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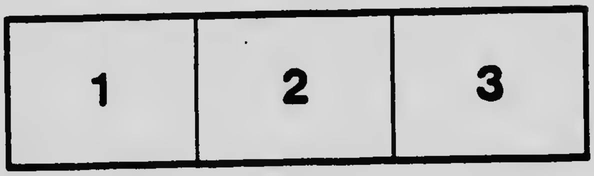
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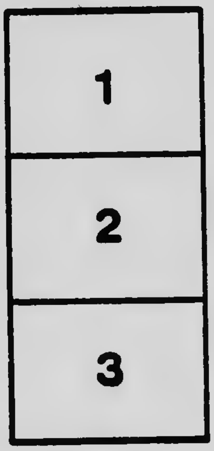
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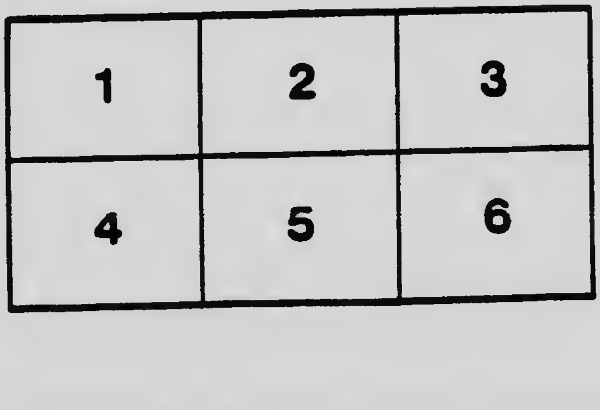
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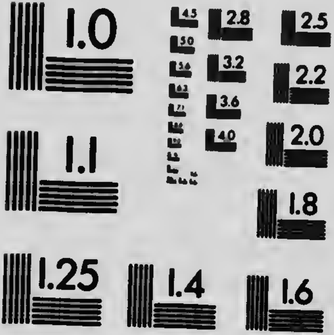

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GEOLOGICAL SURVEY
R. W. Brock, Director.

MEMOIR 39

No. 35, Geological Series.

Kewagama Lake Map-Area Quebec

BY
M. E. Wilson

1842

Ottawa
Government Printing Bureau
1913

No. [illegible]

PLATE I.

A

Scratched and faceted pebble from the conglomerate of the Cobalt series, north shore Kekeko lake, Boischatel township, Pontiac county, Quebec.

B

A typical faceted pebble from the Cobalt series, north shore Kekeko lake, Pontiac county, Quebec.

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CHAPTER IV—*Continued.*

CHAPTER IV—*Continued.*

CHAPTER V.

ILLUSTRATIONS.

THE KEWAGAMA LAKE MAP AREA, QUEBEC.

CHAPTER I.

INTRODUCTION.

GENERAL STATEMENT AND ACKNOWLEDGMENTS.

The following report is an account of the geology and economic possibilities of a region in northwestern Quebec, lying immediately east of the Ontario boundary and south of the National Transcontinental railway. This district was known, in a general way, to be geologically somewhat similar to the adjoining portions of Ontario, but little detailed information was available with regard to either the character of the country, its geology, or its economic possibilities. It was further apparent that, owing to its proximity to regions in Ontario where gold had been recently discovered and the easy access afforded by the National Transcontinental railway, the district would soon be actively prospected. It was, therefore, deemed advisable that the geological examination of the district be undertaken.

Throughout a considerable part of this region, rock exposures are not abundant, and with a limited amount of time available for the work, it was not possible to carry on the detailed investigation which the complicated geology of ancient Pre-Cambrian rocks demands; for this reason the report must be considered as preliminary in character, presenting the broader geological features as observed in scattered outcrops, supplemented by more extended observations on some of the rocky hills and ridges, which occur here and there throughout the region.

The report is accompanied by a geological map on the scale of 4 miles to 1 inch. This, however, includes the area to the south and east of the Kinojevis river examined by Dr. J. A. Bancroft[1], as well as some of the observations of Mr. W. J. Wilson along the line of the National Transcontinental railway, the Harricanaw river, and La Motte (Seals Home) lake [2].

Many of the lakes and rivers of the region had not been previously surveyed, so that a considerable part of the time spent in

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[1] Min. Op. in Prov. of Que., pp. 160-207.

[2] Geological Reconnaissance along the line of the National Transcontinenta railway in Western Quebec, Memoir No. 4, Geo. Surv., Dept. of Mines, Can., 1910.

field work was devoted to the preparation of the topographical map. For this purpose, the Rochon micrometer telescope and surveyor's compass were employed in surveying the navigable waterways, while the chain and surveyor's compass were used on the portages. The larger inland lakes were located by chain surveys, but many of the small ponds were simply sketched and tied to the main traverse routes by paced lines.

As the region included on the map is intersected by numerous base, meridian, and township lines surveyed by the Provincial Crown Lands department, and is limited on the west by the interprovincial boundary line, the surveys made, as outlined above, were checked at numerous points, so that a tolerably accurate map was obtained, upon which the areal extent of the various geological series could be delimited.

In addition to the traverses made by the writer and his assistants, the following surveys were used in the preparation of the geological map.

Survey of Lake Dasserat by Lindsay Russel, 1868.

Interprovincial boundary survey between Ontario and Quebec from Lake Timiskaming to the height of land by O'Hanly and O'Dwyer, 1873-74.

Survey of the eastern part of Kekeko lake, Kinojevis lake, the southern part of the Kinojevis river, and Lake Dufresnoy by John Bignell, 1893.

Survey of Makamik lake, Lois lake, and the Lois river by J. F. E. Johnston, 1901.

Survey of the northwest shore of Labyrinth lake by W. J. Wilson, 1901.

Extension of the Interprovincial boundary survey northward from height of land by Patten and Laberge, 1906.

Survey of the lower part of the Bellefeuille river, part of the Harricanaw river, and La Motte lake by W. J. Wilson, 1906.

Survey of the upper Ottawa, De Montigny lake, the Askowish river, and Piché lake by H. O'Sullivan, 1908.

Base, meridian, and township lines surveyed by the Crown Lands Department of Quebec.

The present report represents the results of field-work carried on during the seasons of 1910 and 1911. Operations were commenced in the vicinity of Lake Abitibi in 1910, and continued eastward and southward across the St. Lawrence-Hudson Bay divide to the Kinojevis river and Kekeko lake in 1911. The month of September, in both years, was spent in an examination of the country in the vicinity of the National Transcontinental railway to supplement the earlier work of Mr. W. J. Wilson.

I was assisted in the field in 1910 by Messrs. N. B. Davis, L. E. Dagenais, J. S. Stewart, and A. C. Simpson, and in 1911 by

Messrs. E. M. Burwash, L. E. Dagenais, J. S. Stewart, and C. P. Sills.

Thanks are due to the officials of the National Transcontinental Railway engineering staff, to the employees of the Walsh Transportation Company, to the officers of the Hudson's Bay Company and of Revillon Freres, to Mr. Chas. Richmond, and to many others who contributed by their co-operation to the progress of the work.

My grateful acknowledgments are also due to Dr. Joseph Barrell, Dr. Isaiah Bowman, Dr. J. D. Irving, and Dr. L. V. Pirsson, of the Geological Department of Yale University, and to Dr. C. K. Leith, Professor of Geology in the University of Wisconsin, for many suggestions and criticisms embodied in the following pages, and also to Mr. Stewart J. Lloyd, Assistant Professor of Chemistry and Metallurgy in the University of Alabama, for the chemical analyses on pages 47, 48, and 50.

LOCATION AND AREA.

The region described lies in northwestern Quebec adjacent to the Ontario boundary and south of the National Transcontinental railway. The map which accompanies the report extends from the interprovincial boundary to La Motte lake and the Harricanaw river and from the National Transcontinental railway to O'Sullivan's base line, or expressed geographically, from longitude 79° 30′ 56″ to longitude 78°, and from latitude 48° 50′ to latitude 47° 45′. The position of the sheet with respect to the adjacent regions is indicated in the index map, Fig. 1.

TRANSPORTATION AND COMMUNICATION.

Until recent years, the usual means of access to this region was by canoe from Lac des Quinze, but with the construction of the Timiskaming and Northern Ontario, and National Transcontinental railways, alternative routes have become available. These are especially advantageous in reaching the northern parts of the district, the canoe routes from the south still affording the easiest means of communication for the more southerly areas.

Since the National Transcontinental railway crosses the northern part of the sheet, this portion of the region is now easily reached by train from Cochrane, Ontario—the junction point of the Timiskaming and Northern Ontario, and the National Transcontinental railways. The districts at a distance

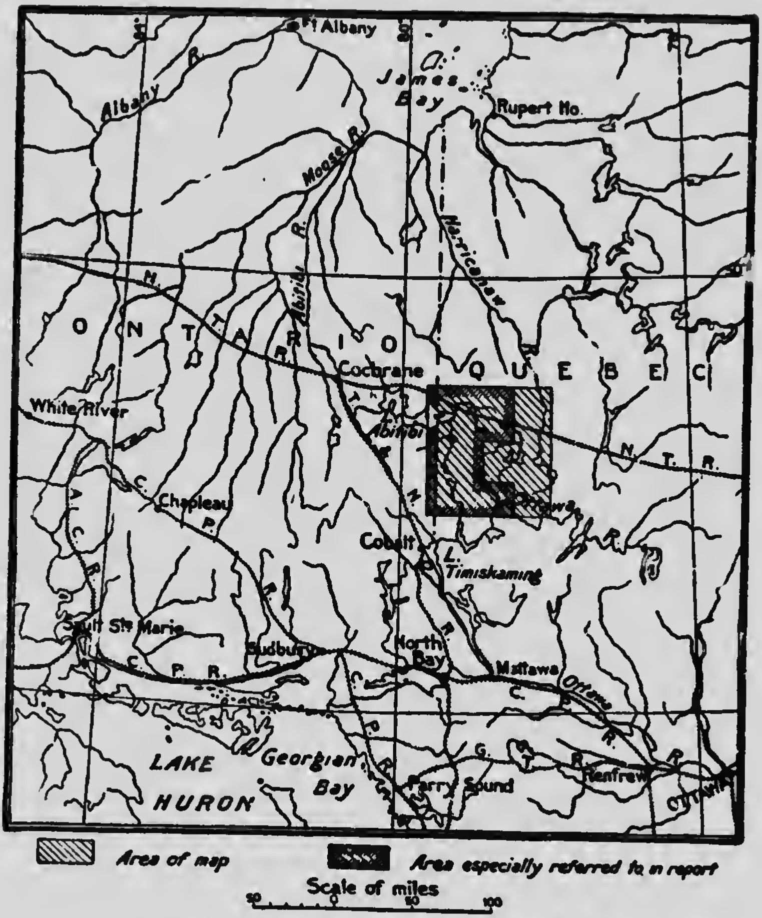

FIG. 1. Index map showing position of area.

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 sheet, the La Sarre river affords an uninterrupted waterway to Lake Abitibi, from which the Abitibi-Timiskaming canoe route may be followed southward. The 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 Agotawekami through Kakameonan and Dufresnoy lakes. This route, however, requires considerable portaging and follows small streams, the headwaters of which become impassable in time of drought.

After the construction of the Timiskaming and Northern Ontario railway to Matheson, Ontario, a common means of access to Lake Abitibi was by canoe from that point along the Black and Abitibi rivers. A number of launches and steamboats were maintained on this route by the Walsh Transportation Company during the summers of 1908, 1909, and the early part of 1910, but were withdrawn as soon as the construction of the National Transcontinental railway to Lake Abitibi rendered them unnecessary.

At the eastern border of the map, there is another line of communication transverse to the National Transcontinental railway, along the Harricanaw river which is navigable without interruption as far south as La Motte lake. Between the Harricanaw and the La Sarre (Whitefish), the streams lie adjacent to the height of land and are consequently small. The Villemontel and Kewagama rivers, however, afford a tolerably good canoe route from the outlet of Fork creek—a point within a half mile of the railway—to Kewagama lake. The Villemontel meanders greatly and is interrupted by a number of rapids and a log jam, but the portages are short and the rapids can all be run when the water is high.

Another canoe route has recently been cut out leading from the southeast corner of Lois lake to a series of lakes which occupy a north-south gorge-like valley in the Abijevis hills, and thence to Horsetail lake and the Kinojevis river. This route is, however, very rough and requires over 4 miles of portaging and for this reason is not commonly used.

The usual means of communication for the southern part of this region is by canoe through some of the waterways tributary to Lac des Quinze. There are two roads which may be followed from Lake Timiskaming to Lac des Quinze, one which leads from Ville Marie to Gillies farm at the south end of Lac des Quinze, and the other, from North Timiskaming to Klock's farm 15 miles farther north on the same lake. The country adjacent to the 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 Barriere, Albee, and Kekeko lakes. The region in the vicinity of Lake Opasatika is easily accessible from Lac des Quinze along the Abitibi canoe route of which Opasatika forms 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 through Raven lake to Opasatika.

HISTORY.

GENERAL HISTORY

The earliest explorations in the region were those of the French who penetrated the northern wilderness of eastern Canada in quest of furs. From the days of the *coureur du bois* until recent years, however, the district has remained a wilderness practically unknown except to the Indian, the fur trader, and the missionary. The extension of lumbering operations to the upper Ottawa about 40 years ago, resulted in considerable activity in the southern part of the region for a time, but these operations had largely ceased when interest in the region was again revived by the construction of the National Transcontinental railway.

The discovery of the silver-bearing veins at Cobalt in 1903 was followed by much prospecting activity in adjacent regions, to which a further impetus was given by the discovery of gold bearing quartz veins at Porcupine in 1909. Following the Cobalt discovery, a number of prospectors visited this region and in July 1906, Messrs. Alphonse Ollier and Auguste Renauld made a discovery of gold in a veinlet of quartz and dolomite which intersected a porphyry dyke, occurring on the south shore of Fortune lake, about 2 miles northeast of the north end of Lake Opasatika. The claim staked by Ollier and Renauld was taken over by the Pontiac and Abitibi Mining Company and later by the Union Abitibi Mining Company. Operations were commenced on this property in 1907, but no progress was made until the past year when active development work was begun.

In the summer of 1901, Mr. J.F.E. Johnston in making a geological reconnaissance for the Geological Survey in this region, noted the occurrence of molybdenite in a quartz vein cutting the granite which outcrops on the peninsula in Kewagama lake. In 1907, Mr. C. H. Richmond discovered molybdenite in pegmatite occurring on the Kewagama river, and since that time, this mineral has been found to be of wide occurrence in pegmatite dykes and quartz veins associated with the granite of that vicinity. Nearly all of these occurrences are held by mining companies some of which have commenced operations for the purpose of attempting their exploitation.

The two localities mentioned, the Union Abitibi Company's claim to the northeast of Lake Opasatika and the molybdenite occurrences in the neighbourhood of Kewagama lake, are the only places in the region where work is, at present, being carried on. The development work on all of the other claims consists merely of stripping or test pits a few feet deep.

PREVIOUS WORK.

The earliest geological work in this region was a report by Mr. Walter McOuat on the "Country between Lake Timiskaming and Abitibi", which was published in the Report of Progress of the Canadian Geological Survey for 1872. This consisted of a fairly detailed account of the lithology of the Timiskaming-Abitibi canoe route and of the shores of Lake Abitibi.

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

In 1904, Dr. 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 Canadian Geological Survey for that year.

During the summer of 1906, Mr. W. J. Wilson investigated the geology along the waterways and railway survey lines adjacent to the National Transcontinental railway. This included the examination of the rocks along the Fly, Bellefeuille, Villemontel, and Harricanaw rivers and along the shores of La Motte and Kewagama lakes. The results of Mr. Wilson's work were published in the Summary Report of the Canadian Geological Survey for 1906, and again in greater detail in Memoir No. 4: A Geological Reconnaissance along the line of the National Transcontinental Railway in Western Quebec. Geological Survey, Department of Mines, Canada, 1911.

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 Mr. J. Obalski.

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CHAPTER II.

SUMMARY AND CONCLUSIONS.

TOPOGRAPHY.

The topography of the Abitibi district exhibits the typical low relief and youthful drainage systems which are generally characteristic of the Laurentian plateau, but local modifications in these features have been brought about by the deposition of stratified clay and sand from a huge lake which covered a large part of the region for a period of about 250 years following the retreat of the last Labradorian ice sheet.

At the beginning of its known physiographic history this region possessed a mountainous topography, but early in the Pre-Cambrian era a most prolonged period of denudation occurred during which the surface of the region was reduced to a peneplain. Upon this ancient erosion surface an assemblage of clastic sediments—the Cobalt series—was laid down. These rocks were later flexed and intruded by the Nipissing diabase and syenite porphyry, after which denudation again began in the region and continued until the Palæozoic when the region was submerged beneath the sea and Silurian sediments deposited.

Since the retreat of the Palæozoic sea this region has suffered no orogenic disturbances, and, as far as known, has always been a positive element in the earth's crust, but has possessed such a low relief throughout all this interval that the progress of denudation has been exceedingly slow. Much of the erosion accomplished consisted in the stripping away of sediments, so that the present topography corresponds very closely in places to one or other of the ancient erosion surfaces upon which the sediments were deposited. It is unknown whether the Cretaceous peneplain described in other parts of eastern North America, extended over this region or not, but, if such a plain was formed, it was developed, in part at least, on the surface of Silurian sediments which have since been eroded away.

The final stages in the physiographic development of the district are closely related to the Labradorian ice sheets which, (1) by denudation and (2) by deposition, imposed a youthful drainage system on a surface of low relief, thus producing the peculiar glacial physiography so typical of the Laurentian plateau.

GENERAL GEOLOGY.

The rocks of the Abitibi district may be classified both according to structure and age into three main classes: (1) the older complex; (2) the Cobalt series and the Keweenawan? intrusives; (3) the Pleistocene and Recents deposits.

The first class—the older complex—may be divided into two main divisions, the surficial rocks which have been designated the Abitibi group and the plutonic types to which belong the batholithic granite and gneiss (Laurentian). The larger part of the sedimentary rocks composing the Abitibi group have been given a separate name—the Pontiac series—partly because they are lithologically different and partly because they appear to consist of a conformable succession of sediments and thus constitute a stratigraphical unit, whereas the remainder of the Abitibi group is composed of a great complex of volcanic flows, the stratigraphical and structural relationships of which are not fully known and which very probably belong to more than one series. It may be possible that a large part of the Abitibi group in reality belongs to the Pontiac series, but the true relations have not, as yet, been worked out. Wherever the plutonic rocks of the older complex were observed in contact with the surficial members, the former were always intrusive into (and hence younger than) the latter, although the presence of pebbles and boulders of granite in the conglomerate of the Pontiac series shows that an older granite must somewhere be present in the region.

The Abitibi volcanic complex includes those rocks which in other parts of the Timiskaming region have been classed as Keewatin. These consist chiefly of basic to acid volcanic flows and their metamorphosed equivalents, but also include some slate and ferruginous dolomite. The volcanic rocks possess typical amygdaloidal and ellipsoidal structures and have suffered intense metasomatic alterations. It is concluded in this report that the ellipsoidal structure owes its origin to subaqueous extrusion, and that the metasomatic alterations were brought about by juvenile gases which were very effective because the open structure of the lavas gave them free access to all parts of the rock and because the presence of the water in these interspaces prevented the escape of the gases and at the same time afforded a medium through which they could act.

The ferruginous dolomite which has been classed in the Abitibi group consists of a lime, iron, magnesium carbonate along with varying proportions of feldspar, quartz, sericite, chrome mica, and pyrite and is always cut by veins or veinlets of quartz. From a consideration of the geological evidence it is concluded that this dolomite has been derived from aplite, quartz porphyry, and related rocks by the action of thermal solutions which circulated through fractures in the original rock and thereby effected its replacement.

The Pontiac series, which includes the major part of the sedimentary rocks of the older complex, consists of three members: (1) greywacke, arkose, and conglomerate; (2) biotite and hornblende schist, and (3) amphibolite. The greywacke, arkose, and conglomerate are evidently waterlain sediments, but whether they were deposited on the seashore or in lakes or by rivers was not ascertained. The biotite and hornblende schist are believed to have been derived from greywacke and arkose by the contact action of an intrusive batholith of granitic rocks. The origin of the amphibolites is not positively known, but they possess certain features which indicate that they were originally volcanic flows interbedded with the sediments.

Both the Pontiac series and the Abitibi group are intruded by batholiths and smaller masses of granite and granite-gneiss, these rocks constituting the plutonic subdivision of the older complex. They are believed to have been intruded during a period when great orogenic crustal movements folded the surficial rocks of the older complex into a great synclinorium, a truncated portion of which occurs in the region described in this report. These batholiths made room for themselves in two ways, (1) by lifting and thrusting aside the overlying and surrounding rocks, (2) by breaking off and assimilating fragments of their roofs: (subcrustal stoping). There is evidence that the first method was of great importance. Whether the second was an important factor or simply a phenomenon of minor significance is unknown.

The rocks of the older complex are overlain by a group of almost flat lying clastic sediments—conglomerate, greywacke, argillite, and arkose—composing the Cobalt series. Where the complete section of these rocks is present there is generally a conglomerate both at the base and at the top, the greywacke, argillite, and arkose occurring as intermediate members. It is shown in the section of the report in which the origin of the Cobalt series is discussed that, the above succession is directly related to the manner in which the various rocks were laid down, the conglomerates being till sheets deposited from continental glaciers and the greywacke, arkose, and argillite interglacial lacustrine deposits.

In the classification of the rocks of the region into major subdivisions the Keweenawan intrusives are classed with the Cobalt series. These consist of dykes of diabase and olivine diabase and a mass of syenite porphyry. It is probable that all of these rocks were derived from the same magma and that they are the equivalent in age, of similar rocks classed as Keweenawan in the Lake Superior region. In the district described in this report the diabase was observed only as dykes cutting the older complex, but in adjacent districts it occurs both as dykes and sills intruding the Cobalt series. The syenite porphyry was seen in only one locality and in that place occurred as an oblong mass with vertical walls in eruptive contact with the basal conglomerate of the Cobalt series.

The Pleistocene and Recent deposits of the region consist of (1) glacial and fluvioglacial deposits, (2) stratified clay and sand. The glacial material consists of a thin mantle of till scattered over the surface of the Pre-Cambrian rocks described in the preceding paragraphs. The fluvioglacial deposits are more localized, occurring here and there as kames or outwash plains. They differ from the glacial material in being roughly stratified. The second division of the Pleistocene and Recent deposits—the stratified clay and sand—overlies the glacial and fluvioglacial materials. It is believed that these sediments were laid down in a huge lake which covered a large part of the region following the retreat of the last Labradorian ice sheet.

ECONOMIC GEOLOGY.

There are no producing mines in the region described in this report nor have any ore deposits been discovered which are of commercial value under present conditions of operation. The principal deposits which have attracted attention are the auriferous quartz veins or veinlets and the quartz veins and pegmatite containing molybdenite.

Veins of quartz occur in all the rocks of the region, but are most extensively developed in those of the Abitibi group. Many of these veins are several feet wide and extend for several hundred feet, but in no case did assays of average samples from these occurrences show that a workable body of ore was present.

The molybdenite occurring in the region is found in pegmatite and quartz veins developed in the contact zone of the Pontiac schist and the southern granite batholith. These deposits are all of small extent, however, and are not at all comparable with the deposits of this mineral occurring in the vicinity of Kewagama lake.

It must not be assumed, however, that the above statement of results has a very important bearing on the future possibilities of the district, for the country has not been prospected except in a very superficial way. Geologically the region corresponds very closely to the Porcupine district of Ontario, and with the increased transportation facilities now afforded by the National Transcontinental railway is probably one of the most easily accessible and promising prospecting fields in northern Quebec.

CHAPTER III.

GENERAL CHARACTER OF THE DISTRICT.

TOPOGRAPHY.

GENERAL ACCOUNT.

Regional.

The region under description belongs to the great Pre-Cambrian plateau which occupies nearly the whole of north-eastern Canada. This great physiographic province may be described as an uplifted and dissected peneplain, which has been further denuded by continental ice sheets. All evidence of the former existence of a peneplain throughout this vast territory has been long since destroyed, except that the present surface of the plateau (1) truncates the structures of the underlying crystalline rocks and (2) possesses an exceedingly low relief. The most striking topographic features of the plateau as seen from its higher elevations, are the general mammalated character of its surface and the remarkable uniformity of its sky-line, as shown in Plates III and IV. This uniformity is due to the general subequality of its elevations, which range from 1,000 to 2,000 feet above sea-level with a local relief in many areas of wide extent, of only 200 or 300 feet. Although the surface of the plateau is thus devoid of great relief, yet in its details, it possesses a minutely rugged and variable topography, for rocky ridges, steep scarps, and gorge-like valleys are encountered everywhere.

The pre-glacial drainage systems of the plateau have been completely disorganized: (1) by irregular glacial erosion, (2) by the irregular deposition of glacial drift, so that the majority of the streams and rivers of the region are without valleys or occupy depressions entirely disproportionate to their size. The depressions in the rocky surface of the plateau and the irregularly scattered glacial debris have together afforded numerous basins which are now occupied by lakes. Much of the drainage in this rocky lake country is accomplished by the water simply spilling over the rim of these basins, at their lowest points, and tumbling downward from lake to lake. Many of the so-called rivers of the Laurentian plateau are in reality a series of narrow lakes connected by rapids and waterfalls.

The completely disorganized drainage systems and infinite number of lakes which occur everywhere throughout the Laurentian plateau, are features distinctly characteristic of regions of low relief which have suffered glaciation, for, while similar effects are produced to a degree in mountainous regions, these are *comparatively* unimportant because, in such localities, the slope of the surface is the controlling factor.

Local.

The region described in this report exhibits in general, the usual characteristics of the Laurentian plateau, but owing to the deposition of Pleistocene lacustrine deposits in all of the lower depressions of its surface, a marked topographic modification has been effected. Areas of rocky hill country characterized by all the topographic qualities of the plateau province occur here and there throughout the district. Around these, stratified clays have been deposited constituting what might be described as a depositional plain.

DETAILED ACCOUNT.

Relief.

The Abitibi district lies somewhat below the general elevation of the surface of the Laurentian plateau, having an average height of from 900 to 1,100 feet above sea-level with hills and ridges rising here and there to elevations from 500 to 700 feet above the surrounding country. The lowest elevation in the region is the surface of Barriere lake which is 867 feet above sea-level[1], while the highest point is Mount Shiminis which has an approximate height above sea-level (aneroid determination) of 1850 feet, giving a vertical range for the district of approximately 1,000 feet.

Mount Shiminis is situated immediately southeast of the 40th mile post on the interprovincial boundary. This haystack-like hill is one of a number of prominent elevations of Huronian rock which occur along the height of land to the northwest of Lake Opasatika. These include the Labyrinth hills, between Labyrinth and Dasserat lakes, the Swinging hills, directly south of Dasserat lake, and the Kekeko hills, which form an east-west trending range to the northwest of Kekeko lake. All the hills of the region other than those mentioned, consist of volcanics of the Abitibi group, the more prominent of these being the Abijevis hills which extend for nearly 15 miles parallel to the south shore of Lois lake, the Smoky hills

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[1] According to determinations by Mr. G. B. Hull, of the Public Works De[illegible].

situated at the headwaters of the Smoky river, the Tenendo hills southwest of Tenendo lake, and Kamak hill rising adjacent to the south shore of Lake Dufresnoy. Next to the higher elevations of Huronian rocks, the Abijevis hills form the most striking range of the whole region, having an elevation of 1,650 feet above sea-level.

The following table of elevations has been compiled from the National Transcontinental Railway surveys, from the determinations of levels along the upper Ottawa by the Public Works Department, and from aneroid determinations by the writer.

Lake Abitibi highwater level	870	feet[1]
Makamik lake	915	“[1]
Robertson lake	1,004	“[1]
Davy lake	1,003	“[1]
Beauchamp lake	1,036	“[1]
Spirit lake	971	“[1]
La Motte lake	966	“[2]
Height of land east of Robertson lake	1,074	“[1]
Lois lake	990	“
Duparquet lake	885	“
Dufresnoy lake	907	“
Height of land between Mackay and Kakameonan lake	950	“
Lake Kewagama	953	“[2]
Lake Dufault	951	“
Kekeko lake	881	“
Caron lake	880	“[2]
Lake Kinojevis	880	“[2]
Albee lake	882	“
Barriere lake	867	“[2]
Lake Opasatika	869	“[2]
Lake Dasserat	913	“[2]
Ogima lake	913	“[2]
Height of land between Ogima and Summit lakes	936	“[2]
Mount Shiminis	1,850	“
Swinging hills	1,600	“
Kekeko hills	1,680	
Abijevis hills	1,650	“

Drainage.

The drainage of the region is about equally divided between the St. Lawrence and James Bay basins, the height of land passing through the map-area in a general northeasterly-

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[1] Transcontinental survey.

[2] Ottawa River Regulation survey.

southwesterly direction but with a very sinuous course. The waters on the south side of the divide find their way into Lac des Quinze either by way of Barriere lake or through the Kinojevis river. The drainage on the James Bay slope, with the exception of a few headwater streams flowing into the Harricanaw river, is entirely into Lake Abitibi, largely through the La Sarre and upper Abitibi rivers.

Since the lower depressions in the rocky surface of the region are occupied by Pleistocene stratified clay, all the rivers have incised their channels in this material, and with respect to the clay, are in reality consequent streams developed on the surface of a constructional plain. Most of these, however, in places, have cut their way through the clay to the underlying rock, so they now consist of stretches of quiet currentless water, where they run over the clay, interrupted, at intervals, by rapids and waterfalls, where they are superposed on the harder rock. These streams have exceedingly wide and deep channels much out of proportion to the volume of water which they discharge. Thus the La Sarre river with a drainage basin of approximately 650 square miles, is from 200 to 300 feet wide and is from 25 to 30 feet deep for several miles above its outlet. The channel of the river is, therefore, over 15 feet deeper than the bottom of Lake Abitibi into which it flows. This overdeepening is probably brought about by the action of spring floods on the easily transported clay in which the channels of the streams occur.

It is evident that all these streams are exceedingly youthful for they have as yet scarcely more than formed definite channels for themselves, nor are the tributary streams well enough developed to effect even a partial drainage of the clay belt, for stretches of muskeg several miles in extent are common in the interstream areas. The larger rivers of the clay belt have sinuous courses, but no well developed meanders were observed. In the smaller rivers and creeks, however, both meanders and cut-offs have been formed.

The island which occurs in the La Sarre (Whitefish) river a short distance north of the National Transcontinental railway, was evidently formed by the lateral diversion of the South river from an outlet at B to an outlet at A, Fig. 2. This capture and the consequent formation of a long narrow island were effected owing to the fortuitous concurrent incision of a meander in the La Sarre and South rivers at the same point A. This mode of stream capture is a common phenomenon in river development, one of the best known examples of the world being the diversion of the Ste. Austreberte by the Seine at Duclair.[1]

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[1] Nat. Geo. Mag., Vol. 7, p. 191, 1896.

As is characteristic generally of the Laurentian plateau, lakes are exceedingly numerous in the region, but occur chiefly in the rocky hill country. Those which occur in the clay belt owe their origin to very slight depressions in the clay surface and are, therefore, exceedingly shallow. Lake Abitibi, for example, although it has an area of approximately 335 square miles—only 50 of which, however, are included in the district under description—has a depth of less than 10 feet throughout nearly its entire extent. Makamik lake is also very shallow, nowhere more than 5½ feet deep.[1]

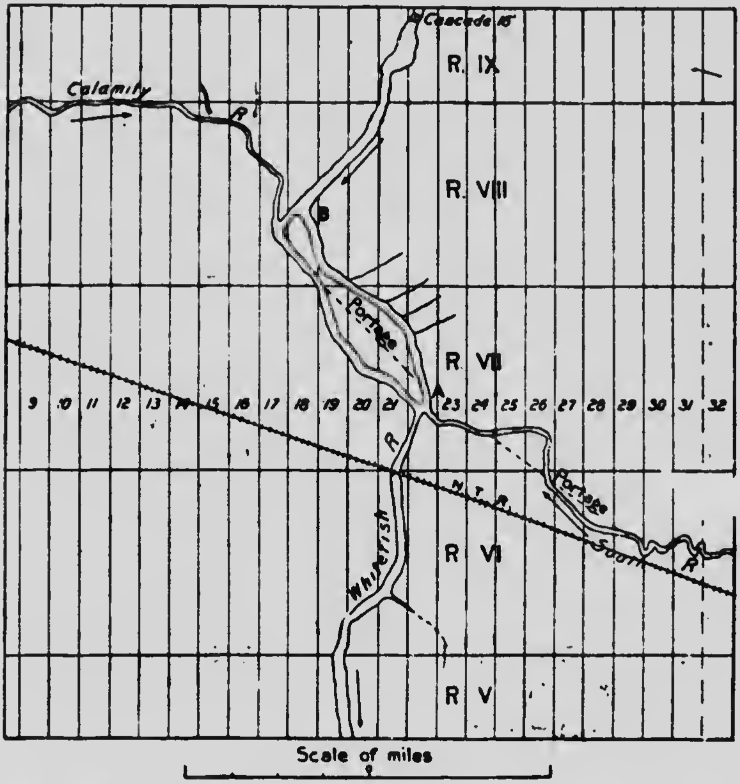

FIG. 2. Island in La Sarre river formed by the lateral diversion of the South river.

The lakes of the rocky portions of the district undoubtedly owe their origin largely to the scattered deposition of glacial

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[1] According to Mr. Frank Johnston (Sum. Rep. Can. Geol. Surv., p. 132, 1901).

drift over an uneven rock surface, since all of these lakes are hemmed in, to a large extent, by glacial material, but, to what extent the irregularities of the rock surface are due to glacial or preglacial erosion is not always evident. As in general the Laurentian plateau underwent dissection for a long time prior to glaciation, it might be expected that in so far as the present rock surface is of preglacial origin, the structures of the rocks would find expression in the topography and this appears to be true of some lake basins. Lake Kakameonan, Lake Dufresnoy, and Sills lake, all have a northwesterly-southeasterly trend parallel to the structure of the tilted volcanic flows in which they occur. The trend of these basins, moreover, is inclined at a considerable angle to the direction of glacial movement, so that they are probably preglacial valleys. In many parts of the region, however, the rocks are of a uniform character without any well developed structure. In such rocks, normal stream valleys, modified by glacial erosion and glacial deposition, or glacial erosion of itself regardless of the former rock surface followed by glacial deposition, would result in the formation of lakes of irregular outline and containing many islands. Lake Duparquet, Lake Dasserat, and Lake Dufault are lakes of this type.

There are a large number of linear valleys in the region, however, which have no relationship to the structure or character of the rocks in which they occur. One of the most striking examples of this was observed in the narrow, rift-like gorge occupied by Abijevis and Eileen lakes in the Abijevis hills. This depression is bordered on either side by precipitous cliffs from 100 to 200 feet high. It is probable that the east end of Lois lake, Fraser lake, Robertson lake, a part of the Kinojevis river, Clericy lake, and Vaudray (Long) lake, all owe their origin to the same cause or set of causes as the Eileen-Abijevis valley since they are in line with one another. This line of depressions extends for 50 miles traversing all the rocks of the older complex and is almost at right angles to their structures. The south ends of Lake Opasatika, Caron lake, and the Barriere-Albee-Kekeko chain of lakes all lie in linear depressions which are entirely unrelated to the structures of the rocks in which they occur. Since these valleys have a north-south or northeast-southwest trend, practically parallel with the direction of movement of the Labradorian ice sheets in this region, it is possible that they owe their origin to glacial erosion. It is improbable, however, that a continental ice sheet would form a line of narrow depression continuous for 50 miles, and furthermore, as is pointed out on page 25, there is evidence which indicates that the similar Lake Timiskaming depression is of a very ancient origin. It is more probable, therefore, that these are preglacial valleys although probably overdeepened or otherwise modified by glacial action.

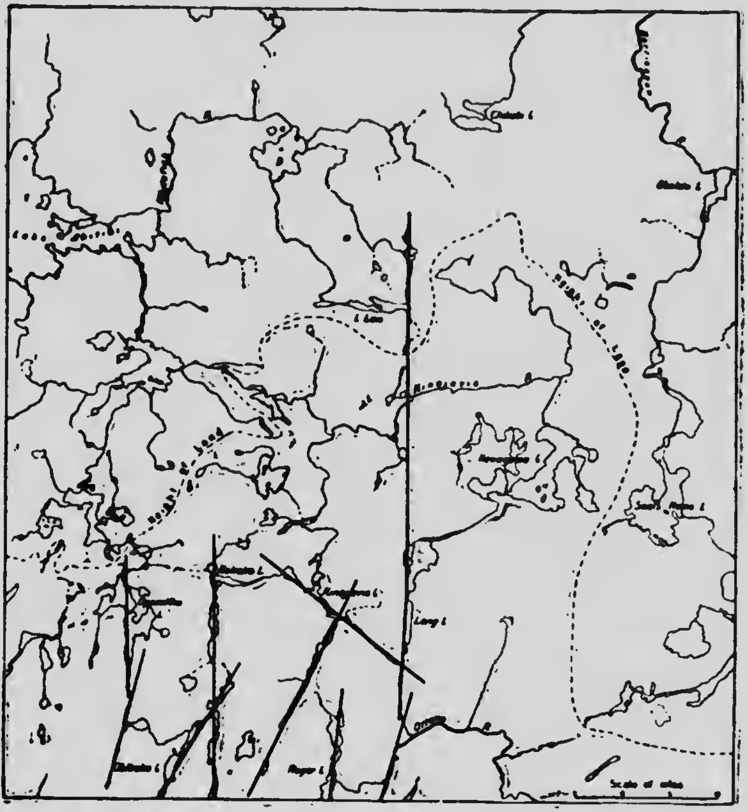

FIG. 3. Linear valleys of the region which are unrelated to rock structure.

Some of the larger lakes of the region and their areal extent are given in the following table:—

Lake Abitibi	335	sq. miles,
Lake Duparquet	16	"
Lois	6	"
Makamik	18	"
Lake Dufault	14	"
Dasserat	15	"
Opasitika	20	"
Kekeko	5	"
Kewagama	48	"

PHYSIOGRAPHIC HISTORY.

The physiographic history of this region is, in its major features, the physiographic history of the Laurentian plateau, and in a more detailed way, the history of the Timiskaming basin. Since the geological succession is more complete in the vicinity of Lake Timiskaming, much of the evidence bearing on the development of its present topography must be obtained from localities outside the particular district to which this report refers. The following discussion is, therefore, an attempt to outline the topographic history of the whole Timiskaming basin in so far as the evidence is available from its fragmentary geological record.

The earliest event in the physiographic history of the Timiskaming region which finds expression in its present topography, was a period of planation in Pre-Cambrian time, following the last batholithic invasion of granite. This period was of such duration that not only were the Laurentian mountains, which no doubt were formed at the time of the batholithic invasion, laid low, but the rocks invaded by the batholiths were all but removed so that they now occur merely as geosynclinal remnants between wide granitic axial belts. It was upon this base-levelled surface that the Huronian rocks comprising the Cobalt series were laid down.

Whether the tremendous denudation of this interval was accomplished in one or many cycles of erosion is unknown, but at the time the deposition of the Cobalt series was initiated the surface of the region was in a mature stage of physiographic development. Since the rocks of the Cobalt series are generally very slightly folded, it may be assumed that the surface upon which they were laid down has not been greatly deformed. It is evident, therefore, that in those localities where numerous scattered remnants of the Cobalt series occur, the present surface corresponds very closely with the ancient erosion surface, and that such elevations as the Abijevis hills which consist of volcanics of the Abitibi group (Keewatin) must have had a still higher elevation prior to the deposition of the Cobalt series, for they have undergone denudation since that series was stripped from their surface. The ancient surface had, therefore, a range in elevation as great or greater than that of the region at present, but was flatter, the hills being local remnants which rose above the general level of erosion. This Pre-Cambrian surface of denudation, therefore, represents a peneplain buried and later exposed, and falls into the class of forms known as a paleoplain.

From an examination of a general geological map of northeastern Canada it may be seen that a wide belt of granite and gneiss (Laurentian)—plutonic rocks—extends continuously from

Georgian bay to the Gulf of St Lawrence, while to the north of this, there is a belt in which rocks belonging to the Pontiac series, Abitibi group, etc.—surficial rocks—predominate and that the rocks of the younger, Cobalt series are largely limited in their geographical distribution to the northern belt of surficial rocks. The absence of the surficial rocks of the older complex from the southern belt and their abundance in the north is no doubt related to the structural history of the region prior to the development of the Pre-Cambrian paleoplain upon which the Cobalt series was deposited, the granite and gneiss representing the core of an ancient geanticlinal mountain range and the surficial rocks, the remnants of a geosynclinal intermontane belt. The association of the rocks of the Cobalt series with the surficial rocks of the older complex might be due to an uplift of the granitic axial belt after the Cobalt series was deposited, with the consequent early removal of such rocks by denudation, but there is no evidence in the attitude of the Cobalt series that such an uplift took place and the more probable explanation of this relationship is to be found in the topography of the region at the time the Cobalt series was deposited. If the granitic belt represents the core of an ancient Laurentian mountain range, and the adjacent rocks of the Abitibi group, etc., in the north represent the remnants of the geosynclinal intermontane belt, then after even n+1 cycles of erosion the mountain belt owing to, (1) its original higher elevation and (2) the superior hardness of the granite and gneiss, would probably lag in erosion somewhat behind the intermontane area. The present distribution of the Cobalt series is, therefore, more probably due to its preservation in a depression which lay somewhat below the general level of the surface of the Pre-Cambrian paleoplain.

Following the deposition of the Cobalt series and the intrusion of the Nipissing (Keweenawan) diabase, a second period of denudation ensued which continued well into the Palæozoic, when a marine submergence occurred, as is shown by the presence of Silurian outliers in the region. It is most probable that the major part of the denudation which has occurred in the district since Pre-Cambrian time, was accomplished during this interval. The most important evidence contributive to this conclusion is to be found in the origin of the large depression in the Laurentian plateau which is occupied, in part, by Lake Timiskaming.

This lake is contained in a remarkable gorge-like valley, 67 miles long, and has a depth reaching 470 feet[1] below the surface of the lake or from 900 to 1,000 feet below the general level of the surrounding country. It has a width of less than 1 mile

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[1] According to soundings by Dr. Barlow (Rep. Can. Geol. Surv., Vol. IV, pp. 162-9, 1897.

throughout nearly its whole length, but becomes much wider at its north end. This widening of the lake is an expression of a change in the character of the whole depression for a large stretch of country to the north, and east of the northern end of the lake has an elevation of less than 800 feet above sea-level and lies from 200 to 400 feet below the general level of the plateau.

Within this expanded portion of the Timiskaming depression, both in the lake and in the surrounding country, outliers of Silurian rocks occur. To account for the presence of these sediments it has been suggested[1] that the Timiskaming valley is a graben formed after the deposition of the Silurian sediments and that these are preserved because "they were below the base level of erosion at the time when the balance of the similiar sediments on what are now adjacent uplands were removed". This explanation is scarcely tenable, however, for if the Timiskaming valley owes its origin to a post-Silurian graben which has dropped from 900 to 1,000 feet, one would expect the Silurian outlier to have a linear margin sharply delimited at the border of the depression. Instead of this, the Silurian occurs in outcrops scattered over a wide stretch of country. A much more probable explanation for the preservation of these sediments is that suggested by Dr. Barlow[2] that they occupy a depression formed by erosion and that they have been preserved because at this point they lay beneath the general level of the Laurentian plateau.

Whether the deep gorge at the south end of the lake is entirely of pre-Silurian age or not, cannot be proven. It may be possible, since it is apparently rock rimmed to a depth of approximately 400 feet,[3] that it has been glacially over deepened, although its trend is somewhat oblique to the directions of ice movement. If the gorge continues beneath the Silurian at the north end of the lake then the whole valley is evidently pre-Silurian in its origin, but borings would be necessary to obtain this information. From the widely scattered distribution of the Silurian sediments, from the low elevations at which they occur, and from the fact that they rest on the surface of the Abitibi volcanics in places, it is apparent, however, that, prior to the Silurian submergence, the Cobalt series and the Nipissing diabase were stripped from the surface of the older complex throughout a wide stretch of country at the north end of Lake Timiskaming.

The numerous outliers of Palæozoic sediments which occur both in the St. Lawrence and Hudson Bay slopes of the Lauren-

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[1] Wilson, A. W. G., Jour. of Geology, Vol. XI, p. 647, 1903.
[2] Rep. Can. Geol. Surv., Vol. 10, p. 6, 1897.
[3] American Jour. Science, Vol. 30, p. 23, 1910.

tian plateau[1] furnish undisputed evidence that the Palæozoic seas at times covered a considerable part of the Canadian shield, for the resulting sediments would be approximately as extensive as the seas themselves and much more extensive than their visible remnants, since they have been undergoing denudation more or less continuously since Palæozoic times. This wide distribution was evidently related to a moderate relief as is shown by the absence of clastic sediments in nearly all the outliers, except for a few feet at their base.[2] From these lines of evidence it is inferred that at the time the Palæozoic submergence occurred, the surface of the Laurentian plateau had but little relief, that the Silurian sediments formerly covered practically the whole of the country north of Lake Timiskaming, and that the present topography of this region is an exhumed pre-Silurian surface. That the limestone has been largely removed from this depression is no doubt due to the soft and soluble character of the rock and the consequent ease with which it is denuded away.

Assuming the above conclusions to be true, it is possible to indicate some of the events in the physiographic development of the region which occurred during this, the late pre-Cambrian and early Palæozoic interval of erosion. Early in the period, possibly accompanying the intrusion of the Nipissing diabase, the Cobalt series was slightly folded or domed.[3] That this folding took place early in the interval seems necessary, in order to allow sufficient time for the denudation which followed. Subsequent to the deformation of the Cobalt series, the region was again base levelled. The evidence for this can be seen in almost any locality where the stratified members of the deformed Huronian occur, by the manner in which the beds are truncated at the surface.[4]

After this period of base levelling, the region was again uplifted and further dissected until much of the Huronian, especially in the northern part of the Timiskaming basin, was stripped from the surface of the older complex. This denudation

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[1] Lawson, A. C., Bull. Geol. Soc. Amer., p. 169, 1890.
Adams, F. D., Jour. of Geology, Vol. I, p. 238, 1893.
Ulrich and Schuchert, Report of New York State Palaeontologist, p. 639,1907.
Wilson, A. W. G., Jour. Geo., Vol. XI, p. 65, 1903.

[2] Bell, R., Geo. Soc. Amer., Vol. V, pp. 359-66.
Adams and Barlow, Memoir No. 6, Geo. Surv., Dept. of Mines, Can., p. 342, 1910.
Baker, M. B., Ann. Rep. Bur. Mines, Ont., Pt. 1, p. 226, 1911.
LaFlamme, J. C. K., Can. Geo. Surv., 1882-3-4, Pt. P.

[3] Rep. Ont. Bur. of Mines, Vol. XXI, p. 38; p. 205, 1907.
" " " Vol. XXIII, Pt. II, p. 24, 1908.
Prel. Rep. on Gowganda Mining Div., Geo. Surv. Bran., Dept. of Mines, p. 28 1907.

[4] See Fig. 7 in the "Prel. Rep. on Gowganda Min. Div." by W. H. Collins: Geol· Surv. Bran., Dept. of Mines, 1909.

was finally terminated by the Palæozoic submergence, and the deposition of limestone containing fossils which have been assigned to the Clinton and Niagara epochs.[1]

It is not possible to ascertain the precise time at which the Palæozoic sea retreated from the region for the last strata deposited have been long since eroded away. But from the thinness, limited extent, and limited range in age of the rocks which remain it is probable that the submergence was of short duration.

Since the withdrawal of the Palæozoic sea the region, as far as known, has always been a land area, but has stood so near sea-level and has possessed such a low relief that it has suffered little erosion. We have no information as to whether a Cretaceous peneplain[2] extended over this part of the Laurentian plateau or not, but if such a plain was developed, it was evidently formed upon the Palæozoic sediments which filled in the Timiskaming depression.

In the preceding pages the broader physiographic development of the Timiskaming region has been outlined, in so far as the record of events was available, but the origin of the more detailed topographic features has not yet been discussed. The drainage system of the Timiskaming basin presents some peculiarities for which no satisfactory explanation has been given. Some of the linear depressions of the region are evidently related to the structures of the rocks in which they occur, since they lie parallel to their strike. Such valleys as that occupied by the Wendigo-Raven chain of lakes which parallels the trend of the eastward dipping Cobalt series, are evidently of this class. In the Gowganda district, W. H. Collins has pointed out, that a relationship exists between some valleys and the contact between the Nipissing diabase and the Cobalt series[3]. The majority of the more prominent linear depressions of the region, however, such as the Timiskaming valley and the Montreal River gorge, are in no way related to such geological conditions since they maintain their linear trend through all the various rocks of the region, without regard to their structure or character.

In order to explain the occurrence of these peculiar valleys, it has been suggested that they owe their origin to faulting[4], but the only evidence in support of this, is the linear character

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[1] Ann. Rep. Geol. Surv., Vol. X, p. 283, 1897.

[2] Science New Series, Vol. IX, pp. 590 and 220, 1896.
Jour. of Geo., Vol. II, p. 658, 1903.

[3] Prel. Rep. on Gowganda Min. Div., Geol. Surv., Dept. of Mines, Can., p. 12, 1909.

[4] Miller, W. G., Ann. Rep. of Ont. Bur. of Mines, Pt. 11, p. 28, 1905, p. 38, 1907.
Pirsson, L. V., Amer. Jour. Sci., Vol. 30, pp. 25-32, 1910.
Hobbs, W. H., Bull. Geo. Soc. Am., Vol. XX, pp. 141-150, 1911.
Miller, W. G., Eng. and Min. Jour., Vol. 92, p. 648, 1911.

of the valleys themselves. In a recent paper published in the Engineering and Mining Journal, W. G. Miller suggests that Lake Timiskaming occurs along a fault plane, and that the small extent of the Nipissing diabase on the east side of the lake is probably due to the fact that the west side is on the downthrown side of a fault and for that reason the diabase has been removed by denudation on the one side while remaining on the other. An examination of the geological map of Lake Timiskaming[1] shows, however, that one side of the lake has in reality suffered little or no vertical displacement with respect to the other, for on the east side of Lake Timiskaming in the vicinity of Baie des Peres, ridges of Huronian quartzite occur lying on granite, the contact maintaining a fairly uniform elevation of a few feet above the lake. On the west side of the lake, the same contact is exposed fringing the lake shore for a distance of over 2 miles. It is evident, therefore, that the pre-Huronian base levelled surface stands at approximately the same elevation on both sides of the lake and has not been vertically displaced to any great extent. This being the case, it follows that no great movement of the rocks on the opposite sides of Lake Timiskaming relatively to one another has taken place since the Cobalt series was deposited. Furthermore, it is not apparent, from an examination of such geological maps of areas in the Timiskaming region as are available, that that there is any change in the distribution of the rocks relative to the courses of the linear valleys—an effect that would certainly be very noticeable if the valleys marked the outcrops of faults having considerable displacement. On the other hand, if it be assumed that these valleys are not related to deformation, and have been developed by normal physiographic processes there is here the anomalous condition of a rectangular system of drainage, in a region of uniformly low relief, and yet unrelated to rock structures. As far as known to the writer, such a system could only develop normally by the superposition of topography from a once overlying series of rocks, presumably in this case from the Palæozoic sediments, since these as far as known, are the only overlying rocks which ever occurred in the region. This hypothesis, however, would give the linear valleys a post-Silurian origin whereas we know the Lake Timiskaming depression had been excavated to a considerable depth, at least, prior to the Silurian.

In the above discussion of the origin of the linear valleys of the Timiskaming region it has not been possible to obtain a definite solution of this complex physiographic problem, but it has been shown that while the linear and rectangular character of the major valleys of the district is suggestive of deformative move-

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[1] Map 18A. Geol. Surv., Dept. of Mines, Can.

nts, other evidence must be secured before this hypothesis be established. If these valleys are related in any way deformation then some evidence of this such as faulting or brecciation should be observed along the borders or ends of the depressions. If, on the other hand, they owe their origin to normal stream erosion the problem must be attacked by studying the physiographic development of the region. By investigation in these various ways, the mode of origin of this peculiar topographic feature may eventually be ascertained.

The last important event in the physiographic development of the Timiskaming region is closely related to the Labradorian continental ice sheets. It is pointed out in discussing the Pleistocene geology of the region[1] that the present rock surface which underlies the glacial and post-glacial deposits, in its major features is probably preglacial in origin, and that the erosive action of the continental glaciers was largely limited to the production of the roches moutonnées rock surfaces so characteristic of glaciated areas. The deposition of drift by the continental glaciers, however, imposed a new type of topography on the region so that although it has the low relief of mature development, its drainage system, composed of innumerable lakes and precipitous river courses[2], is exceedingly youthful. In portions of the region a further modification in topography was effected by the deposition of lacustrine clays which produced local constructional plains in the lower depression of the region. This event practically concluded the physiographic history of the region, denudation since that time consisting merely of a slight amount of stream dissection in the unconsolidated glacial and post-glacial deposits.

CLIMATE.

The accompanying table of meteorological observations taken at the Hudson's Bay Company's trading post on Lake Abitibi, has been supplied by Mr. R. F. Stupart, Director of the Meteorological Observatory at Toronto and affords specific data as to the climate of the district. Since Lake Abitibi occurs in the northern part of the region examined, it is probable that the minimum temperatures in the table are somewhat lower than those for the more southerly portions of the area. The following dates for the formation and breaking up of ice on Lake Abitibi are of interest to persons desirous of visiting the region at these seasons of the year.

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[1] See page 104.
[2] See page 13.

Year.	Opening.	Closing.
1898*	Apr. 11	Oct. 28
1899*	Apr. 28	Nov. 11
1900*	Apr. 30	Nov. 11
1901*	Apr. 11	
1908**	May 19	
1909**	May 20	
1910**	Apr. 25	

*Wilson, W. J., Sum. Rep. Can. Geol. Surv., p. 130, 1901.

**Information supplied by Mr. Driever, factor of the Hudson's Bay Co., at Abitibi Post.

LAKE ABITIBI, ABITIBI DISTRICT, QUE.

TEMPERATURE, PRECIPITATION, ETC., FOR THE YEARS 1897 TO 1910 INCLUSIVE.

Month.	Temperature.				Absolute		No. of days R. or S.	Precipitation in inches.		
	Mean highest.	Mean lowest.	Mean.	Daily range.	Max.	Min.		Rain.	Snow.	Total.
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	19·2	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	72·9	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
Annual	......	......	33·4	......	94	−46	......	18·08	98·8	27·96

Average summer temperature 57·2°; 3 months, 61·1°.
Average date of last frost, June 8.
Average date of first frost, Sept. 14.

AGRICULTURE.

The large areas of post-glacial clay in this region afford a very good soil for the growth of hay, vegetables, and the hardier cereals. At the Hudson's Bay Company's post on Lake Abitibi, land has been cultivated for a number of years with excellent results, 200 bushels of potatoes being produced during the past season from an area of less than three-fourths of an acre. All of the country adjacent to the National Transcontinental railway has now been subdivided by the Crown Lands Department of Quebec and a large number of applications for land from prospective settlers have already been received.

FLORA AND FAUNA.

The forests of this region belong to an intermediate zone between the Canadian and Hudsonian floral belts or to the subarctic subdivision of Canadian flora in the classification of Professor John Macoun of the Geological Survey. The principal trees and shrubs occurring in the district are the following:—

White pine *(Pinus strobus)*, red pine *(Pinus resinosa)*, black spruce *(Picea nigra)*, white spruce *(Picea alba)*, Banksian pine, jackpine or pitchpine *(Pinus banksiana)*, white birch or canoe birch *(Betula papyrifera)*, poplar *(Populus tremuloides)*, balsam *(Abies balsamea)*, balm of Gilead *(Populus balsamifera)*, white cedar *(Thuya occidentalis)*, tamarack *(Larix americana)*, yellow birch *(Betula lutea)*, black ash *(Fraximus sambucifolia)*, red maple *(Acer rubrum)*, wild red cherry *(Pyrus pennsylvanicus)* alder *(Alnus viridus and Alnus incana)*, moosewood *(Dirca palustrus)*, blueberry *(Vaccinium canadense and Vaccinium corymbosom)*, highbush cranberry *(Virburnum opulus)*, low bush cranberry *(Oxycoccus mactocarpus and Oxycoccus vulgaris)*.

The most important tree in the region from a commercial standpoint is the black spruce which occurs everywhere in great abundance. It reaches its best development in clay areas where the drainage is good, having a diameter of 2 feet or more in these localities. This tree taken from the adjacent forest was used for all the structural timber—piles, trestles, ties, etc.—in the construction of the National Transcontinental railway. As black spruce is in much demand for the manufacture of pulpwood, these forests, now that they are easily accessible by railway, are of considerable value. White and red pine trees occur here and there throughout all the rocky portions of the region. The most northerly of these observed were on some of the islands in Lake Abitibi, but their absence from the region beyond this is not due so much to unfavourable climatic conditions as to the unsuitable soil afforded by the clay belt. Much of the white and red pine on the south side of the height of land has been removed by the lumber companies, but a few groves of red pine and some scattered white pine remain. The White River Lumber Company carried on operations on a timber limit between Dushwah and Hébert lakes during the winters of 1909, 1910, and 1911, this being the first log cutting in the region for a number of years.

The other timber to be found in the region is not at present of much commercial importance. In a few localities, as in the vicinity of the east end of Lois lake, Banksian pine grows straight and tall with a diameter as great as 18 inches. This might no doubt be used for rough lumber, pulpwood, or railway ties. There is considerable canoe birch in the region which reaches a diameter of 18 inches to 24 inches, but owing to the fact that birch will not float in water, the difficulties of transportation render this, at present, valueless. Tamarack were at one time abundant in the muskegs of the district, but these were all killed by the larch saw fly about 20 years ago. Cedar, poplar, and balm of Gilead are locally abundant, chiefly along the shores of the lakes and the banks of the streams; the cedar occurring in the rocky districts and the poplar and balm of Gilead in clay areas. These trees are not of sufficient size or quality to be of importance commercially.

There is a striking localization of the forest growth in this region, relative to the character of the soil or other special conditions in the respective localities. In the partially drained portions of the clay belt, the forest consists entirely of black spruce or if the soil is very wet, of tamarack and black spruce. The first constitutes what is known as the black spruce swamp and the second, the tamarack swamp. Along the margins of streams and rivers where the drainage is exceptionally good, poplar and balm of Gilead grow in great abundance, while in sandy areas Banksian pine is the dominant tree. In districts where sand is extensive, large areas are occupied by this species and are described locally as jackpine sand-plains. If, however, a forest fire has swept over a region within recent decades, a thick growth of poplar and birch is generally present. In some places, more especially in rocky areas, a mixed forest occurs, and here the red pine, the white pine, and the jackpine, the birch, the poplar, the balsam, and the spruce may stand side by side.

The fauna of the Abitibi district includes the usual species found in northern Ontario and Quebec. Of the larger game, the moose (*Alce americanus*) is most abundant and although from 50 to 60 of these are killed, each season, during the months of June and July by the Indians assembled at Abitibi Post, the numbers do not seem to diminish. Red deer (*Virginianus cariacus*), and caribou (*Rangifer caribou*), are both present in the region, but are not very numerous.

The fur bearing animals have been trapped for many years by the Indians and many varieties are consequently being gradually exterminated. This is especially the case with the beaver (*Castor fiber*) only a few of which now remain. It was formerly customary for the Indians to take care not to kill all the beaver living in a particular locality in their hunting ground, but of late years this custom has been abandoned. The common fur-bearing species present in the district include the otter (*Lutra canadensis*), the mink (*Putorius vison*), the fox (*Vulpes vulgaris*), the marten (*Mustela americana*), the fisher (*Mustela pennanti*), the ermine (*Putorius erminea*), the lynx (*Felis canadensis*), the wolf (*Canis lepus*), the black bear (*Ursus americanus*), the muskrat (*Fiber zibethicus*), and the skunk (*Mephitis cana*), the rabbit (*Lepus americanus*), the chipmunk (*Tamias striatus*), the red squirrel (*Sciurus hudsonicus*), and the flying squirrel (*Sciuropterus voluaclla*), are also very numerous.

Of the birds observed in the region the most common are the gulls (*Larus orgentatus smithsonianus*, and *Larus delawarensis*), the black duck (*Anas obscura*), the saw bill (*Merganser americanus*), the ruffled grouse (*Bonasa umbellus togato*), the Canadian grouse (*Dendragopus canadensis*), and the king fisher (*Ceryle alcyon*). The less common varieties include the loon (*Uriuator imber*), the raven (*Corvus corax principalis*), and the bittern (*Botaurus lentiginosus*).

The gulls are exceedingly common in the district, usually making their home on the rocky reefs which project out of the water of the numerous lakes of the region. Ducks are not very numerous but there are usually a few on every lake. The two varieties of grouse or partridge are generally abundant but were unusually so during the past summer. A few loons spend the summer in some of the more rocky lakes of the area but these birds are by no means common.

Owing to the abundance of clay in this district nearly all the rivers and larger lakes contain a great deal of suspended material during a large part of the year. These waters consequently afford an unsuitable environment for either trout or bass. As far as known to the writer, there are no lake trout (*Salvelinus mamaycush*) in the lakes of the district although they are found in Ontario a few miles west of the interprovincial boundary. Lakes Eileen and Abijevis in the Abijevis hills, have very clear water and are said to contain brook trout (*Salvelinus fontinalis*), but elsewhere this species is unknown. Black bass (*Micropterus salmoides* and *Micropterus dolomieu*) are present in some of the lakes tributary to the Ottawa in Lake Duparquet and below the Danseur portage on the Abitibi river, although in none of these waters are they very numerous. The most abundant fish of the region are the pike (*Esox lucius*), and (*Esox nobiliur*), which abound everywhere, the pickerel (*Stirostedium vitreum*) and the whitefish (*Coregonas clupciformis*). There are also a great many suckers (*Calostomus teris*) and white trout (*Seniotilus ballaris*) but these are of little commercial value.

CHAPTER IV.

GENERAL GEOLOGY.

GENERAL STATEMENT.

REGIONAL.

Geologically this district belongs to the great glaciated Pre-Cambrian shield which occupies the greater part of northeastern North America. It corresponds very closely to other parts of the Timiskaming region, of which it forms a part, and more remotely to the Lake Superior-Lake Huron geological province.

The basal rocks of the Timiskaming region consist of an ancient Pre-Cambrian complex composed of metamorphosed sediments and basic and acid volcanics and batholithic masses of granite and gneiss. It was formerly customary to divide this complex into two subdivisions, the metamorphosed surficial rocks being known as Keewatin and the plutonic granite and gneiss as Laurentian. More recently geological work has shown, however, that the rocks mapped as Keewatin probably consist of more than one—possibly several series—and that there are also granites of different age present in the region,[1] but detailed geological investigation has not, as yet, proceeded far enough to ascertain the facts necessary for the complete interpretation of these complicated geological relationships.

Overlying the rocks of the older complex and separated from them by a most profound erosional and structural unconformity, a heterogeneous series of approximately flat lying sediments—conglomerate, greywacke, argillite,[2] arkose, and quartzite—occur which, following the nomenclature of Sir William Logan,[3] have been generally called Huronian. In the Cobalt district, Dr. W. G. Miller, at first, subdivided the series into lower and middle Huronian[4] but more recently[5] has adopted the name Cobalt series to include both these subdivisions.

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[1] Wilson, M. E., Sum. Rep. Geo. Surv. Bran., Dept. of Mines, Can., p. 175, 1909.
Miller, W. G., Eng. Min. Jour., Vol. 92, p. 648, 1911.
Harvie, R., Geo. of a Part of Fabre Township, Pontiac Co., Que., pp. 15-17, 1911.
Page 43.

[2] See page 83.

[3] Geo. of Can., pp. 50-51, 1863.

[4] Ann. Rep. Bur. Mines Ont., Pt. 2, pp. 40-42, 1905.

[5] Eng. Min. Jour., Vol 92, p. 648, 1911.

Dr. Miller's classification of the Huronian into two series was based on an unconformity between greywacke and arkose occurring on lot 4, concession XII of Lorrain township, Nipissing district, Ontario, where angular fragments of the greywacke are enclosed in an arkose matrix. Unconformities between a "greywacke conglomerate and an overlying arkose series" are also mentioned by A. G. Burrows in a marginal note on a map of "part of the Gowganda silver area," published by the Ontario Bureau of Mines. Elsewhere, in the region, as far as has been observed, the various members of the series are in conformable relationship to one another,[1] so that the unconformities that have been described are probably interformational in character and do not necessarily signify a break of any importance in the continuity of deposition.

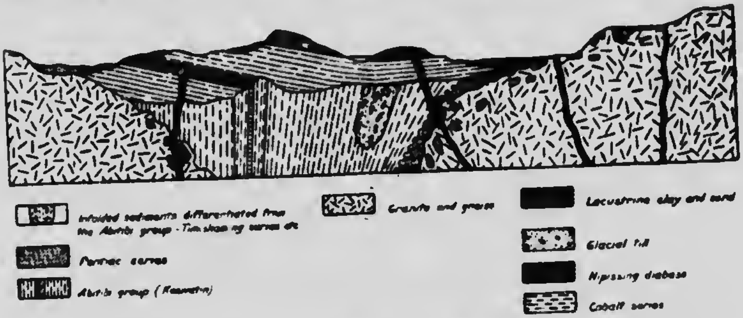

Fig. 4. Diagrammatic section showing the geological relationships of the rocks occurring in the Timiskaming region.

The Cobalt series is now known to occur in the Timiskaming region and vicinity throughout an area of approximately 20,000 square miles, but this is probably a mere fraction of its former extent, for much Huronian, having the same lithological character and geological relationships, occurs in outlying districts such as that on Lake Chibougamau, about 300 miles to the northeastward.

Both the Cobalt series and the rocks of the older complex are intruded by the post-Huronian or Nipissing[2] diabase. In the older complex, these intrusions occur almost entirely as dykes; in the flat lying Cobalt series, on the other hand, they are largely sills. The time at which these rocks were intruded cannot be definitely fixed from the geological evidence obtainable

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[1] Sum. Rep. Geol. Surv., Dept. of Mines, Can., p. 117, 1906.
"Geol. of an Area adjoining the East side of Lake Timiskaming": Geol. Surv. Dept. of Mines, Can., p. 30, 1910.
"Prel. Rep. on Gowganda Mining Division": Geol. Surv., Dept. of Mines, Can., p. 32, 1909.

[2] Eng. Min. Jour., Vol. 92, p. 648, 1911.

in the region, although they were evidently not only intruded but deeply denuded before the Silurian submergence.[1] However, from the facts that the Nipissing diabase is lithologically similar to the igneous members of the Keweenawan series, that it was intruded in late Pre-Cambrian, or early Palæozoic time and that dykes and sills of the same rock type occur throughout the whole region from Lake Timiskaming to Lake Superior where the Keweenawan rocks occur, it is exceedingly probable that the Keweenawan igneous rocks and the Nipissing diabase are all portions of the same magma intruded during the same period of vulcanism.[2]

A number of outliers of Silurian limestone belonging to the Clinton and Niagara epochs[3] occur in the vicinity of Lake Timiskaming, one of which extends from the north end of that lake to Evanturel township, a distance of 40 miles.[4] These outliers occupy a pre-Silurian depression beneath the general level of the Laurentian plateau and for that reason have been preserved. There is no evidence that the region has ever been below sea-level since the Palæozoic, the Silurian limestone, with the exception of unconsolidated Pleistocene and Recent deposits, being the youngest rock in the whole country.

The glaciated rocky surface of the Laurentian plateau, in the Timiskaming region, as elsewhere, is largely hidden beneath a mantle of Pleistocene and Recent deposits. Throughout the larger part of the region these consist entirely of boulders, gravel, sand, and till, materials of glacial or fluvioglacial origin which were deposited from the last Labradorian ice sheet, but, in the northern part of the Timiskaming region and throughout a large part of the James Bay basin, are overlain by stratified clay and sand which were laid down in a huge lake which covered this area in post-glacial time. This lacustrine epoch represents practically the last event in the geological history of the district, for denudation since that time has scarcely begun even in the unconsolidated easily transported clays.

LOCAL.

General.

In this subdivision of the report, a general account of the geology of the country south and east of Lake Abitibi is inserted for the convenience of those who are especially interested in the economic section or who for other reasons,

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[1] See page 22.
[2] Jour of Geo., Vol. 13, pp. 89-104, 1905.
[3] Ann. Rep., Geol. Surv. Can., Vol. 10, p. 289, 1897.
[4] Sum. Rep., Geol. Surv., Can., p. 221, 1904.

wish to omit the more detailed descriptions of formations which follow.

With the exception of unconsolidated glacial or post-glacial deposits, the rocks of the particular district to which this report refers are entirely of Pre-Cambrian age and, for the most part, belong to the older complex which underlies the Huronian, Cobalt series. These ancient rocks may be subdivided into two classes, the first of which consists of deformed and metamorphosed surficial rocks (that is rocks formed at or near the earth's surface)—Abitibi group—and the second of batholithic masses of granite and gneiss—Laurentian?.

Abitibi Group.

General.—It has been customary to call the volcanic flows and associated sediments which form the surficial portion of the older complex occurring in the Timiskaming region, Keewatin, thus assuming that these rocks are equivalent in age to, lithologically, similar rocks occurring in the vicinity of Lake of the Woods and in other localities to the north and west of Lake Superior. It is pointed out in the pages which follow[1] however, that this correlation has been made largely on lithological grounds and is probably incorrect. For this reason the name Abitibi group has been substituted for Keewatin in this report.

For descriptive purposes the group may be divided into two sections—(1) the volcanic complex with which is included some schist and amphibolite, chloritic rocks, slate and ferruginous dolomite, and (2) the Pontiac series which consists largely of metamorphosed clastic sediments.

Abitibi volcanic complex.—Throughout the northern part of the region, the predominant rocks belong to a great volcanic complex consisting of lavas which range in composition from basalt to rhyolite, but the types of intermediate composition are most common. There are associated with these some quartz porphyry, diorite, gabbro, diabase, amphibolite, hornblende schist, chlorite schist, sericite schist, ferruginous dolomite, and slate, as well as intrusive rocks lithologically similar to the extrusive lavas.

The various rocks comprising the Abitibi group have all been more or less metamorphosed, but these alterations have been, largely, mineralogical rather than mechanical, for the schistose rocks are generally of local extent. The hornblende schist and amphibolite are usually associated with the granite batholiths and have evidently resulted from the metamorphism of the

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[1] See page 43.

basalt and related rocks under the contact action of the intrusive. Since sericite schists may result from the mashing of sedimentary or igneous rocks, it is not always possible to ascertain the original character of the rocks from which these were derived, but, in places, the geological relationships are such as to indicate that they are metamorphosed quartz porphyry or rhyolite. The ferruginous dolomite and dolomitic sericite schists are believed to have originated from quartz porphyry, aplite, and similar rocks under the action of hydrothermal solutions. The slates are presumably sediments, but whether these are interbedded with the lava flows or have been subsequently infolded is not known.

In a region where the rocks are, on the whole, not very well exposed it is not always possible to ascertain the structural or stratigraphical relationship of the volcanics of the Abitibi group, but, in places, the attitude and trend of the lava flows can be recognized from the change in texture from centre to margin, from the occurrence of spheroidal, amygdaloidal, and flow structures at the surface of the flows, and from their relationship to associated sediments. Wherever the structure of the rocks was ascertained they were found to have a vertical or nearly vertical attitude, the strike varying from east and west to northwest and southeast.

PONTIAC SERIES.—In the southern part of the region, the prevailing rock is a fine grained mica schist or gneiss, with which is associated some hornblende schist and amphibolite, and which passes on the north into mashed arkose, greywacke, and conglomerate. It is believed[1] that these sediments and the mica schist belong to the same series, the mica schist being the metamorphic product resulting from the contact action of the intrusive granite on arkose and greywacke. All these rocks are, therefore, classed together in the Pontiac series.

The mica schist contained in the Pontiac series is a fine grained rock consisting essentially of quartz and biotite with usually some feldspar. There is generally some sericite present and the biotite is commonly, to a large extent if not entirely, altered to chlorite. When fresh, the rock presents a bright grey appearance, but on the weathered surface is generally rusted, owing to the oxidation of the sulphide of iron which it contains. In places pyrrhotite or pyrrhotite and magnetite occur interlaminated with the schist, in zones which may be several feet in width. Irregular veins and lenses of quartz strung out along the foliation of the schist are also common.

Here and there, hornblende schist and amphibolite are associated with the biotite schist. The relationship of these, owing

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[1] See page 73.

to the absence of exposures, cannot always be ascertained. but in some places they occur in bands conforming in strike and dip to the adjacent mica schist. The hornblende schist is a dark, fine grained, green rock consisting of hornblende and quartz with or without feldspar, and, in places, appears to pass transitionally into mica schist by a gradual change in the ferromagnesian constituent. The amphibolites are coarse green rocks which vary greatly in texture and mineralogical composition but consist chiefly of amphibole—hornblende, tremolite, or actinolite—and feldspar or quartz with sphene, biotite, and a carbonate as accessory constituents. Owing to the excessive variability of the amphibolite, the rock weathers in a most irregular manner presenting a peculiar botryoidal appearance in places. The manner in which the amphibolites and hornblende schist originated has not been definitely ascertained. It is most probable, however, that the fine grained hornblende schists are, in part at least, metamorphosed ferromagnesian sands and that the amphibolites are metamorphosed lavas, contemporaneous in age with the sediments from which the schists were derived. The evidence upon which these conclusions are based is cited on page 74.

The mashed greywacke, arkose, and conglomerate, belonging to the Pontiac series, extends in a belt nearly 2 miles wide along the northern border of the schist. The rock predominating throughout this belt was originally a ferromagnesian sand consisting of quartz and feldspar enclosed in a matrix of chlorite and sericite. This passes into arkose, locally, the rock at these points consisting of quartz, feldspar, and sericite, with very little chlorite. It also contains mashed pebbles and boulders of granite, rhyolite, and quartz porphyry, in places, and thus passes into conglomerates. In all of these rocks the quartz and feldspar fragments have been greatly corroded on their margin or have been partly recrystallized into a fine grained hornfels similar to the schistose members of the series.

Structurally the rocks of the Pontiac series appear to form a monoclinal succession dipping towards the north, away from the granite batholith. The strike varies locally from northwest-southeast to southwest-northeast, but in general the structural trend is approximately east and west.

Since the rocks of the Pontiac series and those of the Abitibi volcanic complex largely occur in separate areas, and since, even in places where they are adjacent to one another, the geological conditions are very obscure, their relationship can only be inferred from their general distribution. At the points where the greywacke adjoins the volcanics of the Abitibi group the two formations possibly pass gradationally into one another, for no definite contacts, conglomerates, or other evidences of unconformity were observed and the two rocks resemble one another so closely that they cannot be distinguished in the hand specimen except from the presence of grains of quartz in the greywacke. The distribution of the Pontiac series, however, in a narrow belt intervening for a distance of 50 miles between the volcanic complex of the Abitibi group and the immense southern batholith of granite and gneiss, suggests that the occurrence of the schist in this relationship is not a mere coincidence but that the Pontiac series is stratigraphically below the adjacent Abitibi volcanics and has been tilted up into its present attitude by the intrusion of the granite batholith. This evidence, however, is insufficient to warrant a positive conclusion, so that the stratigraphical position of the Pontiac series in the Abitibi group must remain for the present an unsettled problem.

Granite and Gneiss.

Both the schists of the Pontiac series and the volcanics of the Abitibi group are intruded by batholithic masses of granite and gneiss, ranging in size from small isolated intrusions to a huge massif of which only a marginal portion, intruding the Pontiac series on the south, occurs within the confines of the region examined. The smaller batholithic masses occur in the northern part of the region and are in igneous contact with the Abitibi volcanics. Since there are probably granites of varying age present in the region, it cannot be assumed that these masses are connected at depth with the larger southern batholith although such may be the case.

Practically the whole of the southern part of the district mapped is occupied by a complex of acid igneous rocks of various kinds, which will be designated, for purpose of description, the southern batholith. It consists largely of granite and gneiss, but these rocks pass locally by loss of quartz and orthoclase into quartz diorite or diorite. They vary greatly in texture and composition from point to point and are cut nearly everywhere by dykes and masses of aplite and pegmatite, the whole forming an igneous mass of a very heterogeneous character.

The junction of the southern batholith and the Pontiac series is marked by a contact zone several miles wide in which dykes and irregular masses of granite, aplite, and pegmatite intrude the schist, increasing in size and numbers towards the south until finally only isolated blocks are observed. These blocks, or xenoliths, in places, maintain the same attitude and strike as the schist farther north, showing that they have not been tilted from their original position; in other localities, however, they lose this relationship and are cut by numerous intersecting dykes of granite, aplite, and pegmatite, the older dykes being faulted along the planes of the younger. In the country to the west of Lake Opasatika the manner of intrusion appears to have been by *lit par lit* injection, innumerable narrow dykes of the granite penetrating the schist parallel the cleavage, at intervals of a few inches or less.

It is probable that the northern part of the region is underlain at no great depth by granite, for small isolated intrusions of this rock are very common, the largest of these, the Lake Dufault, Gauvin Lake, Robertson Lake, and Lake Abitibi batholiths, having diameters of from 5 to 10 miles. The rocks of all these intrusive masses have the same lithological character, consisting of both hornblende and biotite granite which pass locally into granodiorite and diorite so that a granite-diorite series is represented. The ferromagnesian minerals are generally altered to chlorite and the feldspar is largely replaced by green sericite. These alterations in some of the smaller massives have given the rock a dark green basic appearance which appears out of harmony with the numerous quartz grains which it contains. Dykes of pegmatite and aplite, and quartz veins are of common occurrence throughout all these batholiths.

The intrusion of the batholiths was accompanied by the usual exomorphic and endomorphic effects which are characteristic of such magmatic invasions. The surrounding rocks of the Abitibi group are intruded by dykes of rhyolite, quartz porphyry, aplite, and pegmatite and are highly metamorphosed in places, into hornblende schist and amphibolite. The contact of the granite is exceedingly irregular and angular in places, and near the margin of the batholith the granite is filled with angular, subangular, and rounded blocks of the Abitibi volcanics with which are associated amphibolites and local areas of hornblende granite, so that there appears to be complete gradation from blocks of rock which undoubtedly belong to the Abitibi group to hornblende granite. It is probable, therefore, that these hornblendic variations in the granite have been formed by the assimilation of Abitibi volcanics rather than by differentiation from the granite magma.

Cobalt Series.

Lying on the greatly denuded and approximately horizontal surface of the Abitibi group and the granite and gneiss, which together comprise the older complex, a group of clastic sediments occur constituting the Cobalt series. These rocks, no doubt, at one time, extended over the whole region, but are now of comparatively small extent occurring merely as remnantal hills and ridges or small isolated exposures. They are confined almost wholly to Boischatel, Dasserat, and Destor townships.

The Cobalt series may be subdivided stratigraphically into the following four lithological subdivisions, basal conglomerate, greywacke and argillite, quartzite and arkose, upper conglomerate. This classification, however, holds only in a general way for each of these subdivisions is subject to many variations and they pass gradationally into one another. The names given to the various members, therefore, merely implies that this particular rock type is dominant in that portion of the series to which it has been assigned.

The basal conglomerate is an exceedingly variable rock, largely consisting, in some places, of coarse fragments and, in other places, of matrix. The included rock fragments may be angular, subangular, or round in shape, and are commonly 2 or 3 feet in diameter. They consist of every variety of rock represented in the older complex, a large number of these occurring even in a single outcrop. The matrix varies from a coarse arkose to fine grained slate like rock, the latter being the type described by Logan as "chlorite slate conglomerate". As a rule the conglomerate is without stratification, but, in places, cross-bedding or a partial alignment of pebbles can be seen. Where the complete section of basal conglomerate is present, it has an average thickness of 200 feet, but is 750 feet thick in the Kekeko hills. In some places, the contact of the conglomerate and the floor upon which it was deposited is peculiar, the lower beds of the conglomerate being made up entirely of debris derived from the underlying rocks of the older complex so that no definite line of junction can be seen, but, in other localities, the contacts are sharply defined, the conglomerate resting on a smoothly denuded surface.

The second member of the Cobalt series consists of very finely cemented ferromagnesian sediments which range in texture from sand to fine grained mud. The coarse phases constitute the greywacke and the fine grained slate like type the argillite.[1] 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. In those localities where complete vertical sections of the greywacke and argillite are present, this member of the series has a maximum thickness of about 300 feet.

The greywacke and argillite are replaced on passing upward, by arkose, which constitutes the third member of the series. This rock is always stratified although, in places, the bedding planes are indistinct. It has a maximum thickness in complete vertical sections of 230 feet.

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[1] See page 73.

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 of this member observed, was 100 feet.

Owing to the absence of stratification in a considerable part of the Cobalt series, it is only in places that the structures of these rocks can be ascertained, but in those localities the dips are always slight, 20 degrees or less, and indicate that the rocks are folded into gently pitching northeasterly-southwesterly trending anticlines and synclines.

The modes of origin of the various rock types comprising the Cobalt series are discussed at length in a later section of the report. From a consideration of those characteristics of the different members which are related to environmental conditions of deposition, the conclusions reached are that the basal and upper conglomerate represented two till sheets deposited from continental glaciers and that the stratified greywacke, argillite, and arkose were of lacustrine origin and were laid down during an interglacial period.

Post-Cobalt Series Intrusives.

NIPISSING DIABASE.—Throughout the whole of the region under description, dykes of diabase, intruding the rocks of the older complex, are very common. These vary in width from a few inches to several hundred feet and in the case of some of the larger ones outcrop as a continuous ridge for several miles. There are also a few isolated exposures of diabase which have no continuity of outcrop and are, therefore, possibly remnants of sills which spread out along the contact of the Cobalt series and the underlying complex. The diabase occurring in the dykes is of two varieties, one of which contains olivine and the other of which is olivine free. From the fact that in other parts of the Timiskaming region, the olivine diabase intruded the olivine free variety, it is believed that this rock is the younger of the two types. Quartz may or may not occur in the olivine free diabase and, when present, takes the form of micrographic intergrowths with feldspar.

These diabase dykes were not observed to intrude the rocks of the Cobalt series anywhere in the district, but their fresh unaltered character and their general lithological similarity to the post-Huronian rocks of other parts of the Timiskaming region affords ample grounds for their correlation with the Nipissing diabase.

SYENITE PORPHYRY.—Between Ollier and Renauld lakes an elongated irregular intrusive mass of syenite porphyry occurs cutting the conglomerate of the Cobalt series. This rock consists of large phenocrysts—an inch or more in length—of albite, which are enclosed in a matrix of quartz and plagioclase with some chlorite, epidote, sphene, and carbonate.

Pleistocene and Recent.

The ancient Pre-Cambrian rocks thus far described are largely hidden from view by a mantle of Pleistocene and Recent materials which are classed as glacial or postglacial according to the time and manner of their deposition. The lowermost of these deposits consist of sand, gravel, clay, and boulders which are partly glacial and partly fluvioglacial in origin. The fluvioglacial deposits are rudely stratified and usually take the form of kames or outwash plains.

Throughout a large part of the region, the older Pleistocene deposits are overlain by stratified clay and sand sediments which are evidently of lacustrine origin. The stratified clay is uniformly bedded in layers averaging about one-half inch in thickness, the beds, in some localities, being separated by a thin layer of calcium carbonate. Locally, the clay becomes arenaceous and in these places a bed may contain two or three subsidiary layers due to variations in the sand content. The stratified sand is found chiefly in the vicinity of glacial or fluvioglacial deposits in which sand is abundant, and generally overlies the stratified clay.

DETAILED DESCRIPTION.

TABLE OF FORMATIONS.

In the following table the geological formations are arranged in descending order with respect to age.

Quaternary.	
Post glacial	Stratified lacustrine clay and sand.
Glacial	Gravel, sand, boulders, boulder clay.
Unconformity.	
Pre-Cambrian.	
Keweenawan?	Nipissing diabase, syenite porphyry.

Igneous contact.	
Cobalt series	Conglomerate. Arkose. Greywacke and argillite. Conglomerate.
Unconformity.	
(Laurentian?)	Granite and granite gneiss.
Igneous contact.	
Abitibi group (Keewatin?) Pontiac series	Mica schist and hornblende schist. Amphibolite. Greywacke, arkose, and conglomerate.
Slate and phyllite. Ferruginous dolomite. Chloritic rocks. Schists and amphibolites.	
Abitibi volcanics	Quartz porphyry, rhyolite, andesite, gabbro, basalt, etc.

It may be observed that in the above table of formations the various series or groups of rocks have been given local names and have not been assigned definitely to any of the major subdivisions of the Pre-Cambrian as defined in the report of the international geological committee for the Lake Superior region[1]. This course was adopted because there is considerable doubt as to the place of the different rock groups in the general classification.

It has been customary in the Timiskaming region to divide the rocks of the older complex, which underlie the Cobalt series, on a lithological basis, into two classes, the Laurentian and Keewatin, the former term being applied to the deep seated granite and gneiss, and the latter to the surficial rocks consisting chiefly of volcanic flows. It is now becoming evident, however, that both of these subdivisions probably include rocks which differ greatly in age and that the use of these terms as defined by the international geological committee for the Lake Superior region, in this district implies a correlation which is probably incorrect.

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[1] Jour. of Geol., Vol. 12, pp. 90-104, 1905.

In the region described in this report, some of the volcanic rocks of the so-called Keewatin have suffered much less alteration than others having the same mineralogical composition and texture. Undisturbed and comparatively unaltered dykes of andesite and rhyolite also occur cutting across other members of the group which have a vertical or nearly vertical attitude, and in the northern part of the Sudbury district, Mr. W. H. Collins has observed flows of andesite and rhyolite which were much less folded than the volcanic rocks with which they were associated.[1] All of these observations indicate that the prolonged period of vulcanism during which these lavas were extruded was interrupted by orogenic disturbances which are expressed in structural unconformities, and that at least two series of volcanics are probably represented. Furthermore, detailed geological work in the Lake Superior region has shown volcanic rocks to be present in every Pre-Cambrian series of that region, so that the lithological similarity of the volcanic rocks occurring in the Timiskaming region to those of the Keewatin is not a secure basis for correlation. For these reasons it has been deemed advisable to substitute the term Abitibi group for Keewatin, this name to be applied to the surficial rocks of the older complex in contrast with the plutonic (Laurentian?) granite and gneiss.

An extensive area of greywacke, arkose, conglomerate, and mica schist belonging to the Abitibi group, occurs in the region, and these for the purpose of lithological description have been separated from the other members of the group and have been designated the Pontiac series. While these rocks have thus been differentiated from the other surficial members of the older complex it is not intended to imply that they are necessarily different in age. It is shown in the discussion of the structural relations of the Pontiac series that there is evidence which suggests that the series may underlie the Abitibi volcanics which lie adjacent on the north. On the other hand the occurrence of pebbles of granite and rhyolite in the conglomerate indicates that at the time the Pontiac series was deposited, rocks similar to both the Abitibi volcanics and the plutonic granite and gneiss were undergoing erosion, and, if these are now present in the region, the Pontiac series must be younger than parts of the Abitibi group and the granitic (Laurentian?) complex, and a great erosion interval is represented. Despite the incompleteness of our knowledge with regard to the age and relationship of the Pontiac series it has been deemed advisable, however, that these rocks be separately designated because (1) they are lithologically different from the other portions of

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[1] Personal communication.

the Abitibi group; (2) they occupy an area of several hundred square miles; and (3) they are all in conformable succession and hence belong to a single series.

In the Lake Superior region, the name Laurentian has been assigned to those granites and gneisses and related rocks which are older than the series which, in that geological province, is called lower Huronian. But the granite and gneiss which have been classed as Laurentian in the Timiskaming region intrude sedimentary rocks—Pontiac series, Timiskaming series, etc.—which are very similar, both lithologically and structurally, to the Lake Superior lower Huronian. If, therefore, these rocks be classed as Laurentian, an age significance is implied which is probably incorrect. It might be pointed out in this connexion that it is now known that there are granites of different ages in the complex which in the region north and west of Lake Superior underlies the Animikie series, and in the Timiskaming region underlies the Cobalt series, but, owing to the complex geological conditions or to the absence of the lower Huronian or other sedimentary series, it is not possible to make the separation of these granites except in a few localities. For these reasons it seems unfortunate that the term Laurentian should have been restricted to the pre-lower Huronian granite and thus have rendered the name inapplicable throughout the larger part of the Lake Huron-Lake Superior geological province.

For the slightly disturbed Huronian rocks of the region, the name Cobalt series is used following the nomenclature recently adopted by W. G. Miller in a paper published in the Engineering and Mining Journal.[1] This local name is much to be preferred, for, as was pointed out by the writer in the Summary Report of the Geological Survey for 1909,[2] there is yet some doubt as to the relationship of these rocks to the original Huronian of the north shore of Lake Huron. This, of course, also implies a similar doubt as to their relationship to all the various series of rocks classed as Huronian in the Lake Superior region.

ABITIBI GROUP.

General Character and Subdivisions.

The Abitibi group, as has been previously explained, embraces a great complex of surficial rocks, the structural and stratigraphical relations of which have not been wholly ascer-

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[1] Vol. 92, p. 698, 1911.

[2] Page 176.

tained. For the purpose of description, the complex may be subdivided into the Abitibi volcanics, schists and amphibolites, chloritic rocks, slate, ferruginous dolomites, and Pontiac series. Such information as has been obtained with regard to each of these divisions will be presented in the following sections.

Abitibi Volcanics.

DISTRIBUTION.

Local intrusions of granite and gneiss are so common throughout the Abitibi volcanics, that it is impracticable to outline the areal extent of these rocks in detail. They constitute the prevailing rock, however, throughout the whole of the northern part of the region, but, except for a small area of greenstone, between Lake Opasatika and MacLaren creek, are replaced in the south by the Cobalt series, the Pontiac series, or the southern granite batholith.

LITHOLOGICAL CHARACTER.

General.—The rocks included in the Abitibi volcanics, as originally constituted belong to either the quartz porphyry-rhyolite, the diorite-andesite, the gabbro-basalt or lamprophyre families, but have undergone such extensive metasomatic alterations that even in their least altered phases little more than the outline of the original mineral constituents can, as a rule, be [illegible]. They are, on the whole, exceedingly fine grained, aphanitic rocks, but locally, either in dykes or in the centre of a lava flow, become coarse textured and may be ophitic, poikilitic, or porphyritic. In their fine grained facies the volcanics commonly show spheroidal and amygdaloidal structures, features which are evidently associated with the exterior portions of the lava flows.

Quartz Porphyry and Rhyolite.—The acidic rocks belonging to the Abitibi volcanics have been classed as quartz porphyry or rhyolite, according to their texture. The quartz porphyry is a fine grained, granular rock of pink or grey colour, containing phenocrysts of quartz and feldspar. The rhyolite is also porphyritic, but the phenocrysts are small and are embedded in an aphanitic matrix. It may be pink, grey, or black in colour and in the fresher occurrences has an oily or resinous lustre and conchoidal fracture.

Examined under the microscope both the rhyolite and the quartz porphyry are found to consist essentially of phenocrysts of quartz and alkalic feldspar embedded in a matrix of the same minerals. The quartz phenocrysts are usually fresh with characteristic rounded corners, inclusions, and embayments. The feldspar phenocrysts are generally highly altered, but several exceptionally fresh specimens of rhyolite obtained at the south end of Duparquet lake were found, when examined under the microscope, to contain phenocrysts of monoclinic feldspar twinned according to the Carlsbad and Manebach laws. The matrix of this rhyolite also contained minute spherulitic intergrowths of quartz and feldspar (diameter 0·04 mm.) but no trace of glass was present, so that if this was ever present in the rock it has been entirely devitrified. Phenocrysts consisting of micrographic intergrowths of quartz and feldspar were present in some of the thin sections of rhyolite examined. Magnetite, sericite, and chlorite are commonly disseminated through the matrix of both the rhyolite and the quartz porphyry.

In those localities where the rhyolite and quartz porphyry have undergone extensive metasomatic alteration, the original minerals are largely replaced by carbonate, epidote, sericite, and chlorite, the relative proportions of these minerals varying greatly in different occurrences. A small quartz porphyry dyke which intrudes the greenstone on the south shore of Fortune lake was found when examined microscopically, to consist largely of a carbonate with smaller quantities of chlorite, sericite, quartz, apatite, and rutile. Rhyolite occurring on Lake Dufault on the other hand, contained a large proportion of sericite arranged in radial aggregates with little carbonate. The dominant secondary products, however, are generally sericite and carbonate, the epidote and chlorite being comparatively unimportant.

Diorite and Andesite.—The diorite belonging to the Abitibi volcanics is a grey, green, or pink rock which is usually fine textured but locally becomes very coarse. The aphanitic equivalent of the diorite—the andesite—is a grey or greenish grey rock and is usually porphyritic. Owing to the alterations which these rocks have undergone the individual mineral constituents cannot generally be determined without the aid of the microscope, but the epidote which in some localities replaces the feldspar is readily recognized by its greenish yellow colour.

The microscopic study of these rocks reveals something of their original composition and of the nature of the mineralogical changes which have taken place. The diorites are, as a rule, composed essentially of plagioclase and amphibole, the plagioclase when sufficiently unaltered for the twinning to be recognized having in several cases a maximum extinction angle in sections at right angles to the albite twinning plane of about 7 degrees, probably indicating oligoclase-andesine. The amphibole may be actinolite, tremolite, or pale green hornblende and is evidently of secondary origin. Ilmenite, characterized by its typical grating structure, is commonly present in considerable quantity. In places the diorites pass into quartz diorites, the quartz usually occurring in micrographic intergrowth with feldspar. The changes which have occurred in the plagioclase vary greatly from place to place. In its less altered phases it usually contains innumerable microlites of sericite, but zoisite, epidote, or carbonate are generally present and one or all of these minerals may completely replace the feldspar. Other minerals which occur in the diorite are sphene, magnetite, and chlorite, the latter being generally abundant as an alteration product resulting, probably, from ferromagnesian minerals originally present in the rock.

The andesites are 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 feldspar phenocrysts are in some places broken and strung out linearly, a condition which has evidently resulted from the flowage of the lava after the plagioclase had crystallized. Some of the thin sections of the andesite examined contained local areas of quartz and feldspar having the granular appearance of the rhyolitic groundmass. These, in some cases, appear to replace the plagioclase phenocrysts and are, therefore, probably in part, if not entirely, of secondary origin. The alteration products occurring in the andesites, as in the diorites, are epidote, sericite, zoisite, carbonate, and chlorite.

The following analysis of dacite occurring on the northeast shore of Lake Dufresnoy was supplied the writer by Mr. Stewart J. Lloyd.[1]

SiO_2	66·91
Al_2O_3	19·01
Fe_2O_3	3·70
FeO	1·79
CaO	0·35
MgO	0·59
Na_2O	4·62
K_2O	1·44
TiO_2	0·27
H_2O-	0·20
H_2O+	0·64
CO_2	0·26
	99·78

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[1] Ass. Prof. of Chem. and Metal. in the University of Alabama.

Using the method of rock classification proposed by Messrs. Cross, Iddings, Pirsson, and Washington this rock has the following norm.

Quartz	33·24
Orthoclase	8·34
Albite	38·77
Anorthite	1·67
Corundum	9·28
Hypersthene	1·50
Magnetite	5·35
Ilmenite	0·61

and belongs to:—

Class 1	Persalane
Order 4	Britannare.
Rang 1	Liparase.
Subrang 3	Liparose.

A specimen of diorite occurring on the northeast bay of Lake Dufresnoy was analysed by Mr. Lloyd, with the following result:—

SiO_2	49·68
Al_2O_3	15·35
Fe_2O_3	4·53
FeO	9·22
CaO	6·92
MgO	4·40
Na_2O	3·84
K_2O	2·25
TiO_2	1·37
H_2O-	0·29
H_2O+	2·14
CO_2	0·65
	100·64

This rock according to the method of classification devised by Messrs. Cross, Iddings, Pirsson, and Washington has the following norm.

Orthoclase	12·79
Albite	32·49
Anorthite	18·07
Diopside	13·33
Olivine	11·02
Ilmenite	2·74
Magnetite	6·50

and falls in:—

Class 2	Dosalane.
Order 4	Germanare.
Rang 3	Andase.
Subrang 2	

Gabbro, Diabase, and Basalt.—The basic volcanic members of the Abitibi group are green rocks which are essentially similar in mineral composition but differ greatly in texture, the gabbro being allotriomorphic, the diabase ophitic, and the basalt aphanitic. These various phases pass gradationally into one another and commonly occur together in the same flow. The surface of the basaltic flows in places has a clastic appearance, small fragments of the basalt being enclosed in a rusty matrix. The microscopic examination of the matrix, however, shows that this is also basalt having a eutaxitic structure (Plate IX) so that the rock is evidently a flow breccia.

The chemical alterations which this group of rocks has undergone are practically the same as those occurring in the lavas of acid and intermediate composition. In the diabase and gabbro the feldspars are largely if not entirely replaced by sericite, epidote, zoisite, and carbonate; and the original augite has usually disappeared or occurs as residual cores in the midst of secondary hornblende. The interstices between the feldspars and hornblende or augite are commonly occupied by actinolite, tremolite, or chlorite. There are also present small quantities of ilmenite, sphene, and iron oxide. The basalt, unlike the andesite or rhyolite, is not commonly porphyritic, but in places phenocrysts of plagioclase or of plagioclase and augite occur. The plagioclase is generally obscured by the usual alteration products, carbonate, zoisite, epidote, and sericite. In some localities the feldspar is entirely replaced by carbonate in which, however, the zonal structure of the feldspar has been preserved. The groundmass of the basalt consists chiefly of minute crystals of plagioclase which may be extended into long branching fibres. They have generally a dirty colour owing to the iron oxide, chlorite, carbonate, zoisite, and epidote associated with them. Evidence of flowage is recorded in the basalts, not only, as in the case of the andesites, by broken and drawn out plagioclase phenocrysts but by the presence of banding and eutaxitic structure (Plate IX).

Lamprophyre.—The Abitibi volcanics occurring on the southwest shore of Lake Dufault are intruded at a point about 100 yards north of the entrance to the large west bay, by a dyke of biotite lamprophyre 10 inches wide, and a dyke of similar rock, having a width of 10 feet, was observed by Mr. Stewart J. Lloyd in the interior of the peninsula which projects into Lake Dufresnoy. When examined under the microscope this rock was found to be minette consisting of orthoclase, plagioclase, biotite, and a carbonate with smaller amounts of sericite, sphene, chlorite, and iron oxide. The biotite is partly altered to chlorite and the feldspar largely replaced by sericite and carbonate, so that a large part of the rock consists of secondary minerals.

Mr. Lloyd made a chemical analysis of the minette from the Lake Dufresnoy locality with the following results:—

SiO_2	55·39
Al_2O_3	11·90
Fe_2O_3	0·90
FeO	4·71
CaO	7·63
MgO	3·67
Na_2O	1·99
K_2O	4·30
TiO_2	1·24
H_2O-	0·26
H_2O+	6·08
CO_2	2·12
	100·19

AMYGDALOIDAL STRUCTURE.

The fine grained facies of the Abitibi volcanics in places possess an amygdaloidal structure, the amygdules varying in size from that of a pea or less to 2 inches or more in length and consisting of carbonate, quartz, chlorite, or epidote. One of these minerals may form the entire amygdule, but generally two or more occur together. When quartz and carbonate compose the amygdule, the quartz usually occupies the border and the carbonate the centre, whereas when carbonate and chlorite are present the carbonate generally occurs on the periphery and the chlorite in the centre. In places where it was possible to break out the quartz amygdules from the enclosing rock it was observed that the quartz had a pitted surface. In a few localities the amygdules were seen to be exceptionally abundant on the margin of the ellipsoids of the pillow lavas, but this feature is apparently not nearly so common as in the Lake Superior and other regions where the pillow lavas have been described.

ELLIPSOIDAL STRUCTURE.

The ancient lavas of this region very commonly possess the ellipsoidal, spheroidal or pillow structure which has been observed in volcanic rocks in various parts of the world and nowhere more generally than in those of the Lake Superior-Lake Huron province. The widespread occurrence of this structure, its evident genetic relationship to the physical conditions under which the rock consolidated, and its usefulness in working out the structure and stratigraphy of the lava flows renders it of such geological importance that it merits the most detailed investigation.

Structural Features.—The ellipsoidal rocks of this region are composed of large pillow-like masses of basalt or andesite ranging from a few inches to 5 or 6 feet in length. These are sharply outlined on the surface exposure of the rock owing to the differential weathering of the material filling the interspaces (commonly gore-like in form) between the ellipsoids (Plates X, XI, XII, and XIII). This interstitial material varies greatly from point to point, consisting of carbonate or of carbonate and quartz in some places and in others of aphanitic slate-like material which even under the microscope is so fine grained as to afford no positive information as to its origin. It may be sedimentary material deposited between the ellipsoids but is more probably lava which has filled in around the pillows after their partial consolidation.

The pillows of lava are not true ellipsoids or spheroids but are generally irregular in form, the surface of each pillow adjusting itself somewhat to the irregularities of its neighbour. Many of the pillows are also flattened on one side, this feature giving rise to a form which the writer described in the field as bun structure (Plate XI). A similar flattening on one side of the ellipsoids has been described by Daly in the pillow lavas of Newfoundland[1]; by Ransome in the spheroidal basalt of point Bonita, California[2], and by Russell in the lavas of the Snake River plains[3]. Each of these geologists observes that the flattening occurs on the underside and attributes its origin to the flowage of the viscous spheroid of lava under the action of gravity. This feature is, therefore, of importance in working out the structure of the Abitibi volcanics, for in any locality where the bun structure is present, by observation of the side of the ellipsoid on which the flattening occurs, the approximate strike and dip of the lavas can be ascertained. Thus, by means of this criterion an examination of the pillow lava shown in Plate XI indicates that the volcanics have a vertical attitude and that the upper side of the flow is on the right.

Origin.—The various hypotheses advanced to explain the genesis of the ellipsoidal structure have been outlined historically by Clements in the monograph on the Crystal Falls region[4] and later supplemented both by Daly[5] and by Van Hise and Leith[6]. A full discussion of the differing conclusions reached

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[1] American Geologist, Vol. 33, pp. 65-78, 1902.
[2] Bull., Dept. of Geo., Univ. of Cal., pp. 75-85, 1893.
[3] U. S. G. S. Bull. 199, p. 113, 1902.
[4] U.S.G.S., Mon. 36, pp. 119-123, 1899.
[5] Am. Geo., Vol. 32, pp. 65-78.
[6] U.S.G.S., Mon. 52, pp. 510-511, 1911.

by the numerous geologists who have studied this structure in the field will not, therefore, be attempted. A brief summary of these, however, is necessary for a full consideration of the evidence bearing on its origin.

Nearly all the modes of origin suggested consider the ellipsoids to be genetically related to contraction, or movements in the lava, or both. Cole and Gregory,[1] Ransome,[2] and Teal [3] compare the structure of the pillow to that of the pahoehoe lavas of Hawaii. Clements,[4] on the other hand, concludes that the pillow structure is analogous to that of the A A Hawaiian lavas since these, according to Dana,[5] tend to form where moisture is present. A large number of geologists, including Teall,[6] Geikie,[7] Russell,[8] Daly,[9] Reid,[10] Dewey[10],[11], Fenner[11], and Flett[12] have noted that the geological relationships of pillow lavas were such as to indicate that they belonged to subaqueous extrusions.

In the recent monograph on the geology of the Lake Superior region, Leith and Van Hise, after summarizing the literature on the subject conclude that "the evidence seems to be that the ellipsoidal structure is both subaqueous and subaerial in its development that it is produced by the rolling of blocks developed during the flow of lava as a result of cooling, that the development is, therefore, determined by the speed of flow and the rate of cooling, which in turn may be affected by entrance into water . . . . .qualitatively the evidence favours the subaqueous origin of the ellipsoidal basalt."

Dr. Tempest Anderson has recently described the formation of pillow structure in a lava stream which flowed into the sea from Matavanu, one of the volcanoes in the Samoan islands. Above the level of the water the ordinary corded structure was formed; where, however, the lava fell into the sea he states that "the surface is chilled before there is time for it to be wrinkled up into the corded structure and it becomes consolidated into the characteristic form of one variety of pillow lava".[13]

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[1] Quart. Jour. Geo. Soc., Vol. 46, p. 325, 1890.

[2] Bull. Dept. of Geo., Univ. of Cal., Vol. 1, p. 112, 1893.

[3] Quart. Jour. Geo. Soc., Vol. 49, p. 211, 1893.

[4] U.S.G.S., Mon. 36, pp. 125, 1899.

[5] "Characteristics of Existing Volcanics," p. 243, 1890.

[6] Quart. Jour. Geo. Soc., Vol. 49, p. 214, 1893.

[7] "Ancient Volcanoes of Great Britain," pp. 26, 184, etc., 1897.
Quart. Jour. Geo. Soc., Vol. 64, p. 269, 1908.

[8] U.S.G.S., Bull., p. 113, 1902.

[9] Am. Geo., Vol. 32, p. 78, 1902.

[10] Quart. Jour. Geo. Soc., Vol. 64, p. 42, 1908.

[11] Geo. Mag. Vol. 58, p. 262, 1911.

[12] Am. N.Y. Acad. Sc., Vol. 20, Pt. 2, pp. 98-187, 1910.

[13] Quart. Jour. Geo. Soc. Lond. pp. 631-33, 1910.
Geog. Jour. Vol. 39, p. 129, 1912.

According to A. C. Lawson[1] the most "typical spheroidal ellipsoidal basalt to be found anywhere occurs in splendid exposures in the city of San Francisco and at many other localities in the coast ranges of California..... as intrusive rocks." But as far as known to the writer, all the occurrences of ellipsoidal structure which have been described in California occur either in extrusive rocks or in intrusives close to their point of extrusion.[2] It is conceivable that the ellipsoidal structure might originate locally, in dykes or volcanic necks, near their point of extrusion, but the geological relationship and character of the rocks in which it occurs so generally, indicate an extrusive origin and that it is no more probable that these pillow-like forms should be extensively developed in intrusive rocks than the ropy structure, vesicular structure, or any other form typical of volcanic lavas.

Van Hise and Leith in their discussion of this subject conclude that the ellipsoidal structure may be subaerial in its development, although they state that "In the Lake Superior region the interbedding of ellipsoidal basalts with sediments of subaqueous origin . . . . seems to be adequate evidence that the ellipsoidal structure of the Lake Superior basalts is largely of subaqueous origin." But as far as known to the writer no pillow lavas have been described anywhere in the world which are positively known to have been solidified under subaerial conditions. On the other hand, Geikie concluded after numerous observations of ellipsoidal structure in the British Isles, that "all the examples of pillow lavas with which he was familiar were undoubtedly true lavas and belonged to subaqueous eruptions" and a similar conclusion is reached by Dewey[3] and Flett[4] in their recent paper on the pillow lavas of Great Britain. It seems, therefore, that there is a direct connexion between the ellipsoidal structure and subaqueous extrusion and that the full explanation of this relationship has not yet been given.

A complete hypothesis in explanation of the development of the ellipsoidal structure must account for (1) the breaking up of the lava into small masses and (2) the assumption of an ellipsoidal form by the masses after they are formed. The breaking up of the lavas is probably related to two factors—(a) the rapid cooling of the surface of the flows in contact with the water and (b) the pressure from within the lava flows. Dutton in describing the manner in which the pahoehoe structure in the lavas of Hawaii originates states that "The superficial crust of cooled lava undergoes rupture at numberless points, and little rivulets of lava shoot out under pressure. Preserving their liquidity for

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[1] Min. and Sc. Press, Vol. 104, p. 109, 1912.

[2] Bull. Univ. Cal., Vol. 1, p. 202, 1894; pp. 75-103, 1893; Vol. 2, pp. 40-50, 1896.

[3] Quart. Jour. Geo. Soc., Vol. 64, p. 269, 1908.

[4] Geo. Mag., Vol. 58, pp. 201-209, 240-246, 1911.

a short time, they spread out very thin and are quickly cooled, forming pahoehoe. Scarcely is one of these little offshoots of lava cooled when it is overflowed by another and similar one, and this process is repeated over and over again. In a word, pahoehoe is formed by small offshoots of very hot and highly liquid lava from the main stream driven out laterally or in advance of it in a succession of small belches. These spread out very thin, cool quickly, and attain a stable form before they are covered by succeeding belches of the same sort."[1] The breaking up process by which the pahoehoe structure is developed would no doubt take place much more extensively in a subaqueous flow because of the rapid cooling. In this respect the ellipsoidal and pahoehoe structures may, therefore, be similar in their development, but 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 the water, so that masses of lava would be developed which would stretch out into an ellipsoidal form as they detach themselves at their point of ejection.

From the foregoing discussion it is concluded that the ellipsoidal structure in extrusive rocks is always subaqueous in origin and is dependent on two factors—(1) the flowage of the lava and (2) the rapid cooling effected by contact with water. Owing to this rapid cooling, and to the pressure of the lava from within, innumerable fractures are formed in the surface of the lava flows from which the fluid lava of the interior is ejected. This molten material is immediately cooled by the water, however, to a viscous mass which by movement is later drawn out into an ellipsoidal form. By the repetition of this process, great thicknesses of ellipsoidal lavas could be accumulated just as they are known to occur in various parts of the world. Since the above was written a paper entitled "Pillow-lava from the Kiruna District," by N. Sundius, has been received (Geol. Fören Förhandl. Vol. 34, pp. 317-332, 1912.) The author concludes that the pillow-structure is a flow phenomenon in lava and developed under subaqueous conditions.

MINERALOGICAL ALTERATION.

Character of Alteration.—The petrographical examination of the Abitibi volcanics has shown that these rocks have undergone extreme metasomatic alterations throughout their whole extent. The secondary minerals developed are carbonate, epidote, zoisite, sericite, uralite, tremolite, actinolite, chlorite, quartz, and feldspar. The relative proportion of these vary

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[1] 4th Ann. Rep. U.S.G.S., p. 96, 1882-3.

greatly in the different rocks, but the uniformity in the character of the alteration shows that the agency effecting the alteration was the same in every case. Moreover, epidote, zoisite, and carbonate are so abundant in places, as to indicate that not only has there been a rearrangement of the original elements contained in the rock but that carbon dioxide, lime, water, and possibly silica have been added. It may be inferred, therefore, that the transformation of the Abitibi volcanics was brought about by solutions which contained, among other constituents, an abundance of carbon dioxide.

Time of Alteration.—It is pointed out, in the section describing the lithological character of the amphibolite and hornblende schist which has resulted from the dynamic metamorphism of the Abitibi volcanics, that these contain considerable carbonate, which fills the interspaces between the other minerals. This carbonate was undoubtedly a constituent of the rock prior to its metamorphism, so that the carbonation of the volcanics must have taken place before the batholithic invasions of granite and gneiss effected their transformation into amphibolite and hornblende schist. It was also observed that the margin of the pillows in the ellipsoidal basalt, occurring in the vicinity of Ollier lake, was highly charged with epidote and carbonate whereas the interstitial material between the pillows was unaltered. This interstitial material is very fine grained and slate-like in appearance and may be either sedimentary material deposited around the pillows, or basalt of finer texture than the ellipsoids. But in either case, it is apparent that the alterations on the margin of the ellipsoids took place before the interspaces were filled, and that it, therefore, must have been accomplished almost immediately after the ellipsoids were formed.

Process of Alteration.—The extreme metasomatic alteration of ellipsoidal lavas has been noted in practically every locality where the structure has been observed. Ransome, in describing the petrology of the ellipsoidal basalt of Point Bonita, notes that "secondary alteration is generally well advanced, and the rock is permeated with calcite, chlorite, and sometimes quartz".[1] In the monograph on the Crystal Falls region of Michigan, the alterations which have taken place in the pillow lavas of the Hemlock formation are classed by Clements[2] as carbonation, calcification, and silicification, the secondary minerals resulting from these processes being, without exception, the same as those occurring in the Abitibi volcanics. He also observed that the peripheral portions of the ellipsoids were more highly altered than their centres. Daly, in describing the petrography of the variolotic pillow lavas of Newfoundland,

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[1] Bull. of the Dept. of Geo., Univ. of Cal., Vol. 1, p. 80, 1893.
[2] U.S.G.S., Mon. 36, pp. 126–135, 1899.

says: "The rock in the field is apparently fresh and it was expected, in view of the intense glaciation this region has suffered and because of the rapidity of wave-erosion at the sea-chasm, that extensive alteration of the lavas through weathering had not taken place. It was, therefore, hoped that the microscope would throw light on the origin of the peculiar differentiation of matter in the pillows. But every thin section studied showed that both varioles and matrix have suffered almost complete decomposition.

The aphanitic matrix........................consists of a confused, structureless, massive mat of obscure feldspar material, accompanied with exceedingly abundant calcite and with many ragged colourless tremolite or actinolite crystals, much chlorite, zoisite and abundant yellow grains of epidote." He concludes his paper with the following sentence. "Next to the possession of their peculiar structure, the pillow lavas described in Europe and America have no more prominent and unvarying characteristic than this one of manifest profound, metasomatic alteration of the rock". In a recent paper[1] on the Watchung basalt and the paragenesis of its zeolites and other secondary minerals, Clarence N. Fenner concludes that the zeolites and secondary minerals are limited to those portions of the basalt sheet exhibiting the pahoehoe (ellipsoidal) structure, that the pahoehoe (?) structure has been developed over or immediately adjacent to lake beds through quicker cooling of the flow, and that the secondary minerals have been developed from the elements of the basalt and from the sublimates given off by the magma in cooling, through the agency of heated meteoric waters which were enabled to percolate through the sheet of lava because of the more permeable structure above the lake beds.[2] A discussion of the alterations in the British pillow lavas and the rocks associated with them has been recently contributed to the Geological Magazine[3] by Dewey and Flett. The common alteration products mentioned are calcite, chlorite, epidote, zoisite, quartz, and albite. They conclude from the geological evidence presented that the albitization took place soon after the rocks had solidified and that the transformation was brought about through the agency of pneumatolitic emanations consisting of water, soda, silica, and probably carbon dioxide and other substances.

It has been shown that there is evidence which indicates that the metasomatic alteration of the Abitibi volcanics took place almost contemporaneously with the formation of the ellipsoidal structure and, therefore, immediately after their

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[1] Am. Geo., Vol. 32, pp. 65-78, 1903.

[2] N.Y. Acad. of Sci., Vol. 20, No. 2, Pt. 2, pp. 93-187, 1910.

[3] Vol. 58, pp. 201-209, and 241-243, 1911.

extrusion, a conclusion in perfect accord with that of Fenner for the Triassic basalt of New England and that of Dewey and Flett in the case of the pillow lavas of Great Britain. As Fenner has pointed out, the interspaces between the ellipsoids of the pillow lavas would afford excellent channels through which water could percolate; but just as soon as such a circulation of water began, cementation would commence and the interspaces between the ellipsoids would shortly become filled. This process would be especially rapid if the waters were thermal or for other reasons were highly charged with mineral matter. It is probable, therefore, for this reason also, that both the alteration and the cementation of the Abitibi volcanics occurred immediately after their extrusion.

Since the material filling the interspaces between the pillows consists of carbonate or of carbonate and quartz, it is apparent that the waters from which deposition took place, like those by which the metasomatism of the volcanics was effected, contained an abundant supply of carbon dioxide and silica. Moreover, since these oxides are among the most common constituents of the thermal springs, which occur in volcanic regions, it is most probable that both the transformation and the cementation of the pillow lavas were brought about by heated waters highly charged with volcanic gases. As the Abitibi volcanics were probably exteuded beneath the sea, their gaseous emanations must have been evolved under considerable pressure and in the presence of an abundance of water, so that, whereas under subaerial conditions of extrusion the volcanic gases would escape into the atmosphere, under these conditions, they would be held in contact with the lavas and thus effect their alteration.

Conclusion.—It is concluded, therefore, from the geological evidence obtained in this region and from similar evidence observed in other parts of the world, that the metasomatic alteration of the Abitibi volcanics was effected through the agency of volcanic gases, which were evolved either contemporaneous with or immediately following the volcanic extrusions, and that the intensity and uniformity of the alteration throughout the volcanics wherever they occur, is due, in part, to the permeable structure of the pillow lavas and, in part, to subaqueous extrusion, the presence of an abundance of water preventing the escape of the gaseous emanations and at the same time affording a medium through which chemical action was made possible. It is not intended to imply that juvenile water played no part in these reactions, but it was not one of the essential factors, for, under subaerial conditions of extrusion, the magmatic water, if present, escapes into the atmosphere and has little or no chemical effect and under subaqueous conditions would simply be added to the water already present.

MODE OF ORIGIN.

Practically all that is known with regard to the mode of origin of the Abitibi volcanics has already been stated or implied in the previous paragraphs. As the name implies they are all volcanic rocks and occur largely as lava flows, which are believed to be, largely if not entirely, of subaqueous origin. No volcanic centres of eruption have been described in any part of the regions where these rocks occur and little is known as to the type of volcano from which the lavas were extruded, but the dykes of andesite basalt, etc., which cut the volcanics, in places, no doubt served as vents through which extravasations occurred.

STRUCTURAL FEATURES.

Folding.—The volcanic rocks of the Abitibi group possess few features from which their structural position can be worked out, but where the lava flows are steeply inclined their trend can be recognized by their change in texture when crossed in a direction at right angles to their strike. Thus, on the portage from Lake Dufresnoy to Sills lake, a hill occurs in which two flows having an approximate thickness of 600 and 700 feet respectively and striking N. 55° west can be recognized. In some places the amygdaloidal structure, flow structure, or ellipsoidal structure is limited to narrow zones and thus furnishes a clue as to the trend of the rocks. The flattening of the ellipsoids of the pillow lavas on their underside due to gravity can also—as has already been explained[1]—be used to ascertain not only the attitude but the upper and lower sides of the flows. The structural attitude of the volcanics where they are associated with slate and phyllites can, at these points, be ascertained from the strike and dip of the sediments. From the application of the above criteria it was found that throughout a large part of the region—if not throughout its entire extent—the rocks of the Abitibi group have been highly folded and have a strike varying from northwest-southeast to southwest-northeast.

Mashing.—[2]The mashing to which the rocks of the Abitibi group have been subjected is of two kinds, a regional type by means of which considerable areas of rock have been converted into schist and a second, related to local deformations. The former variety occurs in the vicinity of the granite batholiths whereas the latter may be encountered wherever the Abitibi

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[1] Page 51.

[2] The term mashing is here used for deformation in the zone of flowage following the definition of Van Hise, 16th Ann. Rep. U.S.G.S., Pt. 1, p. 694, 1896.

volcanics occur. The local mashing in nearly every case has a strike approximately parallel to that of the rock in which it occurs, so that these have very probably resulted from deformational movements which accompanied the folding.

Relations to Other Formations.—The relation of the volcanics of the Abitibi group to the other formations of the region is discussed at length in later sections of the report. It may, therefore, be simply stated here that the relationship of the Abitibi volcanics to the Pontiac series is unknown, that wherever they were observed in contact with the granite and gneiss the latter were intrusive, that they are overlain unconformably by the Cobalt series and are intruded by dykes of Nipissing diabase.

Schists and Amphibolites.

DISTRIBUTION.

The schists and amphibolites of the Abitibi group are of comparatively limited extent, occurring chiefly in the neighbourhood of the intrusive granite batholiths. They were observed in four separate localities, in the region between Lake Opasatika and MacLaren creek, and along the borders of the Lake Abitibi, Robertson Lake, and Gauvin Lake batholiths. Sericite schist is confined to a few localities where the rhyolite and quartz porphyry have suffered local deformation. The largest area occurs on the south shore of Lake Abitibi, but other small outcrops were observed, on the portage from Lake of Islands to Osiksko lake and at the west end of Lake Dufresnoy. Fine grained fissile sericite schist containing an abundance of carbonate also occurs in a number of localities, but this is possibly of sedimentary origin and will be described along with the slate.

LITHOLOGICAL CHARACTER.

INTRODUCTORY STATEMENT.—The rocks included in this subdivision are exceedingly variable types, but have been grouped together because it is believed that they have all been derived from the Abitibi volcanics as a result of metamorphism. For the purpose of lithological description, they may be classified into two groups, the amphibolite and hornblende schist, and the sericite schist.

Amphibolite and Hornblende Schist.—The amphibolite and hornblende schist are grey to dark green or almost black rocks which vary in texture from a fine grained type containing innumerable minute glistening crystals of hornblende, to coarse amphibolite composed of amphibole crystals half an inch or more in length. At the west end of Nepawa island, in the contact zone of the Lake Abitibi batholith, amphibolite containing pink feldspar was observed to occur as dykes intruding the ordinary dark variety of amphibolite, and similar gradational variations may be observed wherever these rocks are found.

The microscopic examination of the amphibolite and hornblende schist shows that while they are in general of similar mineralogical composition, within these limits there are wide variations. In some places the rock consists almost entirely of ferromagnesian minerals, in other places feldspar is an abundant constituent but quartz is absent, or these conditions may be reversed the quartz taking the place of the feldspar. The most common ferromagnesian constituent of the rocks is a blue green hornblende, but this is replaced by tremolite and actinolite in the Opasatika greenstone area. The feldspars range all the way from orthoclase to andesine, but the sodic varieties are most common. In nearly all the thin sections examined carbonate is disseminated through the rock, filling the interspaces between the other minerals. In addition to the minerals already mentioned, biotite, diopside, epidote, sphene, apatite, pyrite, and garnet are also commonly present. The hornblende schist does not differ from the amphibolites in composition, but has a foliated structure owing to the parallel alignment of rod-like crystals of hornblende.

Fig. 5. Camera lucida drawing of amphibolite occurring on Happy Outlook point. Lake Opasatika. H, hornblende; Q, quartz; C, carbonate; Black, magnetite. Note the uniform distribution of the carbonate.

Sericite Schist.—The sericite schists are light grey or greenish grey, fine grained schistose rocks which commonly occur along zones of mashing in the quartz porphyry and rhyolite. They usually contain considerable carbonate and effervesce freely when treated with strong acids.

When examined under the microscope the sericite schists are found to consist almost entirely of an exceedingly fine grained mosaic of quartz and feldspar throughout which carbonate and innumerable microlites of sericite are disseminated. In some sections a few broken and partially granulated fragments of quartz and feldspar remain, indicating that the original rock was porphyritic. The accessory constituents of the sericite schists are chlorite, iron oxide, pyrite, and rutile.

MODE OF ORIGIN.

The schists and amphibolites of the Abitibi group occur in such geological relationships as to indicate that they were all originally volcanic rocks, but have been recrystallized and foliated either by local deformational movements or through the contact action of intrusive granite batholiths. In every locality where these rocks occur they pass gradationally into the typical volcanic types, and, while no chemical analyses of the original and recrystallized rocks have been made, their mineralogical constitution shows that their chemical compositions are approximately the same. The amphibolite and hornblende schist in every case occurs in the marginal zone surrounding the intrusive batholiths, an association which can be explained in no other way than on the assumption that they are the result of the contact action of the intrusive. The sericite schist, on the other hand, was not observed in the vicinity of the batholiths, but occurs in narrow zones, here and there throughout the region, and is, therefore, probably the result of deformational movements.

Chloritic Rocks.

DISTRIBUTION.

The rocks of this class comprise a large part of the area of greenstone occurring between Lake Opasatika and MacLaren creek, also the two points on opposite sides of the entrance to Moose bay, Lake Opasatika. They were not observed elsewhere in the region.

LITHOLOGICAL CHARACTER.

The chloritic rocks are greyish green, massive, rocks which, when examined under the microscope, are found to consist entirely of chlorite, pyrite, and a small quantity of carbonate. The exposures of the chloritic rocks which occur on the north and south sides of the entrance to Moose bay are peculiar in that in both localities the rock is traversed by a network of seams containing a carbonate and chlorite. The rock throughout a zone about an inch wide on either side of the seams has undergone a change for it stands up conspicuously with a white appearance on the weathered surface (Plate XIV).

Slate and Phyllite.

DISTRIBUTION.

Slate and phyllite were observed in association with the volcanics of the Abitibi group in only two localities, on the north shore of Lake Duparquet and at the Clay Hill rapid on the Kinojevis river. The last named occurrence, however, is in close proximity to an area of greywacke similar to that of the Pontiac series and has been included in that formation. Exceedingly fine grained fissile sericitic schists were observed on the south shore of Chauvigny lake, on the Lacroix claim north of Beauchamp lake, on the south shore of Boundary bay, Lake Abitibi, and on the claim of the Union Abitibi Mining Company, which are all possibly of sedimentary origin and for that reason are mentioned in this section of the report.

LITHOLOGICAL CHARACTER.

The slates and phyllites are grey green or black rocks, the grey colour being due to the presence of carbonate and sericite, the green, to chlorite, and the black, to graphite. Owing to the interbedding of these different facies, the weathered surface of the rock has commonly a banded appearance. Examined in thin section under the microscope, the slate and phyllite are seen to consist largely of chlorite, carbonate, sericite, quartz, feldspar, and pyrite, the relative abundance of these minerals varying greatly in the different types.

STRUCTURAL RELATIONS.

Wherever the slate and phyllite occur they have always a vertical or nearly vertical attitude and are enclosed on all sides by the Abitibi volcanics. These beds may have either of two possible relationships to the volcanics; they may have been laid down contemporaneously with the lavas and have been folded up into their present attitude in company with them, or they may be much younger than the volcanics and have been infolded into their present position. No evidence was obtained from which a positive conclusion could be inferred with regard to these two possibilities, but since there is no evidence of unconformity between the slate and phyllite and the volcanics it is more probable that they were deposited in comformable succession with the extrusive flows.

ORIGIN.

The slate and phyllite contained in the Abitibi group are presumably sediments deposited on the bottom of the Pre-Cambrian sea during the intervals which occurred between the successive extrusions of submarine lava flows. They might be either materials derived by denudation from an ancient land surface or fine grained volcanic ejectmenta, although there is nothing in their character, at present, to indicate a volcanic origin. These characteristics, however, may have been destroyed by metamorphism. The presence of graphite in the rock would indicate that organic material was also present at the time of deposition.

Ferruginous Dolomite.

The widespread occurrence of ferruginous dolomite in association with the volcanic rocks of the older complex, in almost every part of the Canadian shield where geological work has been carried on, and its probable genetic relationship to the auriferous quartz veins of these regions makes this rock of such importance that the fullest possible discussion of its character and origin is demanded. No attempt will, therefore, be made to limit the treatment of the subject to the district under description in this report.

DISTRIBUTION.

Occurrences of ferruginous dolomites similar to those found in the Abitibi district have been described in a large number of localities throughout the older Pre-Cambrian complex of the Lake Superior-Lake Huron geological province. They are known to occur in the Lake of the Woods region[1], on Aird island in Georgian bay[2], Lake Timagami[3], in the vicinity of Kenogami lake[4], in the Larder Lake district[5], on the shore of Lake Abitibi[6], on an island in Night Hawk lake[7], and in the Porcupine district[8].

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[1] Can. Geo. Surv., Vol. I, pp. 60, 61, 145, 1885.
[2] Am. Jour. Sc. 4th Series, Vol. 33, p. 284, 1887.
[3] Geo. Surv. Can., Vol. X, p. 274, 1897.
[4] Sum. Rep. Geol. Surv. Can., p. 127, 1901.
[5] Ann. Rep., Bur. Mines Ont., Vol. 16, p. 207, 1907.
[6] Ann. Rep. Bur. Mines Ont., Vol. 18, p. 270, 1909.
[7] Ann. Rep. Bur. Mines Ont., Vol. 16, p. 270, 1907.
[8] Ann. Rep. Bur. Mines Ont., Vol. 20, Pt. 2, p. 12, 1911.

In the region under description ferruginous dolomite was observed on the south shore of Boundary bay, Lake Abitibi, on Chauvigny and Fraser lakes (Privat township), in the vicinity of Fortune and King of North lakes (Dasserat township), and north of the Cascade rapids on the Kinojevis river (Manneville township).

LITHOLOGICAL CHARACTER.

The ferruginous dolomite in its most typical occurrences is a rusty weathering rock consisting of carbonate which is traversed, wherever it occurs, by innumerable intersecting and anastomosing veinlets of quartz or of quartz and ferruginous dolomite. In places, the veinlets become so numerous as to constitute a stockwork deposit, the quartz at these points comprising a large part of the rock. As a rule, the dolomite contains a large amount of pyrite and in most localities has a bright green colour owing to the presence of disseminated chromiferous mica.

Examined in thin section under the microscope, the most typical dolomitic rock is seen to consist of carbonate, commonly in rhombohedrons, with varying proportions of pyrite, chrome mica, sericite, quartz, and feldspar. Galena and rutile were also present in some thin sections examined. While the amount of feldspar and quartz in the most typical phases of the dolomite is not large, in some places the rock contains a large proportion of these minerals so that all intermediate stages between the dolomite and quartz porphyry or aplite may be observed.

All the published analyses of the ferruginous dolomite occurring in the northern part of the Timiskaming region, are included in the following tables.

	1	2	3	4	5	6	7
Insoluble............	51·82	58·63	47·35	1·73	....	11·42	....
$CaCo_3$..	19·38	19·59	20·98	50·63	51·28	46·63	42·76
$MgCo_3$.	6·08	8·06	8·50	29·51	29·82	28·77	19·86
$FeCo_3$.....	13·49	11·53	12·19	14·15	5·39	5·39	12·01

Nos. 1, 2, and 3 Porcupine district, Ann. Rep. Bur. Mines, Ont., Vol. 20, Pt. 2, p. 13, 1911.

Nos. 4, 5, 6, and 7, ditto, p. 14.

	1	2	3	4
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	......	3·12	......	5·71
MgO	12·98	18·47	7·45	7·98
CaO	26·02	8·02	7·48	6·78
Na_2O	0·03	0·02	......	3·56
K_2O	0·20	0·16	.....	2·22
TiO_2	0·10	0·19	......	0·27
MnO	0·09	trace	0·07	......
CO_2	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.	......	......
Total	99·45	100·06		100·48

No. 1. Reddick claim, Larder lake, Jour. Can. Min. Inst., Vol. 14, pp. 672-689, 1911.
No. 2. Night Hawk lake, ditto.
No. 3. Harris Maxwell claim, Larder lake, ditto.
No. 4. " " " " " , analysis by M. F. Connor, Mines Branch, Dept. of Mines, Canada.

ORIGIN.

The earliest discussion of the genesis of the ferruginous dolomites occurring in the northern part of the Timiskaming region was that of Mr. R. W. Brock in his report on the Larder Lake district[1]. His conclusion as to their origin is included in the following quotation. "The most interesting rock from an economic standpoint near Larder lake is the rusty weathering dolomite (?). About 60 per cent of the rock consists of lime-magnesia-iron carbonate, the remainder of quartz and a soft green talcose silicate, probably serpentine. The origin of the rock is as yet a little uncertain. Certain dykes, when squeezed and altered, produce a rock which bears a strong resemblance to it, but its occurrence with slates and phyllites and with the cherts—undoubted sedimentary rocks— as a conformable band with them, over a wide stretch of country, and its apparent composition, render it much more probable that it is an altered, stratified ferriferous dolomite, probably forming a member of the Iron Ore formation." The apparent geological relationship between the ferruginous dolomites and quartz porphyry occurring in the Larder Lake district was pointed out by the writer in the Summary Report of the Geological Survey for 1909, and the possible derivation of the dolomite from quartz porphyry and aplite was discussed at some length in the final report on

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[1] Ann. Rep. Ont. Bur. Mines, Vol. 16, Pt. 1, p. 207, 1911.

that region[1]. The probable origin of some of the ferruginous dolomite by replacement has been mentioned by W. G. Miller and A. G. Burrows[2], while N. B. Davis who assisted the writer in field work in the Larder Lake district has suggested that they have been derived from rocks of the peridotite family[3].

The derivation of the dolomite occurring in the northern part of the Timiskaming region, from serpentine and related rocks by carbonation and desilicidation, is scarcely a tenable hypothesis, for although serpentine occurs in the region, it has never been observed as far as known to the writer, in association with the typical dolomite, and except for the presence of carbonate seams in places, shows no evidence of carbonation. Moreover, it is shown on the following page that there is much evidence which indicates that the chrome mica has been introduced secondarily into the dolomite, so that the presence of chromium is not an argument in favour of the genesis of the dolomite from ultrabasic chromium bearing rocks.

In discussing the origin of the ferruginous dolomites, only two hypotheses need be considered ; they have either been derived from quartz porphyry, aplite, and related rocks by thermal replacement or are of sedimentary origin, possibly modified in places by igneous intrusions.

The association of the ferruginous dolomite with quartz porphyry, rhyolite, or aplite has been most striking in every region where the rock has been encountered by the writer. During the autumn of 1911, a return visit was made to the Larder Lake district and a suite of rock chips was collected from a typical hill of ferruginous dolomite occurring on the Harris Maxwell claim. The microscopic examination of thin sections from these chips showed that all gradations from almost pure dolomite to a rock consisting almost entirely of alkalic plagioclase—albite and oligoclase—and micropegmatitic intergrowths of quartz and feldspar, were present and that the dolomite was most abundant in those portions of the hill where the quartz veinlets were most numerous. It was observed in those sections of the aplite in which dolomite was not abundant, that the feldspars were contorted and broken and showed undulatory extinction indicating that the rock had suffered considerable deformation, and that minute zones of shearing along which chrome mica, sericite, pyrite, rutile, and dolomite were strung out, occurred in some of the sections. In a ridge of ferruginous dolomite which occurs to the north of the Cascade rapids in the Kinojevis river, a point 50 miles to the northeast of Larder lake, a round mass of similar aplite about 40 feet in diameter occurs completely

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[1] Memoir No. 17, Geol. Surv., Dept. of Mines, Can., p. 23, 1912.
[2] Ann. Rep., Bur. of Mines, Ont., Vol. 20, Pt. 2, pp. 12-14, 1911.
[3] Jour. Can. Min. Inst., Vol. 14, pp. 672-689, 1911.

enclosed in dolomite, and like the dolomite is cut by numerous veins of quartz. The examination of this rock under the microscope showed that the feldspars had been granulated on their margin and that ferruginous carbonate and garnet had developed in these granulated zones. Aplite also occurs at a number of points on the shore of Fitzpatrick bay, Larder lake, and on the Gold King claim adjacent to the Harris Maxwell, and in all these occurrences is traversed by veins of quartz and dolomite.

The association of the ferruginous dolomite with quartz porphyry and rhyolite was also observed in numerous other localities in the Larder Lake district. On claim L.M. 31 which lies immediately north of the Harris Maxwell claim on Larder lake, masses of porphyry occur within the dolomite and every stage in the transition from almost pure dolomite to porphyry can be observed. On the Valentine claim in Skead township, Nipissing district, a band of dolomite occurs in the midst of quartz porphyry and sends off apophyses into the porphyry along its border, from which it might be inferred that the dolomite has been derived from a dyke which had intruded the porphyry. In the vicinity of Fortune lake to the northeast of Lake Opasatika small dykes of porphyry, intersected by veinlets of quartz and ferruginous dolomite, intrude the Abitibi volcanics. All of these dykes are more or less carbonated and one of them when examined under the microscope was found to consist entirely of carbonate, chlorite, sericite, quartz, apatite, and rutile.

The dolomite which occurs on the west shore of Fraser lake, in Privat township, contains a mass of fine grained oily-looking rhyolite, so that under the hypothesis of thermal replacement rhyolite is presumably the rock from which the dolomite at that point was derived.

The association of the dolomite with acidic rocks, in places has also been noted by A.G. Burrows in the Porcupine district in the following paragraph. "Several samples of rock which effervesce strongly with acid show an original igneous structure under the microscope. A sample from near one of the Davidson veins on the southwest quarter of the south half of lot 2 in the fifth concession of Tisdale, is a medium grained, greenish, much altered igneous rock. Plagioclase feldspar, showing albite twinning, may still be recognized and also micrographic intergrowths of quartz and feldspar.............................

....Other examples could be cited of the replacement of igneous rock by carbonate. It is believed that this process has continued in some cases to such an extent that the rock is now largely carbonate while the original rock constituents are largely leached out, or so altered as to show little trace of the igneous rock."

It has already been pointed out that the chromiferous mica occurs in the aplite along minute shear zones in company with dolomite, sericite, pyrite, and rutile, a relationship which can best be explained on the assumption that the mineral has been introduced into the aplite in a secondary manner. Similarly, the chrome mica in the veinlets of quartz and dolomite, which intersect the porphyry dykes occurring in the vicinity of Fortune lake, has evidently been brought in along with the vein filling material. Furthermore the microscopic examination of the green dolomite shows the chrome mica to be distributed along lines similar to the zones of shearing in the aplite, so that in this rock also, the mica is probably present as a result of secondary processes.

The quartz veinlets traversing the ferruginous dolomite occurring in the vicinity of Fraser lake contain minute crystals of a green mineral which when examined under the microscope was found to be tourmaline (Plate XV). The presence of this mineral has a special significance in that it indicates that the solutions from which the quartz was deposited were thermal and that they contained boron, an element found to be present in the chrome mica.

One of the most peculiar features of the ferruginous dolomites are the quartz veinlets which intersect the rock wherever it occurs. Evidence is cited in a later section of the report which indicates that these veinlets have been developed along fractures which resulted from compressive stresses acting in a direction approximately at right angles to the structural trend of the rocks of the region. It is apparent, therefore, that the rock in which the fractures were formed was more competent than the greenstones and slates with which it is associated, but dolomite is one of the least competent of all rocks under conditions of great pressure. This difficulty is fully explained if it be assumed that the rock undergoing the fracturing was an aplite, quartz porphyry, or similar rock.

In summarizing the evidence in favour of the origin of the dolomites by thermal replacement it may be noted:—

(1.) That the mineral composition of the dolomite rock is that which commonly results from hydrothermal replacement.

(2.) That the dolomite is commonly associated with acidic rocks and that all stages in the transformation of these rocks into dolomite has been observed.

(3.) That chrome mica occurs in aplite, in quartz porphyry, and in the dolomite and that there is much evidence which indicates that it has been introduced into all these rocks in a secondary manner.

(4.) That the solutions from which the quartz veinlets were deposited were thermal and contained boron.

(5.) That the dolomites are always intersected by quartz veinlets, which indicates that there is a genetic relationship between the quartz and the carbonate.

The hypothesis that the dolomitic rocks are of sedimentary origin rests on their common occurrence in association with sedimentary rocks. Probably the greatest development of ferruginous dolomite in the whole of the Timiskaming region occurs in the Larder Lake district where it is interbedded with slates and phyllites and extends in uniform continuous bands for many miles. A similar association has been observed by A.G. Burrows in the Porcupine district as stated in the following quotation. "In the township of Deloro there are bands of carbonate which are closely associated with bands of iron formation which may be traced for several miles in an east-west direction. The relationship would suggest a similar origin for these rocks, that is, as beds deposited in sea water and now resting in an inclined position dipping to the north. These dolomitic beds are frequently intersected with quartz veinlets, carrying some gold values, hence their importance".[1]

Under the sedimentary hypothesis it would be necessary to assume that the aplites had intruded the dolomite and had thereby acquired a large proportion of carbonate. It would not explain, however, the deformation of the aplite and the evident relation of the dolomite, chrome mica, rutile, etc., occurring in the aplite, with this deformation. Nor would it explain the presence of the disseminated chrome mica in the dolomite or the relation of the quartz veinlets to the dolomite. The association of the dolomite with sedimentary rocks is not a fatal objection to their origin by replacement, for the evenly bedded slates, phyllites, etc., would afford an exceptionally favourable locality for the intrusion of dykes, which might later undergo replacement.

Having stated the evidence for and against these alternative modes of origin, it is concluded that the ferruginous dolomite which is intersected by quartz veinlets and contains chrome mica, has probably in every case originated by thermal replacement of aplites, quartz porphyries, rhyolite or other rocks, that the original rock which the dolomite replaced had suffered deformation as a result of compressive stresses, and that the fractures formed in this way afforded channels along which solutions containing carbon dioxide, silica, chromium, boron, iron, sulphur, and other elements percolated and thereby effected first the alteration and replacement of original rock by carbonate,

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[1] Ann. Rep., Bur. Mines, Ont., Vol. 20, Pt. 2, p. 12, 1911.

sericite, chrome mica and pyrite, and later developed quartz veinlets by the deposit of the silica along the fractures.

STRUCTURE.

Many of the occurrences of the dolomitic rock are isolated exposures without any continuity in any direction. Those, however, which have a linear outcrop generally parallel the structural trend of the surrounding rocks. If it be assumed, therefore, that the dolomites have been derived from acidic igneous rocks by thermal replacement, it is apparent that these must have been dykes intruded into the volcanics and slate parallel to their strike. Under the sedimentary hypothesis on the other hand, they are bedded rocks laid down contemporaneously with the volcanics and slate.

The internal structural features of the dolomites are related to the fissure systems of the region and will, therefore, be discussed in the chapter on economic geology.

Pontiac Series.

DISTRIBUTION.

The rocks composing the greater part of the Pontiac series occur in the southern part of the region as an east-west belt, averaging about 10 miles in width and extending continuously from a point within less than 2 miles of the Ontario boundary to Kiekkiek lake, a distance of 50 miles. This belt occupies the southern parts of Dasserat, Boischatel, Rouyn, Joanne, and Bousquet townships and the northern parts of Dufay, Montbeillard, Bellecombe, and Vaudray townships and has an areal extent of approximately 500 square miles. There is also an area of greywacke occurring in the vicinity of Clericy lake and the Clay Hill portage on the Kinojevis river in Clericy township, which has been classed with the Pontiac series because of its lithological similarity to the greywacke observed along the northern border of the main area a few miles farther south. The distribution of the series is fixed on the north within fairly definite limits, in part, by its contact with the overlying Cobalt series and, in part, by its junction with the Abitibi volcanics, but on the south its areal extent cannot be definitely shown on the map because of the wide contact zone which marks its junction with the southern batholith.

Lithological Character.

General.—The Pontiac series is composed of rocks which are alike, in that they have all been greatly mashed and more or less recrystallized and are believed to have been laid down during a single period of continuous deposition. Lithologically as well as genetically they fall into three classes: (1) biotite and hornblende schists; (2) amphibolites; (3) greywacke, arkose, and conglomerate.

Pontiac Schist.—The Pontiac schist is composed largely of biotite schist, but locally the biotite is replaced, entirely or in part, by hornblende so that the rock becomes a hornblende schist. It is usually a rusty, grey rock but becomes dark or black in its hornblendic phases. It generally contains considerable sulphide of iron and, in places, magnetite, the latter being most common in the hornblende schist. The sulphide of iron and magnetite become very abundant in some localities and occur interlaminated with the schist, in zones, having a width of several feet. Small quartz veins of an irregular lenticular type occur strung out along the strike of the schist in almost every part of the region where the rock was observed. The schist has very commonly a banded appearance due to variations in the proportion of ferromagnesian minerals which it contains, and, as a rule, has a marked tendency to break off on the surface in slab-like forms which emphasize the bedded character of the rock. One of the most characteristic features of the Pontiac schist is the ridged appearance which it presents on the weathered surface. The ridges may occur in two or more sets and may intersect one another at right angles or obliquely. When examined under the microscope these ridges are found to have a minute fracture at their centre, filled with granular quartz and feldspar precisely similar to that of the schist but somewhat more fresh. It is probable that these fractures are joint planes along which the quartz and feldspar have been deposited.

Examined microscopically, the biotite schist can be seen to consist of biotite and quartz with usually some feldspar, generally orthoclase and albite. The hornblende schist is of similar composition except that the biotite is replaced by a pale bluish green hornblende; it was observed that in the vicinity of Lake Opasatika the schist was much more quartzose and contained less ferromagnesian material than in the district farther to the northeastward, along the Kinojevis river. The common accessory minerals present in the schists are carbonate, pyrite, magnetite, sericite, epidote, garnet, sphene, and apatite. The biotite is generally, in part or entirely, altered to chlorite; the hornblende is also chloritized, in places, but is more commonly quite fresh. The texture of the Pontiac schist is usually fine grained and the quartz and feldspar as well as the biotite and hornblende commonly show an elongation in the direction of foliation (Plate XVIII), but in places the mica schist passes into massive phases possessing a typical granular hornfels structure.

Amphibolite.—Here and there, throughout the Pontiac schist, belts of amphibolite occur which are strikingly similar to those contained in the Abitibi group. They are light to dark green, massive and schistose rocks of exceedingly variable texture and appearence. In some places carbonate is abundant in the rock and weathers to a rusty brown surface in deep depressions between botryoidal-like elevations, a form which suggests the pillow structure of the Abitibi volcanics. On Happy Outlook point on Lake Opasatika a schistose amphibolite occurs interlaminated with dolomite, the weathering of the dolomitic layers giving the surface of the rock a grooved appearance. This outcrop occurs within a few feet of the typical Pontiac schist and has, therefore, been classed with the amphibolites of the Pontiac series.

The amphibolites of the Pontiac series are such variable rocks that it is scarcely possible to give a general petrographical description that will include all types. Their microscopic examination showed that in some places, the amphibolite consisted entirely of tremolite or actinolite and carbonate; while in other places, blue green hornblende composed the larger part of the rock. Some thin sections examined contained a large amount of magnetite, others garnet and one diopside. The most common amphibolite consisted of quartz, alkalic feldspar, hornblende, biotite, magnetite, sphene, and carbonate.

Greywacke, Arkose, and Conglomerate.—The northern part of the principal area of the Pontiac series in the district north of Kekeko and Kinojevis lakes, is composed of greywacke, arkose, and conglomerate, which extends in an east-west belt having a width of about 2 miles. An area of greywacke similar to that in the main belt of the Pontiac series also occurs on the Kinojevis river at the Clay Hill rapid, and on Clericy lake. These rocks are all greenish grey or grey in colour and have all been more or less mashed. The greywacke is everywhere recognized by the quartz grains which it contains. On Clericy lake it was observed to be interbedded with fine grained, almost slate-like material. The arkose is of local extent and differs only from the greywacke in containing more fragments of acidic minerals. The conglomerate consists of mashed pebbles and boulders of granite, rhyolite, and quartz porphyry in a greywacke matrix. No pebbles or boulders of basic rocks were seen.

The microscopic examination of the greywacke, arkose, and the matrix of the conglomerate shows all these to consist of fragments of quartz and feldspar enclosed in a fine grained matrix of similar minerals along with varying proportions of chlorite, sericite, carbonate, sphene, iron oxide, and biotite (Plates XVI and XVII). The arkose differs from the greywacke merely in containing more feldspar and quartz and less ferromagnesian material. The feldspar and quartz fragments are all greatly corroded on their margins and are partially broken and recrystallized. The plagioclase is generally filled with inclusions of sericite and carbonate.

MODE OF ORIGIN.—The greywacke, arkose, and conglomerate belonging to the Pontiac series are uniformly stratified rocks and are evidently waterlain sediments, but do not afford positive evidence as to the manner in which they were laid down. The angularity of the fragmental material and its unsorted character would indicate that it had been deposited at no great distance from its source of supply, while the presence of coarse conglomerate and the exceedingly small proportion of fine grained clastic material suggests shallow water deposition, although ripple marks, current marks, or other shallow water forms were not observed. It is possible, however, that these have been obliterated by deformation. From the features observed the greywacke, arkose, and conglomerate might have been deposited in a shallow sea, in a lake, or on the delta or flood-plain of a river. The abundance of quartz and alkalic feldspar and the pebbles of granite, rhyolite, and quartz porphyry show that they have been largely derived from acidic rocks.

The mica schist with its associated hornblendic facies is believed to have been derived from the arkose and greywacke under the contact action of the intrusive southern batholith, the hornblende schist being the result of local variations in the composition of the sediments. The bedding-like parting which everywhere characterizes the schist, even where it is lying horizontal (Plate XIX), the alteration of light and dark bands parallel this parting, the occurrence of magnetite interlaminated with the schist, the hornfels structure which it exhibits in places when examined in thin section under the microscope, the apparent conformability of the schist in strike and dip to the sedimentary members of the series, and the transition which occurs between the two types of rock, afford ample grounds for this conclusion. The manner in which the greywacke and arkose undergo recrystallization can be seen in thin sections of the rocks, all intermediate variations between the clastic structure and the hornfels being exhibited. The various stages in this transformation are shown by photomicrographs on Plates XVI, XVII, XVIII.

The mode of origin of the rocks comprising the amphibolite member of the Pontiac series has not been ascertained, although they possess some characteristics from which it might be inferred that they are metamorphosed volcanic flows extruded contemporaneously with the deposition of the original sediments. The features which suggest a volcanic origin for these rocks, are their marked similarity to the amphibolites which have resulted from the contact action of the granite on the volcanics of the Abitibi group, and the variations in composition which result in peculiar rounded forms on the weathered surface somewhat similar to the ellipsoidal structure of the pillow lavas. Two other possible modes of origin for the amphibolites suggest themselves, however. They might be metamorphosed, impure calcareous sediments, or they might be metamorphosed intrusive rocks. Against the first possibility, there is the objection that no impure calcareous sediments were observed in association with the greywacke, arkose, and conglomerate, and were, therefore, probably not present in the original rock from which the Pontiac schist was derived. In opposition to the second possibility, it may be observed that intrusive rocks do not usually vary locally in texture and composition, whereas the amphibolites are exceedingly variable. The amphibolites also contain considerable carbonate (Fig. 5), showing that they had undergone carbonation prior to their metamorphism, a change which is not so likely to occur in an intrusive rock as in lavas, especially since such a change is known to have occurred in the volcanic rocks of the Abitibi group.

STRUCTURAL RELATIONS.

Ridged Structure.—The presence of intersecting ridges on the weathered surface of the Pontiac schist, which owe their origin to minute fractures filled with quartz and feldspar, has already been mentioned in describing the lithological character of the schist. In explanation of the origin of this ridged structure it is suggested that the minute fractures are joint planes possibly formed as a result of strains in the rocks accompanying the cooling of the granite batholith, and that shortly after their formation, they were filled with quartz and feldspar from the adjoining schist which, because of its less altered character or because of textural differences, is more resistant to weathering than the other portions of the rock.

Relation of Folding to Bedding.—It has already been indicated in the previous pages that the rocks composing the Pontiac series are more or less foliated, but they also commonly possess a very marked parting at intervals of 2 to 6 inches in planes parallel to the foliation, which gives the rock a bedded-like appearance on the weathered surface (see Plate XIX). Throughout the larger part of the Pontiac series there is no evidence of bedding other than the parting just mentioned, but in several localities the Pontiac schist possesses a banded structure parallel to the foliation which closely resembles the banding present in the greywacke member of the series occurring on Clericy lake. At these points, therefore, the foliation and bedding are coincident, and it is possible that the same relationship may hold throughout.

Folding.—On the east shore of Moose bay, Lake Opasatika, the foliation and parting in the Pontiac series are almost horizontal, but elsewhere in the region they are steeply inclined towards the north (Plate XIX) and hence in a direction away from the granite batholith. Their strike conforms very closely to the trend of the margin of the batholith, being approximately east and west in the larger part of the belt, northwest-southeast on Lake Opasatika, and northeast-southwest in the district west of Papitose lake. If it be assumed, therefore, that the foliation and bedding are parallel, it would seem most probable that the Pontiac series forms a monoclinal succession dipping towards the north and has been tilted up into its present attitude by the intrusion of the granite batholith in a manner similar to that commonly observed in the vicinity of laccoliths.

Relations to Other Formations.—The relationship of the Pontiac series to the Abitibi volcanics, owing to the great deformation and extreme metamorphism which all these rocks have undergone, presents one of the most difficult geological problems of the region. If the Pontiac series is younger than the Abitibi volcanics, some evidence of unconformity at their point of junction should appear, but, since the Pontiac series is largely confined to a single area which is cut off on the north in both Dasserat and Boischatel townships by the overlying Cobalt series, its contact with the other rocks of the Abitibi group can only be studied where the greywacke adjoins the volcanics in Rouyn and Clericy townships. In this district, however, outcrops of rock are very uncommon, and if a definite junction is present it was not observed. The greywacke at these points resembles the neighbouring andesites very closely and could not be distinguished from them in the hand specimen, except by the presence of its quartz grains. This similarity of the two rocks in the vicinity of their contact suggests that the greywacke may pass gradationally into the andesite. Such a condition might arise by the intermingling of the sediments with broken material on the surface of the lava flow, or by the development of soil similar to that at the base of the Cobalt series; in the latter case, an unconformity would be represented. From an examination of the geological map it can be seen that the Pontiac series extends in a continuous belt for 50 miles and intervenes for all this distance between the Abitibi volcanic complex and the southern granite batholith. Moreover, it has already been pointed out that the Pontiac series dips away from the southern batholith, so that, unless these relationships are wholly accidental, the series apparently underlies the volcanics which adjoin it on the north. These rocks, however, have undergone so many structural vicissitudes that this evidence alone is insufficient for positive conclusions and must be considered as simply suggestive.

The relationship of the Pontiac series to the younger rocks of the region is discussed in later sections of the report. It may, therefore, be simply stated here that it is intruded by granite and gneiss, is overlain unconformably by the Cobalt series, and is cut by dykes of the Nipissing diabase.

THICKNESS.

In discussing folding in the rocks of the Pontiac series, it was pointed out that they apparently formed a monoclinal succession dipping towards the north at a high angle, the minimum average being at least 45°. If a geological section be measured in a direction transverse to the strike along Caron lake, Lake Kinojevis, and the Kinojevis river, the series would have a horizontal width of 11 miles, and a minimum average dip of 45°. Assuming, therefore, that there has been no duplication of beds by folding or faulting, and that the foliation and bedding are coincident, the Pontiac series has a thickness of at least 37,000 feet. Several thousand feet of this, however, consists of amphibolite.

CORRELATION.

The Pontiac series cannot be definitely correlated with any of the major subdivisions of the Pre-Cambrian classified in other regions. It may be the equivalent of the rocks designated as the Timiskaming series, in the Cobalt district, but this is merely conjecture. It is very possible that it is the equivalent of the rocks classed as lower Huronian in the Lake Superior region, since these are also intruded by granites. There are also many points of similarity between the Pontiac series and the Coutchiching series described by Lawson, in the Rainy Lake region, but lithological similarity alone in rocks several hundred miles distant from one another is not a basis for correlation.

Granite and Gneiss.

DISTRIBUTION.

Granite and gneiss occur widely distributed throughout the region in batholiths and small isolated intrusions. It may be observed on the accompanying map that the whole southern part of the area is occupied by granite and gneiss, but this is merely a small marginal portion of a huge complex of acidic rocks which extends far to the southward. Since this massif occurs in the southern part of the district it will be referred to as the southern batholith. There are four smaller batholithic masses in the northern part of the region, one of which occurs on Lake Dufault, another in the vicinity of Robertson lake, a third to the northeast of Gauvin lake, and a fourth in the vicinity of Lake Abitibi. The Lake Dufault batholith has a diameter of about 4 miles, and that on Robertson lake 10 miles; the Gauvin Lake batholith was not delimited, except on its southwest border, and the Abitibi batholith extends over the interprovincial boundary into Ontario, but according to a map by Mr. M. B. Baker, is somewhat irregular in shape, its longest diameter being about 14 miles in length. A few very local intrusions of acidic rocks also occur on Hub lake, on the La Sarre river, on Makamik lake, and in other localities.

LITHOLOGICAL CHARACTER.

The rocks included in the batholithic subdivision of the older complex are medium to coarse grained, granular rocks which are generally white or pink in colour, but in some of the smaller batholiths and local intrusions are so very dark that they would never be recognized as granites in the hand specimens if it was not for the abundant quartz which they contain. This dark colour is not due to the presence of abundant ferromagnesian minerals but to the metasomatic alterations which the feldspar have undergone. In the southern batholith biotite granite is the dominant rock type, but in smaller northern massives, hornblende is more common and usually occurs in company with the biotite. The hornblende and biotite may locally show a slight parallelism in their arrangement, but a pronounced gneissoid structure is not extensively developed except in the northern extension of the southern batholith which occurs between Atikameg bay, Lake Opasatika, and Wigwaug lake. The granite is not generally porphyritic, but in a few places phenocrysts of feldspar were observed. The Robertson Lake batholith contains large pseudo-phenocrysts of quartz a half inch or more in diameter.

Aplite and pegmatite dykes are very common in all these rocks but are especially abundant in the southern batholith. These are pink or white rocks which are mineralogically identical in composition, consisting almost entirely of quartz, feldspar, and muscovite, but the aplite has a fine grained felsitic texture whereas the pegmatite is very coarse containing feldspar crystals up to 6 inches in length. In some parts of the southern batholith, notably in the contact zone with the Pontiac series and in the vicinity of Laberge (Lizard) lake, huge areas of pegmatite occur in which red garnet and crystals of muscovite from 1 to 2 inches in diameter are common. The muscovite also occurs in places in peculiar rosette-like aggregates.

The most prominent feature observed in making an examination of an exposure of these rocks is their excessive variability. In some places, a granite containing very little biotite may be seen to cut across another granite in which this mineral is more abundant, or a biotite granite may cut a hornblende granite in a similar manner. Very commonly long schlieren of granite rich in biotite are present or the rock may have a banded appearance owing to variations in the amount of biotite. Local areas of hornblendite are also abundant, but these are probably related to outside rocks which have fallen into the magma during its intrusion and will, therefore, be described in the section on the relation of the granite to other formations.

The microscopic examination of the granite and gneiss shows them to be typical members of the granite-granitegneiss family, consisting largely of hornblende or biotite or both these members with alkalic feldspar—orthoclase, microcline, and albite—and quartz. In a few places the hornblende varieties pass into granodiorites, quartz diorites, or even diorites by the disappearance of potash feldspar, and quartz, but these occurrences are of local extent. The less abundant minerals occurring in the granite and gneiss are muscovite, apatite, sphene, 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.

STRUCTURAL RELATIONS.

It is pointed out in discussing the external relations of the granite and gneiss that these rocks belong to batholiths and smaller intrusive masses which have made room for themselves partly by uplifting and thrusting aside the overlying and surrounding rocks and partly by stoping off and assimilating fragments of their roof. From the large number of these intrusions as well as from their gently sloping surfaces as shown by the wide contact zones which surround them, it is probable that the granite occurs at no great depth everywhere throughout the region. It might be assumed, therefore, that all the granite and gneiss belonged originally to one great magma mass and that the outcrops of granite and gneiss occurring in the region are simply portions of the larger batholith which have penetrated to a higher elevation than the main massif. The occurrence of pebbles and boulders of granite in the conglomerate of the Pontiac series, however, shows that granites of different ages are present in the region so that the conditions may be more complex than this assumption implies.

The striking local variability in the granite and gneiss pointed out in describing their lithological character is evidently due to two diametrically opposite causes, one that of assimilation by which fragments of external rocks have sunk into the magma and have been partially recrystallized, and the other that of differentiation by which an originally homogeneous magma has resolved itself into rocks of different composition, but it is not always possible to ascertain which of the two processes has been operative. Many of the local areas rich in ferromagnesian minerals, as will be shown later, are evidently derived from the Abitibi volcanics, or in the case of the southern batholith from the amphibolites of the Pontiac series. It is probable, on the other hand, that the schlieren of biotite granite are the result of differentiation, although in the final stages of assimilation a product of this type might result and be strung out linearly by movements in the magma. The larger part of the differentiation in the granite and gneiss, however, is of a type which might be described as differentiation by solidification. In those places where, locally, granites of slightly different composition cut across one another, it is evident that the intruded portions must have been at least partially solidified at the time the intrusion occurred. This phenomenon, therefore, probably owes its origin to movements in the magma during solidification which caused the solidified portions to break up, the fractures being immediately filled with magma of slightly different composition. The formation of the pegmatites and aplites is another example of differentiation accompanying solidification, the final stages of consolidation being accompanied by the evolution of juvenile gaseous solutions from which the aplite and pegmatite were deposited.

Relation to the Abitibi Volcanic Complex.—The intrusive relationship of the granite and gneiss to the volcanics of the Abitibi group is apparent not only from the occurrence of numerous dykes of granite, aplite, and pegmatite in the surrounding rocks but from the contact metamorphism which they have produced. The greenstones in the vicinity of the granite have been transformed into amphibolite, hornblende schist, and seri-

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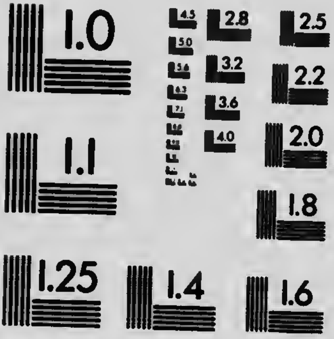
(ANSI and ISO TEST CHART No. 2)



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cite schist, the strike of the schist generally conforming to the trend of the granite margin. This feature indicates that the granite magma exerted considerable pressure on the surrounding rocks. The contact of the granite and the volcanics is sharply defined and angular in places, while the granite adjacent to the contact is filled with inclusions (Plate XX) of the intruded rock. These rock fragments have been evidently stoped off by the magma probably as a result of its differential heat effects on its rocky roof. On passing towards the interior of the batholiths it may be observed that the included zenoliths of rock tend to become subangular and rounded, then undefined, and are finally replaced by local areas of granite rich in ferromagnesian minerals. These different alterations evidently represent stages in the process of assimilation.

The occurrence of fragments of country rock in the granite at points at a distance from the contact shows that these either sank in the magma from above or were carried out from the margin by movements in the magma. The fragments near the contact were no doubt detached from the roof just before consolidation and may have been held because of the viscosity of the partially consolidated granite, but during the earlier stages of the intrusion when the magma was highly fluid, large quantities of the Abitibi volcanics may possibly have sunken into the batholiths, but positive geological evidence in proof of this is not available. It is concluded, therefore, that the batholithic masses of granite and gneiss which intrude the rocks of the Abitibi group made room for themselves in two ways: (1) by lifting and thrusting aside the surrounding rocks, (2) by subcrustal stoping; but whether the latter was of great importance or only an incidental feature is unknown.

Relation to the Pontiac Series.—The manner in which the granite and gneiss of the southern batholith have invaded the Pontiac series is strikingly evident throughout the whole region in the vicinity of their contact. In the district from Lake Opasatika eastward there is a belt several miles wide along their line of junction in which it was impossible to differentiate the two types of rock on the map. In parts of this belt the granite appears to be filled with numerous inclusions of the Pontiac series many of which are intersected by dykes of pegmatite and aplite, the older dykes, in some places, being faulted along the plane of the younger. In the region adjacent to the Kinojevis river, Lake Kinojevis, and Caron (Crooked) lake, there is a contact zone over 4 miles wide, in which dykes and irregular masses of granite, aplite, and pegmatite intrude the Pontiac schist, increasing in size and number towards the south until finally only isolated blocks of the schist are observed. The blocks as a rule, however, maintain the same attitude and strike as the schist farther north showing that they have not been tilted out of their original positions. In the country to the west of Lake Opasatika, the manner of intrusion was somewhat similar to that just described, but the dykes were narrow and penetrated the schist parallel the schistosity at intervals of a few inches or less, a phenomenon generally described as *lit par lit* injection.

Throughout the contact belt to the east of Lake Opasatika, small local areas of rocks rich in ferromagnesian minerals are very common. In some places, these consist largely of hornblende, in others of diopside or of hornblende and diopside together, but generally varying proportions of biotite, feldspar, and quartz are present as well as the less abundant minerals apatite, sphene, magnetite, garnet, epidote, pyrite, and calcite. These masses were never observed to have sharply defined contacts with the granite, yet from their similarity in composition to the contact metamorphic phases of the Abitibi volcanics and the amphibolites of the Pontiac series, it would seem most probable that they are recrystallized and partially assimilated masses of external rocks rather than masses (autoliths) which have segregated from the magma by differentiation.

Beyond the contact zone to the north, local intrusive masses and dykes of granite and related rocks are very common throughout the Pontiac series, some of which seem to have been broken up by deformation so as to simulate a conglomerate. A photograph of some of this autoclastic rock occurring on the east shore of Kinojevis lake is shown in Plate XXI.

It has already been noted, that the Pontiac series dips away from the margin of the southern batholith at a steep angle and that these sediments have been rendered schistose under the contact action of the granite and gneiss. It is, therefore, inferred that this batholith was also enabled to reach its present position, in part at least, as a result of the uplift of the overlying and surrounding rocks. This uplift, while brought about directly by the batholith, is, no doubt, indirectly related to the mountain making movements of which the intrusion of the batholith was simply an incident. To what extent subcrustal stoping was a factor in the opening of the magma chamber of the batholith is unknown, but the relationship of the Pontiac series to the granite in the vicinity of Caron lake and west of Lake Opasatika, suggests that these rocks had a specific gravity which was not much in excess of that of the magma and that stoping was unimportant as far as this series was concerned. It may have been a factor, however, as regards the amphibolites and any volcanics which may overlie the Pontiac series.

Relations to Younger Formations.—The relationship of the granite and gneiss to the Cobalt series and the Nipissing diabase is discussed later in the report. It may, therefore, be simply stated here that the granite and gneiss are overlain unconformably by the former and are intruded by dykes of the latter.

MODE OF ORIGIN.

The mode of origin of the granite and gneiss has already been stated or implied in various sections of the report and need only be summarized in this subdivision. They are believed to form portions of immense, deep seated batholiths which invaded the rocks of the Pontiac series and the Abitibi group as an accompaniment of mountain making movements. The gneisses, since they show no evidence of granulation, undulatory extinction, or other evidence of deformation, were probably formed as a result of pressure in the magma during their consolidation. The aplites, pegmatites, and granites which cut one another are believed, as has already been explained, to be due to differentiation by solidification, while certain other local variations rich in ferromagnesian minerals are believed to have originated by the recrystallization and partial assimilation of intruded rocks which had fallen or floated into the magma.

AGE AND CORRELATION.

The granite and gneiss of this region occur on the northern border of an immense complex of acidic rocks which extend continuously along the whole of the southern part of the Laurentian plateau from Georgian bay to the Gulf of St. Lawrence. These granitic rocks have been generally classed as Laurentian following the nomenclature adopted by Sir William Logan, and the rocks of this district, according to the original classification, should also, no doubt, be called Laurentian. In the Lake Superior region, however, two granites are recognized, the younger of which is classed as post-Lower Huronian, and since there were also at least two granites originally present in the Abitibi district, as shown by the pebbles and boulders of granite in the Pontiac series, the question arises whether the granite and gneiss here described is not, in reality, the equivalent of the younger post-Lower Huronian granite of the Lake Superio region. In view of these complications in the nomenclature has been thought advisable to omit the term Laurentian in describing these rocks. As far as was observed they are intrusive into all the surficial rocks of the older complex, but are overlain with striking unconformity by the Cobalt series. The above statement includes all that is positively known with regard to their age.

Cobalt Series.

GENERAL CHARACTER AND SUBDIVISIONS.

In this district as well as throughout the Timiskaming region generally, the disturbed and metamorphosed rocks of the older complex are overlain by a slightly deformed series of clastic sediments, conglomerate, greywacke, argillite[1], arkose, and quartzite. These rocks are not sharply defined members, for they not only pass gradationally into one another, both horizontally and vertically, but patches of conglomerate commonly occur in the midst of greywacke, or greywacke in the midst of conglomerate, and similar relationship may exist between all the members of the series. Nevertheless, in a general way, there is a succession in most localities, from a basal conglomerate through greywacke and argillite to arkose, which in turn is overlain by an upper conglomerate.

A compilation of all the published observations of the succession and thickness of the various rocks comprising the series throughout the Timiskaming region is given in the accompanying table. Many of these sections are evidently only partial, including in some cases upper members and in others, the middle or lower. It can be seen, however, that there is generally an upper and lower conglomerate with greywacke and argillite, quartzite and arkose as intermediate members.

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[1] At the suggestion of Dr. L. V. Pirsson, the term argillite is here redefined to designate a fine grained slate-like rock which has been very firmly cemented but has no slaty cleavage. Its position in the mud-slate series corresponds very closely to that of quartzite in the sand-sandstone group.

SECTIONS OF THE COBALT SERIES IN THE TIMISKAMING REGION, ONTARIO AND QUEBEC.[1]

[1] (Sections are in descending order.)

Rock.	Thickness. Feet.	Locality.	Reference.
Quartzite, etc	1,100	Timiskaming district.	A. E. Barlow, Rep. Can. Geo. Surv., Vol. 10, p. 104, 1897.
Slate and greywacke	100		
Conglomerate	600		
Slate*	?	Between Rabbit and Timagami lakes.	G. A. Young, Sum. Rep. Can. Geo. Surv., p. 198, 1904.
Conglomerate	?		
Conglomerate	?	Cobalt, Ont	W. A. Parks, Sum. Rep. Can. Geo. Surv., p. 211, 1904.
Quartzite	?		
Quartzite, etc	90	Windigo lake	W. A. Parks, Sum. Rep. Can. Geo. Surv., p. 215, 1904.
Slate* and greywacke	90		
Conglomerate	100	Mount Shiminis	W. A. Parks, Sum. Rep. Can. Geo. Surv., p. 220, 1904.
Quartzite	135		
Slate*	315		
Conglomerate	?	Cobalt, Ont	W. G. Miller, Ann. Rep. Bur. Mines, Ont., Pt. 2, p. 34, 1905.
Quartzite	?		
Greywacke	?		
Conglomerate	?		
Conglomerate	?	Larder lake, Ont.	R. W. Brock, Ann. Rep. Bur. Mines, Ont., p. 211, 1907.
Quartzite	?		
Slate*	?		
Quartzite	?		
Conglomerate	?		
Conglomerate	?	Claims H.R. 34 and 163 South Lorrain.	A. G. Burrows, Ann. Rep. Bur. Mines, Ont., Pt. 2, p. 24, 1908.
Greywacke and slate*	?		
Slate*	?	Everett lake, Gowganda dist	A. G. Burrows, Ann. Rep. Bur. Mines, Ont., Pt. 2, p. 10, 1908.
Quartzite	?		
Conglomerate	?		
Conglomerate	?	Bloom lake	A. G. Burrows, Ann. Rep. Bur. Mines, Ont., Pt. 2, p. 10, 1908.
Slate*	?		
Conglomerate, etc	?	Gowganda dist	W. H. Collins, Prelim. Rep. on Gowganda Dist., pp. 26 and 27, Geo. Surv., Dept. of Mines, Can., 1909.
Greywacke quartzite	?		
Conglomerate	200+		
Greywacke, arkose, etc.	?	Montreal River district.	W. H. Collins, Sum. Rep. Geo. Surv., Dept. of Mines, p. 199, 1910.
Conglomerate	?		

*The term slate is used for a slate-like rock without slaty cleavage, argillite. See page 83.

DISTRIBUTION.

The Cobalt series is extensively developed in only two parts of the district; only one small isolated outcrop was seen elsewhere but it is probable that other similar occurrences are present which were not observed. The greatest development of the series is in the hills which occur to the west and east of the north end of Lake Opasatika. All the prominent elevations of this district, the Labyrinth hills, Mount Shiminis, the Swinging hills, and the Kekeko hills are composed of these rocks, and constitute remnants which rise above the general level of the surrounding rocks of the older complex. A second large area of the Cobalt series occurs along the height of land north of Bellefeuille and Dufresnoy lakes. Unlike the southern area, the series is represented, here, solely by conglomerate which forms very low hills of no topographic prominence. The full extent of the Cobalt series in this locality has not been determined, but it must cover a large number of square miles, for numerous glacial erratics of conglomerate, some of which are as much as 30 feet in diameter, were observed throughout the country to the southward. There is also a small outlier of conglomerate on the Labyrinth river which is, however, only a few feet in extent, the surrounding rocks belonging to the Abitibi volcanics.

LITHOLOGICAL CHARACTER.

Basal Conglomerate.—Wherever the Cobalt series was seen in contact with the rocks of the older complex, the basal member of the series was always a conglomerate. The outstanding feature of this basal conglomerate is its heterogeneity, not only in the size and angularity of the included fragments, but in the variability of the rock, both in texture and composition, from point to point. In some places the conglomerate is largely composed of coarse fragmental material with little matrix and in other places consists largely of matrix with few fragments. As a rule the rock is unstratified, but in places, a partial alignment of the pebbles can be seen.

The matrix of the conglomerate varies greatly in texture and composition and may be either coarse and feldspathic or exceedingly fine grained and slate-like in appearance; the coarser types are, however, by far the most common. Examined under the microscope the matrix is seen to be composed of angular, subangular, and round fragments of quartz, feldspar, quartz porphyry, mica schist, rhyolite, andesite, basalt, and other rocks belonging to the older complex, which are enclosed in a cement consisting chiefly of chlorite but usually accompanied by small quantities of carbonate, epidote, and pyrite.

The pebbles and boulders of the conglomerate include, even in a single rock exposure, nearly every variety of rock occurring in the older complex. Fragments of granite occur everywhere, and are commonly many miles from the nearest occurrence of this rock in the underlying basement from which the Cobalt series was derived. Pebbles of quartz and bright red jasper are abundant in the conglomerate in places, and are conspicuous because of their striking colours. As is generally characteristic of coarsely clastic sediments of this character, the pebbles and boulders are commonly subangular or angular in shape though round fragments are also present.

Greywacke and Argillite.—The basal conglomerate of the Cobalt series commonly passes gradually upward by the loss of its pebbles and boulders into greywacke and argillite. This greywacke was originally a ferromagnesian sand and the argillite a ferromagnesian mud, both of which are now, however, very firmly cemented, the argillite resembling a slate but differing from a slate in possessing no slaty cleavage. The greywacke and argillite like the other members of the Cobalt series vary greatly, and here and there contain beds of arkose, patches of conglomerate, and, in some places, single isolated boulders. In a few places, the greywacke is unstratified, but as a rule both it and the argillite are uniformly bedded. The microscopic examination of the greywacke shows it 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, in this region, are gradually replaced on passing upward by arkose, the transition taking place either by a gradual increase in the feldspar and quartz content or by an alternation of beds of the two rocks. The arkose 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.

Upper Conglomerate.—Wherever the Cobalt series has a considerable vertical thickness, the arkose is overlain conformably by an upper conglomerate which differs in no respect from the lower member of the series and cannot be distinguished from it except where the stratigraphical succession is known.

THICKNESS.

The maximum vertical thickness of the Cobalt series in the region is between 800 and 900 feet. This, however, is slightly greater than the actual thickness since the beds have a dip of from 10 to 20 degrees. The vertical thicknesses of the different members obtained from aneroid measurements in the different hills of the region are compiled in the following table:—

Rock.	Thickness.	Locality.
Conglomerate	750 feet	Kekeko hills.
Pontiac series		
Arkose	220 "	North end
Conglomerate	80	Lake Opasatika.
Pontiac schist.		
Arkose	250 "	Swinging hills.
?	365 "	
Conglomerate	70+ "	
Abitibi group..		
Conglomerate	65 "	Labyrinth hills.
Arkose	165 "	
?	175 "	
Abitibi group.		
Conglomerate	90 "	Mount Shiminis.
Arkose	150 "	
Greywacke argillite	250 "	

Owing to the general absence of exposures on the low slopes of nearly all the hills of the region, the sections are generally incomplete, but sufficient information has been obtained to show that the usual succession found in other parts of the Timiskaming region is generally represented. The excessive thickness of conglomerate occurring in the Kekeko hills differs from the more typical basal conglomerate in the large proportion of arkose which it contains, and in this respect, as will be pointed out in the section on the origin of the Cobalt series, is strikingly similar to the fluvio-glacial deposits of the Pleistocene. It may also be observed that the thickness of the various members varies greatly and that at the north end of Lake Opasatika, the greywacke-argillite member is entirely absent. This feature is a characteristic which commonly belongs to terrestrial deposits and is in perfect harmony with the hypothesis advanced later in the report that all of these rocks are closely related in their origin to continental glaciation.

STRUCTURAL FEATURES.

Folding.—Since the conglomerates of the Cobalt series are usually unstratified and are never uniformly bedded the attitude of these rocks can only be ascertained from the strike and dips of the greywacke, argillite and arkose, but from a large number of such determinations it was found that the series has been gently flexed (dip 5 to 20 degrees) into folds trending in a direction of approximately about 20 degrees east of north.

Faulting.—It is improbable that such ancient rocks as those of the Cobalt series could have escaped deformation by faulting at times in their history, but the sole evidence of such movements observed was a number of brecciated zones in which fragments of the conglomerate or greywacke were included in a quartz matrix. These are very probably breccias formed as a result of faulting.

Relation to the Older Complex.—It has already been explained in discussing the physiographic history of the region that, prior to the deposition of the Cobalt series, these folded and metamorphosed rocks had undergone one of the most prolonged periods of denudation in the known history of the earth, during which the region was reduced to almost a peneplain. This erosion interval was finally terminated by the deposition of the Cobalt series.

The contact between the Cobalt series and the rocks of the older complex is peculiar in places in that no definite line of junction can be seen, the underlying rock passing gradually upward into the basal conglomerate; in other places, however, the contact is very sharply defined, the conglomerate resting on a smoothly denuded surface Examples of the transitional relationship can be seen at the north end of Lake Opasatika, on the south shore of Nissaki lake, and along the northwest shore of Renauld lake on the road to the property of the Union Abitibi Mining Company. At the first two occurrences the conglomerate overlies the Pontiac schist, and at the third, the Abitibi volcanics. The sharply defined contacts were observed at a point about 1 mile south of Kennedy lake, on the east side of the large island in Dufay (Rest) lake, and on the south shore of Dufay lake. 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.

ORIGIN OF THE COBALT SERIES.

Introductory.—The assemblage of clastic sediments comprising the Cobalt series has in recent years been the object of special study by those geologists engaged in field work in the Timiskaming region for the purpose of procuring evidence which would confirm or disprove the glacial hypothesis which has been strongly advocated by Dr. Coleman in a number of recent publications.[1] With this object in view, the writer, while in the field, paid special attention to those characteristics of the various members of the series which might have bearing on the conditions under which they were deposited, hoping in that way to reach some definite conclusions as to their origin.

That the conditions under which the series was deposited were unusual is indicated by the various modes of origin which have been suggested from time to time, by the geologists who have studied these rocks in the field. Owing to the fact that the earlier geologists did not distinguish the Cobalt series from the underlying Abitibi group (Keewatin), the conglomerate was thought to be closely related to the lavas of the underlying basement and were said to be of pyroclastic origin,[2] although it was noted that many fragments of granite and other plutonic rocks were present. In 1905, Dr. A. P. Coleman, in his report[3] on the Sudbury nickel field, pointed out the resemblance of a greywacke conglomerate, occurring in the vicinity of Ramsay lake, to boulder clay; and in the same year, Dr. W. G. Miller mentioned the possibility of a glacial origin for the conglomerate of the Cobalt series, but also suggested desert conditions of deposition in the following quotation. "The writer is not able to offer a satisfactory explanation for the character of the sediments found in some of these strata . . . . To account for the undecomposed and angular character of much of the fragmental material, the writer is inclined to the belief that desert conditions prevailed in this region at the time some of the middle Huronian rocks at least were formed."[4] Mr. R. W. Brock in his report on the Larder Lake district published in 1907,[5] noted some characteristics of the rocks favourable to the glacial hypothesis but concluded that there were still difficulties in the way of its acceptance. He also observed that many of the included fragments had the form of boulders worn by river sands.

Application of Criteria.—Although the various suggestions in the above quotations all imply a continental origin, none of these writers have pointed out the many characteristics of the series which point to terrestial conditions of deposition. The great heterogeneity and general absence of complete sorting throughout the greater part of the series, the presence of ripple marks, current marks, cross bedding and interformational uncon-

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[1] Am. Jour. Sc., Vol. 23, pp. 187–192.
Bull. Geo. Soc. Am., Vol. 19, pp. 347–366.
Jour. of Geo., Vol. 16, pp. 149–158.

[2] Ann. Rep., Can. Geo. Surv., Vol. X, p. 96, 1897.

[3] Ann. Rep., Bur. Mines, Ont., Vol. 14, Pt. 3, p. 129, 1905.

[4] Ann. Rep., Bur. of Mines, Ont., Pt. 2, p. 41, 1905.

[5] Ann. Rep. Bur. of Mines, Ont., Vol. 16, p. 212, 1907.

formities, the presence of an ancient soil at the base of the conglomerate in places, the angularity or subangularity of the fragmental material composing the series, and the great thickness and enormous extent of the conglomerate are features distinctly characteristic of land sediments. It will. therefore, be assumed without further discussion that the Cobalt series is of terrestrial origin, the term terrestrial implying deposition on the land in contrast with deposition in the sea or on the seashore.

Continental clastic sediments may be formed by volcanic action or by weathering, creepage, lakes, rivers, winds or glaciers, the degree of importance and relationship of the latter agencies to one another depending, in part, on climate, and in part, on the topography of the land.[1]

In the following discussion some of the criteria which characterize sediments originating in these various ways will be applied to the different members of the Cobalt series, and in that way an attempt made to reach some conclusions as to the climate and conditions of deposition prevailing during this Huronian period.

(1.) Pyroclastic Origin.—Owing to a misunderstanding of the true relationship of the Huronian of the Timiskaming region to the volcanic rocks of the older complex, the conglomerate of the Cobalt series was at one time thought to be of pyroclastic origin, but it is now known that it is almost if not entirely[2] composed of material derived from the underlying floor. This mode of origin need not, therefore, be considered.

(2.) Weathering and Creepage.—Since weathering and creepage are closely related processes operating together, for the purpose of this discussion they may be considered as one.

The indefinite contacts which occur at the base of the Cobalt series in places, indicate that at the time the deposition of the series was initiated, the surface of the ancient complex was covered by a considerable thickness of soil and that this has been preserved so that the basal beds of the conglomerate at these points represent a fossil regolith, developed *in situ* by weathering

This ancient soil consisted of disaggregated, undecomposed rock fragments, a feature from which some inferences may be drawn as to the climate prevailing at the time it was formed. The domination of disintegration over chemical decomposition on the earth's surface to-day, is characteristic of regions[3] of youthful topography, is also characteristic of arid climates[4]

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[1] Barrell, J., Jour. of Geo., Vol. 16, p. 159, 1908.

[2] [illegible], A., Amer. Jour. Sci., Vol. 19, p. 166, 1905.
Rep., Bur. Mines, Pt. 2, p. 47, 1905.

[3] Willis, B., Jour. of Geo., Vol. 1, p. 477, 1893.

[4] Pumpelly, E., Geo. Soc. Am., Vol. 16, p. 167. 1908.
Barrell, J., Jour. Geo., Vol. 16, p. 167, 1908.

and to a lesser extent of cold or temperate climates[1], but is not characteristic of warm humid climates[2]. Since this region, at the time the soil was formed, was practically a peneplain, the topographic factor may be eliminated. If it be assumed, therefore, that the variations in the conditions for soil development were the same in Pre-Cambrian time as at present, the climate which preceded the deposition of the Cobalt series was either cold and humid, temperate and humid, or arid.

It is possible that owing to the absence of abundant vegetation to supply carbon dioxide to the ground water or because of differences in the composition of the atmosphere, the relationship of the chemical decay in the soil to climate may have been somewhat different at that early period, but it is doubtful whether this would be of sufficient importance to modify the foregoing conclusion.

The abundance of limestone in some of the early Pre-Cambrian formations indicates that carbon dioxide was certainly present in the atmosphere at the very beginning of geological time and may have been more abundant than in later periods, for it seems probable that the loss of carbon dioxide from the atmosphere through the formation of limestone and coal beds since the Pre-Cambrian has been greater than the additions from other sources.

(3.) Lacustrine Deposition.—The uniformly stratified argillite, greywacke, arkose, and quartzite which form a considerable part of the Cobalt series were evidently deposited from standing bodies of water and are, therefore, flood-plain or lacustrine deposits. However, from the general greenish grey or green colour of all these sediments, from the absence as far as has been observed of mud cracks, rain prints, or other evidence of exposure to the air,[3] in even the fine grained argillite, and from the presence of continuous ripple marks in the quartzite, it seems safe to conclude that these deposits have not been laid down from either flooded rivers or ephemeral lakes but were deposited from permanent bodies of water which persisted from year to year.

With regard to the characteristics of these sediments which have a climatic significance, it may be observed from the features mentioned in the previous paragraph, that these, in general, point to a humid rather than arid or semi-arid condition of deposition. Furthermore, boulders occur in places in the

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[1] Russell, I. C., Bull. 52, U.S.G.S., p. 12, 1888.
Merrill, G. P., Bull. Geo. Soc. Amer., Vol. 6, pp. 321-322, 1895.

[2] Hilgrad, E. W., Soil, pp. 398-417, 1906.

[3] Barrell, J., Jour. of Geo., Vol. 14, p. 538, 1906.
Walther, J., Einleitung in die Geologie, p. 816, 1897.

midst[1] of fine grained stratified greywacke and argillite, a condition which seems to necessitate the presence of floating ice. From this, it may be inferred that the climate of this period was not only humid but cold.

(4.) Aeolian Deposition.—Since the greater part of the finer grained material comprising the Cobalt series is uniformly bedded, it is evident that these are subaqueous deposits. Moreover, it was pointed out in the previous paragraph that the climate at the time these materials were laid down was probably cold and humid. Consequently it may be inferred that aeolian action was never a depositional factor and probably played little or no part in the formation of the series.

(5.) Fluviatile Deposition.—The general great heterogeneity of the conglomerate of the Cobalt series, the great variability in the matrix, in the size of the pebbles and boulders and in the rock types, represented in the conglomerate, the varying degree of abrasion to which the pebbles and boulders of the conglomerates have been subjected, the presence of cross bedding in places are all characteristics which commonly belong to sediments of a fluviatile origin which have been deposited not far from the source of supply. The conglomerates of the Cobalt series have, therefore, the essential characteristics of fluviatile deposits.[2]

Notwithstanding, however, the apparent similarity of the conglomerates of the Cobalt series to river deposits, there are some features associated with them which are inconsistent with a fluviatile origin. A considerable part of the boulders contained in the conglomerate, in places, are 2, 3, or even 8 feet in diameter[3] and are commonly many miles from the nearest occurrence of similar rocks in the older complex. Moreover, the surface upon which the conglomerate was deposited was one of mature topography[4] so that the transportation of the large boulders would have to be effected by streams having gentle gradients. In order to explain this difficulty, it has been pointed out[5] that the climate of this Huronian period may have been semiarid and that during floods in regions where such climatic conditions prevail, boulders of large size may be transported long distances by rivers. But it has already been shown from the character of the greywacke, argillite, arkose, and quartzite associated with the conglomerate, that the climate at the time these rocks were deposited was certainly not arid and was probably humid and cold. Furthermore, the green

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[1] Coleman, A. B., Jour. of Geo., Vol. 16, p. 153, 1908.

[2] Mansfield, C. R., Jour. of Geo., Vol. 15, pp. 550-55, 1907.

[3] Jour. of Geol., Vol. 16, p. 151, 1908.
Prel. Rep. Gowganda Min. Div. Geo. Surv., Dept. of Mines, Can. p. 27, 1909.

[4] See page 20.

[5] Ann. Rep. Bur. Mines, Ont., Vol. 14, Pt. 2, p. 47, 1905.

or greenish grey colour which is everywhere characteristic of the conglomerate is not the colour which usually distinguishes more recent fluviatile gravels developed in arid or semiarid regions, so that unless the Pre-Cambrian atmosphere was deficient in oxygen this feature also points to humid climatic conditions. Fluviatile conglomerates of the coarse unsorted types which are characteristic of the Cobalt series are limited on the earth's surface at present to regions of youthful topography or arid climates[1]. These factors, usually operating together, have resulted in the building up of immense accumulations of river gravels on piedmont slopes and in interior basins. If it be assumed, therefore, that the conglomerates of the Cobalt series are of fluviatile origin this conclusion must be reached in the face of the facts that these immense deposits covering a minimum area of 20,000 square miles, were built up in a region having a low relief and a pluvial climate, conditions which in every particular are the reverse of those under which similar fluviatile deposits are accumulating on the earth to-day.

(6). Glacial Deposition.—In a number of papers published within the last few years, Dr. A. P. Coleman has advocated the glacial origin of the conglomerates of the Cobalt series, pointing out their striking similarity to the Pleistocene glacial deposits and to similar rocks in other parts of the world to which a glacial origin has been assigned. The principal features emphasized by Dr. Coleman are the resemblance of the matrix of the conglomerate to boulder clay, the enormous extent and great thickness of the conglomerate, the occurrence of immense boulders at a distance of several miles from the source of supply, the great size, angularity, and variety of the pebbles and boulders of the conglomerate, and finally, the finding of scratched and "soled" pebbles and boulders in the conglomerate at Cobalt, Ont.[2]

As opposed to the glacial hypothesis, it has been maintained that glaciated surfaces should somewhere be found beneath the basal conglomerate instead of the ancient regolith which is commonly present.[3] In reply to this objection, Dr. Coleman has pointed out that "near the edge of a glaciated area

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[1] Medlicott and Blanford, Geology of India, p. 397.
Huntington, Carnegia Inst., Exploration in Turkestan, p. 40.
Barrell, J., Jour. of Geo., Vol. 14, p. 330, 1906.
Trombridge, A. C., Jour. of Geo., Vol. 19, p. 738, 1911.
Hilgarde, E. W., Sci. New Series, Vol. 15, p. 414, 1902.
Shaler, N. S., Bull. Geo. Sc. Am., Vol. 12, pp. 271-300, 1907.
Russell, I. C., Geo. Mag., Vol. 6, pp. 289-295, 1886.
Rich, J. L., Jour. of Sci., Vol. 18, pp. 601-632, 1910.

[2] Am. Jour. Sc., Vol. 23, pp. 187-192, 1907.
Jour. of Geo., Vol. 16, pp. 149-158, 1908.
Bull. Geo. Soc. Am., Vol. 19, pp. 347-466, 1908.

[3] Ann. Rep. Bur. Mines, Ont., Pt. 2, p. 58.
Can. Min. Jour., Vol. 30, pp. 646-697.

where the thickness of ice is not great, the ice sheet often moves for many miles over loose material without even reaching the rock surface beneath," and that this condition existed over thousands of square miles in certain parts of the United States during the Pleistocene continental glacial epoch and also throughout a large part of the area covered by Carboniferous boulder clay in India.[1] It must furthermore be recalled that the number of points at which the junction of the Cobalt series and the underlying basement has been examined is not great and that at some of these the contact is sharply defined, the conglomerate resting on a smoothly eroded surface.[2] The latter might well be glaciated surfaces, although stream erosion or wave action might no doubt produce a similar effect.

Owing to the firmly cemented character of the conglomerates of the Cobalt series, it is difficult to separate the pebbles and boulders from their matrix, but during the past summer an exceptionally favourable locality was found at the eastern end of Kekeko hills, in Boischatel township, where Mr. E. M. Burwash, who assisted the writer in the field, succeeded in breaking out some pebbles from the conglomerate which were definitely scratched in several directions (Plate XXIV A). The conglomerate at this point lies almost horizontal, and has been neither mashed nor faulted, so that the scratches cannot be attributed to dynamic action.[3] The pebbles exhibiting the scratches consist of fine-grained greenstone and possess the typical rounded corners and faceted faces of glacial stones.

In order to obtain further definite evidence bearing on the glacial origin of the Cobalt series, an attempt was made to count the "soled" pebbles and boulders in the conglomerates. Only those stones having rounded corners and two or more plane faces which when projected intersected at a considerable angle were counted,[4] but since it was not possible to break out the pebbles and boulders for examination on all sides, the count was made from observation of the outlines in a given area of rock surface. The results obtained were as follows:—

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[1] Jour. of Geo., Vol. 14, p. 155, 1908.
Can. Min. Jour., Vol. 30, p. 694.

[2] Prel. Rep. Gowganda District, Geol. Surv., Dept. of Mines, Can., p. 31, 1909.
Ann. Rep. Bur. Mines, Ont., Pt. 2, p. 58, 1907.

[4] Plate XXIV B.

Total number of pebbles and boulders.	Number of soled pebbles and boulders.	Percentage.	Locality.
205	17	8%	Dester township, Pontiac co., Que.
210	37	18%	Kekeko hills, Boischatel township, Pontiac co., Que.
99	38	38%	Labyrinth river, Dasserat township, Pontiac co., Que.
168	54	26%	Labyrinth hills, Dasserat township, Pontiac co., Que.
200	60	30%	N. shore Larder lake, Hearst township, Nipissing district, Que.

If it had been possible to break out the pebbles and boulders and observe them in three dimensions instead of one, the above percentages would certainly be greatly increased.

In the preceding discussion of the glacial hypothesis, attention has been confined to the conglomerates of the series. One of the strongest arguments, however, in favour of Huronian continental glaciation is to be found in a comparison of the series as a whole, to the Pleistocene glacial, fluvioglacial, and postglacial deposits of this same region—for each of these has its exact counterpart in the Cobalt series. At the base of the latter there is the conglomerate, which, like the Pleistocene glacial drift, is exceedingly variable in thickness, and, like the drift, is unstratified, in part, resembling till, is rudely sorted and crossbedded, in part, similar to the fluvioglacial deposits of kames, eskers, and outwash plains, and, in places, passes into unstratified greywacke containing scattered pebbles and boulders, thus duplicating boulder clay.[1] Overlying the basal conglomerate, there is the stratified greywacke, argillite, arkose, and quartzite which have their parallel in the Pleistocene post-glacial stratified clay and and of lacustrine origin.[2] In both of these deposits boulders have been found which have been attributed to floating ice.[3] The Cobalt series differs from Pleistocene deposits of northern Ontario and Quebec in the greater thickness of arkose and quartzite which it contains and in the presence of an upper conglomerate[4] overlying the finer grained member of the series. These conditions, however, would simply imply that the lake which covered the region subsequent to the deposition of the basal conglomerate was of longer duration than that of Pleistocene

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[1] Prel. Rep. on Gowganda Dist., Geol. Surv., Dept. of Mines, p. 26, 1909.

[2] Ann. Rep., Bur. Mines, Ont., Vol. 14, Pt. 2, p. 33, 1905; Vol. 18, p. 282, 284, 1909. Sum. Rep., Geol. Surv., Dept. of Mines, Can., p. 278, 1911.

[3] Jour. of Geol., Vol. 16, p. 153, 1908.
Ann. Rep. Bur. of Mines, Ont., Vol. 20, Pt. 1, p. 220, 1911.

[4] See table, page 84.

time, and that following the lacustrine epoch a second continental ice sheet advanced over the region from which an upper conglomerate was laid down. If it be assumed, therefore, that the conglomerates of the Cobalt series are of glacial origin, then there are at least two till sheets present and the stratified greywacke, argillite, quartzite, and arkose constitute interglacial deposits.

The essential similarity of the greywacke and argillite of the Cobalt series to the post-glacial lacustrine clays of the region is shown in the following table of chemical analyses. Number 1 is an analysis of the argillite, and number 2 that of the stratified clay occurring at the north end of Lake Timiskaming. In order to make these more nearly comparable they have been recalculated to a total of 100, omitting the water. In number 5 a partial analysis of argillite from Lily lake, in the Gowganda district, is inserted.

	I.	II.	III.	IV.	V.
SiO_2	62·74	52·00	64·81	57·94	61·54
Al_2O_3	16·94	16·11	17·48	17·92	....
Fe_2O_3	5·07	4·69	5·23	5·83	....
FeO	1·59		1·64		
MgO	3·05	4·10	3·14	4·56	....
CaO	1·39	8·26	1·43	9·20	0·84
Na_2O	6·07	2·76	6·27	3·09	4·73
K_2O		1·74		1·95	2·84
H_2O-	0·36	9·64	....	....	....
HO+	3·20	....	....	....	....
SO_2	....	0·09	....	0·10	....

Number I, Argillite, Ann. Rep. Bur. Mines, Ont., Vol. 14, Pt. 2, p. 48, 1905.
Number II, Stratified clay, " " p. 33, 1905.
Number III, No. 1 recalculated to a total of 100, omitting water.
Number IV, No. 2 recalculated " "
Number V, Jour. Geo., Vol. 18, p. 669, 1910.

It will be observed that in both the argillite and the clay there is an excess of soda over potash, a relationship which is usually reversed in normal sediments of the slate-shale series. The large percentage of lime and magnesia in the post-glacial lacustrine deposits is undoubtedly due to the large amounts of Palæozoic limestone which were denuded away by the Pleistocene continental ice sheets and were thus transformed into glacial drift and later redeposited as clay.

Conclusion.—Having assembled the evidence which might have a bearing on the origin of the Cobalt series, the following conclusions may be stated with regard to the climatic conditions and depositional processes in operation at the time these sediments were laid down. (1) That the series is of terrestrial origin. (2) That the basal portion of the series is in places an ancient regolith. (3) That the stratified greywacke, argillite, quartzite. and arkose are lacustrine deposits. (4) That aeolian deposits are not represented in the series. (5) That the climate of this period was *not* arid or semi-arid and was probably cold and humid. (6) With regard to the mode of deposition of the major part of the conglomerate only two hypotheses need be considered. They are either of fluviatile origin or have been deposited from continental ice sheets. From a consideration, however, of the difficulties of transportation involved in the fluviatile hypothesis and that the climate and topography of the region were wholly the reverse of those under which fluviatile deposits of this character are accumulating on the earth to-day, and on the other hand, the fact that practically every feature of the Cobalt series has its duplicate in the Pleistocene glacial, interglacial, or post-glacial deposits of North America, that the pebbles and boulders of the conglomerates have a characteristically soled appearance, and that striated pebbles and boulders have been found in two localities over 60 miles apart, it seems necessary to conclude that the evidence preponderates in favour of the hypothesis that the conglomerates of the Cobalt series were deposited from Pre-Cambrian continental ice sheets.

In the above pages an attempt has been made to apply the criteria which distinguish the various types of continental clastic sediments, to the different rock types represented in the Cobalt series and thereby to reach a definite conclusion with regard to their origin. As a result it has been shown that not only has every variation in the series its duplicate in the glacial, interglacial, or post-glacial deposits laid down in association with Pleistocene continental ice sheets of this same region, but that no other known depositional process will so well account for all the many peculiarities and associations of sediments found in the series as the glacial hypothesis. Furthermore, the objection that striated surfaces have not been found beneath the basal conglomerate loses much of its force when it is recalled that only an exceedingly small part of the contact between the Cobalt series and the older complex has been observed, that the underlying surface in some places has been smoothly eroded, and that the presence of the overlying conglomerate at these points generally makes an examination for striae impracticable.

With the progress of detailed geological investigation in regions where Pre-Cambrian rocks occur, evidence is accumulating which indicates that the processes at work on the earth's surface to-day were in operation in the very earliest Pre-Cambrian periods. The existence of Pre-Cambrian continental ice sheets would, therefore, be simply another link in the chain [illegible] evidence pointing to the uniformity of natural processes from the very earliest time in the earth's history of which we have any knowledge.

AGE AND CORRELATION.

Since there are no fossils contained in the Cobalt series its age must be fixed solely from its stratigraphical relationships and its lithological similarity to other series. It is known that these rocks are Pre-Cambrian in age, and that they lie above a great structural and erosional break which occurred in the midst of Pre-Cambrian time, and that they, therefore, belong to the group of rocks which Logan classed as Huronian, but information is not yet available which will permit of their correlation definitely with the subdivisions of the Huronian as they occur on the north shore of Georgian bay or elsewhere in the Lake Superior-Lake Huron region.

Post Cobalt Series Intrusives.

NIPISSING DIABASE.

Distribution.—In a large number of localities throughout this region the rocks of the older complex are intruded by dykes and small masses of the Nipissing (Keweenawan?) diabase. There are two varieties of this diabase, one of which contains olivine, and the other is olivine-free, but the olivine-free variety is much the more common for it was observed in 17 different localities, whereas the olivine bearing type was seen at only 5 separate points. The largest dyke in the whole region, however, consists of olivine diabase. This crosses Lake Opasatika at the narrows which subdivides the northern and wider part of the lake into two expansions. It has a width of about 300 yards and outcrops as a continuous ridge extending for a distance of over 3 miles in a northeasterly direction from the lake. In addition to this occurrence, olivine diabase was observed at the east end of Kishkabeka lake, on lot 45, range II, Trécesson township, on lot 33, range X, Villemontel township, and on the east shore of Bruere lake.

Lithological Character.—The Nipissing diabase throughout this region is a rock of remarkably uniform composition but of somewhat variable texture and colour according to the conditions under which the rock solidified. In the smaller dykes and along the margins of the larger masses, the rock is black and aphanitic, but elsewhere it generally possesses a greyish green or dark green colour and medium texture. The ophitic structure is always present and can be readily recognized even in a hand specimen. The porphyritic structure was observed in only one locality, along the National Transcontinental railway on lot 51, range II, LaReine township, where phenocrysts of plagioclase about three-fourths of an inch in length were present.

The microscopic examination of the olivine free 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 border of the larger intrusions, and becomes more abundant as the size of the intrusive mass and the coarseness of grain increases. Apatite is also a usual original constituent of the rock and occurs as rod-like crystals disseminated through the rock. As a rule, the diabase is more or less altered, the secondary minerals being calcite, epidote, zoisite, sericite, hornblende, and chlorite.

The olivine diabase when examined under the microscope is seen to consist of olivine and labradorite enclosed in augite. The olivine generally has a rounded outline when 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.—The internal structural relations of the Nipissing diabase of this region are very simple, the rock being remarkably uniform except for the difference in texture and the accompanying development of micropegmatite already described. No inclusions of country rock or evidence of modifications in the magma by the assimilation of country rock were observed. The relationship of the olivine diabase to the ordinary variety was not ascertained in this region, but in other parts of the country where these rocks occur, the olivine diabase intrudes the quartz diabase and is evidently younger in age. The general similarity of the two rock types and their geographical association with one another, however, indicates that they were intruded during the same period of vulcanism and derived from th

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[1] Nickel and Copper Deposits of the Sudbury Mining District, Geol. Surv., Can., p. 89, 1904.

Sum. Rep., Geol. Surv., Dept. Mines, Can., p. 199, 1910.

same magma, from which it follows that a certain amount of differentiation must have taken place in the magma at depth before the intrusions occurred.

Wherever the relationship of the diabase to the surrounding rock was ascertained it was found to occur as dykes having a vertical or nearly vertical attitude, but it is possible that some of the small isolated occurrences which appear to have no linear extent may be remnants of sills, although the contacts in all these cases were not exposed. The exomorphic effects of the diabase are unimportant, the intruded rock being apparently unchanged even within a few inches of the contact.

Mode of Origin.—The mode of origin of the diabase has already been implied in the foregoing pages, but for the sake of completeness will be here restated. The diabase is believed to have been derived from a huge mass of basic magma which underlay a large part of the Canadian shield in late Pre-Cambrian 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 the ophitic structure and micropegmatite were developed.

Age and Correlation.—The diabase dykes were not observed to cut the Cobalt series in this district, but they are so similar in every respect to those which occur with this relationship in other parts of the Timiskaming region that there can be no doubt that they are also younger than the Cobalt series and are the equivalent of the Nipissing diabase.

SYENITE PORPHYRY.

General Features and 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 Features.—The syenite porphyry forms a rock mass of oblong shape having somewhat irregular but vertical walls. As the Nipissing 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 Nipissing 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.

Pleistocene and Recent.

GLACIAL

The Pre-Cambrian rocks of this region are nearly everywhere overlain by boulders, gravel, sand, and boulder clay, materials laid down from a huge continental glacier which covered northwestern Canada and the adjacent portions of United States in the Pleistocene. In the southern part of the region covered by this Labradorian glacier there are a number of till sheets separated by interglacial deposits, indicating that there were in reality several of these ice sheets. In the district here described, however, there is no evidence, as far as was observed, of the presence of the earlier glaciers, all of the till which now covers the surface of the region having been deposited presumably from the last ice sheet. The movement of the continental glacier in this district as shown by striae was from a direction slightly west of north.

That the continental ice sheets were capable of considerable erosive action is evident from the general mammallatory contours of the surface of the region, from the gently sloping curve of the surface of rock exposures on the north as compared with their more abrupt termination on the south (See Plate XXIV) and from the glacial striae and grooves(Plate XIII) which are commonly observed wherever a rock exposure has been protected from weathering agencies. The scratched and grooved surfaces can generally be seen along the rocky shores of lakes in the summer when the water is low, their preservation in this place being apparently due to the protection from the atmosphere afforded during a large part of the year by the water of the lake.

It is probable, however, that the denudation accomplished by the continental ice sheets was largely of a superficial character and that the surface of the Pre-Cambrian rocks underlying the drift corresponds in its main features with the preglacial topography of the region. The principal evidence in favour of this conclusion, in the district under description, is to be found in the presence of numerous linear valleys continuous for many miles, which certainly do not owe their origin to glacial action since their trend is, in some cases, transverse to the direction of ice movement. But in other parts of the Laurentian plateau evidence pointing to the existence of preglacial topography has been cited by A. C. Lawson[1], A. E. Barlow[2], A. W. G. Wilson[3] and others,[4] all of the features described indicating that glacial denudation modified but did not entirely destroy the preglacial topography of the Laurentian plateau.

The glacial drift in this district generally forms only a thin mantle over the surface of the underlying rocks, the thicker accumulations being very local. Owing to the presence of the post-glacial clays which cover the drift throughout a large part of the region and to the thick forest growth which occurs everywhere, it is generally difficult to obtain any information with regard to the character of the glacial deposits except where they happen to occur on a lake shore or are intersected by a stream or a cut on the line of the National Transcontinental railway. Boulders are scattered everywhere, but are more frequently observed in the hill country from which the more easily transported portions of the till have been swept away. Boulder clay was observed at the north end of the height of land portage from Ogima to Summit lakes, at a number of points on the shore of Duparquet lake and on the shore of Lois lake. This material is not very common, however, for not a single occurrence was intersected in the cuts along the line of the National Trans-

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[1] Bull. Geo. Soc. Am., Vol. 1, pp. 163-173, 1890.
[2] Ann. Rep., Can. Geol. Surv., Vol. 10, p. 25, 1897.
[3] Jour. of Geo., Vol. 11, p. 666, 1903.
Can. Inst., Vol. 7, p. 181, 1901.
[4] Jour. of Geo., Vol. 1, p. 338, 1893.
Ann. Rep. Geo. Surv. Can., 1882-83-84, Part D.

continental railway throughout its whole extent through the district. Some of the glacial deposits of the region consist of till that is partially sorted and roughly stratified and is evidently of fluvioglacial origin. This fluvioglacial material may take the form of elliptical shaped hills (kames), the longer axis of the ellipse having a north-south trend, or may be spread out over a wide stretch of country (outwash plains). A good example of the former having a tail-like prolongation to the south, occurs on the National Transcontinental railway west of the crossing of the La Sarre river, and of the latter in the central part of Trécesson township. A section through the end of the kame near the La Sarre river is shown in Fig. 6.

Fig. 6. Diagrammatic section through kame on the National Transcontinental railway in range VII, La Sarre township.

POST-GLACIAL.

Throughout a large part of the district the glacial drift is overlain by uniformly stratified clay and sand which has filled in the minor inequalities of the underlying surface, thereby forming local plains. The contacts of the stratified material and the drift as exposed in the cuts along the National Transcontinental railway are usually gradational, the stratified clay giving place to stratified sand which in turn passes downward into the typical glacial or fluvioglacial material. The bedding of the stratified clay where it lies upon the drift or a Pre-Cambrian rock surface, is characterized by remarkably steep depositional dips (Plate XXV). These irregularities disappear within a few feet, however, in the overlying beds. The greater part of these stratified deposits consist of uniform beds of clay from one-half inch to three-fourths of an inch in thickness, which are interlaminated with layers of calcium carbonate about one-eighth of an inch thick. In places, the clay contains considerable sand and a bed may contain two or three subsidiary layers due to variations in the sand content. The stratified sand is not nearly so extensive as the stratified clay and occurs chiefly overlying the clay in the vicinity of glacial deposits in which sand is abundant.

It is believed that these uniformly stratified post-glacial deposits were laid down from a huge lake which occupied this region subsequent to the retreat of the last Labradorian ice sheet. The name Lake Ojibway has been proposed for this body of water by Dr. A. P. Coleman. It presumably lay for the most part between the St. Lawrence-Hudson Bay divide and the retreating continental glacier, but during part of its history at least was connected with the Timiskaming basin, for stratified clay occurs on the height of land in Launay and Trécesson townships and extends continuously from this point southward to Lake Timiskaming. On the height of land the clay occurs at an elevation of 1074 feet above sea-level, whereas in the vicinity of Lake Timiskaming it reaches an elevation of only 800 feet. The difference in elevation of the clay in these two localities may be due either to the difference in elevation of the surface upon which the clay was deposited or to tilting since the deposition of the clay, or to both of these causes. In southern Ontario, Goldthwaite[1] has estimated that the beaches of Lake Algonkian and Lake Iroquois have been tilted from 1 to 4 feet per mile towards the southwest, and it may be possible that a similar tilting has taken place in the Timiskaming region. But in order to ascertain whether such regional movements have occurred it would be necessary to determine the elevation of the beaches of Lake Ojibway, and these have not yet been observed and may not be present for the lake was not of long duration.

It is most probable that in those localities where the stratified clay is interbedded with calcium carbonate that these together represent seasonal deposits,[2] the clay layer being laid down during the summer and the carbonate during the winter. If it be assumed, therefore, that each bed of stratified clay represents the deposition of a single season, then by counting the number of beds a precise estimate of the length of time the lake occupied the district can be obtained. The maximum number of beds counted in the cuts along the National Transcontinental railway was 250, so that the post-glacial lake in this region, at least, was comparatively short lived.

The application of the above method throughout the region would no doubt afford considerable information as to the history of this huge lake during the various stages of its existence. In the region traversed by the National Transcontinental railway

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[1] Bull. Geo. Soc. Amer., Vol. 21, pp. 227-248, 1910.

[2] Baron de Geer—Geo. Foren, Forhandl., Vol. 30, p. 459, 1908.

west of Cochrane, Ontario, according to Mr. M. B. Baker, these post-glacial lacustrine deposits consist 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 28 feet.[1] 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 245, which is approximately equivalent to the number observed by the writer. Mr. Baker's measurements, as far as known to the writer, are the only data as yet available from which the number of beds laid down from the lake in other districts might be determined.[2]

In those portions of the region which are underlain by sand, notably in Trécesson township, typical sand dunes are extensively developed. The larger part of these are now preserved from the action of the wind by their forest covering and were evidently formed long ago, but some are of very recent origin, for in one locality where the vegetation had been removed by a recent forest fire, several birch and banksian pine were partly buried in sand.

The Quaternary clays of this region very commonly contain concretions of carbonate of lime which are fantastic in form and, in some cases, possess a striking bilateral symmetry. Photographs of a number of these are shown on Plate XXVII.

These peculiar segregations of material are most probably related to the solution and redeposition which accompanies the shifting of the ground water level. As the clay in which the concretions occur contains a large amount of calcium carbonate, this material is taken into solution wherever water percolates through the soil, an action that would be especially active in the spring of the year when the clays are saturated with water from the melting snows. It is improbable that there is much free circulation of water in these impermeable clays, so that when the soil becomes dry during seasons of drought and the ground water level passes downward, the carbonate of lime is redeposited. This deposition having once commenced at a given point tends to continue at that point and in this way a concretion is built up. The peculiar symmetry of the resulting forms can scarcely be accidental and may be related as suggested by Todd[3] to the process by which additions of material take place in crystal growth.

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[1] Ann. Rep., Bur. Mines, Ont., p. 230, 1911.

Coleman, A. P., Ann. Rep., Bur. Mines, Ont., Vol. 18, Pt. 1, pp. 284-293, 1909.

[3] Bull. Geo. Soc. Amer., Vol. 14, p. 354, 1903.

STRUCTURAL GEOLOGY.

In a structural way, the rocks of this region may be divided into three elements which are strikingly differentiated from one another; to the first of these belongs the older complex, to the second the Cobalt series and the Nipissing diabase, while the Pleistocene and Recent deposits constitute the third.

The older complex in this district may be described, structurally, as a portion of a truncated synclinorium, the major axis of which trends in an approximately east-west direction. Denudation proceeded so far in Pre-Cambrian time, however, that this synclinorium was cut off close to its base, so that the surficial members of the complex are intruded by the numerous isolated batholiths of granite and gneiss which have effected marked local changes in the structural trend of the rocks in their vicinity. In the northwestern part of the region, the rocks of the Abitibi group have a northwesterly-southeasterly strike, but towards the south, where the intrusive granite and gneiss is less abundant, an east-west trend is more general. All the sedimentary members of the complex have been highly folded and have suffered all the vicissitudes which accompany successive mountain building movements and batholithic invasions.

On the profoundly denuded surface of this ancient complex lies the second structural element, the Cobalt series. In striking contrast with the complicated plications of the older element, the structures of these rocks are comparatively simple. They have been very slightly folded into broad, gently pitching, northeasterly-southwesterly trending anticlines and synclines, and along with the older complex are intruded by the Nipissing (Keweenawan) diabase which took the form of dykes in the older basement, but spread out into sills in the flat-lying Cobalt series.

The third structural subdivision, the Pleistocene and Recent deposits of the region, has suffered, as far as could be determined, no disturbances whatever. These rest on the bevelled surface of the Cobalt series and on the truncated surface of the older complex wherever the Cobalt series has been eroded away.

GEOLOGICAL HISTORY.

The description of the general geology of the Abitibi district may be appropriately concluded by an historical outline of the succession of events recorded in the rocks of the region. The geological history of this district in common with the whole of the Canadian Pre-Cambrian shield commences at the very beginning of geological time. During these early periods the Pre-Cambrian regions of eastern Canada appear to have been the centre of one of the greatest outbursts of volcanism which has ever occurred in the known history of the earth, for immense extravasations of lava, thousands of feet in thickness, were piled up over hundreds of thousands of square miles, far exceeding in extent and thickness the lava fields of the Columbian plateau or the Deccan basalts of India. The character of these volcanic rocks is such as to indicate that they were largely extruded beneath the sea, although it is probable that owing to orogenic disturbances or the accumulations of the lavas, land was formed at times, which underwent denudation and thus furnished the material for sediments associated with the volcanics. Along with these surficial evidences of vulcanism, successive batholithic invasions of acidic rocks occurred, accompanied by orogenic movements which folded the volcanic rocks into a synclinorium. One or more intervals of denudation also occurred during this early period, for the batholithic masses were exposed at the surface and underwent erosion from which great thicknesses of arkose and conglomerate containing granite pebbles were built up along with the regional extrusions of lava.

This early era of vulcanism during which the Abitibi group, and granite and gneiss of the older complex originated, was followed by a second era of denudation which was just as remarkable for the absence of igneous activity and orogenic movements as the era of vulcanism had been remarkable for their frequency. The cumulative work of ages of denudation eventually resulted in the destruction of the larger part of the volcanic and sedimentary rocks of the older complex, so that they now remain only as truncated remnants folded into the batholithic masses of granite and gneiss.

The era of denudation was finally terminated by the accumulation of a widespread series of coarsely clastic sediments of such a character as to indicate that they are all due to glacial conditions, there being evidence of the existence of two till sheets, which are separated by widespread interglacial lacustrine deposits.

The next event following this Pre-Cambrian glacial epoch, as far as can be learned from the geology of the region, was a period of igneous activity in late Pre-Cambrian (Keweenawan) times. Whether any volcanic rocks were extruded in the region at this time is not known, but, if they were ever present, they have been long since eroded away, for they now occur only as dykes and intrusive masses of diabase and syenite porphyry. Slight orogenic movements also occurred about this time which folded the Pre-Cambrian glacial series into gently dipping anticlines and synclines. Following the Keweenawan, a second era of denudation began in the region which, except for a short interruption during the Palæozoic when a marine submergence occurred and Silurian limestone was laid down, continued to the Pleistocene. Subsequent denudation has largely removed the Palæozoic sediments so that their original extent is a matter for conjecture.

The closing events in the geological history of this region are closely related to the continental glaciers which covered the greater part of the northeastern part of North America in the Pleistocene. An irregular mantle of gravel, sand, and till was left scattered over the region by the last of these ice sheets in the various forms assumed by glacial and fluvioglacial deposits. Following the glacial epoch a huge lake covered a large part of the region for a period of about 250 years, in which stratified clay and sand were deposited on the surface of the glacial drift.

From the above outline it is seen that the outstanding features in the geological history of the region are the stupendous vulcanism which marked its early history, the manner in which the region has remained an almost undisturbed positive element in the earth crust since that period, and the occurrence of two prolonged eras of denudation, both of which were terminated by continental glaciation.

CHAPTER V.

ECONOMIC GEOLOGY.

GENERAL STATEMENT.

Within the region described in this report there are no producing mines and only one property in which a mining plant has been installed. The district, however, has not been prospected except in a very superficial way, so that the fact that no important discoveries have as yet been made has little bearing on its future possibilities. The deposits which have up to the present attracted attention are the molybdenite bearing, pegmatite dykes and quartz veins, and the auriferous quartz veins or veinlets in ferruginous dolomite, aplite, and quartz porphyry.

GOLD.

GENERAL FEATURES AND SUBDIVISIONS.

Practically all the rocks of the region are traversed by veins or veinlets of quartz which are more or less auriferous, but the most important by far are those occurring in the rocks of the Abitibi volcanic complex, and more especially in the ferruginous dolomite, aplite, and quartz porphyry. These are believed to be genetically related to one another and will, therefore, be described in a group by themselves.

Quartz Veins and Veinlets in the Rocks of the Abitibi Volcanic Complex.

GENERAL.

Veins or veinlets of quartz containing gold are now known to occur in the region described in this report, in the Larder Lake district, at Porcupine, and in numerous other localities throughout the northern part of the Timiskaming region. As will be shown later, there are certain features associated with these occurrences which point to a similar origin for all. In the following pages, an attempt will, therefore, be made to correlate the observations of the writer and others in these various localities.

FISSURE SYSTEMS.

Character and Distribution.—In a number of localities throughout the region, a rock consisting largely or in part of ferruginous dolomite occurs, which is cut by intersecting veinlets or veins of quartz. These veinlets and veins appear to occur in definite systems, a feature which is well developed in a ridge of the dolomite occurring on the north side of the Cascade rapids on the Kinojevis river. This ridge has a width of about 100 yards and a length of one-fourth mile, and throughout its whole extent is traversed by the veinlets and veins of quartz. In order to ascertain the trend of the fissure system, the strike and dip of the veins and veinlets were taken wherever they had any continuity and uniformity of trend. These are plotted in Figure 7. The heavy line represents the trend of the dolomitic ridge, which is also the structural trend of the Abitibi volcanics in this district. The strike of the veins and veinlets is indicated by light lines to the ends of which the dips are attached in the upper half of the diagram.

It can be seen from this figure that the veinlets and veins occur mainly in two systems which strike approximately at right angles to one another, and are inclined at about 45 degrees to the trend of the dolomitic ridge. There is one vein, however, which, while not conforming to the dip of the dolomite, is parallel to its strike. It is in this strike vein that the huge lens of quartz already mentioned is developed.

In the Larder Lake district, quartz veinlets traversing the dolomite are also generally inclined to the structural trend of the enclosing rock. The strikes of veinlets which cut the dolomite occurring in the vicinity of Larder lake (Kerr-Addison, Reddick, and Lucky Boy properties) are plotted in Figure 8, the heavy line indicating the strike of the dolomite as in Figure 7.

In the Porcupine district, according to Mr. A. G. Burrows, the strike of the gold-quartz veins is generally inclined to that of the enclosing rock, and while the dip of the schist is to the north at a high angle, the veins commonly dip to the south across the schistosity.[1] The strikes of the veins as shown on the map of lots 10 and 11, concession 2, Tisdale township (Hollinger, Miller-Middleton, and Dixon claims)[2] are plotted, with reference to the structural trend of the enclosing rocks, in Figure 9. It will be observed that in this locality also, there is a very striking system of veins, the most striking in a northeast-southwest direction, and possibly a second less perfectly developed system,

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[1] Ann. Rep. Bur. Mines, Ont., Vol. 20, Pt. 2, p. 21, 1911.
[2] Map of Porcupine Gold Area, Bur. Mines, Ont., 1911.

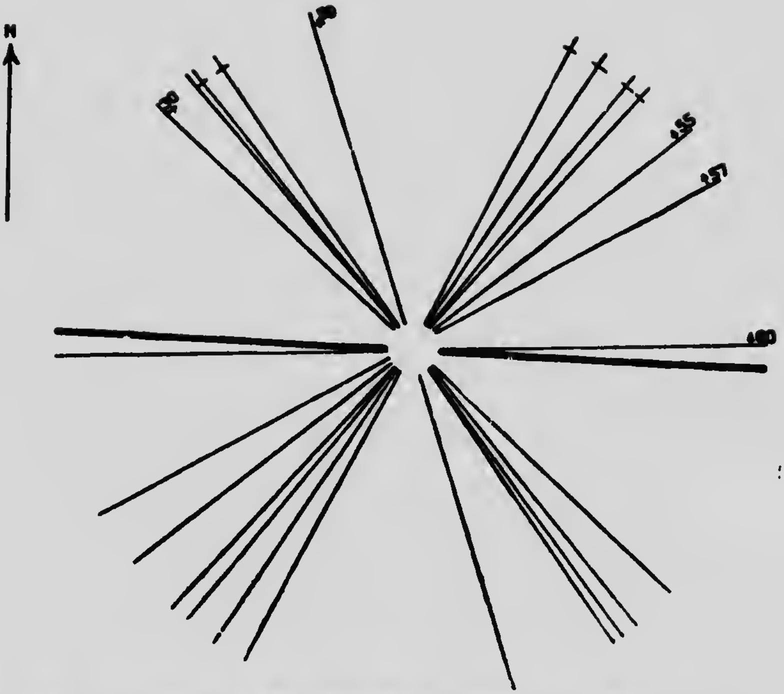

Fig. 7. Strike and dips of fissures in ferruginous dolomite, occurring on the north side of the Cascade rapids on the Kinojevis river, Manneville township. Pontiac county, Que. The structural trend of the dolomite is indicated by the heavy line

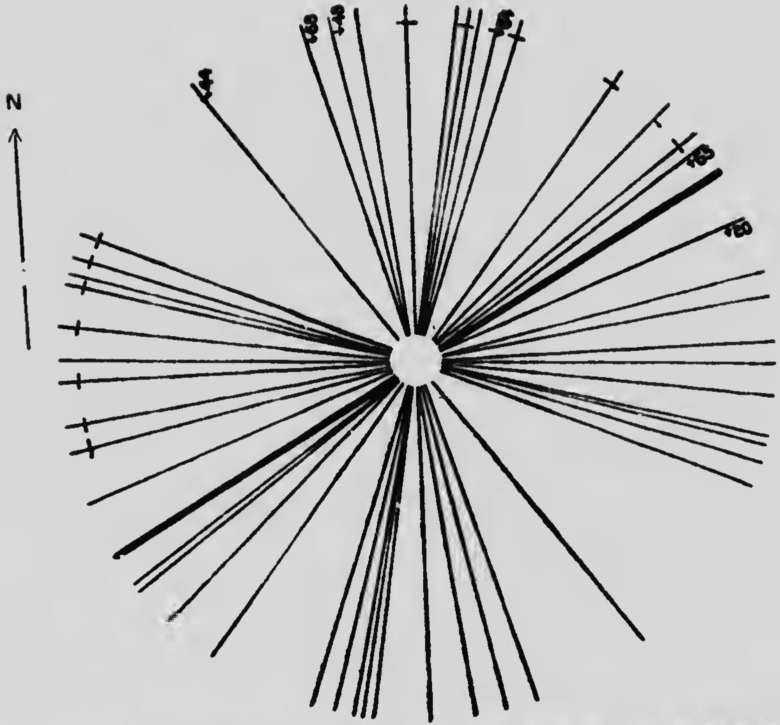

Fig. 8. Strike and dip of fissures in ferruginous dolomite, occurring north of Larder lake, McGarry township, Nipissing district. The structural trend of the dolomite is indicated by the heavy line.

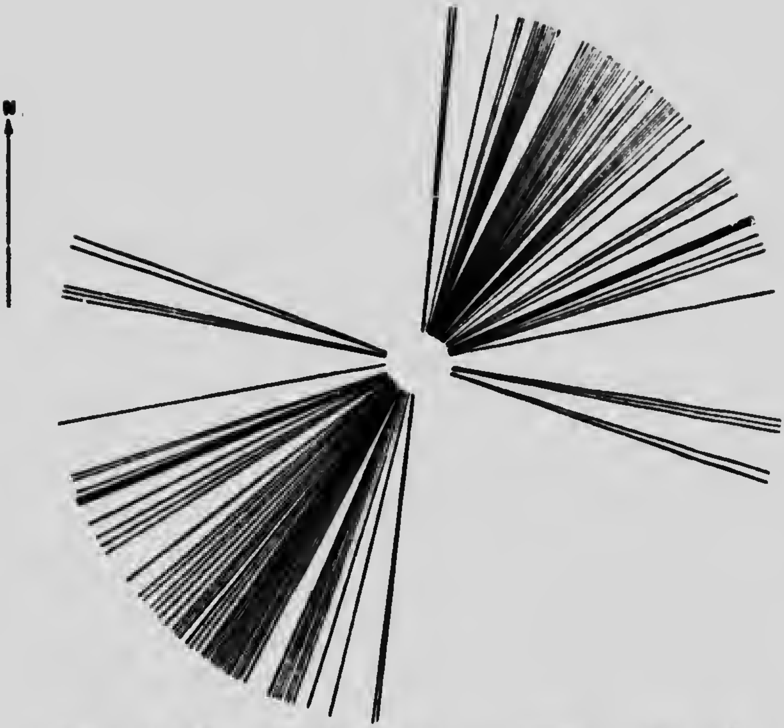

Fig. 9. Strike of fissures occurring on lots 10 and 11, concession II, Tisdale township, Sudbury district, as shown on map of Porcupine Gold Area. The structural trend of the enclosing rock is shown by the heavy line.

having a northwest-southeast trend. These are, therefore, inclined at almost 45° to the strike of the enclosing rock.

Origin.—The foregoing comparative study of the distribution of the gold-bearing quartz veins of the northern part of the Timiskaming region shows in a very striking manner that the fissures along which the gold bearing solutions percolated were arranged in systems having a definite discordant relationship to the structure of the enclosing rocks. The uniformity of this relationship points to a cause which operated throughout the whole region, while the inclination of the fissures at an angle of approximately 45 degrees or less to the structural trend of the enclosing rock suggests that the fracturing owes its origin to compressive stresses acting in the same direction as the stresses which folded the rocks of the region. That such stresses were present at the time the fissures were formed is probable from the evidence presented elsewhere in this report that the vein filling material is derived in part at least from acidic rocks and that the intrusion of these acidic rocks accompanied the folding of the rocks of the region.

If the rocks in which the gold bearing veins of the Timiskaming region occur were fractured by compressive stresses acting in the same direction as the stresses by which they were foliated, then, in the case of an irrotational strain, if the relief of pressure were greatest in a horizontal direction at right angles to the regional stresses two systems of fissures would be developed which, on a flat erosion surface, would cut across the trend of the enclosing rock at an angle of approximately 45 degrees, but, on a vertical surface, would appear parrallel, that is the discordant relationship would be in strike. If, on the other hand, the relief of pressure were greatest in a vertical direction at right angles to the regional stresses, two systems of fissures would develop which would conform in strike to that of the enclosing rock but would cut across the dip at an angle of approximately 45 degrees. In the case of a rotational strain two systems of fissures having a discordant relationship to the foliation would tend to form, as in the special cases just cited, but the fissures in the plane at right angles to the direction of elongation would develop by crevicing. Thus where rocks undergo fracture as a result of regional compressive stresses the fractures may indicate their mode of origin (1) by their discordant relationship to the foliation (provided the stresses act in the same direction as those by which the foliation was developed), and (2) by their occurrence in two intersecting systems. Both of these features are conspicuous in the case of the fissures along which the quartz veins occurring in the Pre-Cambrian volcanic complex of the Timiskaming region were developed.

CHARACTER OF DEPOSITS.

Form.—Those deposits which occur in association with the ferruginous dolomite consist for the most part of innumerable small anastamosing veinlets of quartz from 1 inch to 6 inches in width. In some places these are bordered by a zone of dolomite which when dissolved away leaves the quartz with a denticulated surface (See Plate XXVIII). In other places the veinlets have no definite walls, the junction of the quartz and the wall rock being gradational. In such localities the country rock may be almost entirely replaced by quartz.

The larger veins occurring in these rocks of the Abitibi group are very similar in character and in form regardless of whether they occur in the ferruginous dolomite or any other member of the volcanic complex. They vary greatly in width from less than a foot to several feet in short distances, and may expand abruptly to a large mass of quartz 30 feet or more in width, such as the mass occurring in the ferruginous dolomite north of the Cascade rapids on the Kinojevis river. The essential similarity of the form of these deposits to those of the Porcupine district is shown by the following quotation from Mr. Burrows' report on that area. "The irregular fissuring has produced a great variety of quartz structures, varying from the tabular, though often irregular or lenticular, vein which may be traced several hundred feet, to mere veinlets, often only a fraction of an inch in width and a few feet in length, which ramify through a rock which has been subjected to small irregular fissuring. This latter variety is well illustrated in the fissuring of ankerite bands, so characteristic of many of the gold deposits of Porcupine. Irregular and lenticular bodies of quartz often occur which may have a width of 10 or 20 feet, but which die away in a distance of 50 feet. Again there are dome-like masses of quartz which are elliptical or oval in surface outline, but whose underground extension has not been examined closely . . . . . The most conspicuous dome masses are those of the Dome property, where the two largest are about 125 feet by 100 feet."

Composition of the Deposits.—The mineralogy of these deposits is comparatively simple for they consist almost entirely of milk-white quartz. Ferruginous dolomite is usually present in some abundance, but all the other mineral constituents occur in exceedingly small quantities. The most abundant of these are pyrite, chalcopyrite, galena, and gold. Mr. Burrows also notes the occurrence of zinc blende, pyrrhotite, argentite, feldspar and tourmaline in the quartz veins at Porcupine, and since the publication of his report, the silver telluride, hessite, and the calcium tungstate, scheelite, have also been reported. In the region described in this report, tourmaline was observed in quartz veinlets in the dolomite occurring on Mackenzie lake, and chrome mica in veinlets in porphyry on the property of the Union Abitibi Mining Company, between Renauld and Fortune lake. The presence of the gold telluride, petzite, in the veinlets in the porphyry on the latter property has also been described by Mr. R. Harvey.[1]

COMPOSITION OF THE DEPOSITING SOLUTIONS.

In the discussion of the origin of the ferruginous dolomite it was shown that there was much evidence which indicated that the dolomitic rock had been formed by the replacement of aplite, quartz porphyry, and related rocks through the action of thermal solutions. It is also evident from the occurrence in the quartz veins of the same minerals or elements as replaced the aplite and quartz porphyry, that the solutions which effected the replacement of these rocks were similar in composition to those from which the quartz was deposited; and that a study of the changes brought about in the country rock will afford some information as to the composition of the depositing solutions. In the selection of material for the complete and partial analyses given on pages 64 and 65, specimens of the most striking types of the dolomitic rock—and hence those in which the replacement had been most complete—were generally taken. In order to show the various stages in the transformation of the aplite or porphyry into dolomite, analyses of the fresh and partly altered aplite or porphyry are necessary. The analyses of a slightly altered and a more completely altered aplite are as follows:—

	1		2
SiO_2	52·68	—	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
	101·11		100·48

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[1] Min. Oper. Prov. Que., p. 83, 1910.

Number 1 is a slightly altered aplite from the Gold King claim, Hearst township, Nipissing district, Ontario, analysed by Mr. M. F. Connor.[1] Number 2 is a chrome mica bearing ferruginous dolomite from the Harris Maxwell—a claim adjacent to the Gold King—Hearst township, Nipissing district, analysed by Mr. M. F. Connor. This rock under the microscope can be seen to consist chiefly of albite traversed by fracture zones filled with ferruginous dolomite and chrome mica.

From a comparison of the chemical composition of these two rocks, it is evident that in the transformation of the aplite there has been an abstraction of silica, alumina, and soda, and an addition of carbonate of lime, magnesia, and potash. The solutions which effected the metasomatic alteration of the aplite, therefore, originally, contained an abundance of carbon dioxide, lime, magnesia, and potash, and later, as a result of their metasomatic action, would also contain alumina, silica, an soda.[2]

The chemical composition of the depositing solutions can also be inferred from the minerals contained in the quartz veins. Among other constituents there were present, as shown by the composition of the deposits, silica, carbon dioxide, iron, calcium, magnesium, chromium, gold, tellurium, copper, silver, lead, boron, potassium, and sodium, although the proportion of many of these elements was no doubt very small.

SOURCE OF THE DEPOSITED MATERIAL.

In the report on the Porcupine Gold Area, Mr. A. G. Burrows concluded that the quartz veins of that district were related to granitic intrusions, the principal evidence on which he based his conclusions being (1) the presence of tourmaline and feldspar in the quartz of several deposits, and (2) the occurrence of gold in quartz veinlets in aplite. In the Larder Lake district and in the region described in this report, the association of the auriferous quartz with aplite, quartz porphyry, and the ferruginous dolomite which has resulted from the alteration of these rocks, is still more striking than in the Porcupine district, but this association may be due to the presence of the fractures in the aplite rather than to any necessary genetic connexion between the aplite and the auriferous quartz. The presence of boron and lithium[3] in the dolomitic rock and the minerals tourmaline and scheelite in the quartz veins, however, suggests a derivation from granitic rocks since boron, lithium, and tungsten are among the common elements contained in minerals of pegmatites. It seems improbable, on the other hand, that

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[1] Chemist, Mines Branch, Department of Mines, Canada.

[2] Compare alteration in soda feldspar dykes described by H. W. Turner, Jour. Geo., Vol. 7, p. 379, 1899.

[3] Quart. Bul. Can. Min. Inst., No. 14, p. 187, 1911.

the immense masses of ferruginous dolomite which form the replacement deposits could have been derived from granite, and since the Abitibi volcanics with which the ferruginous dolomite is associated contain an abundance of this constituent it is probable that all of the carbonate has been derived from this source. It was shown in the preceding section of this report that the replacement of the aplite, quartz porphyry, and related rocks by ferruginous dolomite was accompanied by the abstraction of silica, so that the quartz of the auriferous deposits was possibly supplied in part by this process. Positive evidence as to the source of the gold seems wanting, although it is more probable that it was derived from the granite volcanics or its apophyses rather than from the volcanics of the Abitibi group, and these were the only igneous rocks present when the ores were deposited.

AGE OF DEPOSITS.

With regard to the age of these deposits, it is known that they were formed long before the deposition of the Cobalt series, for fragments of the ferruginous dolomite occur in the conglomerate of that series in the vicinity of Larder lake, and the quartz veins which cut the ferruginous dolomite lying north of the Cascade rapids on the Kinojevis river are intersected by andesite dykes, lithologically similar to the volcanics of the Abitibi group, showing that the great era of vulcanism which characterized the early history of this region had not reached its termination at the time the quartz deposits were formed. But, on the other hand, it has been shown elsewhere in this report, that the Abitibi volcanics, rocks in which a large part of the quartz deposits occur, are highly folded and that this folding took place as an accompaniment of great batholithic invasions of granitic rocks, and, since the quartz veins cut across these folded rocks, it is evident that the veins were formed after the larger part of the folding had been accomplished and hence after the last batholithic intrusions of granite and gneiss.

CONCLUSION.

As a summary of the above discussion of the genesis of the veins, veinlets, and masses of auriferous quartz occurring in the northern part of the Timiskaming region, it is concluded that these deposits are associated with fractures which resulted from compressive stresses acting in the same direction as the forces which deformed the rocks of the region, that these fractures afforded channels along which thermal solutions could circulate, and that these solutions first effected the replacement of large masses of country rock by carbonates and other minerals, and later deposited the quartz in fissures and perhaps also in part by replacement of the wall rock. There does not appear to be any definite evidence as to the original source of the circulating waters, but the presence of certain constituents suggests that the deposited material was derived in part from the granite batholiths or their apophyses, and in part from the Abitibi volcanics. It should be noted, also, that, from the evidence cited as to the age of these deposits, it is probable that they were formed almost immediately following the last intrusion of granite in the region, and that at such times any waters circulating in the vicinity of the intrusive would certainly be thermal and contain elements common in pegmatite minerals, and it is possible that the gold may have been obtained from the same source.

Veins of Quartz, or of Quartz and Calcite in Granite, and in the Rocks of the Pontiac and Cobalt Series.

The veins of this class have not been classed together because of any assumed genetic relationship between them, but because of their general similarity in mineralogical composition and because they so far have not proven to be of much economic importance. They are commonly well defined veins of quartz or of quartz and calcite from a few inches to several feet in width and contain small quantities of sulphides such as pyrite, chalcopyrite, galena, and zinc blende. Assays from many of these occurrences have been procured by prospectors, but none of those reported to the writer exceeded $2 or $3 per ton. The veins occurring in the granite are generally large but very irregular ; those in the Pontiac series are generally small and occur irregularly strung out parallel to the foliation ; those in the Cobalt series are more uniform and continuous.

COPPER.

Although the copper bearing mineral chalcopyrite was observed in numerous localities throughout this region, in no place was a deposit seen which was of sufficient extent to be of commercial value. Wherever the chalcopyrite was observed, it occurred in quartz either as small aggregates or minutely disseminated.

COBALT AND NICKEL.

A number of deposits of pyrrhotite were observed in the Pontiac schist, two of the largest of which are exposed on the shore of Lake Opasatika, one on the south shore of Klock bay and the other on the east shore of the lake, about one-fourth mile north of the entrance to Moose bay. A sample from the last mentioned occurrence collected by Mr. McOuat in 1872 was submitted to Dr. Harrington of the Geological Survey, and found to contain traces of cobalt and copper.[1]

MOLYBDENITE.

Molybdenite was observed in the district described in this report, in a pegmatite dyke in the granite which forms the island at the north end of Evain lake, and is also reported to occur in pegmatite in the vicinity of Caron lake, but in both of these localities the quantity of the mineral is small. Molybdenite also occurs in the region included in the accompanying map, on the Kewagama river and on the peninsula in Kewegama lake, but this district has been examined by Dr. J. A. Bancroft for the Quebec Department of Mines and will not be described in this report.[2]

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. Two of the porphyry dykes occurring on the south shore of Fortune lake have been largely replaced by ferruginous dolomite, and are intersected by veinlets of quartz and ferruginous dolomite carrying coarse gold and gold telluride.[3] An east-west belt of dolomitic sericite schist in which some veinlets of quartz were observed also occurs on the property.

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[1] Rep. of Prog., Geo. Surv., Can., p. 122, 1872.

[2] Johnston, J. F. E., Sum. Rep. Geo. Surv. Can., p. 138, 1901.
Wilson, W. J., Sum. Rep. Geo. Surv. Can., p. 123, 1906.
Walker, T. L., Molybdenum Ores of Can., Mines Branch, Dept. of Mines, Can., pp. 32-40, 1911.
Wilson, M. E., Sum. Rep., Geo. Surv., Dept. of Mines, Can., p. 207, 1911.

[3] Min. Oper. Prov. Quebec, p. 83, 1910.

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 accomplished was 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 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 being constructed.

QUINN CLAIM.

The Quinn claim has been located on a brecciated zone in the greywacke of the Cobalt series, on the north shore of Dushwah (Turtle) lake. This zone is about 6 feet wide and consists of fragments of greywacke cemented by quartz containing considerable pyrite and chalcopyrite. The work accomplished consists merely of a small opening on the surface.

GOLD BELT CLAIM.

During the years 1907 and 1908 some development work was done by the Gold Belt Mining Company on some occurrences of quartz in the vicinity of the north end of Lake Opasatika. The principal part of this work consists of a shaft about 25 feet deep on a vein of quartz which cuts the Pontiac schist at a point on the west shore of Lake Opasatika a short distance north of the entrance to Klock bay. This vein has a width of 2½ feet and outcrops for a distance of about 150 feet. It consists almost entirely of quartz, but some feldspar and scapolite occur along the margin.

RENAULD CLAIM.

The Renauld claim is situated directly north of Nabugusk lake. The rock of that vicinity consists of granite and is cut by numerous veins of quartz and of quartz and calcite. In one of these veins the quartz contains considerable chalcopyrite and a few flakes of dendrictic native copper; and in another, calcite containing small quantities of pyrite, galena, chalcopyrite, and zinc blende has been deposited in the centre of the vein as a filling between the crystals of quartz which have grown outward from the wall rock.

BEATTIE CLAIM.

A brecciated zone extends across a small island occurring at the north end of Lake Duparquet, in which considerable quartz and some carbonate have been developed. It was reported that assays of $20 per ton had been obtained from the quartz of this deposit, but an average sample taken by the writer contained no gold when assayed by Mr. L. Leverin of the Mines Branch, Department of Mines.

INDEX.

CLASSIFIED LIST OF RECENT REPORTS OF GEOLOGICAL SURVEY.

Since 1910, reports issued by the Geological Survey have been called memoirs and have been numbered Memoir 1, Memoir 2, etc. Owing to delays incidental to the publishing of reports and their accompanying maps, not all of the reports have been called memoirs, and the memoirs have not been issued in the order of their assigned numbers, and, therefore, the following list has been prepared to prevent any misconceptions arising on this account.

Memoirs and Reports Published During 1910.

REPORTS.

Report on a geological reconnaissance of the region traversed by the National Transcontinental railway between Lake Nipigon and Clay lake, Ont. By W. H. Collins. No. 1059.

Report on the geological position and characteristics of the oil-shale deposits of Canada. By R. W. Ells. No. 1107.

A reconnaissance across the Mackenzie mountains on the Pelly, Ross, and Gravel rivers, Yukon and North West Territories. By Joseph Keele. No. 1097.

MEMOIRS—GEOLOGICAL SERIES.

MEMOIR 1. *No. 1, Geological Series.* Geology of the Nipigon basin, Ontario. By Alfred W. G. Wilson.

MEMOIR 2. *No. 2, Geological Series.* Geology and ore deposits of Hedley Mining district, British Columbia. By Charles Camsell.

MEMOIR 3. *No. 3, Geological Series.* Palaeoniscid fishes from the Albert shales of New Brunswick. By Lawrence M. Lambe.

MEMOIR 5. *No. 4, Geological Series.* Preliminary memoir on the Lewes and Nordenskiöld Rivers coal district, Yukon Territory. By D. D. Cairnes.

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PLATE 12.

Transportation by scow and launch on the Black river.

40591—A

PLATE III.

View looking eastward from the Swinging hills.

PLATE IV.

View, looking westward from the Swinging hills, Mount Shiminis in the distance.

PLATE V.

Lake Dufresnoy and the Abijevis hills from Kamak hill.

PLATE VI.

The Swinging hills from Lake Opasatika.

PLATE VII.

Rapid on the LaSarre river.

PLATE VIII.

The Okikodisik, a typical river of the clay belt.

PLATE IX.

Photomicrograph showing eutaxitic structure in a basalt flow occurring on the portage from Dufresnoy to Sills lake. Ordinary light. Magnified 20 diameters.

PLATE X.

Ellipsoidal structure in the Abitibi volcanics, east shore Lake Duparquet.

PLATE XI.

Bun structure in the Abitibi volcanics, Kamak hill.

Plate XII.

[illegible] surface of Abitibi volcanics due to the weathering out of carbonate deposited between the lava masses, Labyrinthe lake.

PLATE XIII.

Cavities in glaciated surface of Abitibi volcanics due to the differential weathering of portions of the rock containing abundant carbonate, Lake Dufault. Note the glacial striæ.

PLATE XIV.

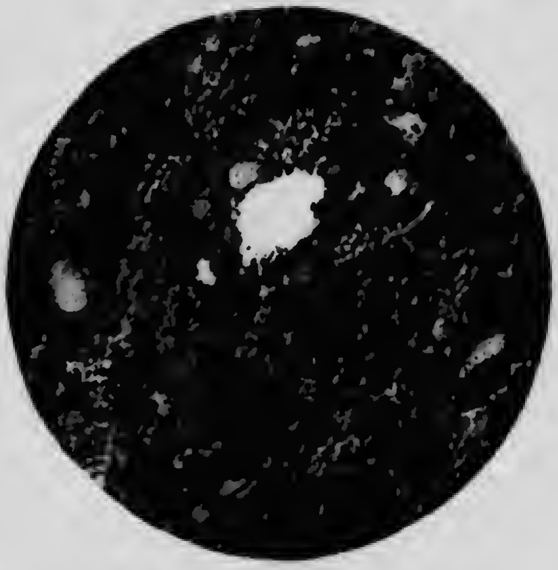
Seams of chlorite and carbonate in chloritic rock, north shore of entrance to Moose bay, Lake Opasatika.

PLATE XV.

Photomicrograph of tourmaline in quartz, from veinlet traversing ferruginous dolomite, occurring on Mackenzie lake, Privas township, Abitibi district, Que. Crossed nicols. Magnified 20 diameters.

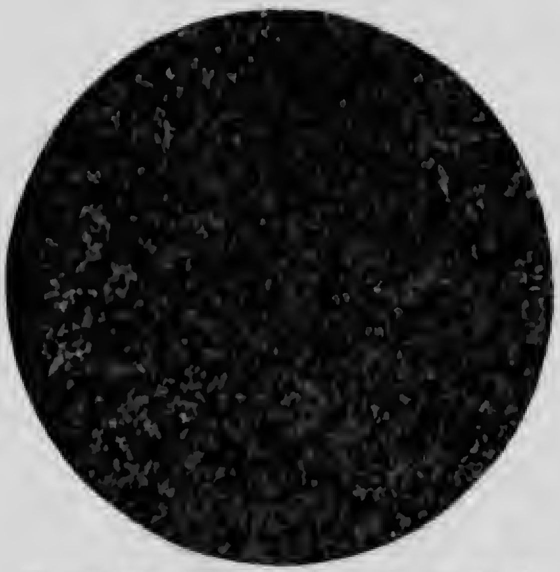
PLATE XVI.

Photomicrograph of the greywacke of the Pontiac series, occurring on Clericy lake, Pontiac county, Que. Crossed nicols. Magnified 20 diameters. Compare with Plates XVII and XVIII.



Photomicrograph of the greywacke matrix of the conglomerate of the Pontiac series occurring on the Kinojevis river. Crossed nicols. Magnified 20 diameters. Note the partial recrystallization and compare with Plates XVI—the original greywacke—and Plate XVIII, the end product of recrystallization.

PLATE XVIII.



Photomicrograph of the Pontiac schist occurring on Kekeko lake. Crossed nicols. Magnified 20 diameters.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)

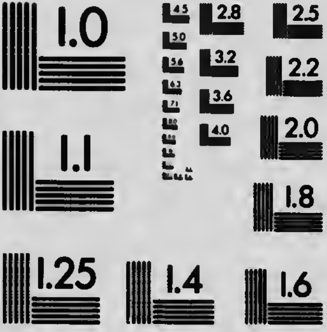
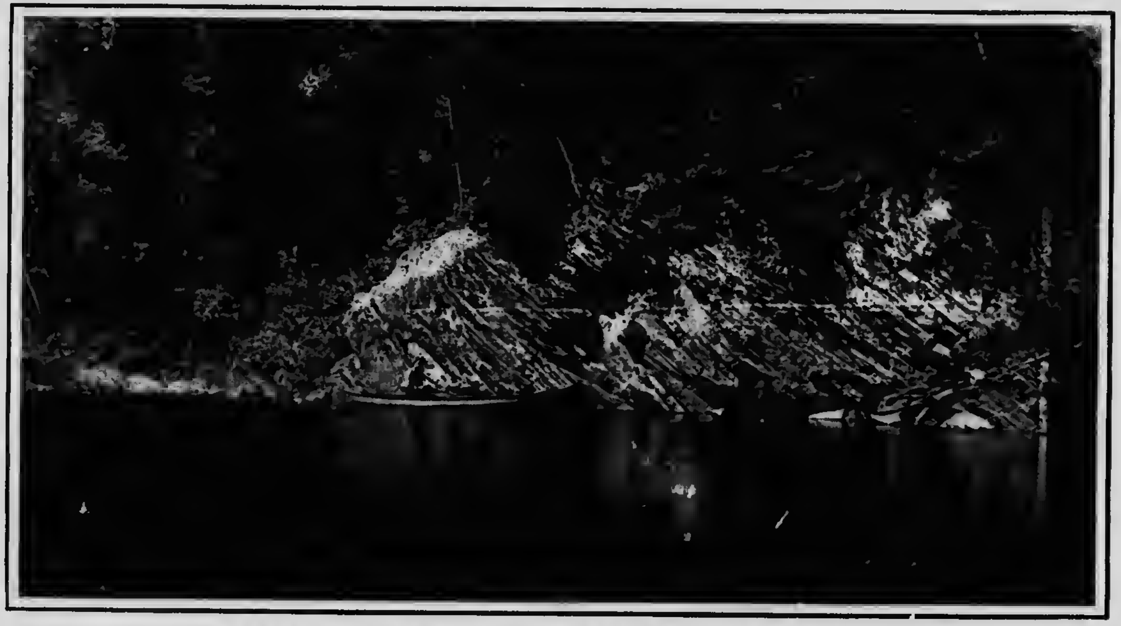


Plate XIX.



Pontiac schist dipping steeply towards the north, west shore Kinojevis lake.

PLATE XX.

Fragments of the Abitibi volcanics included in granite, on the west border of the Robertson Lake batholith. Cut on the National Transcontinental railway, Range 9, Privas township, Abitibi district, Que.

PLATE XXI.

Autoclastic breccia formed by the breaking up of a granite dyke which intrudes the Pontiac schist, east shore of Kinojevis lake, Vaudray township, Pontiac county, Quebec.

PLATE XXII.

Photomicrograph of the matrix of the basal conglomerate of the Cobalt series occurring on the south shore of Lake Dasserat. Ordinary light. Magnified 20 diameters.

PLATE XXIII.

Photomicrograph of the matrix of the basal conglomerate of the Cobalt series, occurring on the south shore of Dasserat lake. Crossed nicols. Magnified 20 diameters.

Glaciated surface sloping towards the north, Lake Dufault, Dufresnoy township, Pontiac county, Quebec. The grooves owe their origin to the weathering out of a sheeted carbonate zone.

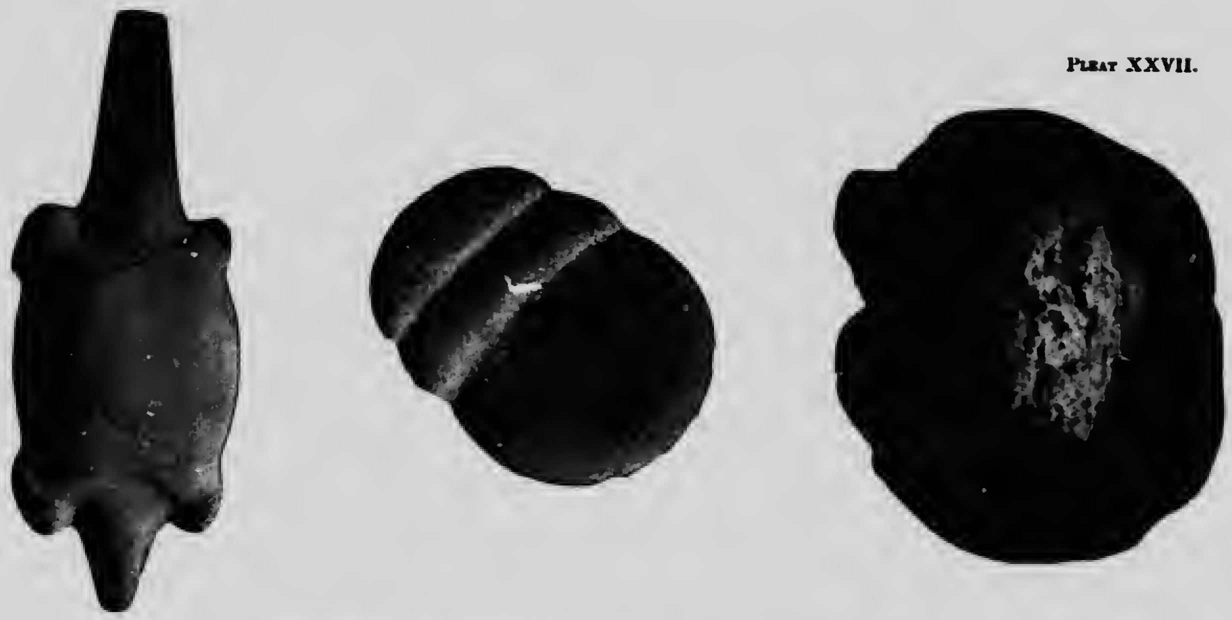
PLATE XXV.

Sttraified post-glacial clay near its contact with the glacial drift, National Transcontinental railway, LaSarre township, Quebec.

PLATE XXVI

Stratified clay, near view, LaSarre township, Que.

PLATE XXVII.



Concretions from clay, occurring on Lake Duparquet, Abitibi district, Quebec

PLATE XXVIII.

A

Surface of quartz on margin of veinlet in ferruginous dolomite from which the dolomite has been dissolved away.

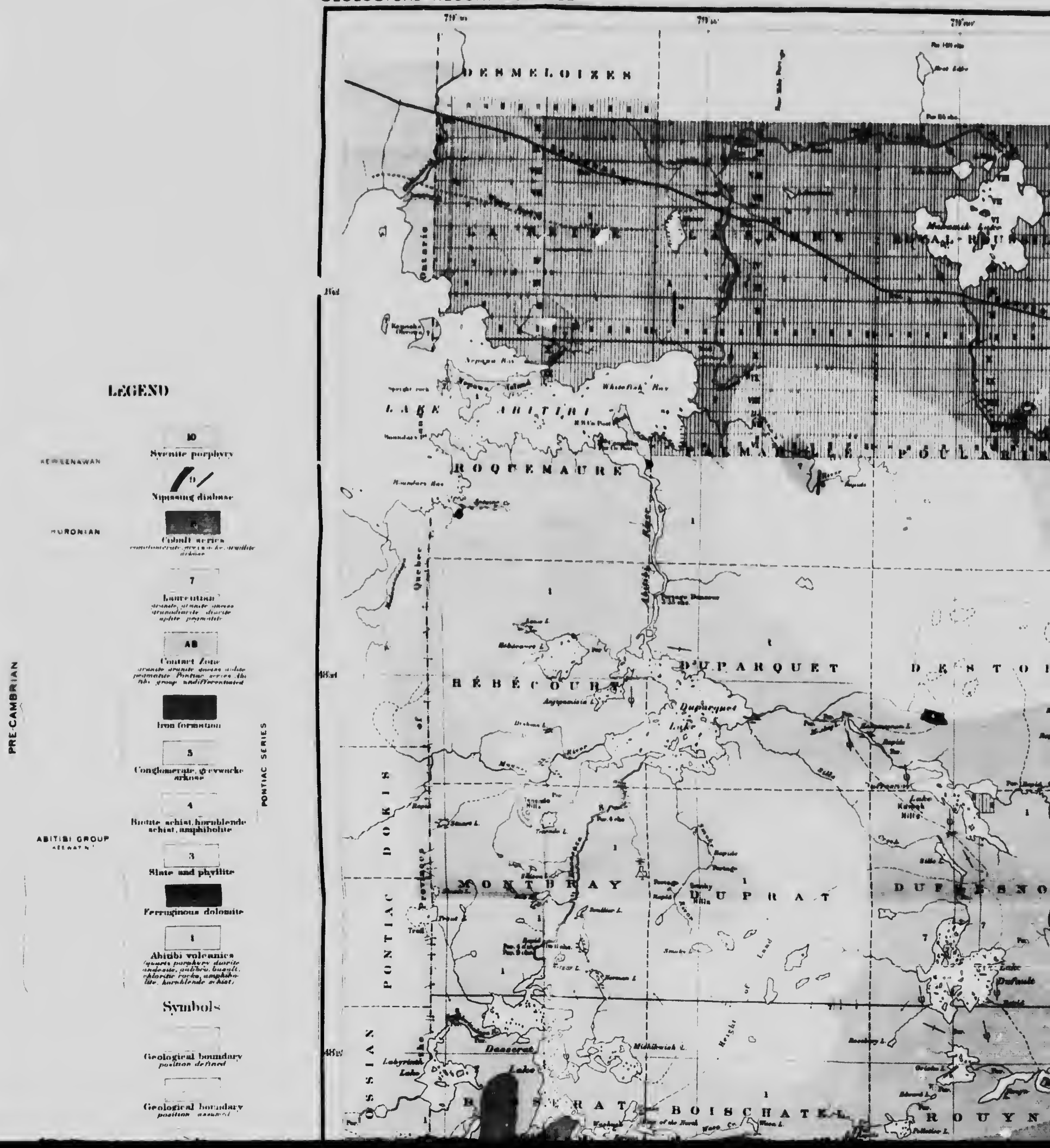
B

Inclusion of dolomitic rock in quartz from which the coarsely crystalline dolomite formed around the margin has been dissolved away.

PLATE XXIX.

Property of the Union Abitibi Mining Company, Pontiac county, Quebec, Oct., 1911.

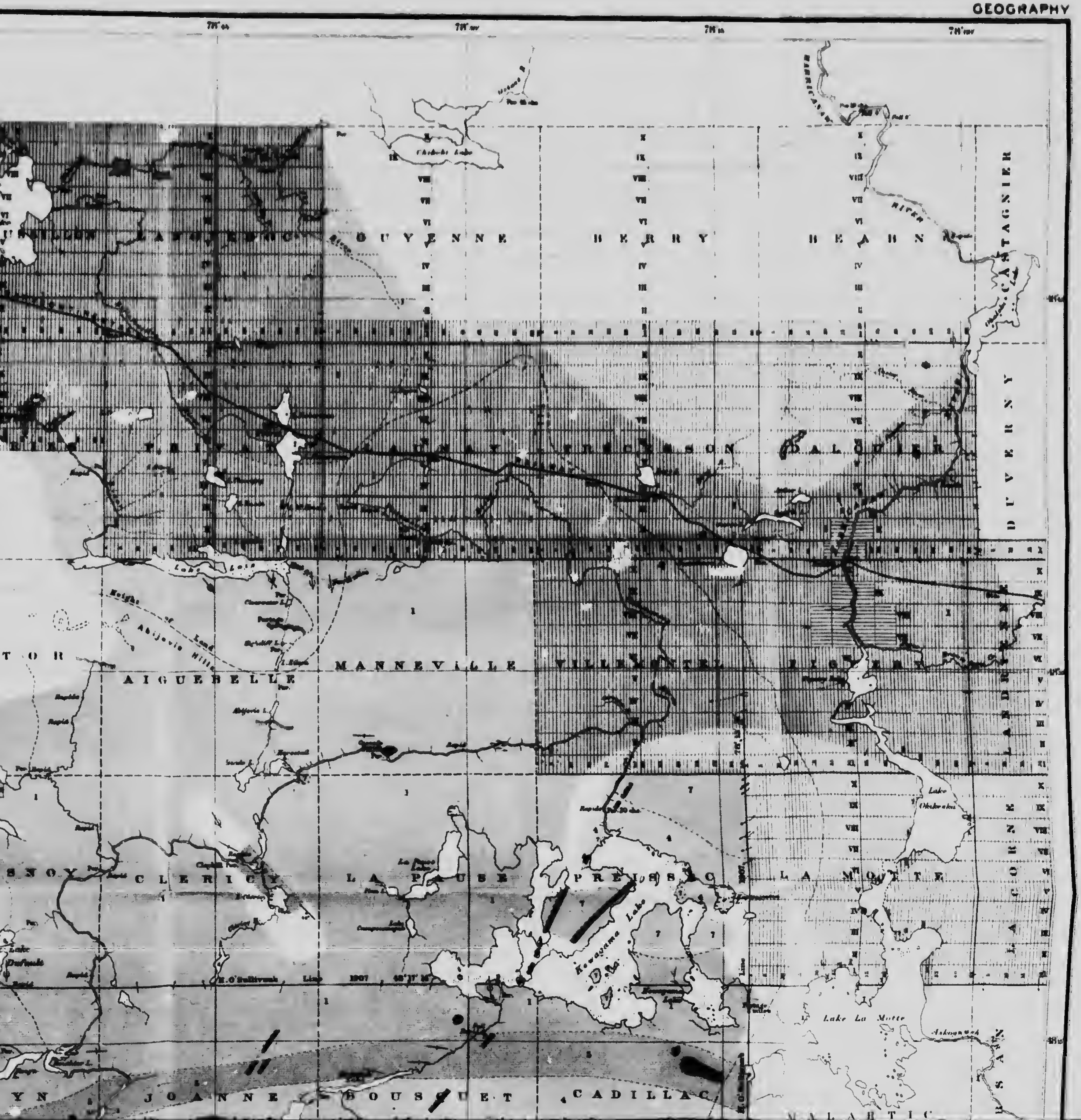
GEOLOGICAL RECONNAISSANCE



Canada
Department of Mines
Hon. L. Coderre, Minister, A. P. Low, Deputy Minister

GEOLOGICAL SURVEY
R. W. Brock, Director

GEOGRAPHY



Geological boundary
position defined

Geological boundary
position assumed

Glacial striæ

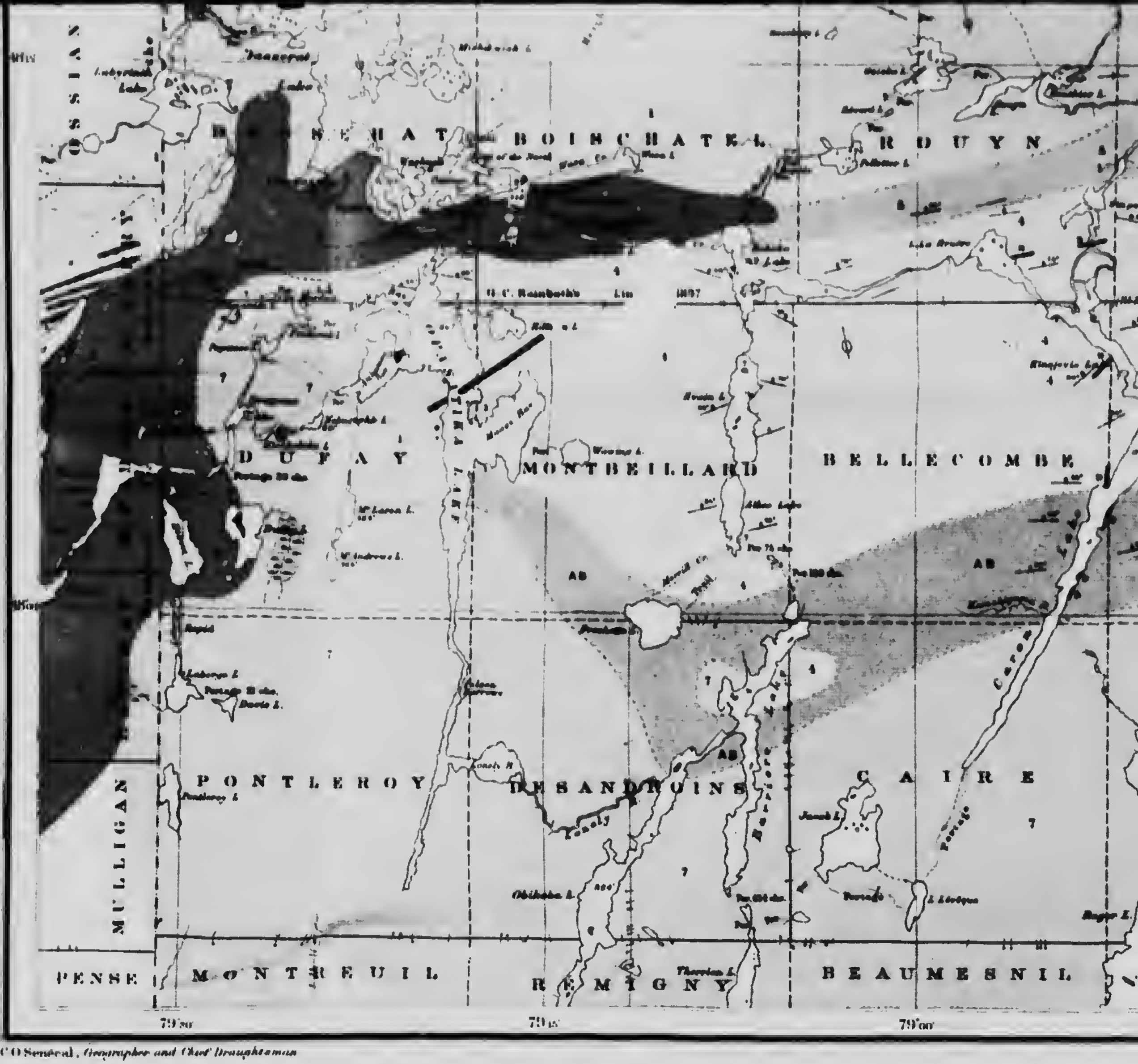
Strike

Strike and dip

Vertical strata

Geographical position based on latitude and longitude observations at [illegible] by Dominion Astronomical Branch, Department of Interior

Magnetic declination about 10° West



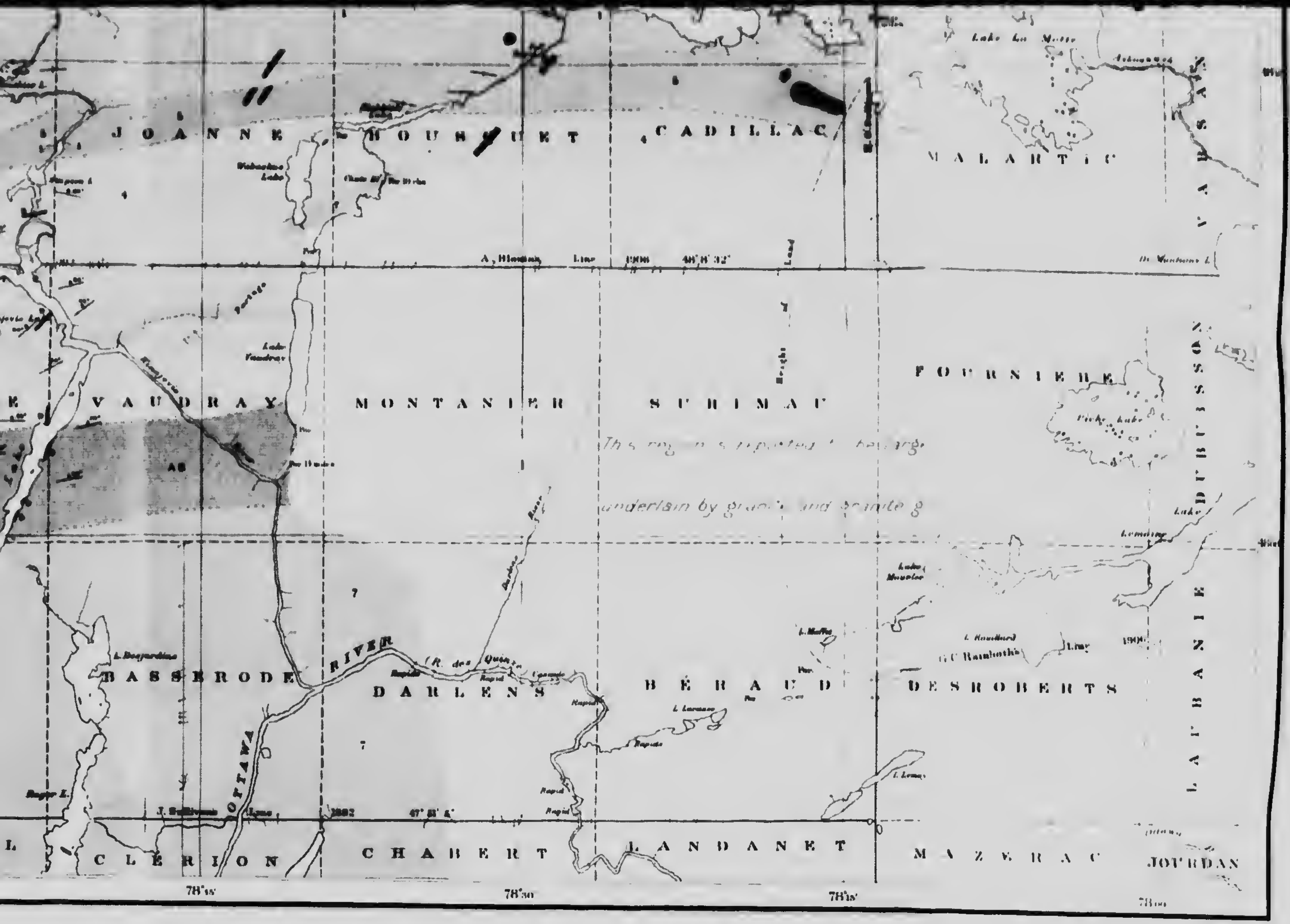
C.O. Senécal, Geographer and Chief Draughtsman

Scale, 250 Miles to 1 Inch

A

To accompany

M.E. Wilson



MAP 93 A
Issued 1913

KEWAGAMA

ABITIBI AND PONTIAC

QUEBEC

Scale, $\frac{1}{253,440}$

Miles

Kilometres

4 MILES TO 1 INCH

GEOLOGY

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