie, R., "Geology of a portion of Fabre township, Pontiac county," Dept. of Colonisation, Mines, and Fisheries, Quebec, 1911, p. 22.

[2] "Min. oper. in the prov. of Quebec," 1911, p. 179.

from a continuous mass of basic magma which underlay a large part of the Canadian shield in late Pre-Cambrian (Keweenawan) time. It is also believed that differentiation took place in this magma, as a result of which acid and basic types of diabase were intruded, the basic, olivine variety being developed last. In the small dykes and on the margins of the intrusions where the rock cooled rapidly, the aphanitic texture was formed; but in the centres of the larger masses, where solidification was slow, ophitic structure and micropegmatite were developed.

SYENITE PORPHYRY.

Distribution.

Between Ollier and Renauld lakes to the northeast of lake Opasatika, the Cobalt series is intruded by a mass of syenite porphyry, about one-fourth of a mile wide and half a mile or more long. This intrusion is apparently unique, for this rock was not observed anywhere else in the region.

Lithological Character.

The syenite porphyry is a massive rock consisting of large phenocrysts of feldspar an inch or more in length embedded in a pink to grey matrix in which chalcopyrite is abundantly disseminated. The rock maintains the same character throughout the whole mass even up to within a few inches of its contact.

It was found on examining the syenite porphyry under the microscope that it consisted of phenocrysts of albite enclosed in a granular groundmass of feldspar and quartz, with sphene, chlorite, carbonate, epidote, and chalcopyrite as accessory constituents. The plagioclases contain an abundance of inclusions of sericite and epidote which have resulted from their alteration. The outline of the chlorite is such as to suggest that this mineral has been derived from biotite, but no trace of the original mineral could be found.

Structural Relations and Correlation.

The syenite porphyry forms a rock mass of oblong shape having somewhat irregular but vertical walls. As the diabase is the only other intrusive in the region known to cut the Cobalt series, and since the syenite is similar in composition to the aplitic differentiates which are associated with the diabase in other parts of the Timiskaming region, it may be possible that this mass is also a differentiate from the diabase.

The junction of the syenite porphyry and the basal conglomerate of the Cobalt series shows distinct evidences of the contact effects of the intrusive. On the north side of the syenite porphyry mass, the conglomerate is mashed in the vicinity of the contact and on the south is traversed by innumerable joints, both of these effects being clearly due to the contact action of the porphyry.

PALÆOZOIC.

ORDOVICIAN AND SILURIAN.

The outliers of Palæozoic sediments which occur at the north end of lake Timiskaming are of exceptional interest to geologists because of their isolated position, nearly 100 miles farther north than any other known occurrences of Palæozoic sediments in the Ottawa basin. They were first described by Sir William Logan in the Report of Progress of the Geological Survey for 1845 and more fully in the Geology of Canada, published in 1863. The names of thirteen species collected from the outliers and identified by Mr. E. Billings are mentioned in the latter publication. Additional collections of fossils made by Robert Bell in 1887, and by A. E. Barlow in 1892-4, were identified by H. M. Ami and L. M. Lambe. From the determination of these fossils Ami concluded that the outliers belonged to the Clinton or Niagara formations, the species being for the most part referable to the Niagara, although a number present belonged to rocks generally assigned to the Clinton. In the autumn of 1914, however, M. Y. Williams visited the district and discovered that dolomite containing Black River fossils occurred in the district north and west of Haileybury on the Ontario side of the lake, and that fossils belonging to both the Niagara and the Trenton formations were present on Chief island.

The areas of Palæozoic sediments which occur on the Quebec side of the interprovincial boundary are limited to Chief, Mann, Oster, Brisseau, and Bryson islands in lake Timiskaming and a number of small scattered remnants which, with the exception of a single outcrop in range II of Guigues township, lie along the east shore of the lake. The outcrops of Palæozoic rocks on Chief island occur as scattered patches of limestone and conglomerate with a calcareous matrix resting on the irregular surface of the quartzite member of the Cobalt series. A number of fossils representing the lower portion of the Niagara formation were obtained from these by Barlow and in one small remnant both Niagara and lower Trenton fossils were found by Williams. The conditions which have brought about these peculiar relationships have not yet been determined.[1] On Mann, Oster, Brisseau, and the north shore of Bryson island there is a light yellow almost flat-lying limestone which, like the larger part of that on Chief island, contains lower Niagaran fossils, over forty species belonging to this horizon having been found

[1] Geol. Surv., Can., Mus., Bull. No. 17, 1915.

on Mann island. On the east shore of lake Timiskaming, the Palæozoic occurs merely as basal remnants fringing the margin of the lake. Thus, on the shore directly east of Bryson island, on the north side of Joanne bay, and on the shore of the bay north of the Wright mine, small areas of an arenaceous well-bedded limestone occur dipping 5 to 10 degrees to the southwest. The shore of the lake between Piché point and Chief island is also bordered by a fringe of conglomerate and calcareous sandstone in which the wave action of the lake has formed a terrace about 3 feet in height. The rock exposed between this terrace and the water of the lake at its lowest stage consists of fragments and hummocks of the Huronian quartzite enclosed in a calcareous matrix in which are fragmental fossiliferous remains. In the district inland from the eastern shore of lake Timiskaming only a single outcrop of the Palæozoic sediments was seen. This was found at the east end of lot 19, range II, Guigues township, and consists of a small knob of calcareous sandstone 10 feet in thickness and dipping approximately 5 degrees southwesterly.

PLEISTOCENE.

GLACIAL.

The bedrock surface throughout the whole of Timiskaming county is more or less hidden from view by a thin mantle of boulders, gravel, sand, and boulder clay—debris laid down from the Labradorean continental glacier. In the clay belt portion of the region, owing to the presence of the overlying lacustrine clay, the glacial drift is almost entirely hidden from view, except on the shores of lakes, or where it is intersected by streams which have cut their way through the Pleistocene deposits to bedrock, or where it has been exposed by excavations along the National Transcontinental railway. In the rocky upland districts, however, it is hidden merely by the vegetable cover and its character can be more easily determined. The glacial materials are genetically of two types; those which are unstratified and are, therefore, believed to have been deposited from the glacier directly, and those which are stratified and on this account are believed to have been deposited from the glacier indirectly by the action of water. The deposits of the unassorted type occur scattered irregularly over the surface of the older bedrocks or in moraines. These are composed for the most part of the coarse varieties of glacial debris, not a single occurrence of boulder clay being seen in any of the cuts along the National Transcontinental railway. Boulders are scattered everywhere throughout the region, but are more conspicuous in the upland areas from which the finer-grained material has been swept away. The gravelly type of moraine is the most common unassorted glacial deposit in the region, two of the largest forming barriers across the Timiskaming trench, at the narrows and at the Long Sault rapids. Boulder clay was not observed in many localities, but was noted at the north end of the Height of Land portage from Ogami to Summit lakes, at a number of points on the shores of Duparquet and Lois lakes, at the north end of Brennan lake, and at Young's farm on Wolf lake.

The fluvioglacial deposits of the region (Plate XII) are found in elliptical-shaped hills (kames), or spread out broadly over a wide area (outwash plains), or in long serpentine ridges (eskers). One of the best examples of a kame seen in the region, is the elliptical-shaped mass with an esker-like prolongation at its southern end, intersected by the National Transcontinental railway, west of the crossing of La Sarre (Whitefish) river. A typical example of the widespread type of fluvioglacial deposits, the outwash plain, occurs in the central part of Trécesson township. The best illustration of an esker observed extends along the west shore of the southern bay of Trout lake—one of the principal lakes on the canoe route from lake Kipawa to Grand lake Victoria. There are also some isolated masses of gravel and sand in this district which are probably kames.

LACUSTRINE CLAY, SILT, AND SAND.

Distribution.

Throughout the northern part of Timiskaming county, the glacial and fluvioglacial deposits are overlain by stratified clay and sand which have filled in the minor inequalities of the drift surface, thereby forming local plains. These deposits (Figure 6) lie approximately north of a line drawn from the north end of lake Timiskaming to the north end of Grand lake Victoria. They are not continuous throughout the whole of the northern part of the county, however, for numerous knobs and ridges of bedrock as well as areas of glacial drift project through the clay silt and sand, so that the latter in reality occur only in the lower depressions of the region.

Character.

These stratified materials consist for the most part of alternating beds of clay and silt or clay and sand, the beds ranging in thickness from half an inch to 3 inches (Plates I, XIV, XV). In a few localities (chiefly in the vicinity of deposits of glacial drift) the stratified clay and silt is overlain by sand. This sand is nowhere of great extent, however, and is generally not more than 4 or 5 feet in thickness. The bedding of the deposits near their contact with the underlying drift, or Pre-Cambrian rock surface, parallels the slope of the surface upon which they were deposited; but these undulations, for the most part, disappear within a few feet, the overlying beds assuming the flat-lying attitude which gives the surface of the clay belt its characteristic plain-like appearance.[1] The total thickness of the deposits nowhere was observed to exceed 25 feet.

Origin.

The origin and character of the stratified post-Glacial deposits of the clay belt are discussed at greater length in Chapter VI, so that it may merely be stated here that it is believed that they were laid down from a large post-Glacial lake which covered the northern part of Ontario and Quebec following the withdrawal of the last Labradorean ice sheet. For this body of water the name lake Barlow is proposed.

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[1]Geol. Surv., Can., Mem. 39, Plate XXV.

CHAPTER VI.

SPECIAL PROBLEMS OF TIMISKAMING REGION.

GENERAL STATEMENT.

In this report, as stated in the introductory section of Chapter I, an attempt has been made as far as possible to separate those sections which are largely theoretical from those which are either largely descriptive or include only those theoretical assumptions which are generally accepted by geologists the world over; and, in accordance with this arrangement, the theoretical geological problems presented by the Timiskaming region (with the exception of those having reference to the physiography and nomenclature discussed in Chapters II and IV) have been included in this chapter. Many of these problems, however, have been discussed at some length in former reports on the region and in such cases merely an outline of the previous discussion is included.

PILLOW STRUCTURE.

Among the structural features exhibited by the ancient volcanics which form the dominant part of the Pre-Cambrian basal complex in the Timiskaming region, one of the most common and interesting is the ellipsoidal or pillow structure, a form formerly supposed to be uncommon but now known to occur in volcanic rocks in all parts of the world, and especially in those volcanics whose geological relationships indicate that they were extruded under water. The structure is of special interest in the Pre-Cambrian volcanics of Timiskaming region, because it can be used in places to determine the upper and lower side of a lava flow and thus aid in working out the complex geological structure of these ancient lavas.

Character.

The pillow structure, as it occurs in the volcanics of the Timiskaming region, consists of round to pillow-shaped, more or less irregular masses of basalt or basic andesite ranging from a few inches to 5 or 6 feet in diameter. Very commonly these masses are finer-grained along their margin than in the interior and in a few localities are amygdaloidal along the margin of the ellipsoids. Between the pillows there are generally numerous triangular spaces which have been filled in with carbonate, quartz, or, in some cases, with fine aphanitic material which has been so much altered that its original character cannot be determined. This might be volcanic ejectmenta deposited between the ellipsoids or merely fine lava. As a result of differential weathering the forms of the pillows are much more sharply outlined on the exposed surface than in the interior of the flows, the interstitial material weathering out entirely or assuming a rusty colour strikingly different in appearance to the masses enclosed.

The pillows of the lava are not perfect ellipsoids or spheroids but irregular in form, the surface of each pillow having apparently adjusted its shape to fit the irregularities of the pillows upon which it was laid down. In places, the pillows can be seen to be flattened on one side so that a bun-like form is produced.[1] This flattening has been observed by numerous geologists in more recent pillow lavas and in every case is stated to occur on the under side.[2] This feature is, therefore, of assistance in working out the structure of the Abitibi volcanics, since, where the bun-shaped pillows are present, the upper and lower sides of the lava flow at that particular point, can be determined. Thus in Plate XI of Memoir 39 the lava flow has a vertical attitude and the top of the flow is on the right.

Origin.

The numerous hypotheses suggested in geological literature to account for the development of the pillow, ellipsoidal, or spheroidal structure in igneous rocks would seem to indicate that the mode of origin of this feature presented an exceedingly difficult geological problem. It is probable, however, that the multiplicity of these hypotheses has arisen, in part, because the terms pillow, ellipsoidal, and spheroidal structure have been applied to wholly different phenomena. Thus, in the Buckingham district, Quebec, recently studied by the writer, ellipsoidal structure remarkably similar to the typical pillow structure was seen in intrusive gabbro; and the so-called leopard rock, found in pegmatite in the same region, is likewise remarkably similar to pillow structure on a small scale. In both of these cases ellipsoidal forms have been developed in intrusive rocks as a result of deformation. It is probable also that jointage, concentric structure, and other forms found in intrusive and extrusive rocks have been frequently described as ellipsoidal or spheroidal structure, and thus confused with pillow structure. In discussing the origin of the pillow structure it may be stated, therefore, at the outset, that the structure under consideration is a flow phenomenon characteristically developed in extrusive lavas only.

In Memoir 39 it was concluded that the ellipsoidal or pillow structure originated in a manner similar to that of the pahoehoe lavas of the Hawaiian volcanoes, that is by the successive ejection of lava under

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[1] Geol. Surv., Can., Mem. 39, 1913, Plate XI.

[2] Daly, R. A., Am. Geol., vol. 33, 1902, pp. 65-78.
Ransome, F. L., Bull. Dept. of Geol., Univ. of Cal., 1893, pp. 75-85.
Russell, I. C., U.S. Geol. Surv., Bull. 199, 1902, p. 113.

pressure through fractures along the margin of major lava flows, but that "whereas under subaerial conditions the lava ejected from fractures in the surface of a flow, spreads out into pahoehoe, under subaqueous conditions it would immediately become viscous owing to its contact with water, so that masses of lava would be developed which would stretch out into an ellipsoidal form as they detached themselves at their point of ejection."

Since the publication of the above memoir, several papers,[1] in which the origin of pillow structure is discussed, have appeared, among them an exhaustive treatise on the subject by J. Volney Lewis.[2] Lewis concludes that not only does the ellipsoidal structure originate in the same way as the pahoehoe structure but that the two structures are the same and that "neither the presence nor the absence of water *per se*, can be predicted as favourable to the formation of this structure." Lewis' conclusion that extrusion under water is not essential for the development of the pillow structure is largely based on the observations of Green and Day in Hawaii. In some of the photographs of the Hawaiian lavas taken by Day and Shepard the pahoehoe appears to approach very closely to pillow lavas in form but in Dutton's description of pahoehoe, it is stated that "the superficial crust of cooled lava undergoes rupture at numberless points and little rivulets of lava are shot out under pressure. Preserving their liquidity for a short time they spread out very thin and are very quickly cooled forming pahoehoe." Thus according to Dutton[3] the pahoehoe lavas more closely resemble the form taken by overlapping plates or pancakes rather than pillows. The explanation of the apparent difference between the forms described by Dutton and the photographs of Day and Shepard may be that both are pahoehoe forms developed according to the temperature of the lava in different extrusions or during different eruptions.

It is conceivable that under subaerial conditions, if the temperature of a highly fluid type of lava were not too high, small extrusions of lava through fractures might become viscous on the outside. These would retain their fluidity in their interior and thus develop a pillow-like form, but such conditions on the whole would be exceptional. On the other hand, if a lava were extruded, under water or into water, no matter how high the temperature, the heat absorbed in converting the water into steam would almost surely cool the surface of the small ejections of lava quickly, thereby producing an outside viscous meniscus which, filling with fluid lava

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[1] Sundius, N., Foren Forhandl., vol. 34, 1912, pp. 317-332.
Capp, S. R., Jour. of Geol., vol. 23, 1915, pp. 45-51.

[2] Bull. Geol. Soc. Am., vol. 25, 1914, pp. 591-654.

[3] U.S. Geol. Surv., 4th Ann. Rept., 1882-3, p. 96.

from within, would develop a bulbous form. This process would be further aided, both by the pressure of the water tending to force the mass into a spherical form and by the buoyant force of the water reducing the pressure under which the lava would have to be ejected. That lavas heated far above their temperature of solidification do take on the pillow structure when extruded into water is borne out by the observations of Dr. Tempest Anderson in Savii, one of the Samoan islands. The lavas extruded from the volcano of Montavanu in Savii have a temperature so high above their freezing point that they commonly spread out in sheets an inch or less in thickness and the surface is honey-combed with channels along which the lava has flowed; yet, when these flow into the sea, typical pillow structure is developed as described in the following quotation: "Where the lava was flowing in smaller quantity, explosions were much less noticeable, and the lava extended itself into buds or lobes. The process was as follows: an ovoid mass of lava, still in communication with its source of supply and having its surface, though still red hot, reduced to a pasty condition by cooling, would be seen to swell, or crack, into a sort of bud, like a prickly pear on a cactus, and this would rapidly increase in heat, mobility, and size, till it either became a lobe as large as a sack or pillow, like the others, or perhaps stopped short at the size of an Indian club or large florence flask. Sometimes the neck supplying a new lobe would be several feet long and as thick as a man's arm, before it expanded into a full sized lobe; more commonly it would be shorter, so that the freshly formed lobes would be heaped together.........The whole surface seemed to be chilled at once as the waves rolled off and on, and examination of cooled specimens between high and low water mark........confirmed this. The surface at and below the water level was roughly granular like that of air chilled bombs......while higher up the ordinary corded or pahoehoe structure was seen."[1]

In conclusion, it may be pointed out that observations, in numerous localities throughout the world, have shown that pillow lavas, in most of their occurrences, are found in such relationships as to indicate that they have been extended under or into water; and furthermore, in order that the structure may develop under subaerial conditions, it is necessary that the lava be extruded at a definite temperature not far above its freezing point, whereas under subaqueous conditions the lava may be extruded either at this limiting temperature or any temperature above this limiting temperature. Thus it may be inferred both from observational data and from theoretical considerations that the pillow or ellipsoidal structure so commonly observed in lavas throughout the world is

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[1] Quart. Jour. Geol. Soc. Lond., 1910, pp. 631-33.
Geog. Jour., vol. 39, 1912, p. 129.

characteristically developed under subaqueous rather than subaerial conditions of extrusion.

ORIGIN OF FERRUGINOUS DOLOMITE.

General Statement.

In numerous localities throughout Timiskaming region, masses and bands of ferruginous dolomite occur in association with the volcanics of the basal complex which are of interest not only because of their widespread occurrence and peculiar composition but because of the gold-bearing quartz veins which are commonly associated with them. It was formerly supposed that these rocks were normal sedimentary deposits somewhat similar in origin to the deposits of iron carbonate found in association with the iron ores of the Lake Superior region; but the study of the deposits as they occur in Timiskaming region has shown that there is considerable evidence which indicates that a large part, if not all, of these rocks may in reality be replacement deposits. The discussion of this problem contained in the following pages has been divided into two parts: an introductory section in which the lithological character and composition of the rock is described; and a section in which the evidence for and against the two probable modes of origin is presented.

Lithological Character and Composition.

Lithologically, the ferruginous dolomite is a siliceous, impure, iron-magnesian-lime carbonate generally containing an abundance of chromiferous mica to which it owes its bright green colour. Wherever it occurs, the dolomite is traversed by innumerable anastomosing and intersecting quartz veinlets which in places are so numerous that the rock becomes a stock work deposit. In some localities, the veinlets occur in regular intersecting systems so that they outcrop on the surface as a rectangular or rhomboidal network. As a rule, the veinlets terminate abruptly at the margin of the dolomite or at most extend only a few inches into the adjoining greenstone. Owing to the siliceous character of the rock, it is generally more resistant to erosion than the surrounding greenstones and occurs as knobs or ridges, the red colour of its weathered surface making it a conspicuous land mark.

Examined under the microscope, the ferruginous dolomite is seen to consist of carbonate with varying proportions of pyrite, chrome mica, sericite, feldspars, and quartz. Galena and rutile were also present in some thin sections examined. The chrome mica does not occur uniformly distributed through the rock, but in a linear manner which suggests that the mineral may have been introduced into the rock secondarily. In some places the proportion of feldspar and other minerals in the rock is very small, but more commonly (as the analyses indicate) a considerable part of the rock consists of impurities and not more than 50 per cent is carbonate.

Several typical analyses of the ferruginous dolomite as it occurs in the northern part of Timiskaming region are included in the following table.

Analyses of Ferruginous Dolomite.

	1	2	3	4	5	6	7
SiO_2	....	....	....	30·63	36·90	44·00	45·92
Al_2O_3	....	....	....	1·66	7·47	....	9·38
Fe_2O_3	....	....	....	2·78	6·56	....	0·50
FeO	83·4	7·17	3·68	....	3·12	....	5·71
MgO	28·0	3·83	13·70	12·98	18·47	7·45	7·98
CaO	10·53	10·58	27·23	26·02	8·02	7·48	6·78
Na_2O	....	....	....	0·03	0·02	....	3·58
K_2O	....	....	....	0·20	0·16	....	2·22
TiO_2	....	....	....	0·10	0·19	....	0·27
MnO	....	....	....	0·09	trace	0·07	....
CO_2	16·96	17·60	36·18	24·31	17·58	15·10	15·94
H_2O	....	....	....	0·14	1·20	0·24	2·20
S	....	....	....	0·41	0·11	....	....
Boron	....	....	....	trace	strong test	....	....
Insol.	51·82	58·63	11·72	....	....	....	....
Total	....	....	....	99·45	100·06	....	100·48

Nos. 1, 2, and 3, Porcupine district, Ann. Rept., Ont. Bureau of Mines, vol. 20, pt. 2, 1911, p. 13.
No. 4, Reddick claim, Larder lake, Jour. Can. Min. Inst., vol. 14, 1911, pp. 672-689.
No. 5, Night Hawk lake, *idem.*
No. 6, Harris Maxwell claim, Larder lake, idem.
No. 7, Harris Maxwell claim, Larder lake, analysis by M. F. Connor, Mines Branch, Dept. of Mines, Canada.

Origin.

From study of the lithological character, the chemical and mineralogical composition, and the geological relationship of the ferruginous dolomite, it is evident that certain features presented by these deposits point to a sedimentary origin, while others indicate that they have been formed by the action of thermal replacement of certain acidic rocks of the granite and syenite family and especially of those types in which soda feldspar is abundant.

The evidence in favour of the latter conclusion may be briefly summarized as follows:

The chromiferous mica which occurs so abundantly in the dolomite is not usually found in normal sedimentary rocks, but, on the other hand, is common in association with minerals believed to have been deposited from deep seated thermal solutions.

In numerous localities throughout Timiskaming region quartz porphyry, syenite-aplite, and related rocks are found, which have been partially altered to ferruginous dolomite and all stages in the transformation can be observed. In order to obtain more definite information as to the character of this transformation, two specimens of partially altered syenite-aplite collected from the Gold King and Harris-Maxwell claims at Larder lake, Ontario, were analysed by M. F. Connor of the Mines Branch, Department of Mines, with the following results:

Analyses of Ferruginous Dolomite from Larder Lake.

	1	2
SiO_2	52·88	45·92
Al_2O_3	16·29	9·38
Fe_2O_3	2·58	0·50
FeO	3·08	5·71
MgO	3·31	7·98
CaO	5·46	6·78
K_2O	0·87	2·22
Na_2O	8·11	3·58
H_2O-	0·44	2·00
H_2O	0·06	0·20
TiO_2	0·31	0·27
CO_2	7·72	15·94
Total	101·11	100·48
Specific gravity (powdered)	2·78	2·82
" " (massive)	....	2·85

No. 1 consists mainly of albite with a few scattered flakes of biotite, some rhombohedral grains of carbonate, and here and there granular aggregates of magnetite. The rock is thus a syenite aplite containing, according to the chemical analyses, over 68 per cent of albite.

No. 2 consists of carbonate, albite, quartz, colourless and pale green mica, pyrite, and rutile, the latter minerals occurring in zones of granulation. The process of alteration was evidently accompanied by considerable deformation as shown by the undulatory extinction in the feldspar and the presence of granulated zones. A comparison of the mineralogical composition of the two specimens would seem to indicate that the transformation has consisted in a decrease in the proportion of albite, biotite, and magnetite contained in the rock and an increase or entire addition of quartz, ferruginous dolomite, sericite, chrome mica, and pyrite. If it be assumed that the alteration process has not been accompanied by an appreciable change in volume, then the character of the metasomatic action can be determined by a direct comparison of the analyses of the two specimens, the latter of which is much more altered than the former. On making such a comparison it is seen that there has been an abstraction of alumina, ferric iron, and soda and an addition of carbonate of lime, magnesia, iron, potash, and water.

While ferruginous dolomites having different modes of origin might be found in the same district, it is very improbable that this would occur in the case of dolomites containing an uncommon mineral such as chromiferous mica. The presence of chrome mica in a partially replaced syenite aplite would indicate, therefore, that all the chrome mica-bearing ferruginous dolomite originated in a similar manner, by the replacement of syenite aplite or related rocks.

Since the ferruginous dolomite is everywhere traversed by innumerable quartz veinlets it is obvious that the rock must have been exposed to attack by the solutions from which the quartz was deposited. Moreover, the occurrence of tourmaline and related minerals of pegmatitic association in the quartz veins indicates that these solutions were thermal.

In some places the ferruginous dolomite occurs in the form of dykes penetrating and including fragments of the adjoining rock.

The principal evidence indicating that the ferruginous dolomite is possibly of sedimentary origin is as follows:

Cherty iron carbonates of a somewhat similar character are found among the late Pre-Cambrian rocks of the Lake Superior region, which are undoubtedly of sedimentary origin.

In places the ferruginous dolomites occur in association with greywacke, slate, etc., as if it were a normal sediment. Thus in the district north of Larder lake in Ontario, several bands of ferruginous dolomite, up to 600 feet in width, are apparently interstratified with slate and phyllite and maintain a remarkable uniformity in width for several miles.

In conclusion, it may be pointed out that although it is not possible to draw a positive conclusion from the conflicting evidence cited in the previous summary with regard to the mode of origin of the ferruginous dolomite; yet on the whole the balance of evidence at present seems to be most favourable to the hypothesis that these peculiar rocks have originated by thermal replacement of syenite aplite, quartz porphyry, rhyolite, and related rocks.[1]

STRATIGRAPHICAL AND STRUCTURAL RELATIONS OF PRE-CAMBRIAN BASAL COMPLEX.

General Statement.

In several places in this report, it has been pointed out that the Pre-Cambrian basal complex of the Ottawa basin falls naturally into three great southwesterly trending belts or zones, the northern and southern of which consist in the main of surface rocks, while the central belt is largely composed of plutonic banded gneisses. In the sections which follow, the principal stratigraphical and structural relationships of these great basal belts are described and hypotheses suggested to explain these relationships.

Timiskaming Belt.

The most northerly belt of the Pre-Cambrian complex is composed of highly folded and more or less metamorphosed volcanic lavas and clastic sediments which here and there have been intruded by small batholiths of granite or granodiorite. These intruded rock masses, while lithologically similar to the great central belt of banded gneisses, differ from the latter in that they are not generally banded and only partially foliated. Whenever the contact of the batholiths with the adjoining surface rocks has been observed, their intrusive relationships are indicated by the recrystallization which has occurred in the intruded rock near the margin of the intrusive, by the foliated character of the intruded rocks along the contact with the intrusive, by dykes penetrating the rocks adjoining the batholiths, and by the presence of numerous inclusions of the intruded rocks within the batholith.

As regards the relationships of the surface rocks of the Timiskaming belt to one another, little is positively known. In places conglomerate members containing pebbles of granite and volcanic rocks are present and in some localities there is an erosional unconformity between con-

[1] For a more complete discussion of this subject see Mem. 39, pp. 65-70.

glomerate and the volcanics, but whatever structural discordance may have been present originally has been largely obscured by deformation. As indicated in the chapter on correlation, the belt of sediments composing the Pontiac series extends almost continuously for 100 miles along the northern margin of the belt of banded gneisses. Its occurrence in this relationship intervening between the great intrusive massif on the south and the volcanics on the north suggests that it originally underlay the volcanics and has been elevated into its present position in company with the intrusion of the central massif; but the conglomerate members of the Pontiac series contain pebbles of volcanic rocks and for this reason, the series has been regarded as possibly younger than the volcanics.

Grenville Belt.

In the Grenville belt are included a greater variety of rocks, both sedimentary and igneous, than occur in the Timiskaming belt and the stratigraphical and structural relationships of these types is accordingly even less completely known than those of the northern volcanic belt. The surface rocks consist for the most part of highly folded and metamorphosed, well sorted, interstratified sediments; but, in eastern Ontario, volcanic rocks are also represented. In only one locality, the Madoc district in eastern Ontario, has an unconformity been recognized within the surface rocks. But the smallness of the area in which this has been recognized may be partly due to limited knowledge of the geology of the Grenville belt rather than to the absence of these relationships in other localities. As in the Timiskaming belt, the detailed structural relationships of the two series apparently present in these localities, have not yet been completely worked out. The intrusive rocks occurring throughout the belt include numerous injections and intrusive bosses or batholiths of basic to intermediate rocks, as well as bosses and batholiths of granite and syenite. In the Bancroft district studied by Adams and Barlow and in the localities studied by the writer, the basic to intermediate rock types are intruded and metamorphosed by the acidic types and are, therefore, older in age. Evidence indicating that acidic batholiths of two ages are present has been found in only one locality; but it cannot be concluded on this account that elsewhere these rocks all belong to a single period of batholithic invasion, for their relationships have been studied in detail in only a few localities throughout the whole Grenville belt.

Ottawa Gneisses Belt.

The central belt of gneisses is largely composed of granite, syenite granodiorite and related rocks, with some associated sediments, all of which are highly folded and generally banded and like normal deformed sediments have been folded into pitching anticlines and synclines. Along the southern margin of the belt, the gneisses include small lenticular, partially or completely silicated masses of crystalline limestone elongated in a direction parallel to the trend of the enclosing gneiss. The relationships of these inclusions of the surface rocks belonging to the Grenville belt suggest that they are detached fragments or thin infolded bands which have become involved in the central massif during its intrusion or at the time the banded structure of the massif was developed. The junction of the banded gneiss with the Pontiac series on the north is marked by a contact zone throughout which the mica schist phase of that series is intimately injected and intruded by dykes of granite and pegmatite. On proceeding northward from this zone, the intrusions become less numerous and the mica schist is gradually replaced by conglomerate, greywacke, and arkose. Towards the south, on the other hand, the mica schist becomes less and less common and the granite and pegmatite more and more abundant until all trace of the Pontiac series has finally disappeared. In the region most remote from the intrusive, the rocks of the Pontiac series have generally a vertical attitude, but nearer the belt of gneisses and in the contact zone, the foliation and bedding planes have a general dip of approximately 45 degrees towards the north and away from the intrusive—a relationship which maintains itself even in the most southerly inclusions within the central massif.

Mode of Batholithic Intrusion.

The preceding description of the regional structural relationship of the Pre-Cambrian basal complex in northwestern Quebec indicates that the two great belts of surface rocks which occur in this region have a structural trend parallel to that of the great central massif of banded gneisses. Moreover, geological investigation throughout the world has shown that wherever mountain chains are greatly denuded batholithic massifs are generally found at their centres. It is concluded, therefore, that the belt of banded gneisses represents the interior of a great Pre-Cambrian mountain chain laid bare by prolonged denudation. The structural relationships of the basal complex in this region should, therefore, afford some information with regard to the process by which this great massif was intruded. Did it make room for itself by marginal assimilation, or by stoping and deep-seated assimilation, or was it intruded as an accompaniment of a great crustal upheaval? The geanticlinal relationship of the massif, the manner in which the adjoining sediments of the Pontiac series dip away from the belt of banded gneisses, and the highly foliated character of the surface rocks parallel to the margin of the central batholithic zone, all point to the conclusion that the roof rocks which originally overlay the massif, were thrust aside and elevated as the latter was intruded. On the other hand, the central batholithic zone is in igneous contact, on the south, with a great series of normal marine sediments and, on the north, with normal clastic sediments, the conglomerate member of which contains granite pebbles. In neither case has any trace of the floor upon which these sediments were laid down been found; yet the occurrence of the belt of orthogneisses in this relationship can scarcely be explained on any other hypothesis than that, not only the floor, but the lower portions of the series of surface rocks flanking the belt of orthogneisses have undergone assimilation or melting.

The contact of the small batholiths which occur here and there throughout the northern geosynclinal belt are in part gradational and in part definite. At the points where the first type of contact is seen, the adjoining volcanics have been generally transformed into amphibolite which, when traced towards the batholith, passes indefinitely into granite by a gradual loss of ferromagnesian constituents and a corresponding increase in its feldspar and quartz content. In the localities where the definite contacts are found, the margin of the batholith is filled with inclusions of the intruded rock which, towards the interior of the intrusive mass, lose their original character and pass into amphibolite.

Along the northern margin of the belt of banded gneisses, as previously described, there is a contact zone several miles in width composed of mica schist injected and intruded transversely by dykes of granite and pegmatite. In a few places, along the inner margin of this zone there is apparently a complete transition from mica schist to granite, as if the former rock had been granitized in the manner described by Sederholm in the case of the rocks intruded by Rapakivi granite in Finland. More commonly, however, the transition from mica schist to granite takes place by a gradual increase in the proportion of intruded material and a corresponding decrease in the proportion of mica schist to a point where only widely separated inclusions of mica schist occur in the granite. As indicated in Figure 5, throughout the whole contact zone, even to the inclusions most remote from the margin of the massif, the mica schist maintains the same attitude. This relationship indicates that at such points the magma was intruded under such conditions that not only were the inclusions of the mica schist prevented from sinking in the magma, but were held in their original position. In such localities, therefore, subcrustal stoping and deep-seated assimilation were certainly not in progress. Nevertheless, throughout the interior portion of the belt of banded gneisses, as pointed out in the section of the report which follows, there are areas of gneiss, in places, having a chemical and mineralogical composition such as would probably result from the partial assimilation of sedimentary rocks. Unless these occurrences are remnants of roof pendants they indicate that deep-seated assimilation was in active process within the belt of gneisses, in places at least, during the time of consolidation.

The conclusions which may be inferred from the preceding discussion are twofold; that the contact relationships of the central belt of banded gneisses indicate that either during or preceding this batholithic invasion a considerable thickness of solid rock must have undergone assimilation or melting; on the contrary, that the regional relationships of the belt adjoining, indicate that the massif has attained its present position as an accompaniment of a great crustal upheaval and this alone would be quite sufficient to account for the intrusion of the mass without the assistance of additional processes such as assimilation or subcrustal fusion.

ORIGIN OF BANDED GNEISSES.

General Statement.

The most striking of the structural features characterizing the great central massif of gneisses which intervenes between the Abitibian geosyncline and the Grenville belt of sediments is the banding which everywhere prevails. This structure, moreover, is not limited to the single belt described in this report but is characteristically developed throughout extended areas of gneiss in various parts of the Canadian Pre-Cambrian shield and is, therefore, of special interest in Canadian geology.

The most probable ways in which a banded structure in gneisses might be developed, are the following:

By the metamorphism of laminated sediments.

By the *lit par lit* injection of (a) an igneous magma into bedded sediments; (b) an igneous magma into older foliated igneous rocks (either volcanic or plutonic); or (c) an igneous magma into its consolidated portions during its intrusion.

By the flattening out of masses of country rock included in an igneous magma.

By the regional deformation of a heterogeneous complex of igneous rocks long after consolidation.

By the deformation of a heterogeneous igneous magma during or immediately following its consolidation.

In the following sections the possible importance of these various processes in the development of the banded gneisses of the central massif is discussed.

Metamorphism of Laminated Sediments.

The early Canadian geologists, in accordance with the prevailing conceptions of the period in which they carried on their work, generally regarded all the banded gneisses which they encountered to be of sedimentary origin. This error was easily made since a large part of the banded gneisses of the region in which they worked were actually metamorphosed sediments and a considerable part of those of igneous origin had a bedded-like character and a folded structure similar to that usually exhibited by deformed sedimentary strata. With the introduction of petrographical and chemical methods of investigation, however, it was discovered that a considerable part of the banded gneisses of the Laurentian highlands had the chemical and mineralogical composition and textural character of igneous rocks, and the sedimentary hypothesis was forthwith abandoned for the igneous hypothesis as regards the larger part of the banded gneisses of the Laurentian plateau. It is probable, however, that a greater part of the banded gneisses of the Laurentian complex is of sedimentary origin than is generally supposed. Thus, in the region studied by the writer, there are considerable areas of banded garnet gneiss, mica schist, cyanite gneiss, and other rocks which have mineralogical compositions such as usually result from the metamorphism of sedimentary formations. Chemical analysis of a specimen of cyanite gneiss from a point on the east shore of the Ottawa river about one-half mile north of the outlet of Snake creek and that of a similar rock from the belt of banded gneisses occurring south of Sudbury, Ontario, are given in columns 1 and 2 respectively, of the following table. Analyses of specimens of garnet gneiss belonging to the Grenville series as represented in the Buckingham district, are given in columns 3 and 4 for the purpose of comparison. In both of the analyses of cyanite gneiss the alumina content is greatly in excess of the 1 to 1 ratio necessary to satisfy the lime and alkalis, and the potash is in excess of soda; but unlike the analyses of garnet gneiss in columns 3 and 4, the magnesia is not in excess over the lime. Nevertheless, the small relative proportion of magnesia in analysis 1 and the high alumina content in analysis 2, indicate that both of these rocks are probably of sedimentary origin.

Analyses of Gneisses.

	1	2	3	4
SiO_2	66·94	57·30	60·33	49·61
Al_2O_3	17·84	26·03	17·17	22·00
Fe_2O_3	....	1·39	3·93	1·93
FeO	4·30	5·24	6·55	9·55
CaO	1·86	3·35	0·90	0·36
MgO	1·82	2·03	3·35	6·33
Na_2O	1·85	1·07	0·73	1·40
K_2O	3·36	3·21	4·57	3·88
TiO_2	....	....	1·52	2·00
P_2O_5	....	0·14	0·04	0·06
MnO	....	....	0·09	0·05
H_2O	1·90	0·38	1·00	2·20
Total	99·87	100·14	100·18	99·37

1. Barlow, A. E., Geol. Surv., Can., Ann. Rept., vol. X, 1897, pt. I, p. 53. Analysis by F. G. Wait.
2. Coleman, A. P., Ann. Rept. Ont. Bureau of Mines, vol. 23, pt. 1, 1914, p. 209. Analysis by W. K. McNeill.
3. Garnet gneiss, lot 12, range I, Portland East township, Quebec. Analysis by M. F. Connor.
4. Sillimanite-garnet gneiss, lot 19, range XII, Buckingham township, Quebec. Analysis by M. F. Connor.

Lit par Lit Injection.

By means of the process known as *lit par lit* injection,[1] a banded structure may be developed in any rock having a bedded or foliated structure by the intimate injection of an igneous magma, or of solutions emanating from an igneous magma, along the parallel planes of weakness. *Lit par lit* injection may take the form of either an actual magmatic intrusion or a slow infiltration[2] of highly fluid magma or of solutions emanating from a magma, accompanied by crystal growth along the planes of foliation or bedding of the intruded rock. A process of injection also probably occurs where a magmatic mass consolidates under differential pressure, for very commonly in the banded gneisses of the Laurentian highlands an interlamination of thin aplitic laminæ with less salic bands of rock occurs, the relationships suggesting that the banding is of primary origin, the magma having differentiated during its consolidation. Such differentiation might presumably occur wherever a primary foliation was being developed in a consolidating magma, either by injection or slow infiltration of residual aplitic material along the planes of foliation or, possibly, also by the crystallization of salic constituents along the planes of foliation, the material necessary for crystal growth being drawn by diffusion from the adjoining partially consolidated bands.

It may be observed that the various types of *lit par lit* injection described in the preceding paragraph, fall naturally into three classes according as the injection takes place into bedded sediments, older foliated igneous rocks, or into consolidated portions of the same magmatic mass. The first and third are represented in the belt of banded gneisses, but evidence of the presence of the third is wanted in the region studied by the writer.

Lit par lit injection of igneous material into sediments can be seen throughout the contact zone, approximately 10 miles in width, which extends along the junction of the belt of banded gneisses and the Pontiac series. Throughout this area the magmatic material has been intimately injected into the mica schist member of the sedimentary series, in places

[1] Levy, Michel, Bull. Soc. Geol. Fra., 3rd. ser., vol. 16, 1887-88, pp. 102-113. Carte Geol. Fra. No. 36, vol. 5, 1893-94.

[2] Sederholm, J. J., Trans. Inter. Geol. Cong., Stockholm, 1910, p. 573.
Fenner, Clarence N., Jour. Geol., vol. 22, 1915, pp. 594-612, 694-702.
Barrell, J., U.S. Geol. Surv., Prof. Paper, No. 57, 1906, p. 144.

cutting across the bedding of the schist but generally conforming to the stratification, the relationships leaving little doubt as to the method of intrusion.

The possibility that the second type of injection, into older igneous rocks, might have occurred in the central massif is suggested by the fact that the sedimentary rocks intruded by the massif contain granite pebbles indicating that an older granite was originally present in the region; also by the fact that in the region north of lake Huron, post-Huronian batholiths of granite occur which are younger than the belt of gneisses,[1] so that granitic batholiths of at least three different ages are or were originally present in Timiskaming region. In that portion of the central massif studied by the writer, however, the only rocks observed which were not intensely deformed were dykes of aplite and pegmatite and of these, there appeared to be a complete series from those with no trace of deformation to those most intricately plicated; and, while it might be possible that these dykes were derived from a younger batholith, it seems more probable that they were merely emanations from the interior portions of the massif intruded at intervals, while the massif was undergoing deformation. On the other hand, if the belt of banded gneisses were composed of granitic rocks of different age intruded prior to the deformations, the younger of the two intrusives would undoubtedly occur as bosses or batholiths in places, and, despite the effects of deformation, would almost certainly be recognized as a younger intrusive; yet no such masses were observed. As far as was observed, therefore, the central massif is composed of a single batholithic mass.

The third type of injection, injection of unconsolidated magma into its consolidated portions, was probably the most important of all processes by which the banding of the gneisses of the central massif was developed. It was in this manner that all the minute, less definite banding and that formed by the intrusion of the dykes of pegmatite and aplite parallel to the banding or foliation while deformation was in progress were produced. But, throughout the belt of gneisses as a whole, intense deformation has obliterated most of the evidence having a bearing on the relative importance of this type of injection as compared with other processes in developing the banded structure of the great central complex originally present.

Flattening Out of Masses of Country Rock Included in an Igneous Magma.

The theory, that the development of a banded structure along the contact of the Pre-Cambrian granite batholiths of the Canadian shield was caused by the flattening out of xenoliths, has been advocated by a

[1]Collins, W. H., Geol. Surv., Can., Mus. Bull. No. 8, 1916.

number of Canadian geologists.[1] This is undoubtedly an important process in the development of the structure in some places; but, so long as the process was confined to the margin of a batholith, it would necessarily be limited in area and could nowhere result in the development of extended belts of banded gneisses such as occur throughout the Laurentian plateau. If, however, the xenoliths sank in the magma mass or were carried out into the interior of the magma mass, they would be found throughout the whole batholith in all stages of assimilation, and, if flattened out by deformation, would form a banded complex of great heterogeneity. Is it possible that the banded gneisses of the Laurentian plateau have originated in part or wholly in this manner? and, if so, is there any evidence in the character or composition of the gneisses by which the relative importance of the process can be determined? In the case of the belt of banded gneisses under consideration, whatever roof rocks became engulfed in the magma would presumably be similar in composition to the surface rocks intruded by the massif along its northern and southern margin. These consist, in the main, of basic to intermediate volcanics or metamorphosed sediments of the well sorted types, namely, crystalline limestone, quartzite, and garnet gneiss. Furthermore, if these rock types underwent partial assimilation in a granitic magma, the resultant rock type would necessarily be of a composition intermediate between that of the magma and the rock undergoing assimilation; that is, the volcanics would result in amphibolite or hornblende gneiss, the limestone in rocks containing lime-silicate minerals, the quartzite in highly siliceous rocks, and the garnet gneiss in rocks containing a relatively high proportion of alumina, potash, or magnesia. It so happens that all of these intermediate rock types are represented among the banded gneisses of the central massif. While some of these rock types might be formed as a result of differentiation from an igneous magma, it is probable that the larger part are the products of partial assimilation, as in the case of the band of lime silicate rocks (pyroxenite and amphibolite) which occur along the southern margin of the belt in proximity to inclusions of Grenville limestone. As regards the larger part of the banded gneisses, however, this process was evidently not the major factor in the development of the banded structure; for the dominant rocks of the belt are not these intermediate types resulting from assimilation but pegmatite and biotite granite gneisses.

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[1] Lawson, A. C., Geol. Surv., Can., Ann. Rept., vol. III, 1887, pt. 1, p. 138F.
Adams, F. D., and Barlow, A. E., Geol. Surv., Can., Mem. 6, 1910.
Miller, W. G., and Knight, C., Rept. Ont. Bureau of Mines, vol. XX, 1911, pp. 280-284.

Deformation of a Heterogeneous Complex of Igneous Rocks Long After Consolidation.

A heterogeneous complex of igneous rocks formed either by successive intrusions of igneous rocks, or by differentiation in a single igneous mass, or by a combination of these two processes, might be transformed into banded gneisses by the flattening out of its heterogeneous parts as a result of deformation. The evidence cited in previous sections and in the section which follows, indicates, however, that the central massif of banded gneisses was in a magmatic condition at the time the banded structure was being developed, and this mode of origin need not, therefore, be considered.

Deformation of a Heterogeneous Igneous Magma During or Immediately Following its Consolidation.

Igneous magmas very commonly differentiate themselves into rocks of different composition during their intrusion, and, if such a heterogeneous magma were deformed during or following its consolidation, a banded complex might result.

It has been pointed out in previous sections of this report, that the belt of banded gneisses has a geanticlinal relationship to the adjoining belts of surface rocks and apparently represents the core of a Pre-Cambrian mountain chain; that the gneissic bands of the belt have been folded into pitching anticlines and synclines trending in a southwesterly direction parallel to the trend of the whole massif; that in the region studied, as far as could be determined, the whole belt of gneisses belongs to a single batholithic massif; and that the presence of dykes of aplite and pegmatite in all stages of deformation, cutting across the gneissic bands, indicates that the interior portion of the massif was in the magmatic condition at the time the banding was being developed. If these observations and deductions are correct, then it seems evident that the rocks composing the belt of gneisses were subjected to mountain-building stresses during their consolidation, and such conditions would necessarily result in the development of a banded structure provided the magma were heterogeneous. Moreover, it is probable that mountain-building stresses acting on a consolidating magma would in themselves bring about differentiation both by breaking up the consolidated portions of the massif and by squeezing out the magma of slightly different composition from the interior. Just as soon as a foliated or banded structure developed, however, the intrusions of magma would tend to follow these planes of weakness and the differentiation would take the form of *lit par lit* injection.

Conclusion.

In the preceding discussion of the origin of the banded gneisses of the great central massif which separates the Grenville belt of sediments from the Abitibian geosyncline, it is pointed out that, while these have been formed, in part, either by the metamorphism of laminated sediments, or by the injection of igneous material into bedded sediments, or by the deformation of xenoliths of intruded rock included in an igneous magma, they are in the main igneous rocks and owe their banded structure to deformation during their consolidation. In support of this conclusion evidence is cited which indicates that the belt of gneisses represents the core of a Pre-Cambrian mountain chain and was subjected to mountain-building stresses during its solidification. As a result of this action, the solidified portions of the magmatic mass would presumably be broken up and the residual fluid magma of slightly different composition squeezed out to fill the fractures around the broken fragments and the variations in the complex produced in this way would then be flattened out by deformation into banded gneiss. During the later stages of deformation the intrusions of igneous material from the interior of the massif, would probably follow the planes of foliation and banding and thus further develop a banded structure by *lit par lit* injection. As deformation continued, the banded gneisses produced in these various ways would no doubt behave very much like sedimentary strata and crumple into anticlinal and synclinal forms. Thus by the action of mountain-building stresses on a magmatic axial mass, a folded, banded, and granulated gneissic complex, such as that occurring in this great belt, might be developed.

ORIGIN OF COBALT SERIES.

Introductory Statement.

The group of clastic sediments composing the Cobalt series presents one of the most interesting geological problems of the Canadian Pre-Cambrian, the characteristics of the various formations composing the series being such as to indicate that these were laid down during an epoch of continental glaciation.

The evidence upon which this conclusion is based, has been discussed at considerable length in previous publications,[1] however, and merely a summary of former discussions of the problem will, therefore, be included in this report.

[1] Jour. Geol., vol. 19, 1913, pp. 121-141.
Geol. Surv., Can., Mem. 39, 1913.

Conglomerate.

The following data may be cited as evidence indicating that the conglomerate members of the Cobalt series were deposited from a continental ice-sheet:

The enormous extent and great thickness of the conglomerate.

The great variety of rock types represented in the pebbles and boulders of the conglomerate.

The unsorted character of the conglomerate.

The great variability in the texture and composition of the conglomerate, and especially the presence of phases in which fine-grained greywacke or argillite comprise the larger part of the rock, the pebbles and boulders being sparsely disseminated.

The subangular form of the pebbles and boulders contained in the conglomerate.

The presence of scratched and faceted pebbles in the conglomerate.

The enormous size of the boulders contained in the conglomerate and the occurrence of these at points several miles distant from the nearest occurrence of similar rocks in the underlying basement.

The extremely low relief of the surface upon which the conglomerate was laid down, thus precluding the possibility of a fluviatile origin.

In objection to the glacial hypothesis, it has been pointed out that no striated surfaces have been found beneath the basal conglomerate member of the series; and on the contrary the contact with the underlying floor is generally gradational, the typical heterogeneous conglomerate being gradually replaced by a rock composed entirely of debris derived in situ from the adjacent floor[1]. In reply to this objection it has been noted, however, that the presence of an ancient regolith beneath the Cobalt series does not preclude the possibility of Huronian glaciation; for, near the margin of continental glaciers, the ice commonly moves for miles over unconsolidated material without anywhere reaching the underlying rock surface.[2]

Greywacke, Argillite, and Arkose.

The greywacke, argillite, and arkose members of the Cobalt series are believed to be of lacustrine origin for the following reasons:

They pass gradationally into conglomerate which possesses all the typical characteristics of a continental glacial deposit.

The uniformity in their stratification and the absence of mud cracks, rain prints, or other evidence of exposure to the air shows that they were deposited from a permanent body of water.

The discontinuity and variability of the deposits, and the abundance of ripple-marks indicates that they were laid down in a shallow, discontinuous body of water.

The incompletely sorted character of the deposits, as shown by their mineralogical and chemical compositions, are features characteristic of terrestrial rather than marine formations.

Ville Marie Quartzite.

The Ville Marie quartzite, as previously explained, is a local phase of the Huronian occurring in the vicinity of Ville Marie, on the east shore of lake Timiskaming. It differs from the typical arkose member

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[1] Ann. Rep., Ont. Bureau of Mines, vol. 19, pt. 2, 1913, p. 87.

[2] Jour. of Geol., vol. 14, 1908, p. 155.

of the Cobalt series, in its more highly sorted character, in the more rounded character of its grains, and in the presence of lenticular aggregates of quartz and jasper pebbles; lithologically it is similar to the Lorrain formation which apparently forms the topmost member of the Cobalt series throughout a wide area in the region west of lake Timiskaming. The well sorted and uniformly stratified character of this formation would seem to indicate that it was deposited in a standing body of water, and the presence of ripple-marks and pebbles in lenticular aggregates points to shallow water conditions of deposition. As far as can be inferred from the character of the formation, therefore, the Ville Marie quartzite might be either a lacustrine or shallow water marine deposit.

Conclusion.

In the preceding summaries of the evidence bearing on the origin of the Cobalt series the distinctive characteristics of each member of the series have been noted; but it is only by a consideration of the relationships of the series as a whole, that the full importance of the evidence pointing to glacial conditions of deposition can be appreciated; for the succession of formations in these ancient deposits is similar in almost every respect to the succession of members composing the Pleistocene (glacial, fluvioglacial, interglacial, and post-glacial) deposits found in the same region. Thus at the base of the Cobalt series there is a conglomerate, which, like the Pleistocene glacial drift, is unstratified in part, resembling till, is rudely sorted in part and cross-bedded resembling fluvioglacial deposits, kames, eskers, and outwash plains, and, in places, passes into unstratified greywacke containing scattered pebbles and boulders, resembling boulder clay. Overlying the basal conglomerate there is the stratified greywacke, argillite, and arkose which are similar to the Pleistocene interglacial and post-glacial lacustrine deposits. The upper conglomerate which in its turn overlies the greywacke, argillite, and arkose in places, would presumably represent an upper till sheet and thus complete a succession similar to that found in the border zone of Pleistocene glaciated areas.

The conclusion that the conglomerates of the Cobalt series were deposited from Pre-Cambrian continental ice-sheets is not based entirely, therefore, on the remarkable similarity of the conglomerate to a glacial deposit, but is also based on the fact that every variation in the series has its duplicate in the glacial, interglacial, or post-glacial deposits laid down in association with Pleistocene continental ice-sheets of the same region, and on the fact that no other known depositional process will so well account for all the many peculiarities and associations of sediments as the glacial hypothesis. Moreover, the objection that striated surfaces have not been found beneath the basal conglomerate loses its importance as contradictory evidence when it is considered that the succession present indicates that the series was laid down in the outer zone of an area of continental glaciation, that the underlying surface beneath the Cobalt series has been smoothly eroded in some places, and that the presence of the firmly cemented, overlying conglomerate at these points generally makes an examination for striæ impracticable.

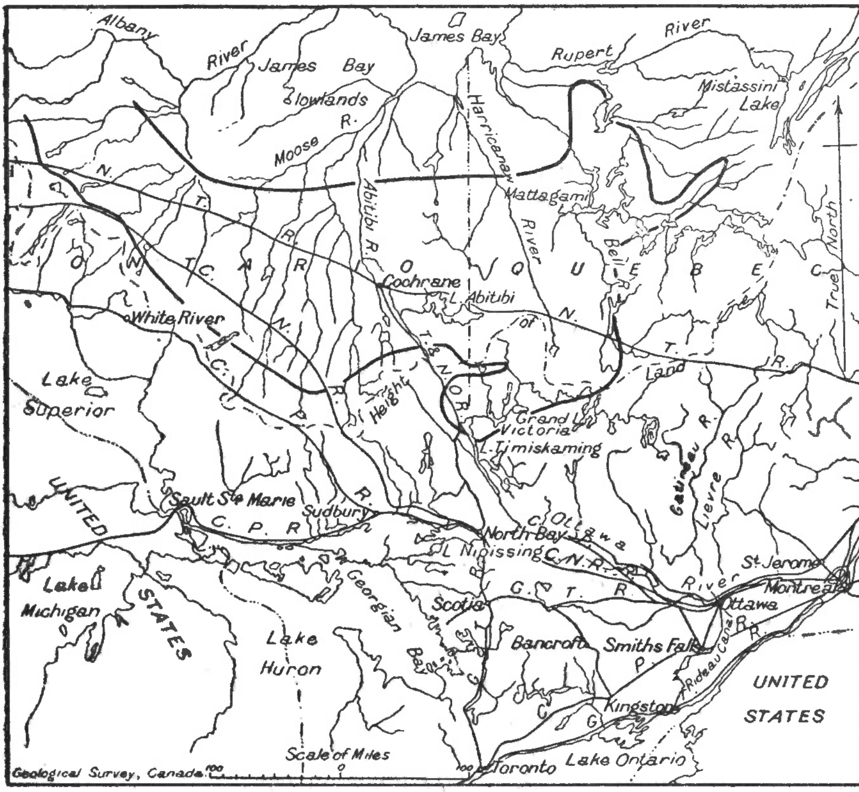

Figure 6. Clay belt of northern Ontario and Quebec.

CLAY BELT OF NORTHERN ONTARIO AND QUEBEC.

Introductory Statement.

Throughout a wide extent of territory in northern Ontario and Quebec, the glacial and older rocks are hidden beneath a mantle of stratified clay, silt, and sand which has filled in the minor inequalities of the underlying surface so that an extended plain, interrupted here and there by ridges and knobs of rock, has been formed. This wide depositional or constructional plain approximately 68,000 square miles in extent, constitutes what is generally called the clay belt of the north and is believed to have been formed by deposits laid down from large post-glacial lakes which occupied basins hemmed in, in part, by the front of the retreating continental glacier.

Limitations.

Considerable information with regard to the clay belt is contained in the various reports having reference to the geology of this region, which have been published from time to time by the Canadian Geological Survey, the Ontario Bureau of Mines, and the Mines Branch of the Department of Colonization, Mines, and Fisheries for Quebec.[1] In most of these publications, the points at which the clay terminates are not definitely stated so that only the approximate limitations of the belt are known. With the exception of a small area lying north of lake Timiskaming all of the clay belt of northern Ontario lies north of the height of land between the St. Lawrence and Hudson Bay basins, the southern boundary being generally only a few miles north of the divide. In Quebec, however, a broad embayment extends south across the height of land to the north end of lake Timiskaming. The northern margin of the freshwater, lacustrine portion of the clay belt in Ontario is apparently continuous with stratified clay and sand of marine origin lying south of James bay. In Quebec, however, the northern margin of the clay belt is delimited by glacial drift.[2]

Character.

The greater part of the deposits composing the clay belt consist of interlaminated beds of clay and silt ranging from one-quarter inch to three-quarters of an inch in thickness (Plate I). Locally, the silt is absent and the deposit consists entirely of clay or of clay interlaminated with thin layers of calcium carbonate. In the vicinity of large masses of glacial drift, on the other hand, clay beds may be entirely absent, the deposit consisting of beds of silt and sand or of sand entirely. In such localities, the beds are generally from 1 to 3 inches thick and less sharply defined (Plate XIV). Extensive areas underlain by stratified sands are uncommon in the clay belt, however, and, where present,

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[1] Bell, R., Geol. Surv., Can., Ann. Rept., 1870-71, p. 350.
McOuat, W., Geol. Surv., Can., Ann. Rept., 1872-73, p. 134.
Wilson, W. J., "Report on a portion of Algoma and Thunder Bay districts," Geol. Surv., Can., 1909.
Burwash, C. M., Ann. Rept., Ont. Bureau of Mines, vol. VI, 1896, pp. 177-183.
Parks, W. A., Ann. Rept., Ont. Bureau of Mines, vol. VIII, 1899, pp. 175-176; vol. IX, 1900, p. 142.
Kay, G. F., Ann. Rept., Ont. Bureau of Mines, vol. XIII, pt. 1, 1901, p. 115.
Kerr, H. L., Ann. Rept. Ont. Bureau of Mines, vol. XV, pt. 1, 1906, pp. 131-133.
Miller, W. J., Ann. Rept., Ont. Bureau of Mines, vol. XVI, pt. II, 1907, pp. 34-35.
Bancroft, J. A., "Min. oper. in the prov. of Que.," 1911-1912.
Cook, H. C., Geol. Surv., Can., Sum. Rept., 1914, p. 95.

[2] According to information given the writer by H. C. Cook and T. L. Tanton of the Geological Survey.

generally form merely a veneer over the stratified clay and silt where the latter adjoins the glacial drift in which sand is abundant.

The contacts of the stratified clay and silt with the underlying glacial drift as exposed in the cuts along the National Transcontinental railway, are generally gradational, the stratified clay and silt giving place to stratified sand, which, in turn, passes downward into typical glacial or fluvioglacial material. The bedding of the stratified clay and silt where they lie upon the drift or a Pre-Cambrian rock surface is characterized by remarkably steep and irregular depositional dips (Plate XIII).[1] These irregularities disappear within a few feet above, however, in the overlying beds. In two localities along the National Transcontinental railway (in Courville township, a short distance east of the crossing of Coffee river and in Senneterre township about 3 miles east of the crossing of Bell river) the stratified clay and silt were observed to have been locally deformed. In the first locality the beds have been folded and in places overturned towards the east throughout a zone from 1 to 3 feet in thickness (Plate XV), while at the second point there is a zone of brecciation and folding throughout a thickness of 2 feet (Plate XVI). Whatever the cause of these peculiar deformational structures it is evident that they were contemporaneous with deposition, for the stratification is uniform in both the overlying and underlying beds.

The thickness of the lacustrine deposits underlying the clay belt is nowhere very great, the average being probably less than 25 feet. In numerous sections observed by the writer in Timiskaming county, Quebec, the vertical thickness was usually less than 20 feet; and in the region adjoining the National Transcontinental railway, west of Cochrane, Ontario, the maximum thickness observed by M. B. Baker was 25 feet.[2] The maximum thickness recorded for the whole clay belt is in scarps on the shore of Night Hawk lake where a thickness of 40 to 50 feet is exposed.[3]

Origin.

Throughout the territory in northeastern North America covered by the Pleistocene continental ice-sheets there are numerous areas of stratified deposits similar to those of the clay belt of northern Ontario and Quebec and believed to have been deposited from extensive lakes which occupied basins hemmed in, in part, by the front of the retreating glaciers. A great series of such lakes occupied the upper part of the St. Lawrence basin following the retreat of the Labradorean ice-sheet; and, since the stratified clays of northern Ontario and Quebec do not occupy a topo-

[1] See also Plate XXV, Mem. 39.
[2] Ann. Rept., Ont. Bureau of Mines, 1911, p. 230.
[3] Parks, W. A., Ann. Rept., Ont. Bureau of Mines, vol. VIII, pt. 2, 1899, p. 175.

graphic basin, these also were presumably laid down in a lake or lakes formed in front of this glacial barrier during a later stage in its retreat.

Coleman[1] suggested that a body of water connected with lake Algonquin (the most widespread of the glacial lakes occupying the upper part of the St. Lawrence basin) extended from the Timiskaming region across the St. Lawrence-Hudson Bay divide and that with the continued withdrawal of the ice-sheet, this lake was finally drained off and a separate body of water formed north of the divide for which the name Ojibway was proposed. At the time Coleman's paper was written, the full extent of the stratified clays south of the height of land in northwestern Quebec had not been determined and much of the evidence pointing to the existence of a large glacial lake preceding lake Ojibway was at that time unknown. It has since been discovered, however, that, in northwestern Quebec, the clay belt extends continuously across the St. Lawrence-Hudson Bay divide showing that the stratified deposits of James Bay basin were laid down, in part at least, from the same body of water as those of Timiskaming region. Furthermore, since the stratified deposits of the clay belt are nowhere continuous with the stratified deposits of lake Algonquin occurring in the vicinity of lakes Huron and Superior, it is evident that this body of water, during the greater part of its history, was not a part of lake Algonquin but a separate lake. It is, therefore, suggested that this body of water be separately designated and that the name lake Barlow be used.

Extent of Lake Barlow.

As regards the extent of lake Barlow very little is positively known. It certainly covered all the territory underlain by stratified clay in the Timiskaming basin and in addition, all that part of the clay belt north of the height of land not covered by lake Ojibway. It is possible also that it covered portions of the region occupied by lake Obijway, for the basins of the two lakes may have overlapped. If this were the case, lake Ojibway would probably form beach terraces in the Lake Barlow deposits and thus afford evidence from which the approximate extent of the two lakes might be determined.

Glacial Barrier.

Since the bottom of the lower part of the Timiskaming trench has an elevation of only 425 feet above sea-level and is over one mile in width, it is obvious that a glacial lake covering a large part of the Timiskaming basin could not have existed unless the relative elevations of the northern and southern parts of the Timiskaming basin have changed

[1] Ann. Rept., Ont. Bureau of Mines, vol. XVIII. pt. I, 1909, pp. 284-293.

several hundred feet since the lacustrine deposits were laid down; or unless a glacial ice-lobe projected from the front of the Labradorean ice-sheet across either the lower part of the Timiskaming trench, or the Ottawa valley below the Timiskaming trench. Of these two major hypotheses, the latter seems the more probable for two reasons, namely: from the distribution of the glacial lakes in the upper St. Lawrence basin it is believed that a glacial ice-lobe projected across central Ontario between Lake Huron and Lake Ontario basins; and at a number of points along the southeastern margin of the clay belt in northwestern Quebec, the clay disappears abruptly without regard to topographic elevation.

A basin would be created in the upper Timiskaming valley by an ice barrier lying across either the Timiskaming trench or the Ottawa valley below the Timiskaming trench (that is east of the town of Mattawa); but in the latter case, a body of water occupying the Timiskaming basin would be connected with the upper St. Lawrence basin by a narrow strait extending along the Timiskaming trench and the Mattawa valley. A search for possible lacustrine deposits along the Mattawa and the lower Timiskaming valleys was made by Taylor in 1896, however, without finding positive evidence of the existence of a glacial lake connecting the Lake Huron and Lake Timiskaming basins.[1] No stratified deposits such as form the clay belt were observed and possible beach deposits were seen at only two points. It is probable, therefore, that if such a connexion existed, it was only temporary (possibly during late stages in the withdrawal of the ice-lobe from the Ottawa basin) and that lake Barlow was cut off during the greater part of its history by an ice-lobe lying across the lower part of the Timiskaming trench.

The preceding conclusions would indicate that lake Barlow and lake Ojibway occupied embayments between the Ontario ice-lobe and the main front of the Labradorean ice-sheet. As long as the lower Ottawa was barred by the Ontario ice-lobe the basin of lake Barlow, presumably, extended itself farther and farther northward, following the retreating ice front. When the ice-lobe withdrew from the lower Ottawa, however, the whole lake, with the exception of the part north of the height of land having an elevation below the lowest point in the divide (930 feet above sea-level at present) would necessarily be drained off. With the further retreat of the continental glacier, lake Ojibway would also, presumably, extend northward and fall to lower levels until James Bay basin was free of ice, when it would also be drained off.

Duration of Lake Barlow and Lake Ojibway.

It is probable that in those localities in the clay belt where the stratified clay alternates with beds of silt or thin laminæ of calcium

[1] Taylor, F. B., Am. Geol., vol. 18, 1896, pp. 108-120.

carbonate, that each pair of beds represents an annual deposit, the fine-grained layer being deposited during the winter and the coarse during the summer. If it be assumed, therefore, that one pair of these beds was laid down each year, then by counting the number of beds an exact estimate of the length of time the lake or lakes covered a particular point can be obtained.[1] The maximum number of such pairs of beds counted by the writer in the cuts along the National Transcontinental railway in northwestern Quebec was two hundred and fifty. In the region traversed by the National Transcontinental railway west of Cochrane, in Ontario, the post-glacial lacustrine deposits are described by M. B. Baker as consisting of alternating layers of clay and sand usually half an inch but in places reaching 3 inches in thickness, the total thickness in the deepest cut observed being 25 feet.[2] Assuming that a layer of sand and clay together represents an annual deposit and has an average thickness of 1¼ inches, the maximum number of beds in that locality would be two hundred and forty-five which is approximately equivalent to the number observed by the writer in the region farther eastward. The preceding estimate of 250 years would, of course, represent the duration of the lake or lakes at only a single point; but, even if the migrations of the lake basins in company with the retreat of the ice front be taken into consideration, it is apparent that these glacial lakes were comparatively short lived.

Change in Elevation.

At the present time, the surface of the clay belt varies in elevation from nearly 1,100 feet above sea-level throughout a considerable area adjacent to the height of land in northwestern Quebec to 600 feet above sea-level in the vicinity of lake Timiskaming. It is probable that this difference in elevation is due, in part, to the difference in elevation of the surface upon which the clay was deposited; but it is also possible that changes in elevation have occurred in the surface of the clay belt since the clay was deposited. From a series of levels taken on the beaches of lake Algonquin in southwestern Ontario, Goldthwait has found that that region has been tilted 1 to 4 feet per mile towards the southwest. It is possible that a similar movement has occurred in Timiskaming region; but, in order to determine the extent of such a movement, it would be necessary to determine the elevations of the beaches of lake Barlow and lake Ojibway, and this information is not yet available.

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[1] Baron de Geer, Geo. Foren, Forhandl, vol. 30, 1908, p. 459.

[2] Ann. Rept., Ont. Bureau of Mines, 1911, p. 230.

CHAPTER VII.

ECONOMIC GEOLOGY.

GENERAL STATEMENT.

Although a considerable variety of minerals has been discovered in different localities in Timiskaming county, there are no producing mines in the district at present, and only a single property, the Wright mine, at which actual mining has been carried on, at any time in the history of the county. This does not necessarily imply, however, that the region has no future possibilities as a mining district; for until recently only a very small part of the county was accessible by railway and, even at the present time, there are many areas in the district so difficult of access that they have scarcely been prospected at all. Furthermore, in the northern part of the county where minerals of commercial value are most common, prospecting is rendered unusually difficult because a large part of the bedrock surface is covered by stratified clay.

HISTORY OF MINING IN TIMISKAMING COUNTY.

The history of mining in Timiskaming county commences at a very early date. The position of the deposit of galena and calcite at the Wright mine, on the east shore of lake Timiskaming, is indicated on Bellin's map of Canada published in 1744. Actual mining operations were not commenced in the district, however, for nearly 150 years after that date and only during the last decade has the district been actively prospected.

Mining operations were commenced in the district at the Wright mine in 1886 by Mr. C. V. Wright and were continued at intervals at this property by successive companies until 1902 when all work ceased. During these years, except for the operations at the Wright mine, the mining possibilities of the Timiskaming region attracted very little attention and very few prospectors visited the district; but, with the construction of the Timiskaming and Northern Ontario railway and the discovery of the silver-bearing veins at Cobalt in 1903, a period of prospecting set in which has continued to the present time.

From the Cobalt district, the prospectors gradually extended their activities farther and farther northward from lake Timiskaming both in Ontario and Quebec. In July 1906, gold was discovered at a point about 2 miles northeast of the north end of lake Opasatika by two prospectors, Alphonse Ollier and Auguste Renauld, the specimens obtained consisting of quartz carrying considerable coarse gold. This discovery led to a prospecting boom in this vicinity for several years but with disappointing results. The original discovery of Ollier and Renauld was acquired, first, by the Pontiac and Abitibi Mining Company and, later, by the Union Abitibi Mining Company. Both of these companies carried on development work, but in 1912, operations were discontinued and have not since been resumed.

In 1901, J. F. E. Johnston of the Geological Survey, in the course of a reconnaissance along Kinojevis river and its tributaries, noted the occurrence of molybdenite and bismuthinite in quartz veins on the shore of Indian peninsula in Kewagama lake. A specimen of the quartz, assayed by G. C. Hoffmann, was also found to contain 0·117 of an ounce of gold to the ton.[1] This information attracted no special attention at the time, but in August 1906, Mr. C. S. Richmond discovered another occurrence of molybdenite in pegmatite on Kewagama river, about 2 miles below the outlet of Kewagama lake, and, following this discovery, numerous other occurrences of this mineral were located in that district. A number of companies were organized to develop these properties and for several years active development work has been carried on, but up to the present, actual mining has not been attempted.

In the autumn of 1910, it was reported that gold had been discovered near Kiekkiek lake—a point in the central part of Timiskaming county nearly 70 miles northeast of lake Timiskaming and 8 miles southwest of lake Kewagama. As this report became known, a rush to the region began and before spring over four hundred claims[2] had been staked in the vicinity of Kiekkiek and Wabaskus lakes; but when these various claims were examined the following season it was found that, while the rocks of the Pontiac series adjoining Kiekkiek and Wabaskus lakes contained numerous small quartz veins, the veins contained no gold. Most of the claims were consequently abandoned and all development work came to an end.

The last and most important discovery of gold in Timiskaming county was that made by Messrs. Sullivan and Authier, in July 1911, on the east shore of Kienawisik or De Montigny lake in Dubuisson township. When the report of this discovery became known numerous prospectors were attracted to the district and a large number of claims were staked in the vicinity of the original discovery. Development work has since shown that there are small quartz veins carrying gold on several of these claims, but mining operations have not yet been attempted on any of them.

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[1] Geol. Surv., Can., Sum. Rept., 1901, p. 138.
[2] Bancroft, J. A., "Min. oper. in the prov. of Que.", 1911, pp. 83-186.

In addition to the localities mentioned in the previous paragraphs, development work for gold and silver has been carried on at several points in the district, but the results in every case have been disappointing.

GOLD.

Character.

Up to the present time gold has been discovered in only two localities in Timiskaming county, namely on Fortune lake near the north end of lake Opasatika and on several claims in the vicinity of De Montigny (Kienawisik) lake. In the Fortune Lake locality, the gold occurs in irregular veins of quartz and ferruginous dolomite intersecting dykes of altered quartz porphyry. The maximum width of the outcrop of these veins is about 2 feet. In the vicinity of De Montigny lake, the gold is found in irregular quartz veins, traversing either the Abitibi volcanics or Laurentian granodiorite. In addition to gold, the quartz in these veins usually carries some pyrite, calcite, chalcopyrite, and an abundance of tourmaline. Considerable metasomatic action has occurred in the vicinity of the veins both in the Fortune Lake locality and in the Kienawisik district; but in the Fortune Lake veins, the porphyry adjoining the deposit has been replaced by ferruginous dolomite, pyrite, and chalcopyrite, whereas in the De Montigny area, the adjoining rocks have been altered to sericite, chlorite, and calcite, and impregnated with tourmaline.[1]

Origin.

The origin of the auriferous deposits of northwestern Quebec and the adjoining portions of Ontario was discussed at some length in previous reports so that merely a few general conclusions need be mentioned here. The conclusions briefly stated are the following:[2]

The veins in which the gold occurs are, in some places, arranged in systems trending[3] obliquely to the foliation of the country rock and have been drag folded and faulted in a uniform direction. These features suggest that the veins owe their origin to compressive stresses acting in the same direction as the stresses which foliated the rocks of the region.

As regards the source of the gold it has been generally concluded that it has been derived from granite, quartz porphyry, albite syenite aplite, or other acidic rocks which intrude the Abitibi group. The reason for regarding the gold as genetically related to these intrusions is the presence of minerals such as tourmaline, scheelite, feldspar, and other minerals of the pegmatitic association in the deposits.

The geology of the region has not yet been worked out in sufficient detail to definitely determine the age of the deposits, other than that they are older than the Huronian

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[1] Bancroft, J. A., "Min. oper. in the prov. of Que.", 1912, p. 219.

[2] Geol. Surv., Can., Mems. 17 and 39; "Min. oper. in the prov. of Que.", 1912, pp. 199-236.

[3] The most striking example of these features in the whole Timiskaming region may be observed in the veins of the Hollinger mine at Porcupine. The veins on this property are drag folded and faulted to the west, and in consequence in following a vein, the continuation of the lode is always found, on the left, at the point of dislocation.

and that the rocks in which they occur had been considerably foliated before the veins were formed. Whether all the deposits were formed during a single epoch of mineralization or not is as yet unknown.

Prospects.

Union Abitibi. The claims of the Union Abitibi Mining Company are located about 2 miles northeast of lake Opasatika on the north shore of Renauld lake. There is a small remnant of the basal conglomerate of the Cobalt series exposed on the road which borders the northeast shore of Renauld lake, but elsewhere on the property all the rocks exposed belong to the Abitibi group and consist largely of ellipsoidal basalt intruded in places by dykes and irregular masses of quartz porphyry.

Numerous veinlets of quartz and calcite are exposed in prospect pits on the property, but the larger part of these carry, at most, only a trace of gold and, even if more highly mineralized, are too limited in extent to be of commercial importance. The most important of these deposits lies on the south shore of Fortune lake, at the point where Messrs. Ollier and Renauld made the original discovery of gold. In this locality veinlets of quartz carrying coarse gold and gold telluride occur traversing two very irregular dykes of altered quartz porphyry. The larger of the two dykes has a maximum width of about 2½ feet and a length of, approximately, 70 feet. At the time the property was examined in 1911 a pit 10 feet in depth had been sunk at the western end of the larger dyke.

The discovery of gold in this locality was made by Messrs. Ollier and Renauld in the summer of 1906, and during the following winter the Pontiac and Abitibi Mining Company was formed to take over the property. During 1907, a few test pits were sunk on some small calcite and quartz veins but no further development work was done until 1910, when a saw-mill, engine, boiler, and compressor were installed. At the time the property was visited by the writer, in October 1911, an inclined shaft (55 degrees) had been sunk to a depth of 155 feet and drifts were being driven towards the northeast and southwest, at a depth of 130 feet on the shaft. The total amount of drifting amounted to about 300 feet. With the exception of part of the northeast drift which was being extended into the adjacent basalt, all of this work had been done in the band of barren dolomitic sericite schist at a point about 150 yards east of the occurrence of gold in the quartz veinlets on the shore of Fortune lake. The buildings on the property consisted of an engine house, camp building, office, shaft house, and a building to cover the saw-mill. A mill was in course of construction. During the winter of 1912 work on the property was stopped, however, and since that time has not been resumed.

Sullivan. This claim, situated on the east shore of De Montigny (Kienawisik) lake about 4 miles from its outlet, was the property upon which the first discovery of gold in the Kienawisik district was made. Messrs. Sullivan and Authier found the deposit in July 1911.

The gold on the property occurs in small irregular veins of quartz traversing a knob of gneissoid granodiorite which protrudes through the post-Glacial stratified clay.[1] The veins encountered in development work on the claim up to the summer of 1912 are described by Bancroft as follows: "The widest vein on the property was that where the first discovery was made. This vein strikes nearly east and west, with a very steep dip towards the north. At the bottom of a shaft, about 10 feet deep, which had been sunk so close to the margin of the lake that it is flooded during high water, the dip becomes very nearly vertical. It was on June 21 that the water of the lake had subsided sufficiently to permit an examination of this shaft. The vein has a maximum width of 18 inches where it appeared from the water at that time. The shaft is about 8 feet farther eastward. On the west wall of the shaft the vein is about 16 inches wide; on the east wall, 6 inches; but at the bottom another stringer of quartz, 4 inches in width, appears toward the northern face. By stripping, the vein has been exposed for 50 feet eastward from the shore, where it tapers into a crack which is black with tourmaline. Eastward from the shaft, it varies from 3 to 10 inches in width. It is well mineralized with pyrite, a little chalcopyrite, galena and zinc blende, and a few specks of native gold. In places, the quartz is dark in colour because of the abundance of tourmaline. An assay of a picked sample, showing no free gold upon its surface, which was taken from the dump, yielded $118 per ton in gold. An assay of fragments, representing the complete width of the vein at the bottom on the western wall of the shaft, yielded $15.80 per ton in gold. A sample, representing the complete width of quartz on the eastern wall of and at the bottom of the shaft, returned $6.20 per ton in gold. A large sample of the country rock immediately adjacent to the vein did not yield a trace of gold.

"About 250 feet southward from this vein another quartz vein striking nearly west to east, had been exposed for a distance of about 25 feet, where it displayed a maximum width of 10 inches. Irregular in width and tapering to a small stringer at the eastern end of the exposure, this vein contains more tourmaline than the one just described and a few specks of pyrite and chalcopyrite. The marginal portions of the veins are, in places, very nearly pure tourmaline. For a few feet, the enclosing diorite has been brecciated in small fragments, which are now distributed through a matrix of quartz and tourmaline, the latter mineral predomin-

[1] According to J. A. Bancroft, "Min. oper. in the prov. of Que.", 1912, p. 220.

ating. Adjacent to the vein, the granodiorite is much sheared, and up to a distance of 3 feet from the vein, contains a few large cubical crystals of pyrite. One of these crystals was observed to be 2 inches across the side. Some of them contain a little quartz irregularly disseminated through the pyrite. Two of these crystals, when assayed, returned $33 per ton in gold. Eastward about 200 feet and in direct line of strike with this vein, where a low bluff of granodiorite rises, a quartz vein is exposed, starting towards the top of the outcrop as a mere fracture lined with tourmaline and widening to 6 inches where it passes beneath the overburden. Very rich in tourmaline, a few specks of native gold were found within this vein.

"In many other places, the granodiorite was observed to be traversed by small veins of similar character, none of which possessed a width greater than 10 inches. In most instances it was plain that they were mere stringers appearing and dying out within a few feet or yards."

In the summer of 1914 this property was examined by T. L. Tanton of the Geological Survey, who reports[1] that an average sample taken throughout a width of 6 feet from a prospect pit on the claim was found to contain 3·52 ounces per ton in gold when assayed by H. A. Leverin of the Mines Branch.

Smith. This claim lies about a quarter of a mile to the southeast of DeMontigny (Kienawisik) lake, where a ridge of the Abitibi complex rises above the stratified lacustrine clays of the clay belt. The following brief summary description of the property has been compiled from Bancroft's report on the region:

The rocks on the property consist of greenstones partially altered to chlorite schist intersected by dykes of porphyry. At the time Dr. Bancroft visited the district in 1912, a quartz vein varying from 3 to 14 inches in width had been laid bare at intervals for several hundred feet across the claim. Irregularly distributed within the quartz of this vein were numerous grains of pyrite, a little chalcopyrite, black tourmaline, calcite, epidote, and a few specks of gold. "A comprehensive sample composed of small fragments taken across the vein at intervals of every 2 feet, yielded 20 cents per ton in gold. Samples similarly taken along the best mineralized portion of the vein yielded $1.20 per ton in gold."

Bernard. The quartz vein upon which the Bernard claim was staked outcrops on the east shore of De Montigny lake about 2 miles south of its outlet. At the time the property was examined by Bancroft, a width of 19 feet of quartz was exposed, only the southern wall of the vein being visible above the water of the lake. The wall rock of the vein

[1] Personal communication.

consists of albite syenite containing scattered crystals of pyrite, a specimen of which when assayed returned $1.40 per ton in gold. The quartz of the vein is a milk white variety containing numerous needles of tourmaline, disseminated grains of pyrite, some chalcopyrite, and a little iron carbonate. "A sample of the vein containing all its component minerals and especially rich in pyrite yielded a mere trace of gold."

SILVER.

The proximity of the east side of lake Timiskaming to the silver-bearing district of Ontario has directed the attention of a large number of prospectors to this area during recent years, but, so far, the results have been largely disappointing. Since the diabase, with which the silver-cobalt ores of the Timiskaming area are associated, has its largest extent in the township of Fabre, these minerals are more likely to occur in that district. The diabase occurring in Fabre township, however, is so poorly exposed that prospecting is rendered very difficult, and although a number of minerals have been found in association with these rocks, no deposits of commercial importance have as yet been discovered.

Prospects.

Wright Mine. The most important and interesting ore deposit of the district east of lake Timiskaming is that on the property known as the Wright mine, which comprises the western part of lots 61, 62, and 63, range I, Duhamel township, shown on the maps as blocks A and B.

The rock exposed in the neighbourhood of the deposit is Huronian conglomerate, but of that peculiar gradational type found where the conglomerate has apparently been formed in place from debris derived from the immediately underlying basement complex. At this particular point, the underlying rock is evidently the porphyry member of the Abitibi complex, for the conglomerate is composed entirely of masses of this material. The ore-body is exposed for a width of approximately 50 feet on the waterworn rock surface bordering on the lake shore and consists of a breccia of the conglomerate cemented by calcite containing galena, iron, and copper pyrites.

Operations on this deposit were first begun in 1886, by Mr. C. V. Wright, of Ottawa, but no extensive work was carried on until 1890, when the property was acquired by the Mattawa Mining and Smelting Company. A very complete plant was installed and mining actively prosecuted until March, 1891, when work was suspended. From 1896 to 1902 the mine was operated in a small way, first by the Petroleum Oil Trust and later by the British Canadian Lead Company, both of these corporations representing English capital. In 1906 the property was purchased by the La Rose Mining Company, of Cobalt, the present owners. Active mining, however, has not been resumed. At the time of the suspension of work in 1902, a depth of 250 feet had been reached in the main shaft, while short drifts had been made at the 65, 100, 200, and 250-foot levels.

A number of assays of the ore from this mine have been made, both in the Department of Mines and by private assayers. The galena entirely free from gangue is found to yield from 13 to 26 ounces of silver to the ton, with about 18 ounces as a mean value. It is also found to have a lead content of about 52 per cent, and usually yields traces of gold. The average value of the ore was diminished many times, however, by the large amount of rock which had to be mined and the consequent crushing and concentrating which this involved. During the earlier part of its history the lack of transportation facilities was also a difficulty.

Quinn Point. At the time the writer examined the geology of the region east of lake Timiskaming in 1906, prospecting had only begun in that district and most of the development work since carried on was undertaken subsequent to that investigation. An account of the work in the township of Fabre up to the year 1910 has been given, however, in a report on Fabre township by Robert Harvie, published by the Mines Branch of the Department of Colonization, Mines, and Fisheries for the province of Quebec.

The results of development work on the Quinn Point claim up to that time are described by Harvie as follows: "The diabase of the lake shore in the vicinity of Quinn point, on lots 35 to 41 of range II, contains numerous veins. On lot 35 on the slope overlooking Lavallee bay, a shaft 20 feet deep has been sunk on a calcite vein 2 inches wide traceable for several chains, and showing very abundant cobalt bloom. On the west side of the same hill there are two shafts, one of them 50 feet deep, on an aplite dyke 2 inches wide showing cobalt and nickel blooms, pyrite, and smaltite; the other on a calcite vein also showing pyrite and smaltite, had reached a depth of 40 feet when visited. On lot 36 an aplite dyke averaging nearly 18 inches wide is exposed on the lake shore for about a chain in length. It shows segregations of calcite and carried disseminated pyrite and chalcopyrite. On lot 37 a shaft 70 feet deep has been opened on a calcite vein 5 inches wide in places and showing small amounts of pyrite, chalcopyrite, and smaltite. On lot 41, an adit has been driven for 20 feet on an aplite dyke 5 inches wide, and various other pits sunk on other smaller veins and dykes.

"Most of this work mentioned above has been done by La Cie Minière de la Vallée du St-Maurice."

On the lake shore at the end of Fabre wharf, and cutting the diabase, there is a calcite vein 10 inches wide in places, but not showing any metallic minerals. Nearby, small veins of quartz and calcite carry small amounts of pyrite and traces of a cobalt mineral.

Pontiac Mining and Milling Company. A mineral deposit occurring on lot 5, range V, in the township of Fabre, the property of the Pontiac Mining and Milling Company, is of interest because of its similarity to aplitic dykes or veins associated with the post-Cobalt series diabase in the Gowganda district of Ontario. The deposit consists of specularite and sulphides of iron and copper on the surface; but, on the walls of the shaft beneath, it can be observed that these minerals represent merely the weathered outcrop of a dyke or vein consisting of red orthoclase and calcite through which are disseminated galena, pyrite, and chalcopyrite. The calcite and orthoclase are very irregularly distributed in the deposit, calcite predominating at one point and orthoclase at another. The whole deposit is traversed by irregular anastomosing veinlets of white calcite ranging from a fraction of an inch to 6 inches in width. The proportion of metallic minerals in the deposit is exceedingly small and whatever silver is present is probably limited to that contained in the galena; for an average sample of the vein material assayed by M. F. Connor contained only 3·12 ounces of silver per ton.

A shaft approximately 50 feet in depth was excavated on the property by the Pontiac Mining and Milling Company, during the summer of 1907, the maximum width of the deposit exposed on the walls of the shaft in that depth being 3 feet. No further development work has been attempted on the deposit since that time.

Mill. On the Mill claim, lot 44, range IV, in the township of Fabre, there are a number of veins intersecting diabase and Abitibi greenstone, which consist of calcite carrying a considerable amount of smaltite and cobalt bloom.[1] When the property was examined by Harvie in 1910 a prospect pit 27 feet deep had been excavated on a vein of calcite 2 inches wide.

Terra Nova Mines Limited. A large amount of prospecting for possible silver-bearing veins both on the surface and underground was done on lot 3, range V north, Fabre township, by the Terra Nova Mines Limited during the years 1909 and 1910.

The main vein on which development work was attempted was a shatter zone 4 to 5 inches wide composed of fragments of aplite enclosed in calcite, chalcopyrite, hematite, and smaltite. A number of other small calcite veins carrying hematite and small quantities of sulphides were also opened up.[2]

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[1] According to R. Harvie.

[2] Harvie R., "Geology of a portion of the township of Fabre, Quebec," Dept. Colonization, Mines, and Fisheries, Que., 1910.

MOLYBDENITE.

General Statement.

Since the presence of molybdenite in a quartz vein traversing granite on Indian peninsula in Kewagama lake was first noted by J. F. E. Johnston of the Geological Survey in 1901 numerous occurrences of this mineral have been discovered in the region adjoining the original discovery, and a considerable amount of development work has been undertaken for the purpose of determining the commercial value of these deposits. In the following sections the character and origin of the deposits are briefly discussed and the principal prospects of the district described.

Character.

On Indian peninsula in Kewagama lake and in the region northeast of Kewagama lake the rocks of the Abitibi group (chiefly Pontiac schist) are intruded by small batholiths of a light coloured, coarse-grained biotite—muscovite granite. These masses along with the rocks which adjoin them are intersected by numerous veins of quartz and dykes of pegmatite, both of which have evidently emanated from the batholithic masses. In these veins and dykes the molybdenite is found as disseminated flakes or crystals along with bismuthinite, native bismuth, chalcopyrite, and other minerals. In a rough way the deposits may thus be regarded as belonging to two types according as the molybdenite occurs in quartz veins or in pegmatite.

The molybdenite-bearing quartz veins which traverse the granite batholiths and adjoining rocks, although generally irregular and discontinuous, are exceedingly numerous and in some cases maintain a width of 10 to 15 feet for several hundred feet. The quartz composing the veins is generally a translucent variety and, in addition to the disseminated flakes and crystals of molybdenite, contains disseminated pyrite, chalcopyrite, bismuthinite, fluorite, feldspar, and muscovite. The amounts of molybdenite contained in the quartz are exceedingly variable, both in different veins and in different parts of the same vein; but in general, the percentage of the mineral is small. Assays of large quantities of the average type of ore available have not been made, but it is certain that the average percentage of molybdenite contained in most of the quartz veins in the region, is less than one-half of one per cent.

The pegmatite type of deposit is generally a coarse variety rich in muscovite and containing scattered crystals of molybdenite, some of which are 2 inches or more in diameter. Other minerals present in these deposits are beryl, garnet, bismuthinite, native bismuth, fluorite, pyrite, pyroxene,[1] phenacite,[2] chalcopyrite, and zinc blende.[2] In places large aggregates of muscovite in which crystals of molybdenite are embedded occur within the pegmatite, but all of these masses, so far disclosed in development operations, have been small.

Origin.

Following the preceding description of the character of the deposits, it is scarcely necessary to state that the molybdenite deposits occurring in the vicinity of Kewagama lake are pegmatitic in origin, the occurrence of the mineral in pegmatite, the association of both the pegmatite and the quartz veins with granite batholithic masses, and the mineral association found both in the veins and in the pegmatite all pointing to this conclusion.

Prospects.

The following descriptions of properties have been compiled in part from the observations of the writer made during a brief visit to the district, in the autumn of 1910, but mainly from the reports of J. A. Bancroft[3] and T. L. Walker,[4] both of whom examined the prospects in the district in some detail.

Height of Land Mining Company. The property of the Height of Land Mining Company is situated in the township of Villemontel, on the west side of Kewagama river about 2 miles north of Kewagama lake. The rocks outcropping on this claim are pegmatite and mica schist, similar to the Pontiac schist, but, directly eastward across Kewagama river, a granite batholith occurs; so that the rocks at the point where the deposits of molybdenite occur, lie on the contact zone of the granite batholith and the mica schist, the latter trending in a southwesterly direction parallel to the granite contact and dipping to the northwest away from the intrusive mass. The molybdenite deposits are of the pegmatitic variety, occurring in dykes of pegmatite outcropping within a few feet of the west bank of Kewagama river.

The development work includes two shafts 50 and 74 feet deep and two drifts driven from the bottom of the 74-foot shaft in opposite directions, one extending south 60 degrees east for 60 feet, and the other north 60 degrees west for 27 feet. Near the northern end of the property some pits have been excavated near the margin of a pegmatite dyke where some masses of muscovite in which numerous crystals of molybdenite were embedded, were encountered. "A sample

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[1] According to T. L. Walker.
[2] According to J. A. Bancroft.
[3] Bancroft, J. A., "Min. oper. in the prov. of Que.," 1911.
[4] Walker, T. L., "Molybdenum ores of Canada," Mines Branch, Dept. of Mines, Can., 1911.

from the Height of Land Mining Company's workings—such as might readily be selected for concentration—was assayed in the laboratory of the Mines Branch, Department of Mines, with the following result:[1]

Molybdenum	2·39 per cent.
Bismuth	nil
Tungsten	nil
Copper	3·10 per cent."

St. Maurice Syndicate. A number of claims were staked on Indian peninsula in Kewagama lake by the St. Maurice Syndicate. These are known as the O'Brien, Hervey, Sweezy, Doucet, and Huestis claims.

The O'Brien claim is situated on the southeast shore of Indian peninsula, some of the quartz veins on the property outcropping at the water's edge. The rock exposed on the claims is a muscovite granite passing into pegmatite in places. The rock is traversed by numerous irregular quartz veins, ranging from a few inches to 10 feet in width. All these veins are composed of translucent quartz carrying disseminated molybdenite, muscovite, bismuthinite, fluorite, pyrite, chalcopyrite, and feldspar. The prospect work accomplished on the property consists of surface stripping, prospect pits, and open rock cuts a few feet in depth.

The Sweezy, Doucet, and Huestis claims are located on the northern slope of Burnt mountain, on the western side of Indian peninsula, and near the northern edge of the granite batholith which occupies the central part of this land mass. The contact between the granite and the batholith crosses the northeast corner of the Sweezy claim, the strike of the adjoining schists conforming to the margin of the granite mass. Numerous quartz veins, striking in a northwesterly direction and dipping to the northeast, traverse the granite on Burnt mountain and quartz veins and pegmatite also occur in the schist in the northeastern part of the Sweezy claim. The veins range in width from a few inches to 12 feet. The minerals present include the usual varieties: molybdenite, bismuthinite, muscovite, feldspar, pyrite, and fluorite. On the whole, the molybdenite content in these veins is not great, but a sample collected from a vein on the Sweezy by Walker and assayed in the laboratories of the Mines Branch was found to contain 2·60 per cent of molybdenum.

Prospect work on these claims consists of numerous surface openings and pits a few feet in depth.

Peninsular Mining Company. The claims of this company are all situated in the central part of Indian peninsula between the northern and southern claims of the St. Maurice Syndicate. The deposits are

[1] "Molybdenum ores of Canada," Mines Branch, Dept. of Mines, Can., 1911.

of the same type as those exposed on the claims of the St. Maurice Syndicate, the granite as elsewhere, being traversed by numerous veins of quartz. Near the southern border of the Smith claim, a deposit of the pegmatitic type is also present in one locality. A number of open-cuts and prospect pits have been opened up on the claims.

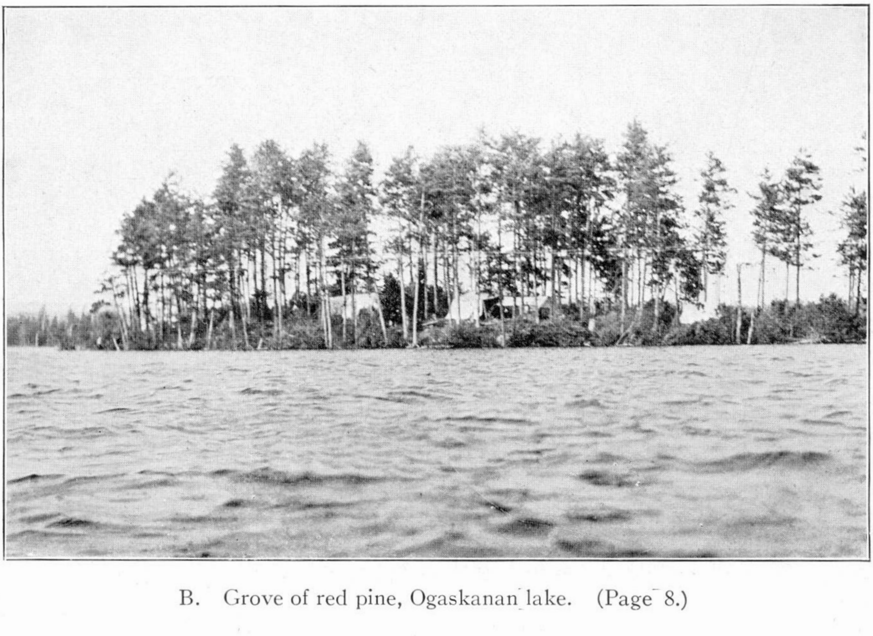
Recently a sampling mill has been erected and additional development work performed by the St. Maurice Syndicate, according to information given the writer by Mr. W. E. Simpson.

A. Typical black spruce swamp of the clay belt, Trécesson township. (Page 8.)

B. Banksian pine, west shore of Matchimanito lake. (Page 8.)

PLATE III.

A. Muskeg, Senneterre township. (Page 8.)

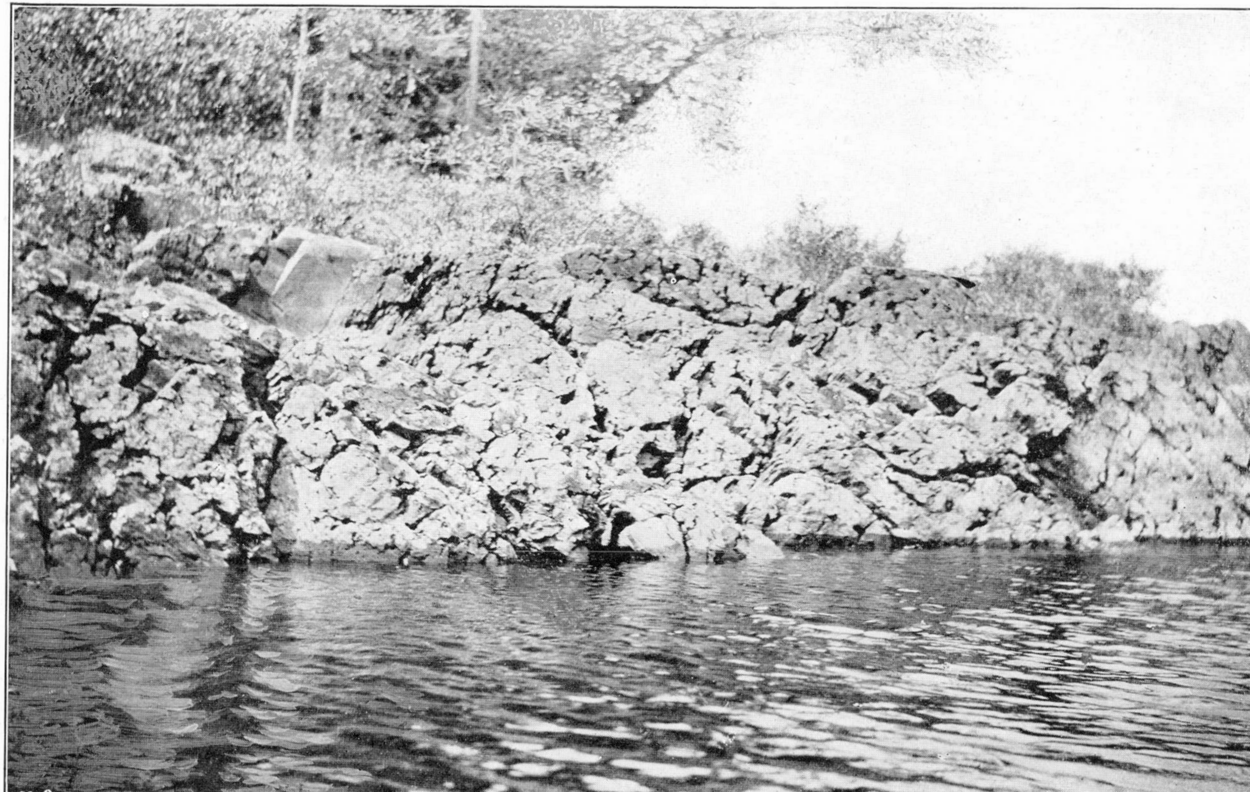


B. Grove of red pine, Ogaskanan lake. (Page 8.)

PLATE IV.

Turners chute, upper Kipawa river. (Page 27.)

PLATE V.



Abitibi volcanics, showing flow structure, Shabogama lake. (Page 87.)

Abitibi volcanics, head of Kiask rapids, Bell river. (Page 82.)

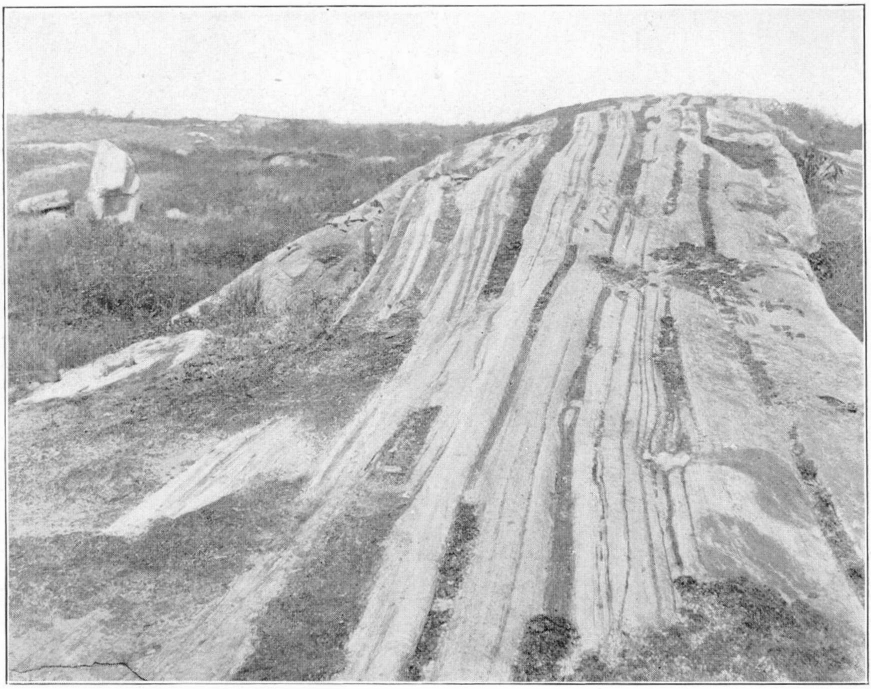
PLATE VII.

Glaciated surface of seamed chloritic greenstone, lake Opasatika. (Page 84.)

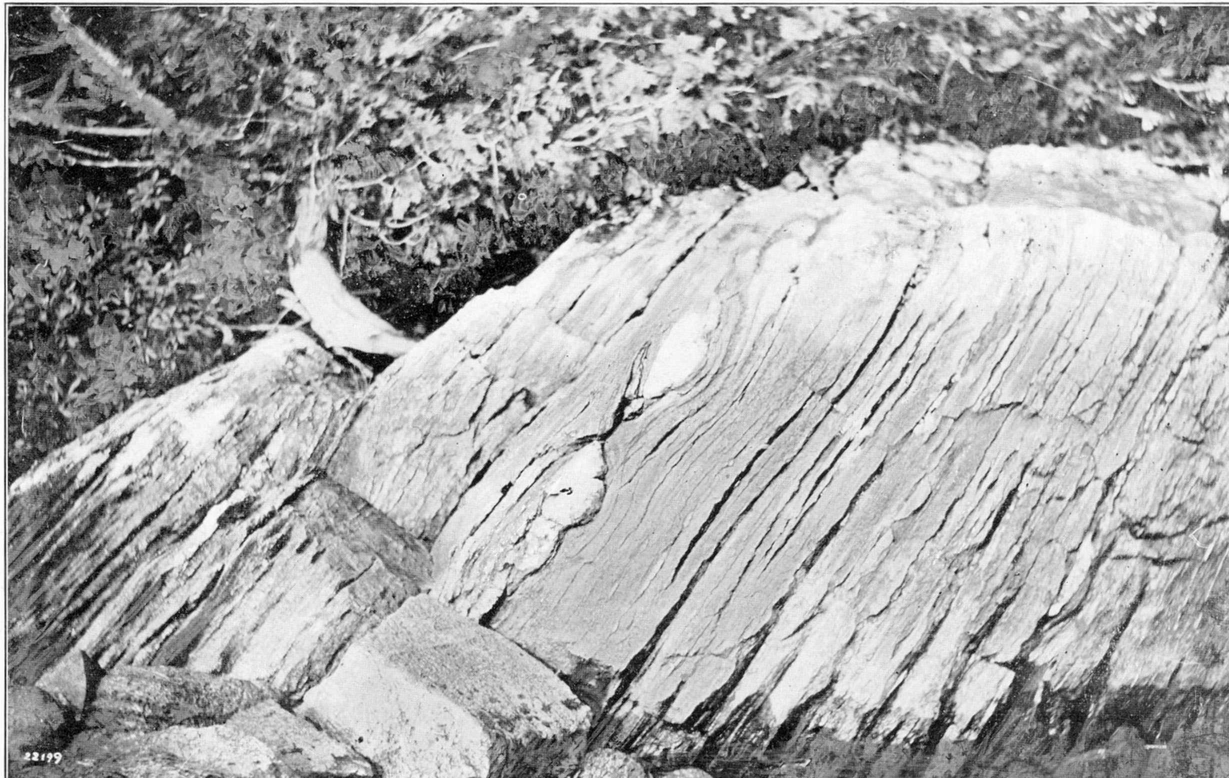
PLATE VIII.

Pontiac schist, dipping northeastward, lake Opasatika, Dasserat township. (Page 96.)

PLATE IX.



Truncated anticline of banded gneiss, Hunter point, Turtle lake. (Page 102.)



Lenticular inclusions of pegmatite in granite gneiss, Grand lake Victoria. (Page 102.)

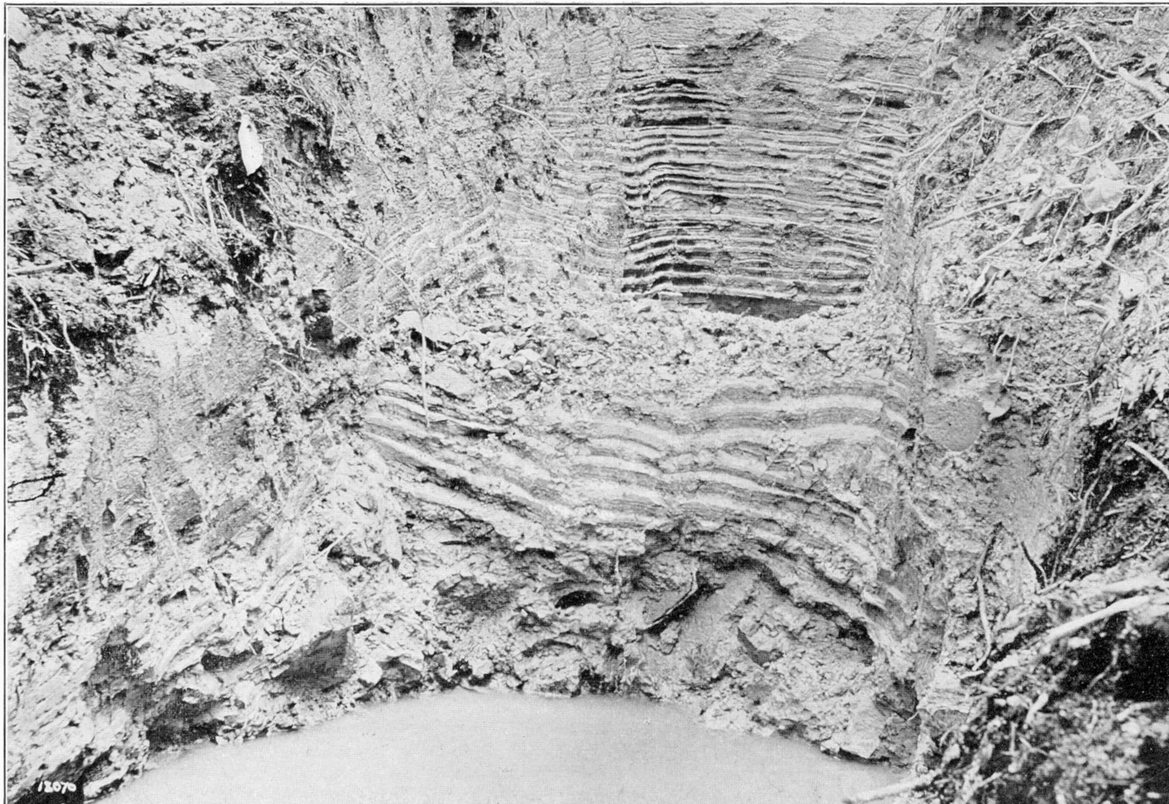
PLATE XI.

Contact of diabase dyke with granite, west shore of Shabogama lake. (Page 112.)

PLATE XII.

Cross-bedded glacial drift, Courville township. (Page 118.)

PLATE XIII.



Stratified post-Glacial clay in prospect pit, Kewagama river, Preissac township. (Page 142.)

Stratified sand overlain by boulders, Courville township. (Page 118.)

Plate XV.

Contemporaneous folding in stratified clay, Courville township. (Page 142.)

PLATE XVI.

Broken stratified clay, Senneterre township. (Page 142.)

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