CANADA
DEPARTMENT OF MINES
SIR JAMES LOUGHEED, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY
W. H. COLLINS, DIRECTOR

MEMOIR 127

No. 108, GEOLOGICAL SERIES

Beauceville Map-area, Quebec

BY

B. R. MacKay

OTTAWA
F. A. ACLAND
PRINTER TO HIS MOST EXCELLENT MAJESTY
1921

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Chaudière valley above Devils rapids. (Pages 5 and 45.)

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Beauceville Map-area, Quebec

CHAPTER I

INTRODUCTION

GENERAL STATEMENT

This report and accompanying maps (Nos. 1756 and 1835) present the results of an investigation, made in 1916, 1917, and 1918, of the placer deposits of the Chaudière River basin, especially of the most productive part lying within Rigaud-Vaudreuil seigniory, Beauce county. Mining operations were spasmodically carried on in these deposits from 1847 until a few years ago. The objects of the investigation were to obtain as much knowledge as was possible of the physiography and geology of the area, and especially the source and distribution of the gold in the placer deposits; to determine whether conditions warranted a resumption of mining operations; and the most economical way of exploiting the deposits. Other deposits occurring within the district, including copper, molybdenite, iron, platinum, asbestos, steatite, marble, clay, and pigments, also received attention.

ACKNOWLEDGMENTS

The writer acknowledges the numerous kindnesses received from residents of the district, throughout the course of the work. Special acknowledgments are due to Mr. Isaie Préfontaine, President of the Champ d'Or Rigaud Vaudreuil Company, and to Mr. A. O. Dufresne, Assistant Superintendent of Mines, Quebec, for the loan of plans, reports, and other data in their possession, and for other favours received.

METHODS OF FIELD WORK

TOPOGRAPHICAL MAPPING

Over half of the time spent in the field was occupied in making the accompanying topographical base map (No. 1756) which was constructed on a scale of 4,000 feet to the inch with a 20-foot contour interval. A degree of accuracy was sought in making this map such that in the final sketching of the detail no location was to be out in elevation more than one-quarter the contour interval employed, or out in position more than $\frac{1}{100}$ of an inch on the map surface.

In obtaining the vertical control it was necessary to carry a line of primary levels through the map-area from a bench-mark established by the Public Works Department at Valley Junction, 15 miles north of Beauceville. Along this level line stations were established, from which other traverses were run, or to which they were tied. The primary horizontal control consisted of a triangulation net of twenty-five stations, placed on

prominent points, and so distributed as to control all parts of the area mapped. A base-line for the triangulation scheme, about 4,500 feet in length, was measured near the centre of the map-area, on the flood-plain of Chaudière river, a short distance above Devils rapids. The base-line was tied to the line of primary levels, and from this datum the elevations of the different triangulation stations were determined by transit observations.

During the course of the topographical mapping H. Roscoe, W. Y. Barrett, I. Monette, A. P. LaRose, and W. B. Davidson were attached to the party as student assistants and rendered efficient service. In the geological work James Hill and T. A. Link acted as assistants and their efficient aid contributed greatly to the results obtained.

LOCATION AND AREA

The district described in this report lies along Chaudière river which rises at the International Boundary and enters the St. Lawrence about 7 miles above Quebec city and is one of the most important streams in southern Quebec.

The map-area is about 15 miles long by 6 miles wide, the northern limit being a few miles south of St. Joseph, or about 42 miles southeast of the city of Quebec (Figure 1). The total area embraced is 115 square miles.

HISTORY

The Chaudière valley has formed from the earliest time a natural avenue of communication between the settlements along St. Lawrence river and those to the south. The Indians who formerly inhabited the district not only plied their canoes up and down the river, but used well-trodden trails along both banks of the stream. With the arrival of the white man, the Indian was gradually forced to vacate the district and his trails became wagon roads. In the scheme of colonization carried out by the French Government the district along Chaudière river was surveyed into large blocks, termed seigniories, which blocks were given to certain individuals as payment or as a token of appreciation for services rendered. In return the recipients were obliged to subdivide their holdings and induce colonists to settle on the land, by leasing farms at low rentals. The fertility of the soil along the flood-plains and valley slopes of Chaudière river attracted settlers from the more populous parts of the province along the St. Lawrence, and all parts of the district were soon rendered accessible.

During the troublous times before the ceding of Quebec to Britain, and again before the granting of independence to the American colonies, the roads along Chaudière river were converted into military routes and were used for the transfer of troops of the opposing armies. A few years ago the Provincial Government of Quebec macadamized the old military road on the east side of the river to form part of a highway from Lévis to Kennebec. This road is one of the best in the province, and forms the provincial section of a highway connecting Quebec and Portland.

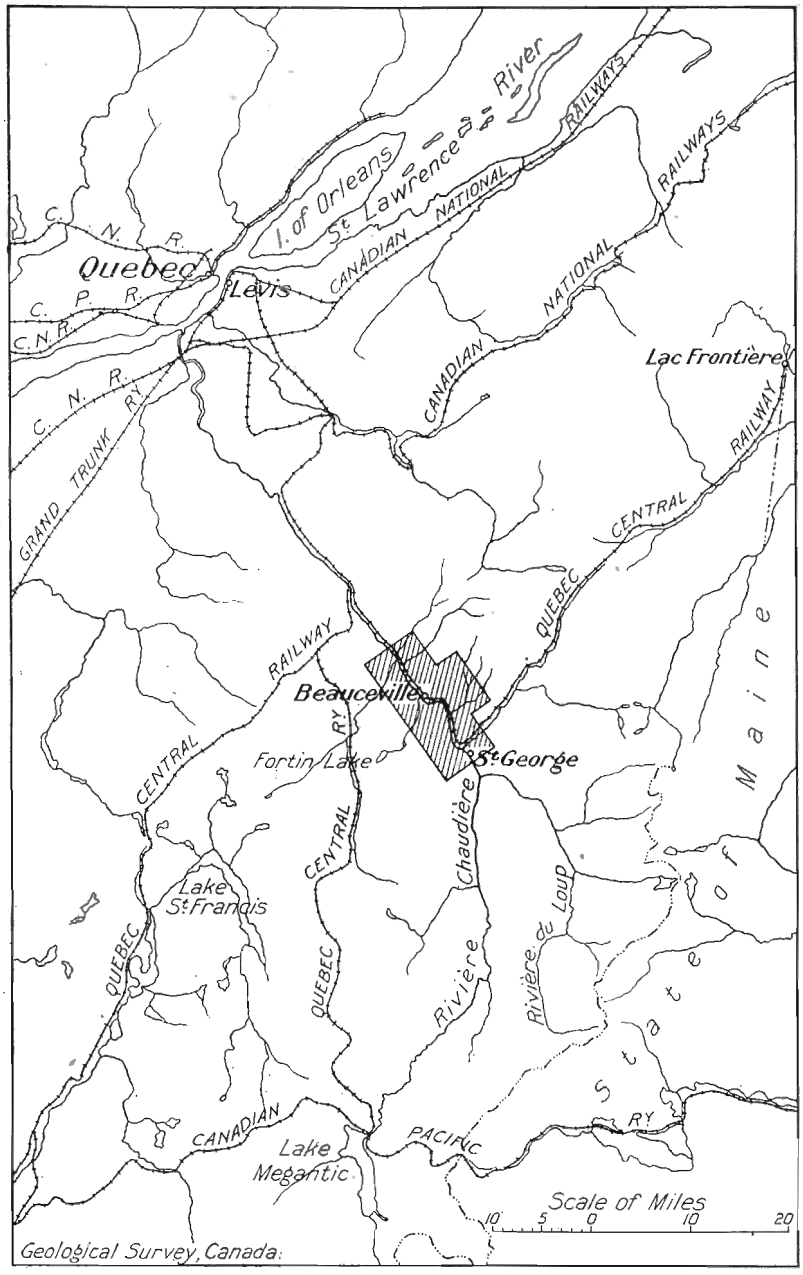

Figure 1. Index map showing location of Beauceville map-area.

The less important roads are of gravel or clay and are kept in remarkably good condition, except in the sparsely populated parts of the district several miles distant from the river.

The Quebec Central railway which runs from Lévis to Lac Frontière at the International Boundary passes through the district, paralleling Chaudière and Famine rivers.

The shallow nature of Chaudière river and the presence of falls, some of considerable magnitude, make the river unnavigable except for rafts and small boats. It is of great service, however, in the transporting of pulpwood, and at certain periods of the year, the river is almost hidden by the mass of floating logs.

CLIMATE

The accompanying tables supplied by Sir Frederic Stupart, Director of the Meteorological Observatory, Toronto, afford specific data as to the climate of this part of southeastern Quebec.

Table Compiled From Meteorological Observations Taken at Beauceville, Quebec, 1913-1918, Inclusive

—	Temperature Fahr.			Rainfall in inches	Snowfall in inches	Total precipitation in inches
	Mean high	Mean low	Mean			
January	19·8	−0·06	9·8	0·71	29·7	3·7
February	20·1	−4·2	7·9	0·51	21·5	2·7
March	30·8	8·5	19·6	0·10	18·2	1·9
April	46·1	26·2	36·1	1·44	4·8	1·9
May	59·9	38·0	48·9	2·91	4·0	3·3
June	69·7	45·6	57·6	3·99	.....	4·0
July	77·9	54·0	65·8	4·52	.....	4·5
August	75·6	51·0	63·3	2·63	.....	2·6
September	65·9	42·5	54·2	2·99	.....	3·0
October	53·6	34·3	43·9	3·31	2·0	3·5
November	37·5	20·0	28·7	1·32	8·3	2·2
December	23·9	5·5	9·2	0·54	10·9	2·4

Table Compiled from Meteorological Observations Taken at Megantic, 1914-1918

—	Temperature Fahr.			Rainfall in inches	Snowfall in inches	Total precipitation in inches
	Mean high	Mean low	Mean			
January	21·2°	− 0·5°	10·3°	0·53	26·2	3·1
February	21·3	− 0·1	10·6	1·05	24·6	3·5
March	29·3	10·6	20·0	0·04	24·7	2·5
April	46·4	26·1	36·3	1·45	12·1	2·6
May	62·3	37·8	50·0	2·99	4·7	3·4
June	67·5	46·1	56·8	4·96	.....	4·9
July	75·1	54·3	64·9	5·31	.....	5·3
August	72·4	52·7	62·5	3·62	.....	3·6
September	64·4	44·8	54·6	4·40	.....	4·4
October	53·5	35·5	44·5	3·73	1·4	3·8
November	36·2	21·5	28·8	1·27	14·7	2·7
December	23·6	0·7	12·2	0·49	24·8	3·0

The snowfall is generally heavy and covers the ground from the middle of November until late in April. At Beauceville, for the last six years, it has averaged 107 inches, and at Megantic it averages 133 inches annually. The monthly average snowfall for December, January, February, and March is about 25 inches.

Steady cold prevails during December, January, and February, accompanied by a clear, bracing atmosphere and frequent sharp winds. The average temperature during this period is 10 degrees. In March there is a decided rise (the mean for this month being 20 degrees) which increases until July, when the mean reaches 60 degrees, after which it begins to decrease.

The greatest rainfall in one month was in June, 1917, when a record of 10·94 inches was recorded at Megantic and 8·48 inches at Beauceville. The month of July of the same year was almost equally wet, 7·49 inches of rainfall being recorded at Megantic and 8·43 inches at Beauceville. During these two months heavy storms were frequent and were generally accompanied by floods.

The run-off derived from the melting of the snow and from heavy rains is generally rapid. This is due chiefly to the thinness of the soil blanket which covers the rocky uplands. This together with the low gradient of Chaudière river which prevents the drainage being carried off sufficiently fast, causes frequent floods. These floods occasionally rise several feet above the banks of the river, and do considerable damage. In April, 1884, during the "break-up" of the ice, the river reached a height 6 feet above the floor of the church at Beauceville. Again, in the spring of 1914 the river flooded the main street of Beauceville to a depth of more than 6 feet, and a similar flood occurred in the spring of 1918.

The most disastrous flood occurred on August 1, 1917. An exceptionally large precipitation during June and July had raised the river considerably above its normal level. On July 31, a heavy rain storm began which continued uninterruptedly throughout the day and part of the following night. By the next morning, Chaudière river and its tributary streams had become veritable torrents, the waters finally overflowing their banks. The Chaudière at Beauceville rose 35 feet above its low-water-mark, reaching the floor of the iron bridge spanning the river. It completely submerged the lower part of the valley, carried away dwellings, barns, bridges, railway tracks, box cars, pulp rafts, telegraph, light, and telephone poles, tore up macadam roads, and destroyed all crops encountered, the damage done totalling over $2,000,000. The flood reached its maximum height 7 a.m. August 1, remained at this level for an hour, and then slowly subsided. By night the river had again dropped within the borders of its flood-plain.

The chaotic effect of the flood and the great rise of water may be seen in Plates I and II.

AGRICULTURE

This district is not as suitable for agriculture as are many other parts of southern Quebec. The shortness of the summer season, frequent frosts during the early summer months, the shallow and stony nature of the soil

covering much of the upland area, and the hilly nature of the surface present serious handicaps. As a result of these, together with the primitive methods generally employed in tilling the soil and harvesting the crops, agriculture in the upland parts of the area is very restricted.

In the southern part of the map-area, and especially that part lying west of Chaudière river, the drift deposits have considerable thickness, and in many places the surface is occupied by stratified clay. The soil in this section is very fertile and well-cultivated farms are common. The most productive part is the flood-plain and terrace flats of Chaudière river, but the excellent crops of wheat, oats, hay, and vegetables grown on these flats are frequently destroyed completely by the river's high and rapid rise.

Many fine maple groves occur on the western slope of the valley, and syrup and sugar-making from the sap of the trees is an important industry.

Sheep-raising is also an important industry and thousands of sheep are shipped in the autumn to the various markets. Much of the wearing apparel and household material used by the inhabitants is obtained by home-spinning of the wool.

LUMBERING

The cutting of spruce, basswood, and poplar for the manufacture of paper pulp is another important industry. In addition to the many settlers engaged in supplying timber from their farms for this purpose, two companies carry on extensive lumbering operations. The timber cut and barked during the summer is hauled in the winter to the shipping centres, from which it is either sent by rail to pulp mills in Canada and the United States, or is floated down rivière du Loup, Famine and Chaudière rivers to Lévis where it is rehandled. For several weeks in the spring the Chaudière is packed with floating logs.

WATERPOWER POSSIBILITIES

Twenty-five waterfalls occur within the limits of the Beauceville map-area. Owing to the limited flow of water, most of these are of more value as scenery than for use; but in a number of cases the flow is sufficient to develop considerable power. As yet the only one extensively developed is on Chaudière river at Great falls (a few miles south of the map limits) where a concrete dam across the river gives a head of about 20 feet. The power developed is used in the lighting of the town of St. George.

Famine river, near the eastern border of the map-area, and about 3 miles east of Chaudière river, drops 75 feet in a distance of about 600 feet, in a series of falls and rapids. There is an excellent site for a dam, and from this large drainage basin considerable power could be developed.

A series of falls occurs on Pozer river, 1½ miles west of the Chaudière, having a combined drop of 135 feet in a distance of about 1,000 feet. Good dam sites are also available at this locality, but the average flow of the stream does not admit of any great development of power. Down-

stream, about one-half mile from the Chaudière, a concrete dam has been constructed and the power developed runs a flour mill.

On rivière des Plantes, 4,000 feet east of the main highway along Chaudière river, there is a cascade (Plate XII) of 80 feet in a distance of 400 feet. The volume, however, is not sufficient for the development of any great amount of power. On the lower part of this stream, about 1,000 feet east of the highway, a timber dam was constructed, and the power developed was used for a number of years in running a mill, but this has now fallen into disuse.

A few small falls accompanied by a stretch of 1,200 feet of rapids, and having a combined drop of 33 feet, occur on St. Victor[1] river near the western border of the map-area where the stream channel makes a sharp bend to the east. On September 29, 1910, a measurement, made by Mr. Fritz Cirkel, gave the flow of water over the falls as 4,166 cubic feet a minute. With this estimated flow and an 85 per cent efficiency 223 horsepower could be developed. As there are certain seasons of the year in which the flow of water is much less than the amount specified, the amount of power obtainable did not warrant its development.

A 30-foot waterfall, which is being used in running a small mill, occurs on Slate creek, 1,500 feet east of Chaudière river.

Several waterfalls occur on Gilbert river and its main branches. The principal fall, one mile from the mouth, has a drop of 20 feet. For a number of years it was used to run a small mill, only the ruins of which now remain.

A small waterfall on Meule creek, 1,000 feet west of Chaudière river, runs a flour mill.

A prominent waterfall occurs on Caldwell river, having a drop in five steps of 11 feet, in a distance of 100 feet. Near the mouth of the Caldwell a small waterfall is made use of by Mr. Gilbert in running a saw and grist mill.

Numerous other smaller falls occur which add greatly to the scenic attractions of the district.

PREVIOUS WORK

The discovery of placer gold deposits in the Chaudière basin invited the early attention of the Geological Survey, Canada, and descriptions of the area and the deposits, by various members of the Survey staff, have appeared from time to time.

Brief descriptions of the gold discoveries appear in the reports from 1847 to 1851, and a report by T. Sterry Hunt on assay tests on vein quartz and black sand concentrates from the area is found in the report for 1853-56. The information obtained by the early explorations is summarized by Sir Wm. Logan, along with the results of his own observations, in "Geology of Canada", 1863. In this report Logan describes a generalized section along the Chaudière, and some of the rock formations in considerable detail. He also gives an account of the placer deposits, the quartz veins examined, and the occurrences of serpentine, steatite, marble, and clay.

[1]Formerly Bras river.

In the report, "Geology of Canada, 1863-66", A. Michel describes the placer deposits and quartz veins of the Beauce area and Hunt reports on the assay results of quartz samples. He adds a description of the nature and origin of the gold alluvions of Canada, and a brief note on the hydraulic process as employed in California in mining similar deposits.

In 1870 and 1871, A. R. C. Selwyn made a geological investigation of these gold fields together with those of Nova Scotia. An account of this work was published in the Report of Progress of the Geological Survey for 1870-71.

In 1880 and 1881, A. Webster investigated the Chaudière area; his observations are included in the report of A. R. C. Selwyn on "The geology of a southeastern portion of the province of Quebec", Report of Progress, 1880-81-82.

During 1885-1886, R. W. Ells worked on the geology of the Eastern Townships and his results are given in the Annual Report for 1886. He summarizes the previous work in this field and adds considerable data relating to the origin and distribution of the gold.

From 1895 to 1897, R. Chalmers studied the geology of the superficial deposits of this area, and his results are given in the Survey reports 1895-1897.

In 1898, a report by J. Obalski was issued by the Department of Colonization and Mines, Quebec, which reviewed the history of gold mining in this region. The report was accompanied by a map, on a scale of 1 mile to 1 inch, showing the approximate locations of the placer deposits on Meule creek.

Keele's observations on the hydraulicking carried on there in 1911, are recorded in the Summary Report for that year.

In addition to these reports, numerous papers bearing on the region have appeared from time to time. A list of the more important reports and papers is given in the following bibliography.

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CHAPTER II

SUMMARY AND CONCLUSIONS

PHYSIOGRAPHY

The Beauceville map-area exhibits the general relief and matured topography characteristic of the Appalachian Mountain physiographic province. It lies wholly within the Chaudière basin, the physiography of which was modified locally by the advance of the Pleistocene ice-sheet and by the submergence of the lower parts of the district on its retreat. The area has a maximum relief of 900 feet, the highest point having an elevation of 1,380 feet, whereas Chaudière river at the northern end of the map-area is 475 feet above the sea.

In the development of the present mature topography several stages can be detected. In the first place, considerable orogenic movements prior to and following the deposition of the Devonian beds are indicated by the angular unconformity between these and the underlying formations and by the close folding and thrust faulting to which the Devonian as well as the earlier series have been subjected. Secondly, the plateau-like character of the uplands developed on these highly folded sediments suggests the later formation of a peneplain, but the absence of post-Devonian sediments leaves the date of this base-levelling in doubt. These uplands may possibly be remnants of the Cretaceous peneplain supposed to have extended over this part of eastern North America. Thirdly, after being base-levelled the area was considerably raised and warped, and into its elevated surface the streams cut mature valleys reducing most of the region to slope. Rock terraces marking stages in the lowering of these valleys occur at different elevations along Chaudière river and its tributaries. Whether in its early stages the Chaudière conformed to its present course, or took a circular course by way of the broad valleys of Gilbert river and rivière des Plantes, or whether there were two opposite flowing drainage systems could not be definitely determined. The abnormal hour-glass configuration of the present valley of the river considered in conjunction with the difference in direction of the courses of its tributary valleys entering above and below Devils rapids, and other evidence, leave little doubt that during a considerable period in the physiographic history of the area the Chaudière drainage system was composed of two opposite-flowing systems separated by a height of land now marked by a bedrock summit, which traverses the map-area in a northeast-southwest direction in the vicinity of Devils rapids. This condition appears to have existed until late in Tertiary time when orogenic movements are thought to have reversed the course of what is now the upper part of Chaudière river, forcing it to flow northward across the low col which separated it from the northward-flowing stream, and developing the gorge at Devils rapids.

During the glacial period erosion on the uplands and deposition in the valley bottoms resulted in a general lowering of the relief and the imposing

of a youthful topography on the district. These conditions were further accentuated by deposition in glacial lakes or in an estuary of the sea, formed after the retreat of the ice. As a result of this deposition many of the valley bottoms received a deposit of clay which obliterated numerous irregularities in the bedrock and glacial drift. At the time of marine submergence the area stood about 560-585 feet lower than at present. It has since been differentially uplifted to its present altitude and the streams flowing in new courses have cut out terraced valleys in glacial drift or gorges in bedrock.

GENERAL GEOLOGY

The rock formations outcropping at the surface or thinly covered by glacial drift are Devonian or pre-Devonian, and consist of four main series—the Caldwell, Beauceville, Serpentine, and Famine—the areal distribution of which is shown on the accompanying geological map (No. 1835). Numerous small diabase dykes also occur in different parts, but their areal extent is insignificant.

The Famine series, the youngest of the four groups, is the only one which contains a known fossil-bearing horizon and whose age, therefore, can be definitely determined. Fossils collected from these beds place the series as Devonian in age. The series is composed of conglomerate, limestone, and shale, and forms a long, narrow synclinorium plunging northeastward in the common axial direction of the folding of the district. Numerous thrust faults occur within the series and one of these is thought to determine its southern boundary.

Lying beneath this series and separated from it by a marked angular unconformity is the Beauceville series, composed of interbedded extrusive igneous and sedimentary formations which include volcanic tuffs and flows, conglomerates, impure quartzites, and slates. The series is closely folded and is cut by numerous faults. In many places the beds are so altered that it is impossible to distinguish the volcanics from the sediments. The exact age of this series could not be definitely determined, but by long range correlation based on the physical character of the sediments they are placed with known Ordovician sediments.

To the north of the Beauceville series, and evidently in faulted relationship with it, is a thick series of highly inclined overturned formations striking north 32 degrees east and dipping 75 degrees west. This group of formations, to which the name Caldwell series has been given, is composed chiefly of quartzites with minor amounts of slate, but contains in the northeastern part of the map-area a thick formation of volcanic rocks comprising massive and ellipsoidal greenstones, agglomerates, volcanic tuffs, red and green slates, and associated red marble. Owing to the absence of fossils as well as the structural relationship which exists between the Caldwell and the Beauceville series, neither the relative nor the exact ages of these two series were definitely determined, but the presence in the Beauceville conglomerate of quartzite pebbles similar to the Caldwell quartzites suggests that the Caldwell series is the older. According to this the beds are overturned and the younger formations lie to the south of the older

ones across the map-area. There is, furthermore, some structural evidence that this is the case.

Long range correlation based on physical character of the beds places the series as of Cambrian age.

Intruded along the fault zone between the Beauceville and Caldwell series and in the Beauceville series itself in the vicinity of the faulted zone there occurs a group of igneous rocks ranging in composition from basic dunites and peridotites through pyroxenites, gabbros, and diorites to granites and aplites. The magma from which the various types have arisen had differentiated in part at least before intrusion and the intrusions appear to have been in the order of decreasing basicity, as the diorites, granites, and aplites intrude the more basic pyroxenites and peridotites. The igneous bodies have the form of lens-shaped tongues shot along fault planes or other lines of weakness and of irregular-shaped plugs. The age of the intrusive is not definitely known. Intrusion occurred some time after the faulting that brought the Beauceville and Caldwell series in contact. Considerable faulting has also taken place since the intrusion, as is shown by the crushed and slickensided condition of much of the Serpentine series.

Numerous diabase dykes, 1 to 2½ feet in thickness, also traverse the Beauceville and Serpentine series. Although these occur within a short distance of Devonian outcrops and were not seen to cut them, they are possibly Devonian in age.

The unconsolidated formations overlying the solid rock consist of: (1) Tertiary stream gravels, (2) ground moraine, (3) fluvio-glacial deposits, (4) stratified clay and alluvium.

Tertiary gravels occur in the majority of the buried stream channels, and the deposits vary in thickness from one to several feet. They pass downward into decomposed bedrock, and upward into fluvio-glacial gravels, or are terminated abruptly by a deposit of boulder clay. Generally they are auriferous and are the source of most of the gold mined within the map-area.

Ground moraine or glacial till composed of unstratified boulder clay conceals the bedrock over most of the area. On the uplands this covering is generally thin, but in some of the valleys it has completely buried the old stream courses and effected numerous changes in the drainage.

The fluvio-glacial deposits are more localized. They consist of eskers and outwash plains, both of which deposits are composed of stratified sands and gravels.

Deposits of stratified clay occur in different parts of the area. Although most of these deposits were, probably, laid down in glacial lakes, those found in the Chaudière valley are thought to have been deposited in an estuary of the sea which extended up the valley on the retreat of the ice. These deposits, in almost all cases, are capped by more recent gravels and alluvium deposited by the streams during flood conditions.

ECONOMIC GEOLOGY

Gold is the only one of the numerous minerals that has been mined to any extent or which gives any promise of being an important factor.

The district has produced nearly $2,000,000 in placer gold, practically all from the pre-glacial gravels in the deep channels of Gilbert river, Meule creek, and rivière des Plantes and of this amount Gilbert river yielded over $1,500,000. As a result of the various mining undertakings carried on since 1842, the easily accessible deposits may be said to be completely exhausted. There still remain, however, considerable deeply-buried auriferous gravels, but the presence of water and quicksand, the large amount of barren overburden, and the lack of gradient and dumpage room are factors which make the successful mining of such deposits very difficult. This is especially so in the lower part of Gilbert river and the neighbouring part of Chaudière valley. At these localities the auriferous gravels lie about 100 feet below the surface and are covered chiefly by sand and gravels. The only method by which they can be handled is by dredging, and the large outlay of capital necessary for such an undertaking renders their successful mining doubtful. Much shallower auriferous ground is found higher up the tributary streams and it is altogether likely that these deposits will continue for some time to attract small groups of placer miners who can easily earn good wages by carrying on ground-sluicing and small drift mining operations. At present only a few small parties are engaged in this work on Meule creek and Gilbert river.

On Caldwell river a marble quarry has been opened up, but as yet no shipment has been made.

CHAPTER III

PHYSIOGRAPHY

REGIONAL FEATURES

Southeastern Quebec embraces parts of two physiographic provinces, the St. Lawrence lowland and the Appalachian province. The former is a low marine plain bordering St. Lawrence river and the latter forms the northeastern extension in Canada of the Appalachian mountain region of the United States. The two provinces merge imperceptibly into one another, the border extending northeastward from lake Champlain towards the lower part of the St. Lawrence valley. Southeast of Lévis the border is about 13 miles from the St. Lawrence.

The Beauceville map-area lies wholly within the Appalachian province. As a result of orogenic movements the rock formations are aligned into three anticlinal ranges running in a northeast-southwest direction. The highest and most easterly of these ranges, known as the Megantic anticline, forms part of the International Boundary. Farther west, the Stoke Mountain anticline extends northeastward as far as lake St. Francis, where it becomes inconspicuous. An equal distance farther west, a little beyond lake Memphremagog, the Sutton Mountain anticlinal range of hills extends from the Green mountains of Vermont northeastward and eastward to Gaspe peninsula, crossing Chaudière river at Valley Junction. None of the peaks of these ranges attains the elevation of the higher peaks of the Appalachian mountains. The ranges are highest near the International Boundary, and are lower toward the northeast, becoming in places only a little above the general level of the country, but again increase in height and in Gaspe peninsula attain an elevation of 3,500 feet.

Erosion has removed the Palæozoic rocks from the crests of these anticlines, exposing the Precambrian schists in bands of varying widths. The Cambrian and later strata which outcrop on their flanks and in the intervening troughs rest unconformably on the underlying series indicating that orogenic movements had occurred prior to their deposition. Thus, though the present anticlinal ranges are probably of late geological age the intervening troughs have apparently been basins of accumulation of sediments from very early geological time.

The areas lying between these anticlinal ranges have an average elevation of from 900 to 1,500 feet and in places present a remarkably level surface, the whole forming a maturely dissected plateau.

The absence of post-Devonian sediments causes much uncertainty as to the later physical history of the region. During this extensive period of time the region has been subjected to subaerial denudation, probably many changes of level took place, and doubtless several thousand feet of sediments have been removed from the surface. Owing to their greater resistance, the crystalline rocks were, however, not reduced to the level of the surrounding sedimentaries.

Entrenched into this plateau and running in a northwest direction transverse to the structure of the rocks are a series of large rivers of which the Chaudière, St. Francis, and the Etchemin are the three most important. Throughout the greater part of their courses these streams occupy wide, mature valleys, and lie about 500 feet below the general level of the plateau. On the slopes of these wide valleys are rock benches indicating remnants of former base-levels which occurred in the lowering of the valleys to their present depth. At certain places along both the Chaudière and St. Francis valleys, the wide stretches give place to narrow, gorge-like intervals and the evidence obtained indicates that these different parts are of very different ages.

During the Tertiary, the region is thought to have stood considerably higher than at present, for pre-glacial valleys occur to the north, east, and south of the general area, lying hundreds of feet below the present sea-level.

There is much uncertainty also as to the changes of level which occurred during the Pleistocene. At the time of withdrawal of the ice-sheet, parts of the region stood over 500 feet lower than at present as is evidenced by the development of shore features resting on the boulder clay. Since then, differential upwarping has elevated these features to their present altitudes.

LOCAL FEATURES

The Beauceville district lying as it does between the Sutton Mountain and Megantic anticlines presents the general features of a maturely dissected plateau, the uplands having an average height of from 900-1,200 feet above sea-level. The level of Chaudière river at the northern end of the area is 475 feet, and the highest elevation in the district—at Ste. En-Peine—is 1,380 feet, so that the maximum relief on the map-area is approximately 900 feet. The average relief, however, approximates 500 feet. Owing to mature dissection most of the district is on slope, all the territory draining into Chaudière river.

Numerous and marked changes in the drainage of the area have occurred at various times and from different causes. Most of them have been brought about by the unequal deposition of glacial drift, but others are, undoubtedly, pre-glacial. Practically every tributary of Chaudière river has in some part of its course been forced to pursue a direction different from that in pre-glacial times. These new courses are invariably characterized by waterfalls and rock gorges. Twenty-five such waterfalls occur within the map-area. A waterfall is generally developed at the spot where the stream re-enters its pre-glacial channel, and with the migration of the waterfall upstream, a rock gorge is formed. As the falls migrate upstream, they not infrequently leave the tributary streams lying far above the bed of the gorge and forming hanging valleys. A hanging valley 75 feet above the main stream has been developed in this way on the south side of Famine River gorge 3 miles east of Chaudière river (Plate III A) and a similarly developed valley with a drop of 40 feet occurs on the south side of Pozer river 1½ miles west of the Chaudière. In the same way caves, developed in the sides of these gorges by eddies which were caused by projecting

spurs, have been left high above the stream bed and serve to mark the level of the water prior to the migration of the waterfall upstream.

The former and present sites of waterfalls are generally characterized by a development of pot-holes. All sizes of these occur from minute pockets up to holes 5 feet in diameter. Well-developed pot-holes occur in the rock gorges of Famine, Pozer, des Plantes, Caldwell, and St. Victor rivers. Although the forms they assume are in part controlled by the structure of the rock in which they occur, in general they are one-half deeper than wide and are considerably larger at the bottom than at the top so that in section they resemble stockings with the toes pointing downstream.

That rock structure is a most important factor in determining the direction of new channels is evidenced by numerous streams whose courses are determined by the bedding or schistose planes.

The few lakes present are very small and are confined to the uplands near the western border of the map-area, at an elevation of approximately 1,000 feet. These owe their origin to the irregular deposition of boulder clay.

CHAPTER IV

GENERAL GEOLOGY

INTRODUCTORY STATEMENT

The area under discussion is characterized by strata, ranging from Precambrian to Devonian, which at various times and over extensive areas were highly folded, faulted, and intruded by igneous rocks.

As already mentioned, the rocks of southern Quebec form three anticlinal ranges from which erosion has removed the crests, exposing Precambrian schists in bands of varying widths. Cambrian strata outcrop on the flanks and rest unconformably on the lower series, indicating that orogenic movements had occurred prior to their deposition. The troughs between the three anticlinal ranges are occupied, for the most part, by sediments, thought to be Ordovician. These lie unconformably on the lower series and are much disturbed. They, in turn, have infolded Silurian and Devonian sediments which in places, at least, are bounded underneath by an angular unconformity, and are closely folded and faulted.

Associated with these sediments are volcanics and intrusives of various composition. The volcanics consist of ellipsoidal greenstones, tuffs, and flows of several different ages. The intrusives comprise a series of rocks ranging in composition from highly basic dunites through peridotite, pyroxenite, gabbro, diorite, and granite into aplites, all apparently of nearly the same age. Fine-grained diabase dykes and granitic plugs of a later period of intrusion also occur.

The Beauceville map-area lies on the southeastern limb of the Sutton Mountain anticline and representatives of most of the sedimentary and igneous rock formations of the Appalachian mountain province are found within its borders. Over 95 per cent of the area is underlain by sedimentary and volcanic rocks believed to range in age from Cambrian to Devonian. The Devonian beds are the only ones which have yielded abundant fossils and whose age is definitely known. Two small brachiopods were obtained from the underlying Beauceville series, but the species was undeterminable. The state of development of these forms, the physical characteristics of the series, and its relationship to the overlying Devonian beds combine in placing it in the Ordovician. The rocks which are designated as the Caldwell series bear a structural relationship to the Beauceville series, indicating that they are the older. From their physical characteristics they are correlated with sediments of Cambrian age.

The various deep-seated igneous bodies which underlie the remaining part of the area are differentiates of the one main intrusive. The differentiation probably took place before the magma was intruded. The exact age of the intrusion cannot be determined, but it occurred some time after the faulting which brought the Beauceville series in contact with the Caldwell. On the other hand, the Devonian sediments of the area are not known to be intruded by igneous rocks.

Table of Formations

Era	Period	Series	Description
		Sedimentary and Interbedded Volcanic Rocks	
Quaternary	Recent and Pleistocene		Alluvial deposits (gravel, sand, and silt). Marine and glacial lake deposits (stratified clay and sand). Fluvio-glacial deposits (eskers). Glacial deposits (ground moraine).
		Unconformity	
Cenozoic	Tertiary		Alluvial deposits (stream gravels in places cemented, oxidized clay, decomposed bedrock).
		Unconformity	
	Devonian	Famine series	Shale, slate, limestone, and conglomerate.
		Unconformity	
Palæozoic?	Ordovician?	Beauceville series	Sediments—slates, impure quartzites, conglomerates. Volcanics—acid tuffs, rhyolite flows, agglomerates.
		Faulted Contact	
	Cambrian?	Caldwell series	Sediments—impure to pure quartzites, slates. Volcanics—red and green slates, ellipsoidal greenstones, agglomerates, tuffs, marbles.
		Igneous Rocks	
	Devonian?	Serpentine series	Diabase dykes—fine-grained granite. Dunite, gabbro. Pyroxenite (partly serpentinized). Peridotite, dunite (in places wholly serpentinized).

DESCRIPTION OF FORMATIONS

It seems advisable to deal separately with the sedimentary and interbedded volcanic rocks on the one hand, and with the intrusive igneous rocks on the other, because neither the exact ages of the intrusives rocks nor their relative ages with respect to some of the sedimentary formations are yet known. They are possibly Devonian, but whether they are older or younger than the Devonian sediments could not be determined.

The sedimentary and interbedded volcanic rocks range in age probably from the Cambrian to Recent. They include sediments and associated

volcanics of Cambrian? and Ordovician? ages, sediments of Devonian age, gravels of late Tertiary age, and till, stratified clay, gravels, sands, and silts of Quaternary age.

CALDWELL SERIES (CAMBRIAN?)

Rocks believed to be of Cambrian age occupy most of that part of the area northwest of St. Victor river and rivière des Plantes. They consist largely of sedimentary rocks, principally quartzites with minor amounts of slate but also of an important interbedded volcanic member. These formations are designated the Caldwell series after the river of that name which traverses them. Glacial drift and forest growth conceal the greater part of the bedrock, especially northwest of St. Victor river. Sufficient scattered exposures occur, however, to establish the structure and general relationship of the formations. The southeastern border of the series which has been fairly accurately determined across the map-area follows a remarkably straight course extending from the gorge on St. Victor river 3 miles west of Chaudière river northeastward along that river, and past the mouth of rivière des Plantes to the eastern edge of the area.

SEDIMENTS

The sedimentary members occupy about nine-tenths and the volcanic members one-tenth of that part of the map-area underlain by the Caldwell series. The sediments consist principally of massive quartzite and less massive beds of black, grey, and green slate.

The quartzite beds vary greatly in thickness, in texture, and in degree of sorting. Beds 60 feet thick were observed. In some the individual quartz grains are one-quarter inch in diameter, whereas in others they are of microscopic dimensions. Some beds are composed of pure silica; other beds are largely argillaceous. Gradations from coarse-grained quartzite through fine-grained quartzite into slates are common. On fresh surfaces the quartzites are a decided green, but on weathering they assume various shades of light grey, light red, and light brown. In the more massive beds the bedding is distinct and little if any schistosity is developed. In other beds the quartzites have been changed by dynamic metamorphism into either quartzitic or sericitic schists, according to the relative amounts of argillaceous material they contained.

The strata have a general strike of north 40 degrees east and are either vertical or dip to the west at high angles. Faulting within the sedimentary formation is indicated by local differences in strike and dip of adjacent beds. Apparently the series is overturned. The variation in size of grain in individual beds; crossbedding; the plane-convex forms both of lenses of mechanical deposition and of erosion scours; all point to such a conclusion. Further corroborative evidence of overturn is supplied by the associated volcanic formation.

VOLCANICS AND ASSOCIATED SEDIMENTS

The Caldwell volcanics and associated sediments comprise massive and ellipsoidal greenstones, agglomerates, and tuffs together with red slates

and red marble, the slates and marble being of undoubted sedimentary origin. They occupy a wedge-shaped area in the vicinity of Caldwell river near the northern border of the map, extending from Chaudière river northeastward to beyond the confines of the map-area. The beds strike north 32 degrees east and dip 75 degrees west. At the eastern border of the area the formation has a thickness of 3,000 feet, but on being traced southwestward the formation decreases in thickness and on Chaudière river is less than 1,000 feet thick. What appears to be an off-shore phase of the same formation occurs in a comparatively small outcrop of highly-folded, thin-bedded, red and green slates at the western edge of the area 500 feet north of the St. Victor River road. This outcrop lies along the projected strike of the formation and the slates bear the same relationship to underlying and overlying quartzites as does the main mass.

Diligent search for other possible outcrops between this locality and that of the main mass failed to reveal any similar rock, but in the St. Victor River channel, near the southwestern border of the map, there are glacial erratics of ellipsoidal greenstone identical with that of the Caldwell series, which suggests the possibility of drift-covered remnants lying between these two localities.

The following section obtained in passing across this volcanic formation from south to north at the marble quarry, Caldwell river, 1,000 feet east of Chaudière River road, gives an idea of its complex nature. Members are listed in descending order. The beds strike north 32 degrees east and dip 75 degrees west. The formation is overturned. Observed thickness, 1,341 feet.

Description of Member

	Thickness Feet
Dirty green, impure quartzite	Overlying bed
Greenish white, volcanic ash changed to sericitic schist	90
Red, sandy schist, a volcanic tuff shows inclusions of red slate	13
Dark brown slate, highly schistose, on schistose planes rocks tarnish to purple	12
Red marble composed largely of calcite but contains fragments of red tuffaceous marble and red slate. In places grades into a dark brown slate	7
Red to dark grey volcanic tuff, highly schistose, contains inclusions of red slate	3
Tuffaceous red marble, laminæ $\frac{1}{16}$ inch in thickness, cut by calcite veins	11
Red slate	17
Red, ellipsoidal lava	33
Red, ellipsoidal lava, individual pillows distinct, separated by volcanic tuff material which is more resistant to weathering than the pillows	50
Volcanic flows—ellipsoidal lavas	115
Volcanic tuff, fine fragments of red slate embedded in green sericitic material. Fragments oriented along planes of schistosity	7
Ellipsoidal lavas, flows about 1 foot thick, distinct pillows separated by volcanic ash, consisting largely of chloritic material with epidote, calcite, and quartz. Pillows show radial jointing and differential weathering	61
Crushed flow breccia—composed of irregular angular fragments of pillows embedded in a greenish white matrix composed largely of quartz, epidote, and chlorite. Fragments vary in size up to pieces size of man's fist	20
Ellipsoidal lavas: pillows distinct, range in size to individuals 3 feet in length and 2 feet in thickness. Many pillows show a gradation in colour from surface to the centre, passing through various shades of purple-brown and green. Cavities wholly or partly filled with quartz exist in many of the pillows	58
Volcanic flow breccia (fragmental pillow lava)	15
Volcanic tuffs—slaty	10

	Thickness Feet
Greenstone, pillows indistinct	30
Crushed breccia (fragmental pillow lava)	10
Greenstone, pillows indistinct	10
Crushed breccia	2
Massive greenstone bed	15
Volcanic flow breccia: pillows fractured and separated; fragments 2 inches by 4 inches embedded in ashy material	25
Well-developed pillows	15
Flow breccia—polygonal fragments of pillows separated in places by only a few inches	5
Volcanic tuff showing shaly beds	7
Massive greenstone—light green to purple	20
Volcanic tuff	10
Crushed volcanic breccia formed by breaking up of pillows	100
Greenstone—individual flows apparent, pillows in places distinct	220
Massive greenstone—pillows only poorly developed, individual flows distinguishable in places	270
Pillow lavas	20
Massive greenstone—pillows indistinct—varies in colour through light green, dark green, brown, dark red, to dark purple	260
Dirty green, impure quartzite	Underlying bed

MASSIVE AND ELLIPSOIDAL GREENSTONE

The greenstones of the Caldwell series present a variety of colours. On the fresh rock dark red and green shades prevail but on the weathered surface various shades of yellow, green, purple, brown, and red occur. The rock is generally of a fine-grained aphanitic texture, microscopic examination showing it to be a basalt. Locally it is porphyritic, the phenocrysts of plagioclase feldspar being in places $\frac{1}{10}$ inch in length. The phenocrysts are embedded in a fine-grained groundmass composed largely of incipient feldspar crystals. The rock is cut by numerous veins of quartz, epidote, and calcite, and as a result of metasomatic alteration the feldspars are changed into these minerals. Where epidote and quartz occur together, the epidote is later than the quartz and occurs as crystals filling druses in the quartz or as comb structure in open fractures.

The greenstones vary in constitution from massive beds in which the bedding is indistinct or altogether unrecognizable to less massive beds in which the individual flows are plainly distinguishable. In many of these flows ellipsoidal or pillow structure is perfectly developed. This structure consists of a series of pillow-like masses ranging in size up to forms having a length of 4 feet, a width of 3 feet, and a thickness of $1\frac{1}{2}$ feet (Plate III B). Many of the pillows are characterized by peripheral and radial joint planes, evidently developed by rapid cooling. Weathering along these joints gives to the rock a brilliant display of colours. Some pillows present a zonal arrangement of colours. The outer zone, about $\frac{1}{4}$ inch thick, is a dark purple, the succeeding zone, $\frac{1}{2}$ inch to 6 inches in thickness, is bleached light green, an inner zone is brown, and the centre of the pillow shows shades of light green and purple. The interpillow spaces are filled by greenish fine-grained material, composed largely of chlorite and epidote with smaller amounts of quartz, so altered, however, that it is impossible to determine whether it is of sedimentary or volcanic origin. This material

is much more resistant to weathering than are the pillows, and stands out as bordering ridges and triangular-shaped masses ½ inch or more above the enclosing pillows.

Although the pillows are of irregular shape, one side of the pillow usually is bulbous and the shape of the other side is determined by the irregularities of the adjacent bed. Thus, when the pillows are in contact with tuff beds they present a flat surface on the adjacent side, but when in contact with other pillows this side of the pillow is wedge-shaped, so that the pillows fit snugly into one another. These forms obtain over most of the area and are seen in vertical section on a 60-foot cliff at the mouth of Caldwell river.

The forms which pillows assume have frequently been made use of in determining the top and bottom of beds, the bulbous side being the top and the flat or wedge-shaped side the bottom. This is the case in these volcanics, whose attitude, as determined by these structures, agrees perfectly with that indicated by the evidence of the overlying and underlying sediments.

Amygdaloidal structure is common in the pillows, many of the amygdules being over 1 foot in length. They are wholly or partly filled with quartz, calcite, and epidote. Many of the amygdules have a pillow-like form.

The conclusion that these pillow structures are of subaqueous development is based on the peripheral and radial fracturing of the pillows, developed, probably, by contraction through rapid cooling, the bulbous form of the pillows, and the close association of the flows with marble beds which are of undoubted sedimentary origin.

AGGLOMERATES

The agglomerate or flow breccia of this formation is composed of fragments of pillows, ranging from pieces a fraction of an inch in thickness to masses the size of a man's hand. All gradations occur from pillows which are merely separated into pieces by the intersection of the radial and peripheral joint planes to beds composed of a mass of jumbled fragments which are either embedded in ash or cemented by quartz, calcite, and epidote. There is little doubt, therefore, that these agglomerates were formed by the rapid cooling and movement of the pillows during the time the rock was in a state of flow.

TUFFS

The tuffs of the formation vary in texture from fine-grained varieties resembling well-sorted sediments to coarse-grained types composed of fragments of red slate and greenstone embedded in a fine-grained groundmass of ash, chlorite, epidote, and quartz. In places the fragments make up over 60 per cent of the rock.

SLATES

Red and green slates, most of which appear to be of volcanic origin, occur throughout the formation. In places the slates include fragments of

greenstone, and all gradations from coarse-grained varieties to fine-grained ash were observed. The finely-bedded slates north of St. Victor River road at the western border of the map were probably laid down under water, as were some of the finely laminated red slates associated with the marble beds.

MARBLE

Marble forms a very small part of the formation, being confined to two beds of 7 and 11 feet in thickness, found on the southeast side of Caldwell river, and traced, by means of isolated outcrops, for a distance of 2 miles from Chaudière river. The beds lie near the top of the formation and are overlain, underlain, and intercalated by beds of fine volcanic ash. The marble is of a light pink to dark red colour. The beds are conformable with the associated volcanics, dip steeply towards the northwest, and are greatly folded, faulted, and brecciated, so that in places they contain a considerable proportion of the associated volcanic tuff scattered through them. Thickening of beds at the crests of folds and thinning on the limbs is very conspicuous.

The volcanic formation is everywhere highly inclined, the beds possessing a somewhat uniform strike of 32 degrees east of north and a dip of about 75 degrees to the west. As indicated by the form of the pillows the formation lies in an overturned position, and this overturn is confirmed by the evidence of the conformable overlying and underlying sediments.

The different members of the formation are faulted and locally show evidence of intense brecciation, the fragments being firmly cemented by quartz or calcite. In places a sheeted structure is developed trending with the strike of the flows but cutting through them at a marked angle to the bedding.

The great variation which exists in the thickness of the formation when traced northeasterly from Chaudière river; its abrupt termination at the Chaudière in a cliff over 60 feet in height; the difference in the general strike of the flows and the trend of the northwestern boundary of the formation; the presence of a fault in the gorge of Caldwell river at the eastern border of the map-area; and the alignment of valleys between this locality and the lower part of St. Victor river strongly support the conclusion that a fault determines the northwestern border of the volcanic formation. Actual proof of the fault, however, is not possible because of the contact of the volcanics and drift that obscures the adjacent sediments.

BEAUCEVILLE SERIES (ORDOVICIAN?)

The series herein designated the Beauceville comprises a group of extrusive igneous and sedimentary rocks which include acid tuff, rhyolite flows, slates, impure quartzites, and conglomerates. Slate makes up by far the greater part of the series, the incompetent members of both sedimentary and igneous origin having been converted into this rock by the earth movements to which the series has been subjected. Owing to the difficulty of distinguishing between the component volcanic and sedimentary beds and of working out the complicated folded and faulted structure

which the series exhibits—and this is made even more difficult by the mantle of glacial drift—only a rough approximation was obtained of the thickness of the series. The greatest measured thickness of sediments obtained was over 5,000 feet, but from the uniformity of dip the thickness in places appears to be almost 2 miles.

These rocks underlie approximately 85 per cent of the area. The northern border of the series runs northwestward along St. Victor river, across the mouth of rivière des Plantes, and along the southern slope of the ridge lying between rivière des Plantes and Caldwell river. The whole area south of this line, with the exception of a narrow belt of Devonian rocks south of Famine river, is underlain by rocks of the Beauceville series. Within this area there is a partially selective distribution of the component members of the series. The conglomerates are confined to the northern part of the area, and the acid tuffs, although widely distributed, have their greatest development in the neighbourhood of rivière des Plantes. The remaining members of the series appear throughout the area at irregular intervals because of the intricate and close folding which characterizes the series.

VOLCANICS

Acid Tuffs

Beds of acid tuff or volcanic ash closely associated with rhyolite flows are widely distributed, but principally in the vicinity of rivière des Plantes, where they extend over more than a square mile and their minimum thickness exceeds 1,000 feet. The tuffs vary greatly in texture. In some, the fragments are microscopic and the beds resemble a fine-grained sedimentary rock; in others the fragments have a length of 4 or 5 feet and are so numerous that the rock may be correctly termed an agglomerate. The inclusions consist largely of rhyolite, but there are some of slate and quartzite. The groundmass is of rhyolitic material in a much finer state of division. Banding is perfectly developed in some of the fine-grained varieties and is so conspicuous that at a distance the beds resemble true sedimentary rocks. The bands vary from $\frac{1}{10}$ inch to $1\frac{1}{2}$ inches in thickness and run perfectly parallel for hundreds of feet. This banding is apparently due to differences in texture of the material. Where the rocks have been subjected to later mineralization by carbonated solutions this difference in texture is clearly brought out, the more porous layers being much more highly altered than are the more compact beds. In this alteration the feldspars have been changed into calcite, and the pyrite into iron carbonate, giving to the altered bands a reddish brown colour.

As a result of the forces to which these beds were subjected the included fragments have been considerably flattened, elongated, fractured, and oriented into positions more or less parallel to the foliation of the rock. Many of the fine-grained beds are more resistant to weathering than the adjacent slate beds, and stand out conspicuously above them. The bed crossing the Chaudière at Devils rapids is a fine-grained acid tuff. In some of the coarser-grained varieties the fragments are so loosely held in the matrix that they can easily be removed with a hammer.

Rhyolite Flows

The rhyolite flows which are widely distributed seldom exceed 100 feet in thickness. They have a slate-grey colour, and are composed of a fine-grained groundmass of plagioclase feldspars, and quartz, in which occur lath-shaped phenocrysts of plagioclase feldspar, quartz phenocrysts, and amygdules, many of which are filled with quartz. As a result of later mineralization by carbonated solutions the feldspar and pyrite are altered into carbonates. Through pressure many of the flows are changed into slates. Under the microscope the phenocrysts of the rock and the quartz amygdaloids are seen to be fractured and faulted, and the fractures filled with later quartz. On weathering many of the volcanic flows assume an earthy-brown colour, the weathered feldspar phenocrysts giving to the rock a speckled appearance.

SEDIMENTS

Slates

The Beauceville sediments are made up largely of slates and impure quartzites with minor amounts of conglomerate. The slates form by far the larger part of the series. The individual slate members vary from beds a foot or less in thickness to massive beds 120 feet thick. Certain exposures indicate a thickness of over 200 feet, but this is due to the close folding to which the series has been subjected.

The slates have been formed from incompetent beds of both sedimentary and igneous origin, and it was found impossible in many cases to determine in the field whether the rock was derived from a true sediment or from a volcanic. In cases of doubt the rock was generally assigned to the sedimentary phase of the series, and consequently the volcanic rocks of the series are doubtless more prevalent in the field than the outcrops on the map would indicate.

Impure Quartzites

Beds of impure quartzite are found in different parts of the area, but quartzite beds composed of pure silica do not occur. The impure beds were undoubtedly derived from the re-sorting of the volcanic ash, as all gradations from the one rock type to the other were noted, making it extremely difficult to draw a dividing line. In cases of doubt the beds were mapped as sedimentary, so that many of the rocks shown as belonging to this phase doubtless belong to the volcanic phase. The beds have an average thickness of 60 feet, the maximum thickness observed being 110 feet. They lie interbedded with the slates and, being more resistant, form conspicuous ridges.

Conglomerate

Conglomerates tentatively placed in the Beauceville series occur in the vicinity of rivière des Plantes and St. Victor river, fringing and apparently overlying a massive acidic tuff member belonging to this series. Along the northeasterly-running roadway, a mile south of rivière des Plantes, small

outcrops of conglomerate occur at distances of 1,000 feet, and a mile east of Chaudière river. Almost directly opposite this locality on the west side of the river, a series of small exposures occurs ½ mile west of the main roadway. Another exposure of small areal extent is found on the north bank of rivière des Plantes just east of the main highway. Still another outcrop of conglomerate differing somewhat in composition from the others, in being composed largely of slate pebbles, occurs on St. Victor river at the western limit of the area.

Most of the pebbles found in these various outcrops are less than 4 inches in diameter and are composed of impure quartzite, acid tuffs, and slates, the slates, with the exception of the outcrop on St. Victor river, being present in inappreciable amounts. From their composition the pebbles appear to have been derived from the quartzites of the Caldwell series and from the acid tuff member which is placed in the lower part of the Beauceville series. The absence of slate pebbles in most of the conglomerate outcrops suggests that the conglomerate is possibly older than the greater part of the Beauceville series which is composed principally of slate. For these reasons most of the outcrops are thought to be of an intraformational conglomerate belonging to the lower part of the Beauceville series. At one outcrop, however, lying about 1,000 feet west of Le Rocher post office, what appear to be large blocks of granite, some of which are 10 feet in length, occur embedded in a slaty matrix. A plug of similar granite intrusive in peridotite occurs a few thousand feet distant, and as the peridotite in turn is found to be intrusive into the Beauceville series, this conglomerate appears to be considerably later in age, possibly as late as post-Devonian. In the absence of further data the question as to the age of the conglomerate must remain open.

STRUCTURE

The Beauceville series has been much disturbed from its original more or less horizontal position by the earth movements to which this part of North America was subjected. It now forms part of a broad synclinorium characterized by a series of closely folded anticlines and synclines. It is intricately faulted, and its incompetent members of both sedimentary and igneous origin have been converted into slates. The folds have an average strike of north 39 degrees east, and plunge generally to the west at from 2 to 28 degrees. The axial planes of most of these folds, as indicated by the cleavage planes of the slate members, dip to the north. The folding has been so close that over most of the area the dips of the beds are seldom less than 60 degrees. In a few places, however, as at the bridge crossing Gilbert river, and a mile west of Chaudière river, along the continuation of the fold, the crest of the fold is over 1,000 feet in width. Near rivière des Plantes, also, beds of acid tuff appear to form another broad anticline. Folds of various orders of magnitude occur. The axes of the major folds lie a mile or more apart; within these occur smaller folds, the axes of which are about 500 feet apart. These in turn include still smaller folds a few yards across, and in the incompetent slate members these folds give place to minor crenulations.

In an area characterized by such close folding numerous faults may be expected, especially of the thrust type. Along many of the faults the displacement of the beds is small, but on others it is measured in hundreds of feet. The complex nature of much of the faulting and folding and the obscuring of a great part of the bedrock by glacial drift and timber growth rendered impossible the tracing of the beds in detail. Some idea of the complex nature of the faults and folds may be had from Figure 2 which represents the structure of the beds at the flour mill on Pozer creek, 3,000 feet west of Chaudière river. The beds of slates and impure quartzites are here standing on edge with the plunge of the fold vertical, and in a distance of 75 feet along the strike of the beds nine dislocations were observed.

Relations to Older Formations

On the northwest the series lies in apparent faulted relationship with the Caldwell series, which has been shown to be overturned, but in no place was their actual contact observed. The nearest approach to an actual contact is on St. Victor river at the bend at the western edge of the area. Here, the two series lie in highly inclined unconformable attitudes about 100 feet apart, separated by a tongue of the Serpentine intrusive. From here the faulted contact of the Beauceville and Caldwell series extends in a northeasterly direction along St. Victor river across the mouth of rivière des Plantes and along the southern slope of the ridge lying between rivière des Plantes and Caldwell river. Owing to the drift which obscures the bedrock, the course of this fault plane as shown on Map 1756 is necessarily approximate only.

Relations to Younger Formations

South of Famine river the Beauceville series lies unconformably beneath Devonian rocks, indicating that considerable diastrophism and folding of these beds had taken place before the Devonian rocks were deposited. The form of the Devonian outlier indicates that as a result of this folding an embayment was found in the Beauceville land surface in which the Devonian rocks were deposited.

SPECIAL STRUCTURAL FEATURES

Washboard Structure

Certain of the slate members of the Beauceville series exhibit a peculiar structure which, as far as the writer is aware, has not previously been described. It was observed in two widely separated localities on Bernard creek and Slate creek, being best exhibited at the top of the small waterfall on Slate creek, 2,000 feet east of Chaudière river, where it is exposed on a surface 25 feet by 10 feet. This surface is corrugated in a direction normal to the bedding planes of the slate. The beds strike north 40 degrees east and dip 57 degrees south, whereas the corrugated surface strikes north 53 degrees east, and dips 33 degrees north. The corrugations consist of a series of saw-tooth ridges and troughs running parallel to the bedding of the slate (Plates VI A, B, C). The ridges are on an average

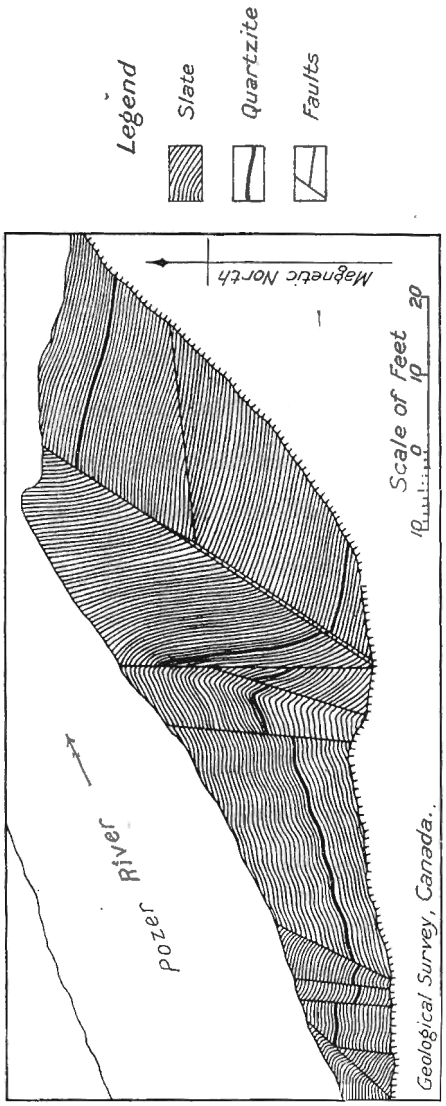

Figure 2. Plan showing folds and faults, Beauceville series.

0·2 inches apart and the distance from the base of the trough to the top of the ridge is also about 0·2 inches. The ridges and troughs are characterized by thinning and swelling due to later movements along a series of schistose planes, which cut the slate at an angle of about 15 degrees to their trend. These schistose planes lie at an angle of about 45 degrees to the corrugated surface, and determine one slope of the corrugation. In places the corrugated surface merges into a finely striated plane.

In the same zone as the corrugated surface are three sets of joint planes intersecting it at angles of 15 degrees, 80 degrees, and 90 degrees, none of which shows any signs of corrugations. Another corrugated surface lying parallel to the first occurs about 3 feet distant.

The corrugated surface resembles ripple-mark more closely than it does any other structure, but as it lies normal to the bedding, this origin is precluded. A possible explanation is that it is a joint plane that has become corrugated through later movement. This theory receives substantial support from the fact that in places the flutings of the surface become less pronounced and the corrugated surface passes into a plane marked by finely spaced striæ and ridges. The fluted surface was, probably, developed prior to the formation of the other joint planes which show no corrugations.

Concretionary and Bomb Structures

What appear to be concretionary structures occur in both the slate and volcanic ash members of the Beauceville series. In the slate members they appear to be true concretions. They are generally small and globular averaging a few inches in thickness, but a few ovoid forms having a length of a foot were observed. The slate concretions, which are identical in composition and physical characters with the enclosing rock, are composed of a dark, fine-grained compact mass which breaks with a conchoidal fracture, and in which the schistosity is very poorly developed.

In the impure quartzite or stratified ash beds ovoid forms of a different origin occur. Although most of these forms average 2 feet in length, some of them have a length of 3½ feet, a width of 3 feet, and a thickness of 2 feet. The forms apparently always lie with their longer axes conforming to the bedding, and the bedding planes of the rock wrap about the structures rather than traverse them, so that when a bed was cleaved along the laminæ the compressed ovoid structure which it enclosed remained intact. The structures are composed of a dense, uniform mass of acidic tuff and show no evidence of radial growth. Exfoliation layers characterize their surfaces.

The structures are well developed in Famine River gorge 3 miles east of Chaudière river. Here, numerous forms occur embedded in two stratified ash beds which lie about 100 feet apart. The beds at this locality strike north 70 degrees east and dip 63 degrees south and the forms which are greatly compressed conform to the bedding. Stream erosion has exposed them so that they now project above the beds in which they lie.

The quartzite beds in the Beauceville series have been largely derived by sorting of the volcanic ash, and all gradations from quartzite to true volcanic ash occur. The presence of these structures in volcanic ash beds, the fact that the bedding planes of the rock do not pass

through the structures but wrap about them, and that the surfaces of the forms are characterized by exfoliation layers, suggest that the forms are bombs which were shot out when the ash beds were being deposited. The compressed ovoid shapes have been developed by the earth movements to which they have been subjected since they were enclosed in the sediments.

DEVONIAN

FAMINE SERIES

Distribution

The rocks of known Devonian age are confined to a belt 1,500 feet in width lying southeast of Famine river and extending from Chaudière river northeastward beyond the map limits. This group of rocks is designated the Famine series from the river of that name, near which it occurs. It comprises a basal conglomerate member, an intermediate shaly limestone member, and overlying shale members. The fauna of the upper part of the limestone member, which is highly fossiliferous, places it as probably of Onondagan age. Glacial drift conceals all but a small fraction of the series and the total thickness of the series could not be determined.

The conglomerate formation referred to on page 27 occurs 10 miles northwest of this belt and may possibly be of the same age as the Famine series. It contains granite boulders of the Serpentine series which may be of Devonian age.

Conglomerate. The conglomerate which forms the lower member of the Famine series is about 50 feet thick and is composed largely of boulders of quartzite, vein quartz, slates, tuffs, and volcanic flows. All these boulders are firmly cemented in a shaly matrix, which through earth movement has been changed in places to a slate. The boulders average 2 inches in diameter, but in the basal part of the bed boulders over a foot in diameter are common. The boulders are generally elongated and flattened, and oriented with their longer axes parallel to the axial lines of the folds (Plate VII). This member can be traced along the southern slope of Famine valley and southward for a distance of 1,300 feet to where it is cut off by a fault. The best exposure of conglomerate is seen on the glaciated slope of Chaudière valley just west of the macadam highway 3,000 feet south of Famine River road bridge. Here the outcrop is about 100 feet in width and the conglomerate overlies the limestone which elsewhere is found overlying it, so that at this locality there is evidently an overturn to the structure. Elsewhere the conglomerate lies on the eroded and upturned edges of the various members of the Beauceville series.

Limestone. Overlying the conglomerate conformably is a shaly limestone bed which grades upward into a highly fossiliferous limestone. This bed is about 40 feet thick but in places it has been considerably thickened by close folding and crumpling. As a result of its resistance to erosion the limestone forms a prominent projection from the western edge of the ridge south of the Famine. Two hundred feet east of the macadam highway several quarry excavations in the limestone beds give excellent exposures for the collecting of fossils. Forty species have been

determined from this locality and this number could be considerably increased should systematic collecting be undertaken. As the outlier is one of the principal outcrops of Devonian rocks in this part of Quebec an exhaustive search for the fauna it contains is well worth while.

The following lists indicate that the beds are probably of Onondagan age.

Fossils Collected from Devonian Limestone, Famine River Locality

	Those listed in Geology of Canada 1863, p. 428, determined by E. Billings.	Those listed in Geol. Surv., Can., Annual Report, 1887–1888, vol. III, pt. II, p. 10 K, determined by H. M. Ami.	Those collected 1917, determined by E. M. Kindle.
Corals	Favosites gothlandica	Favosites gothlandicus	
	Favosites basaltica		Favosites basaltica
			Favosites cf limitaris
		Favosites sp. indt.	
			Alveolites sp.
	Diphyphyllum arundinaceum	Diphyphyllum	Diphyphyllum arundinaceum
		Syringopora hisingeri	Syringopora hisingeri
		Cyathophyllum ?	Cyathophyllum ?
	Zaphrentes sp. indt.		
	Heliophyllum oneidaense		
Crinoids		Crinoid fragments	
Fenestelloids			Fenestella sp. indt.
Brachiopods	Strophomena rhomboidalis	Strophomena rhomboidalis	
		Stropheodenta (2 sp.)	Stropheodonta
	Productus (small form)	Productus?	
			Productella
			Athyris spiriferoides
	Chonetes (2 sp.)		Chonetes cf arcuata
		Atrypa reticularis	Atrypa reticularis
			Atrypa spinosa
	Spirifera gregari	Spirifera gregari	Spirifera gregaria
	Spirifera duodenaria		Spirifera duodenaria
		Spirifera sp. indt.	
	Spirifera acuminata		
			Camarotœchia
	Orthis striatula		
		Orthis sp. indt.	
			Orthothetes pandora
	Cyrtia like C. rostrata		
		Leptocœlia flabellites	
			Meristella cf nasuta
			Actinopteria cf boydii
Pelecypods		Pterinea textilis	
Gastropods		Paracycles	Paracyclas cf lirata
			Macrocheilus cf macrostomus
			Orthoceras
Trilobites		Proetus crassimarginatus?	
			Proetus sp.
		Phacops sp. indt.	
			Acidaspis

Shales, Etc. Overlying the fossiliferous limestone horizon conformably is a series of shale and limestone beds of undetermined thickness. The

lower member is a 40-foot bed of soft shale. This is followed by a limestone member the individual beds of which are 1 foot thick. This in turn is overlain by an 80-foot bed of soft shale containing thin beds of limestone. Towards the top the shale is so soft that it can be cut easily by a knife, and it is traversed by numerous veinlets of calcite. Glacial drift completely obscures most of the rock surface, hence the overlying members of the series could not be determined.

Structure

The rocks of the Famine series have been folded and afterwards eroded so that what now remains is in the form of a closely folded and faulted synclinorium. The conglomerate bed marking the northern limb of this synclinorium has been traced for several miles along the southern slope of Famine valley. Just east of the macadam highway at Chaudière river the western end of the trough occurs. Here the border of the synclinorium turns abruptly southward and its closely folded and faulted nature is seen to best advantage. The basal conglomerate with the overlying limestone and shale members are seen to be closely folded into a W form. A thrust fault running more or less parallel to the trend of the fold cuts the series near the centre of the synclinorium, causing a repetition of the conglomerate and limestone beds. Thirteen hundred feet south of the northern border of the synclinorium a second thrust fault terminates the conglomerate bed abruptly, and brings the underlying Beauceville series in contact with it. The entire absence of conglomerate outcrops northeast of this exposure and the marked difference in dip of the rocks in adjoining outcrops suggest that the fault continues northeastward and determines the southern border of the series. Owing to the paucity of exposures the exact course of this fault could not be determined and its course as indicated on the map is approximate only.

That considerable orogenic movements took place between the laying down of the Beauceville series and the deposition of the Famine conglomerate is indicated by the angular unconformity between these two series. This unconformity is best exhibited in the bed of the creek that empties into Famine river a mile east of Chaudière river. Here, the contact of the two series is distinctly visible. The underlying slates of the Beauceville series dip 68 degrees south, whereas the conglomerate bed dips 26 degrees south.

TERTIARY

Stream gravels and associated deposits of decomposed bedrock which are clearly pre-glacial and are probably late Tertiary in age occur within the area. These gravels are the principal source from which the placer gold has been derived and they attract more than ordinary attention especially as their presence is least expected in a heavily glaciated district.

The gravels occur in the buried channels of most of the main tributary streams of Chaudière river, especially along those sections of the deep channels which lie transverse to the general direction of ice movement. They are, generally, buried beneath a blanket of drift which is in places 100 feet thick. This overburden is most often composed, in ascending

order, of blue clay, quicksand, boulder clay, and recent stream gravels. As all the old mining excavations have long since caved in, the character of the deposits can be determined only from the few exposures made either by stream-cutting or by recent mining operations.

In most of these exposures the gravel bed is less than 5 feet thick and is composed entirely of boulders of local origin including slates, tuffs, feldspar, porphyries, and vein quartz. The gravel possesses a characteristic yellow colour which clearly distinguishes it from overlying fluvio-glacial or Recent stream gravels. In the lower part of the gravel bed the boulders are intermixed with a yellow, plastic clay having a greasy feel and a putty-like consistency. This clay—which was undoubtedly derived by decomposition of the slate bedrock—is only a few inches thick and grades downward into fractured bedrock and fresh unaltered slates. It contains numerous cubic limonite pseudomorphs after pyrite, which mineral is very abundant in the slate. The edges and corners of these forms are perfectly sharp, indicating that little if any transportation of the material has taken place. In the deep channels of Gilbert river, Meule creek, and rivière des Plantes the gravels and decomposed bedrock were found to be highly auriferous. In the deposits of Gilbert river numerous nuggets, one of a value of $851, were recovered. The nuggets, though greatly waterworn, were probably from the upper parts of veins which cut the various members of the Beauceville series near these deposits and of which only the barren roots now remain.

An outcrop of cemented gravels believed to be of Tertiary age occurs on the north side of rivière des Plantes about 1,500 feet east of the main road bridge (Plate VIII). These gravels rest on a bevelled surface of serpentine and lie 15 feet above the level of the river. They consist of waterworn boulders of local origin embedded in sand. Both boulders and sand are firmly cemented and stained a dark brown to black by iron oxide. The gravels, which contain a large amount of black sand, are only slightly auriferous.

QUATERNARY

PLEISTOCENE

Abundant evidence within the area indicates that during Pleistocene time this part of eastern North America was completely buried beneath an ice-sheet of great thickness. Boulder clay and glacial striæ occur on the highest hill in the area, at an elevation of 1,380 feet, and at points much higher just outside the limits of the map.

Over most of the area the bedrock is concealed by a mantle of ground moraine composed largely of rock flour in which are embedded angular, smoothed, and striated boulders of both local and foreign origin. The deposit is highly heterogeneous in composition and shows no signs of stratification.

In other places the drift consists of fluvio-glacial deposits, composed of beds of stratified sand and gravel, arranged either in the form of long, serpent-like ridges, a mile or more in length, known as eskers, or as broad gravel plains termed "outwash plains".

In still other localities, the drift consists mainly of stratified clay, deposited in glacial lakes formed in front of the ice during its advance and retreat; in lakes formed by dams of glacial debris; or in an arm of the sea which extended up the valley of Chaudière river on the withdrawal of the ice-sheet.

Fluvial deposits of gravels and alluvium overlie the glacial till and stratified clays on the flood-plains of the numerous streams and form terraces and delta deposits at numerous places along the valleys of the larger streams.

The exposed bedrock presents fresh unweathered surfaces which in most places show the effects of intense glacial erosion.

Glacial Till or Ground Moraine

The prevailing type of glacial deposit consists of unstratified drift known as boulder clay or till. It is composed of ground-up rock and boulders ranging in size from small fragments to erratics 30 feet in diameter, but averaging less than 5 feet. Most of the boulders have travelled less than 10 miles from the parent rock outcrop; but there are many which could have been derived only from outcrops at least 50 miles away. The till varies in composition with the character of the underlying formation, further evidence of the large percentage of local rock material in its make-up. As a rule the till is more stony on the uplands than at lower elevations. Thus in the northeastern part, at an elevation of about 1,300 feet, boulders are so abundant that in clearing the soil numerous piles of them have been built less than 100 feet apart. On the other hand, in the southern part, especially west of Chaudière river, the drift consists principally of rock-flour, and the boulders are much less abundant and are small and water-worn. This difference in the character of the drift appears to be due chiefly to the different altitudes of the deposits. On the uplands the ice would have a sluggish motion in rising to this height, and the tendency would be to deposit the boulders. Moreover, the bouldery nature of the drift would be accentuated by rain wash and run-off water, which would carry off the finer rock-flour and leave the coarser parts. In the valley areas, however, any original rocky character the drift possessed would be masked by the finer material brought from the uplands by the run-off water, and by the alluvium deposited in lakes that occupied the valley during the retreat of the ice-sheet. Good sections of this rock-flour drift may be observed along Pozer river. In one place the drift is so cemented by percolating solutions that it forms a cliff 50 feet in height.

On the uplands the drift forms only a thin veneer, but along the tributary valleys of Chaudière river its thickness in places exceeds 60 feet. The reason for this is that these valleys lie transverse to the general directions of glacial movement and the residual soils and fragmentary rock removed from the uplands have been deposited in these troughs. This filling-in was so pronounced that the old channels were completely buried and in many places the streams now occupy entirely new courses.

Sections along many of the streams show the drift blanket to be composed of two phases of boulder clay which, in some places, are separated by a bed of stoneless clay or one of stratified gravel varying from a few feet

to 30 feet in thickness, but which in other places grade imperceptibly into one another. The lower till in nearly all the sections is of a blue colour, compact, plastic, and rich in pyrite grains freed from the slates by the grinding action of the ice. The boulders in the lower till are largely slates and quartzites of local origin and are generally angular, polished, and unweathered, and rarely more than 1 foot in diameter. The upper till in nearly all places is brown, porous, arenaceous, and friable, and contains very few pyrite grains. As a rule the boulders of the upper till present a more weathered appearance and are larger than those of the lower till, and a greater number of them are of foreign origin. Whether these two types of till are different sheets or whether the upper is only a weathered phase of the lower is not clear. In either case, the evidence supplied by certain of the boulders seems sufficient to indicate that both tills are of northern derivation. Boulders of red slates and serpentines occur in both tills, more than 10 miles south of the most southerly known outcrops: on the other hand several large erratics lie 1,500 feet to the north of the most northerly known outcrop, but it is possible that these boulders were torn from outcrops lying a short distance farther north, which were later buried under the mantle of drift. With these few exceptions the absence in the numerous sections of boulders derived from known outcrops south of the localities supports the view that all the drift within the map-area is of northern origin.

Numerous erratics are so characteristic of the rock formation from which they were derived that the direction in which they moved could be determined. One of basalt breccia (Plate IX A) was found about 9 miles southeast of the outcrop from which it was evidently derived, and another, of highly folded quartzite schist (Plate IX B), came, probably, from the quartzite formation several miles north of the map-area.

Terminal Moraines

Well-developed terminal moraines have not been recognized within the map-area. Although there were undoubtedly halts in the retreat of the ice-sheet, the moraines that were formed have been so modified by the action of water either during the glacial lake stages or during the marine invasion, that all trace of them is lost. What appears to be a large terminal moraine occurs near Tring Junction just northwest of the map-area running northeast-southwest.

Fluvio-glacial Deposits

Fluvio-glacial deposits of stratified sands and gravels occur either as broad, gently sloping outwash plains, or as long, winding eskers.

A few miles north of the map-area at Beauce, or Valley Junction, there is an extensive outwash deposit, a section of which, 160 feet in height, is exposed by river and artificial cutting for some distance along both sides of the valley. Apparently the deposit formerly extended across the valley. Well-developed benches are found at elevations of 555 and 626 feet, 65 and 135 feet above the railway level. The deposit consists of interlaminated beds of pebbles and sand showing marked crossbedding, which in the section examined has a gentle dip to the north. The pebbles,

some of them 6 inches in diameter, are largely of local derivation, but pebbles of granite and gneiss of foreign origin are also present. The deposit can be traced for some miles southwest past St. Frederick and forms the outwash plain sloping southward from the well-marked recessional moraine.

Within the map-area the "outwash plain" type of deposit may be observed along Pozer river, underlying the till. Similar deposits were noted by Chalmers in the Hardman tunnel on the north side of the Chaudière at St. George.

No kames were observed within the map-area.

The only esker noted occurs on the western slope of Chaudière valley about 3 miles north of St. George. It is approximately 2 miles in length, 30 feet in height, 400 feet in cross-section at the base, and has a very narrow crest. It becomes distinctive at an elevation of 900 feet and runs southeast with a few gentle curves, decreasing gradually in altitude and size until it finally merges into a gravel terrace at an elevation of 580 feet. Sections exposed by stream cutting show it to be composed of stratified beds of sand and gravel, the gravel ranging in size up to cobbles 8 inches in diameter. A rough estimate of the percentages of different sized material in the esker is as follows:

Sand		20	per cent
Gravel	bird's egg size	50	"
	hen's egg size	20	"
	larger size	10	"

The esker was, probably, formed near the edge of the ice-sheet during the last retreat and thus has escaped destruction.

CHANGES IN DRAINAGE CAUSED BY GLACIATION

The changes in drainage brought about by the deposition of drift are much less pronounced in the Chaudière valley than elsewhere. Owing to the size and alignment of the valley the stream throughout its length departs very little from its pre-glacial course. The valley was too wide and deep to be obliterated by the drift blanket, and, as it lay nearly in the general directions of ice movement, glaciation tended to accentuate it rather than bury it with debris. This statement is substantiated by the polished and striated outcrops found along both slopes of the valley. At several places the outcropping of rock in the channel, together with the absence of rock on one or other of the banks, indicates that the stream has departed somewhat from its pre-glacial channel. Thus about 15 miles upstream from Devils rapids, slightly beyond the southern border of the map, rapids and falls at Lesser and Great falls suggest that at these points the present channel does not correspond with the pre-glacial.

Rock outcropping in the channel, or a rock channel itself, is not, however, certain proof that the stream is occupying a new course. At Devils rapids where the stream runs on bedrock for about 4,000 feet, there is no evidence of any buried channel, and all the evidence obtainable shows that the pre-glacial channel corresponded closely with the present

course. The oxidized gravels and decomposed slate on the south side of the rock channel, a little above water-level, indicate that the present channel at Devils rapids is somewhat deeper than the pre-glacial channel.

Glacial deposition was much greater and glacial erosion was less in tributary valleys than in the Chaudière valley. These valleys are much smaller than the main valley of the Chaudière; and as they lie, in general, transverse to the directions of ice movement, they were protected from its erosive action. In many of these valleys the pre-glacial deposits lie undisturbed and, where they have been removed, the bedrock shows little, if any, sign of scouring. The action was principally one of deposition, rather than of erosion; material eroded from the weathered outcrops of the uplands with much that was foreign to the area was deposited in these valleys. The deposition of drift was so pronounced that many of the small, pre-glacial valleys were completely obliterated and the streams were obliged to take entirely new courses. Where the material was not sufficient to fill, completely, the old valleys, the streams still lie within them, but are in places superimposed on rock shoulders which projected into the former channels. In these parts the stream is characterized by gorges and falls. More than twenty-five prominent falls and gorges occur within the map-area; the falls vary in height from 5 to 80 feet, and on Pozer river a series of falls give a total drop of 135 feet. Thus, indirectly, the glacial drift has contributed to the commercial possibilities of the area in providing for the development of electrical power.

GLACIAL STRIÆ

Nearly all the rocks show the effects of glacial abrasion. A representative number of the 655 glacial striæ recorded have been plotted on Map 1756. The conclusions drawn from these observations are presented in Chapter V.

MARINE AND LACUSTRINE DEPOSITS

Clays

Clay deposits of lacustrine and possibly of marine origin occupy many of the upland depressions and much of the low-lying ground. Some of the upland basins contain extensive deposits, as for instance the Rivière des Plantes basin 1½ miles east of Chaudière river. The high elevation of these deposits and the sudden difference in altitude between neighbouring deposits point to their lacustrine origin.

In the lowlands along Chaudière river disconnected deposits occur along both sides of the valley and extend for short distances up the valleys of tributary streams. They range from a few feet up to 70 feet above mean water-level of the river. These deposits were laid down in an extensive lake formed during the recession of the ice front or in an arm of the sea which extended up the valley following the retreat of the ice-sheet, or in a combination of these water bodies. It is apparent that during the retreat of the ice-sheet there would be a ponding of the waters, in valleys which drained towards the north, and on the withdrawal of the ice the part of the area beneath sea-level would continue to be submerged, so

that it would experience both lacustrine and marine conditions. Evidence collected in this and in neighbouring districts (Chapter V) indicates that on the withdrawal of the ice-sheet the region stood over 550 feet lower than at present. Most of the clay along Chaudière valley lies below this altitude, but its lack of fossils leaves in doubt the question whether lacustrine or marine conditions prevailed.

That some of the deposits found along Chaudière river are lacustrine is indicated by their stratigraphic position separating two boulder clays. The best known example of this is found near the mouth of rivière du Loup, a short distance beyond the southern border of the map, at which place a 13-foot bed of stratified clay separates deposits of glacial till. This clay bed was, the writer believes, deposited in a temporary lake formed during a minor retreat of the ice front, but some observers think it was deposited in marine waters (Chapter V).

It is not likely that the original surfaces of the clay deposits extended across the valleys at a uniform level; they conformed, probably, more to their U-shaped outlines, although the deposits were doubtless much more extensive than at present. That they have been in part removed by erosion is indicated by the terracing of the deposits.

The deposits vary greatly in character. On Famine river, about 2 miles from its mouth, the material is silty with a very small percentage of clay; near the mouth of Doyon creek it is composed of layers of clay one-half to 3 inches thick separated by layers of sand and silt about one-half inch thick, but most of the other deposits consist almost entirely of clay.

Generally the bedding of the stratified clay is either perfectly level or only very slightly inclined, but at one place on rivière des Plantes, about 2 miles northeast of Chaudière river, the laminæ have been locally deformed. This locality is near the eastern edge of an abandoned lake basin. Fifteen hundred feet downstream, near the centre of the basin, the beds lie perfectly horizontal. The crumpling appears to have been caused near this place by the weight of overlying gravels which were deposited in the form of a fan. The weight of the gravels caused a thinning and spreading of the underlying clay beds which were thrust westward toward the centre of the basin until the excess of bedding had to be taken up by the development of minor folds.

Concretions though not common in the clays are particularly abundant in the Doyon Creek deposit, which is exposed by stream cutting in a cliff 40 feet high, about 1,000 feet east of the main highway. The concretions are confined to the sandy beds, in one of which, about 15 feet above the base of the cliff, they are so numerous that the horizon is easily followed for more than 100 feet. These concretions are uniform in thickness, this dimension being determined by the width of the sandy layer. Their width, length, and shape vary greatly. They lie with their longer axes nearly parallel, in a direction normal to the face of the cliff. Some of them were very soft and could be easily deformed, but on drying all became stony. None of those opened had a nucleus, beyond the presence in some of a small crystallized speck of calcite. They appear to have been formed in place by overcharged calcareous solutions percolating along the sandy beds. The deposition of the calcareous material was, probably, effected

by the escape of carbon dioxide from the solutions on approaching the stream valley. This is a common method of precipitation in the formaation of calcareous spring deposits.

Sands

Stratified sands of about the same general period of deposition as the clays overlie most of the clay deposits both in the upland basins and in the low-lying areas of Chaudière river. They have been derived mainly by the re-sorting of the boulder clay and the fluvio-glacial gravels which flank the valley slopes. This re-sorting took place during the closing stages of the marine submergence following the retreat of the ice-sheet.

The sand deposits vary in thickness from a few inches to 10 feet. They form terrace deposits more or less continuous along both sides of Chaudière valley, and deltas, extensively developed at the mouths of tributary streams. In the terraces the sands occur either horizontally bedded or with a gentle slope towards the river, but in the deltas cross-bedding of the sands is in evidence. In the upland basins and along many of the tributaries of the Chaudière, similar sand deposits overlie the lacustrine clays. These deposits grade imperceptibly into recent alluvial or flood-plain deposits, and were not differentiated in the mapping.

RECENT

Alluvium

Alluvial or flood-plain deposits consisting largely of fine gravel, sand, and silt occur along Chaudière river and the adjacent parts of Famine, Pozer, and Gilbert rivers. All the islands in Chaudière river are composed of this material and numerous islands which formerly existed have been silted up during flood conditions and now form part of its extensive flood-plain. The larger part of the flood-plain was doubtless formed in this way. When floods occur there is deposited over the flooded area a layer of silt, the thickness of which depends on the duration of submergence. During the flood of August 1, 1917, silt 4 inches thick was laid down in the main street of Beauceville in a period of 12 hours. Floods are of annual occurrence and this silt naturally conceals the earlier clay and sand deposits of lacustrine and marine origin.

IGNEOUS ROCKS

The intrusive igneous rocks may be grouped under the Serpentine series consisting of deep-seated rocks, and the diabase dykes. Whether these two groups belong to the one general period of igneous activity or to different periods is not known. If the dykes belong to the period of vulcanism during which the Serpentine series was intruded they mark the end phase of this vulcanism, for they cut various members of the Serpentine series. The fact, however, that the dykes are widely distributed over the map-area, whereas the Serpentine series is confined to a narrow belt in the north, points to the two groups being derived from different reservoirs

and belonging to different ages. If this be so, the diabase records a period of igneous activity of much less importance and of later date than that in which the Serpentine series was intruded.

SERPENTINE SERIES

Distribution

This series is a group of intrusive igneous rocks embracing dunites, peridotites, pyroxenites, gabbros, diorites, granites, and aplites, all of which belong to the same general period of intrusion.

It forms a chain of irregular bodies outcropping at intervals along the southeastern limb of the Sutton Mountain anticline, which extends from Vermont into Gaspe peninsula. Within the Beauceville area the various types which make up this series lie at, or close to, the faulted contact of the Caldwell (Cambrian?) and Beauceville (Ordovician?) series and occupy the area in the vicinity of St. Victor river and rivière des Plantes. At St. Victor River gorge, a tongue of these rocks 60 feet wide and exposed for a distance of 1,000 feet, occurs along this contact. Many outcrops having the same relationship to these sediments occur on the southern slope of St. Victor valley, 2 miles farther to the northeast. Another outcrop occurs on the east bank of Chaudière river 1,000 feet north of Rivière-des-Plantes post office and an almost continuous belt extends from near the mouth of rivière des Plantes northeastward beyond the limits of the map. The dunite and peridotite were mapped as one; these rocks are, areally, the most important. Pyroxenite occupies a much smaller area and the granitic rocks though the least extensive have an economic interest in that they furnish excellent building stone. At their contact also with the peridotite small deposits of molybdenite are developed and in the dyke which runs from a granitic plug on rivière des Plantes specks of gold were seen. Specimens of this rock are in the Victoria Memorial Museum.

Dunite, Peridotite. The intimate relationship which exists between these two rock types and the fact that both have been largely altered to serpentine through hydrothermal agencies make their separation in the field almost impossible. Consequently, they have been mapped as one. The dunites are as a rule a lighter green than are the peridotites, but a marked variation in colour takes place in each of the types so that colour cannot be always used to differentiate.

The mass of dunite-peridotite extends as a belt from the mouth of rivière des Plantes northeastward and can be traced by numerous exposures through the glacial drift on the northern slopes of des Plantes valley. Small, isolated outcrops are also found on the valley slope south of the river. On the west side of Chaudière river several outcrops occur. One of these lies in the gorge of St. Victor river near the western border of the area, and is exposed for more than 1,000 feet. Smaller outcrops occur in the channel 2 miles farther down stream, and still other exposures on the southern slope of St. Victor valley about 3,000 feet south of that river and a mile west of the Chaudière.

There is little, if any, unaltered dunite or peridotite, all the specimens examined being altered in some degree into serpentine. The colour, softness,

and feel of the rock vary with the amount of alteration, the less altered rock being hard and compact, the altered rock, soft with a greasy feel. On fracture surfaces the glistening faces of the fresh olivine shine out in the fine-grained groundmass of duller serpentinized olivine. The fresh rock varies from white, through light pea-green, dark olive-green to a dark greenish black. It has a fine-grained, dense texture, and breaks easily in various directions. On weathering the rock assumes various shades of pea-green, brown, yellow, and brick red. In a few places it is cut by numerous veinlets of chrysotile asbestos, the majority of the veins being less than ¼ inch thick, though some were over an inch. Ribbon-structure, produced by a parallel series of asbestos veinlets, is frequent, as for instance at the asbestos prospect 700 feet north of rivière des Plantes and 1½ miles east of the Chaudière.

Faulting and slickensiding are common in this rock type, especially along its contact with the sediments. At the lower chute of rivière des Plantes a slickensided fault zone occurs where the rock is broken up into numerous conchoidal fragments, aptly described as resembling flakes of cooked fish-meat. At St. Victor River gorge an undulating fault plane in the peridotite is traceable for over 100 feet, the peridotite having a pseudo-conglomeratic appearance. The outcrop is characterized by boulder-like or bomb-like fragments of comparatively fresh peridotite lying in a crushed matrix of highly altered peridotite and dunite. The fragments vary from pebbles the size of hens' eggs to masses 8 feet in length. In places the fragments are elongated and lie with their longer axes parallel to the schistosity and are arranged in belts as if they had formed parts of larger fragments. These bomb-like fragments evidently represent the more competent parts of the rock. Their ovoid and spheroidal forms are the result of movements in the rocks.

Pyroxenite. The most prominent outcrop of this rock, on the east side of Chaudière river 1,000 feet north of Rivière-des-Plantes post office, forms a marked ridge running eastward. A small exposure occurs in the prominent rock knob on the opposite bank of the river, and several small outcrops occur on the valley slope 2,000 feet east of Le Rocher post office. Another is found on the northern slope of the small knoll 3,000 feet north of Rivière des Plantes. This rock, composed almost wholly of pyroxene, varies in texture from fine-grained to exceptionally coarse-grained. Some of the outcrops are composed of crystals over 3 inches long which lie in all directions. These coarsely crystalline rocks break with uneven surfaces into rough chunks, making it exceedingly difficult to procure well-shaped specimens.

The pyroxenite has suffered much less hydrothermal alteration than have the peridotites and dunites, and has less variety of colours. On fresh surfaces it is greyish green to deep-green and when weathered is generally greenish grey.

These rocks are apparently of the same age as the peridotite-dunite bodies. The relationship appears to be a case of differentiation on intrusion rather than that of a series of separate intrusions. The rocks are intruded by diabase dykes, which in places, through diastrophic movements, have been crushed into fragments, and the fragments have been isolated from the main body.

Gabbro-diorite. These two rock types, closely associated in mineral composition and occurring in the same outcrops, were not differentiated in the mapping. They occupy only a small part of the area underlain by the Serpentine series. The principal outcrop, covering an area less than 700 feet square, occurs 1,000 feet north of Rivière-des-Plantes post office. It is quite possible that this exposure belongs to a much larger body extending northward toward rivière des Plantes, but owing to the glacial drift this could not be determined. Several smaller outcrops occur 1½ miles west of Chaudière river and 1 mile south of St. Victor river.

The different outcrops vary greatly in colour and texture. Those lying west of Chaudière river have various shades of light grey to reddish brown and a fine-grained texture, whereas in the outcrop east of the Chaudière the rock is dark green to black and much coarser. Under the microscope, the gabbro-diorites are seen to be greatly altered, the feldspars, pyroxenes, and hornblendes becoming secondary minerals—zoisite, pistacite, chlorite, talc, and actinolite.

The paucity of outcrops and the mantle of drift makes the determination of the relative age of these and the other members of the series difficult. On the east side of Chaudière river the pyroxenite and gabbro-diorite appear to grade imperceptibly into one another as if they were differentiates of the same intrusion.

Granite. The rocks mapped as granite include various rocks having a granitic texture and composed essentially of orthoclase, plagioclase, quartz, and white mica, with or without small amounts of biotite. This class includes, therefore, besides true granites, quartz syenites, monzonites, granodiorites, and quartz diorites.

These rocks occupy a relatively small part of the area underlain by the Serpentine series. They occur as small, disconnected, irregular bodies and dykes intrusive in the peridotite. One such body accompanied by a prominent dyke occurs on the north side of rivière des Plantes near its mouth, the dyke crossing the river 1,000 feet east of the main highway. Another outcrop occurs on the south bank of St. Victor river a mile from its mouth. Two prominent knobs of granite standing 40 feet above the surrounding peridotite occur 3,000 feet northwest of Le Rocher post office midway between Chaudière and St. Victor rivers, and smaller outcrops are found just south of these.

The granitic rocks are greyish white and coarse-grained. In most of the larger outcrops the rock is fresh, but in some of the granitic dykes it has been hydrothermally altered to a dense compact mass composed of white garnet, grossularite. This is the case in the dyke crossing rivière des Plantes. On weathering, the granites assume a speckled brown appearance due to the weathering of the mica in the rock.

The relationship between the granite and the peridotite is clearly shown at several localities. On the southern granite knob 3,000 feet northwest of Le Rocher post office remnants of peridotite occur on the sides of the granite mass and peridotite completely surrounds the base of the hill, indicating the intrusive nature of the granite. At the outcrop near the mouth of rivière des Plantes granite is unquestionably intrusive into the peridotite, the contact between the rocks being sharp and characterized by a small deposit of molybdenite. Although the granites were

less altered by dynamic metamorphism than the more basic members of the series their sheared condition testifies to the pressure to which they were subjected. Recrystallization of the minerals has taken place, in some of the varieties, there being a pronounced development of white mica The minerals are aligned into bands, giving to the rock a characteristic gneissic appearance.

Structural Relations

The different basic members of the Serpentine series are seldom sharply differentiated from one another. Dunite, peridotite, pyroxenite, gabbro, and diorite pass imperceptibly into one another in the order cited. The granitic members of the series on the other hand are sharply separated from the basic types and intrude these previously intruded rocks—together with the dykes which run from them.

The effects of dynamic metamorphism, although apparent in all the rocks, are much more pronounced in the basic members of the series than in the acidic types. In the former, also, foliation is pronounced, but in the latter, jointing is more apparent. Numerous faults of small displacement occur in the basic members of the series, breaking up the rock into small fragments each of which is characterized by slickensided surfaces. Open lenses, in places filled with quartz, are common.

The contact of the Serpentine series with the adjacent sediments is clearly intrusive and indicates that the intrusion took place some time after the period of faulting that brought the Caldwell (Cambrian?) series in contact with the Beauceville (Ordovician?) series. The results of studies carried on by different workers in neighbouring districts indicate that during the Silurian period this part of North America was in a state of quiescence and that considerable vulcanism took place in the Devonian. It is, therefore, probable that this intrusion is assignable to the Devonian period.

DIABASE DYKES

Numerous small diabase dykes intrude the different rock formations with the exception of the Famine series and are widely distributed. None of the dykes has a width greater than 2½ feet and the majority are less than 1 foot wide. Consequently, they have effected little if any metamorphism in the rocks they intrude. Although they occur over the greater part of the area they appear to be especially abundant in the vicinity of Pozer and Gilbert rivers, where they intrude the sediments and associated volcanics of the Beauceville series. As a result of dynamic stresses they are generally fractured, faulted, and brecciated, and fragments occur completely isolated within the rocks they intrude. This condition obtains in the outcrop of pyroxenite on the east shore of Chaudière river opposite Le Rocher post office. The dykes appear to have been intruded either as a last phase of the igneous activity represented by the Serpentine series or at a later period of vulcanism of much less magnitude and importance.

CHAPTER V

SPECIAL PHYSIOGRAPHIC PROBLEMS OF THE BEAUCEVILLE MAP-AREA, QUEBEC

CHAUDIÈRE VALLEY

The study of the pre-glacial physiographic history of Chaudière valley is interesting both from a scientific and an economic standpoint. It contributes critical evidence of the recency and character of the orogenic movements in this part of North America and affords an hypothesis to account for the configuration of Chaudière valley different from any hitherto suggested, an interpretation which may be applicable to other large stream courses in the district. It embraces the difficulties met in mining the deep placer deposits of lower Gilbert river, Slate creek, and the neighbouring parts of Chaudière river. The economic phase is fully discussed in Chapter VI; the former phase is here considered.

Chaudière river, the principal geographic feature of the district, rises in the uplands near the International Boundary, flows in a general northwesterly direction, transverse to the rock structure, and empties into St. Lawrence river about 8 miles above the city of Quebec. A mile south of the Beauceville map-area, Chaudière river is joined by its largest tributary, rivière du Loup, also flowing northwesterly. Within the map limits, the Chaudière is fed by a number of large streams, the most important of which are Famine, Gilbert, des Plantes, and Caldwell rivers on the east side, and Pozer, Mill, and St. Victor rivers on the west. That the courses of these tributary streams, with the exception of rivière du Loup, were determined by the rock structure is shown by the fact that they flow for considerable distances in a northeast-southwest direction along the schistose and bedding planes of the rock.

The streams have entrenched their valleys deeply in an elevated tableland, which within the area has a general level of 1,000 to 1,200 feet and has the appearance of a highly dissected plateau. The valleys as a rule are wide and mature, but in the bottom of some, rock gorges occur.

Devils rapids, one of the most prominent gorges on Chaudière river, has received much attention owing to the occurrence there of lode and placer gold. The stream, which above the rapids occupies a wide, drift-floored valley cut transverse to the rock structure (Plate I), here passes abruptly into a narrow rock gorge and runs for nearly a mile in a rock channel cut parallel to the bedding, with rock walls rising several hundred feet above the bed of the stream (Plate XI). This constriction has been attributed by some observers to the occurrence of rocks of greater hardness than are found at other places along the valley[1], and by others to diversion of the river from its old channel by glacial agencies[2]. Neither of these explanations appears to be satisfactory.

[1]Keele, J., "Placer gold on Meule creek," Geol. Surv., Can., Sum. Rept. 1911, p. 303.
[2]Tyrrell, J. B., "Gold-bearing gravels of Beauce, Quebec," Bull. Am. Inst. Min. Eng., March 15, p. 611.

It is true that resistant acidic tuffs outcrop on opposite sides of the valley and form the prominent rock ridge crossing the channel at the rapids, but similar igneous rocks occur at other places along the valley and result in no marked constrictions. Even allowing that a greater hardness of rock here than elsewhere is a contributing factor in the narrowing, it is not by any means the controlling factor, as is shown in the discussion that follows.

The glacial-diversion hypothesis advanced to account for the narrow gorge at this point is not tenable. Not only did a diligent search for a possible buried channel reveal no place where such a channel could exist without postulating a much narrower and deeper rock gorge than the present one, but the fact that the present gorge shows evidence of glacial abrasion along its lower slopes, and the occurrence of yellow pre-glacial gravels and undisturbed decomposed slate at protected places along the south side of the channel indicate its pre-glacial age.

An hypothesis[1] advanced by Chalmers is far more probable, even though it does not explain satisfactorily all the existing features. Chalmers noted, from prospecting shafts sunk along the valley, that a reversed slope in the bedrock channel occurred for many miles upstream from the rapids. On this subject he states:

"It appears, however, that the ancient channel has suffered deformation in pre-glacial and also in post-glacial times, for, while the rock surface at the Devils rapids is exposed in the channel and there is no evidence of an older or deeper course for the river on either side, yet above the rapids, the ancient valley, as it now stands, is considerably below that level. Indeed, it would seem that the river-bed at these rapids must have sustained a transverse local uplift, with perhaps a correlative subsidence of a belt of country crossing the Chaudière valley between that point and the mouth of the du Loup. The ascent of the river from these rapids to the last-mentioned point, is from 45 to 50 feet (aneroid) and shafts have been sunk in three places in that distance as described below:

"On the east side of the Chaudière river, on a flat just above the Devils rapids, about 10 feet above river level, a shaft was put down under Mr. Lockwood's direction. The following series of deposits was passed through :

	Feet
1. Surface soil mixed with sand and heavy river gravel about	15
2. River sand and gravel, finer than above, about	4
3. Blue clay, with a few boulders of no great size (probably boulder clay) about	30
4. Clay and sand with small stones, about	21
	70

"Water coming in rapidly, the shaft had to be abandoned. Neither yellow gravel nor bedrock was reached, nor was any gold obtained.

"Another shaft was sunk by Mr. Lockwood's men on the east bank of the Chaudière and near the mouth of Gilbert river (about 5 feet above river level), disclosing the following beds in descending order : (1) 'Loose heavy gravel, about 10 feet; (2) blue clay (possibly boulder clay, thickness not given); (3) close (compact) hard clay, a few feet (apparently "pipe-

[1]Chalmers R., "Report on the surface geology and auriferous deposits of southeastern Quebec," pp. 112-114 J.

clay"); (4) clay, mixed with sand and fine gravel.' At a depth of about 60 feet water came in so rapidly that the miners had to abandon the shaft. The bedrock was not reached here either.

"On the west side of the Chaudière, opposite Jersey Mills (1 mile south of map-area), a shaft 77½ feet deep was sunk in a terrace, the level of which is 18 or 19 feet above that of the river at the nearest point. The bottom of the boulder clay was not reached in the shaft. Evidently an old pre-glacial channel of the Chaudière exists here, whether occupied by the auriferous Tertiary gravels or not, remains to be determined.

"In proof that the barrier at the Devils rapids is merely a local one, and the result of a transverse uplift in this part of the valley of the Chaudière, it may be stated that at St. François village, below these rapids on the west bank, a shaft was sunk some years ago to a depth of 60 feet, or about 50 feet below the level of the river at the nearest point..... and that the bedrock was not reached..... The rock in situ is exposed on the east side of the Chaudière a short distance farther down, and the pre-glacial valley of the river appears to be close to the foot of the bank or hillside on the west for 2 or 3 miles immediately below the Devils rapids.

"Mr. L. Blanchet, of the Registry Office, St. François, had a shaft sunk just at the foot of the rapids, on the west side of the river, reaching a depth of 20 feet or more without finding bedrock. Water coming in very fast, the work had to be stopped."

The foregoing quotation gives Chalmers' interpretation of the narrowing of the valley at Devils rapids, and of the reversed grade of the bedrock channel above this locality. As the level of the river at Jersey Mills, a mile south of the map-area, is only 40 feet above the bed of the stream at Devils rapids, the bottom of the shaft, mentioned by Chalmers as having been sunk in boulder clay, lies 18 feet below the level of the rock channel at the gorge, 9 miles farther downstream, and there is no doubt that the rock channel at this locality lies considerably lower.

According to Chalmers' hypothesis, the lowering of the bedrock channel had been advanced to its present stage before the local bowing at Devils rapids had occurred, and the rock cutting that has since taken place has been confined to the incision of the gorge in the bottom of the earlier valley. If such be the case, the slopes of the former wide valley, cut prior to the bowing, should be above the level of the gorge. The contoured map, however, shows that the narrow valley continues to a height of at least 200 feet above the bed of the channel, and that there is no abrupt change into a wide, mature valley, similar to that which exists along the other parts of the stream course.

HYPOTHESIS OF REVERSAL OF DRAINAGE RESULTING FROM DIASTROPHIC MOVEMENTS

This hypothesis is here advanced as the one which best explains the existing features. The sketch map (Figure 3) shows the principal drainage courses of the area, the bedrock summit traversing it and the configuration of Chaudière valley as shown by the 700-foot contour line and by a series of transverse sections. A contour 200 feet above the level of the stream at Devils rapids was chosen because it indicates the configuration of the rock valley more accurately than one lower down, where the bedrock is in places completely obscured by a thick drift. The features revealed in the sketch map are: (1) the bedrock summit, shown by a broken line traversing the map-area, and crossing the Chaudière valley at Devils rapids; (2) the drainage patterns on opposite sides of this bedrock summit are almost exact counterparts; the tributary valleys north of this summit join the main valley by a northerly course, i. e. fork downstream; whereas those south of the rock summit join it, as a rule, by a southerly course, i. e. fork upstream; (3) there is a progressive lowering of the relief both up and downstream from the rock summit as is shown by the transverse section and the topographic map (No. 1756) and relief model; (4) the configuration of the Chaudière valley is the same both above and below Devils rapids, revealing a gradual widening of the valley away from the gorge; the narrowing of the valley at the southern limit of the map-area, as indicated by the 700-foot contour, is due to filling-in of the valley by glacial and alluvial deposits; (5)the rock-bed of the channel slopes in opposite directions from the gorge, and apparently holds this slope upstream, as well as downstream for a considerable distance; (6) the gorge lies at right angles to the general trend of the valley, and is much younger than the other parts of the valley.

These features warrant the assumption that instead of the present drainage system there were two systems flowing in opposite directions from a height of land now represented by the bedrock summit, and that they were far advanced in their erosion cycle before the reversal of drainage of the southerly-flowing system took place. This is indicated by the mature condition of that part of the drainage system south of the bedrock summit and the progressive widening of the main valley of the Chaudière upstream. This increase in width and the general lowering of the relief of the district is traceable as far south as lake Megantic, lying near the headwaters of Chaudière river. It may be probable that this old valley can be traced through one of the several low passes occurring at the International Boundary to the south or southeast of this lake, and leading thence into Kennebec river which empties into the Atlantic.

Chalmers, in his investigation in southern Quebec, calls attention to the broad valleys, parts of which are now occupied by lake St. Francis and lake Megantic, and states that they are probably parts of the same valley. It is probable that lake St. Francis lies near the headwaters of the northwest branch of an ancient river system, which united with the northeast branch at lake Megantic and flowed southward into Kennebec

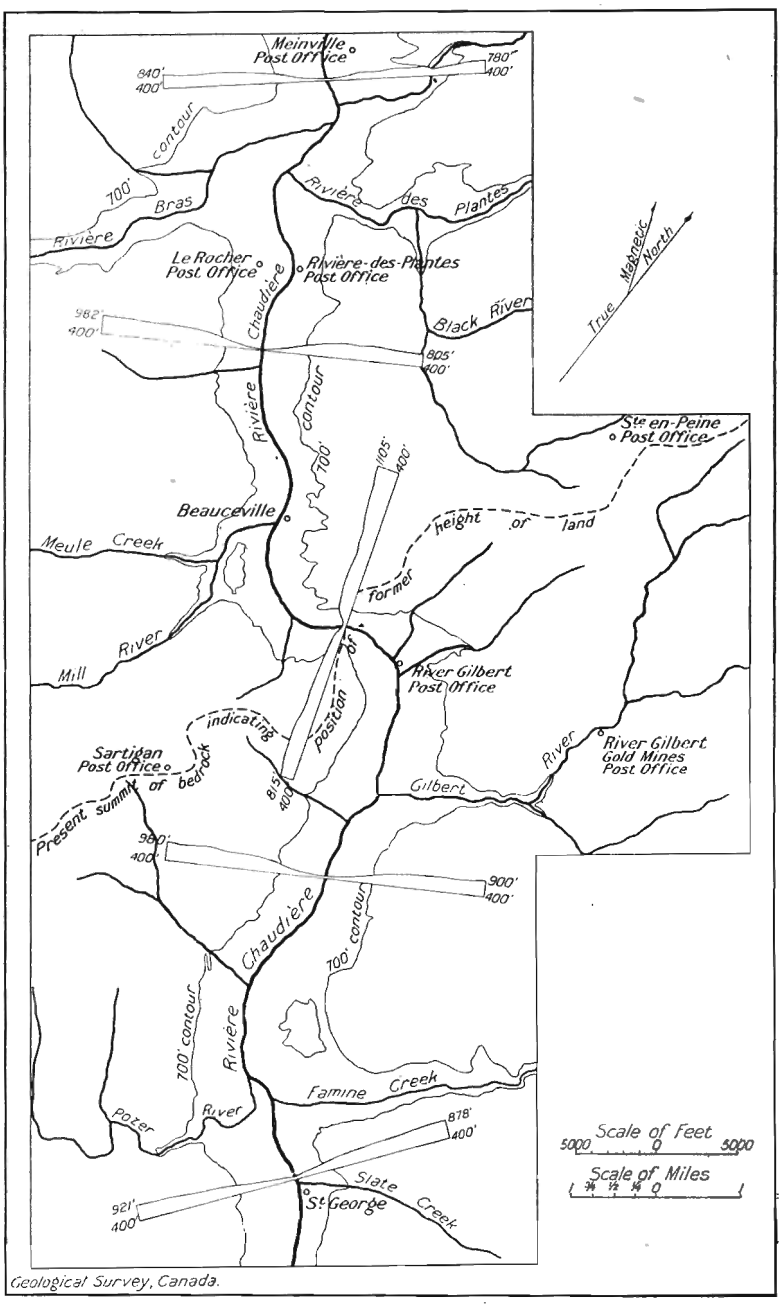

Figure 3. Drainage map of Beauceville area.

river. The locus of main uplift, which caused the reversal of drainage, appears to lie along the height of land which now forms the International Boundary. The date at which the reversal of drainage took place has not been definitely determined, but it was probably very late in the Tertiary. Prior to the uplift, Gilbert river probably formed the headwaters of the southward-flowing system and Mill river that of the northward-flowing drainage system. That part of Chaudière valley lying between the mouths of these two streams was at that time occupied by a number of smaller streams flowing in opposite directions from the height of land into the two drainage systems. The broadness of the basins on the opposite sides indicates that the area had been reduced to a mature state of dissection with a low col or pass lying between them now marked by Devils rapids. As a result of orogenic movements in the neighbourhood of lake Megantic, the southerly-flowing drainage was dammed, and formed a large lake in the valley of Chaudière river which rose to a level determined by the elevation of the col at Devils rapids. The surplus drainage escaped through this col and into the northward-flowing system, and the development of the channel at this locality commenced. At the contact of the beds of acidic tuff and the slates lying on the downstream side, falls would develop. With the erosion of the channel these falls receded upstream and formed the gorge. While the gorge was being cut, the stream above it was widening the valley by lateral planation, with the result that that part of the valley lying between Devils rapids and Gilbert river is considerably broader than it would otherwise be. A corresponding widening of the valley also took place below the gorge, though this is not so marked.

That the gorge was lowered to near its present level in pre-glacial times is indicated by the presence of decomposed slate bedrock and undisturbed oxidized gravels on the slope of the gorge near the present level of the river.

It is also significant in this connexion that the tributary valleys entering Chaudière valley north of Devils rapids are characterized by inner gorges, which are pre-glacial, although those entering south of the rapids do not have gorge-like bottoms. The explanation of this appears to be as follows: in late Tertiary time the northern parts of the region as well as the southern parts were affected by uplift, but to a less extent, and the whole region stood several hundred feet higher than at present. This elevation caused the streams lying north of the bedrock summit to be rejuvenated and to entrench themselves in new channels in the beds of their mature valleys, whereas the streams entering the main channel south of the bedrock summit could not lower their channels on account of the temporary base-level established by the rock lip which is now Devils rapids.

It has generally been accepted, as indicated by the numerous submarine river valleys along the borders of northeastern North America that this part of North America was considerably elevated in late Tertiary time. The present study indicates that the elevation which affected the Chaudière region was differential in character and that the maximum elevation occurred in the vicinity of the International Boundary.

DIRECTIONS OF ICE MOVEMENT AND MULTIPLICITY OF GLACIATION

GENERAL STATEMENT

The directions of movement of glacial ice over the district and the number of glaciations to which the district has been subjected are problems on which there is a diversity of opinion. Many geologists believe that during the glacial period the area was overridden by an ice-sheet which advanced southward from the Labrador peninsula, crossed the height of land forming the International Boundary, and reached, when at its maximum, to the vicinity of the forty-first parallel of latitude; that it then slowly retreated to its original gathering ground, and that during the main advance and retreat of the ice there were numerous minor advances and retreats, and changes in the direction of ice movement.

Chalmers and Ells, however, found that many glacial erratics occur miles north of the most northerly known outcrop from which they could have been derived, and R. Harvie confirms these observations and adds that the erratics frequently occur at elevations higher than the outcrops from which they were apparently derived[1]. They also observed that the boulder clay was divisible into two parts, a lower till composed largely of local material and an upper till containing numerous boulders of foreign origin; and that the striæ fall into several groups, the greatest number indicating a southward movement of the ice-sheet, but a large percentage apparently indicating a northward movement. Chalmers contended on this evidence that in early Pleistocene time an ice-sheet developed in the Appalachian highlands of New Hampshire and the Eastern Townships of Quebec near the International Boundary and spread thence in radial directions, reaching in some places to the marine plain of the St. Lawrence valley. This glacier or group of glaciers he designated the Appalachian glacier, and to it he attributed the underlying boulder clay, many of the glacial striæ, and the erratics found north of the most northerly known outcrops. The overlying till and the remaining striæ he considered the product of at least two later Laurentian ice-sheets, the first moving in a south and southeasterly direction; the other southwesterly. From the presence in places of stratified sands and clay separating the boulder clays he inferred that there was an amelioration of climatic conditions, and a withdrawal of the Appalachian ice-sheet accompanied by a submergence of the low-lying parts of the district, before the advance of the first Laurentian glacier. As this interpretation of the glacial history of the region is somewhat at variance with the views of other geologists the area was critically examined to see whether the evidence supported the conclusions arrived at by Chalmers and Ells. This evidence will be considered under the headings of glacial striæ, till sheet, and erratics.

GLACIAL STRIÆ

Striæ are found on most of the rock outcrops, their degree of preservation, however, varying greatly with the difference in the character and

[1]Personal communication.

texture of the rock. They vary from mere hair lines to gouges over 20 feet in length. This variation in size is due largely to the amount of post-glacial weathering that has taken place, but is also dependent on the hardness of the rock. The quartz veins have been affected least by post-glacial weathering, and in places the surfaces of these, bevelled and polished by glacial erosion, now stand up through differential weathering to the height of 1½ inches above the quartzites they cut. On these surfaces numerous hair-like striæ are well preserved, but owing to the hardness of this rock very few large striæ were developed.

Striæ (Plate X A) are especially well marked and preserved on the slates, particularly where a veneer of sod has protected the rock from weathering. Many striæ which were only faintly visible on the outcropping rock were well developed beneath the moss covering. In one instance the stria measured 21 feet 6 inches in length.

On the coarse, granular quartzites, which disintegrate readily, post-glacial weathering has removed all except deeply incised or soil-protected striæ. This is even more marked on the outcrops of marble, pillow lava, and serpentine. An indication of the minimum amount of post-glacial weathering of the pillow lavas is shown by the differential weathering of the pillows and the interpillow material, the latter standing out as elliptical ridges or triangular blocks from one-quarter to three-quarters of an inch above the adjacent pillows. Post-glacial weathering of the serpentine has developed a yellow or reddish-brown, lateritic layer, from a few millimetres to one inch in thickness, with the complete obliteration of any striæ that may have existed there.

A peculiar type of striæ occurs in a number of places along the southern slope of Famine valley (Plate X B). They are generally less than 10 feet in length and canoe-shaped in outline, being pointed at both ends, and gradually widening to as much as 1½ inches at the centre. They are V-shaped in section, the maximum depth being three-quarters of an inch.

Discordant striæ are frequent, on some outcrops pointing in almost all directions, and on one outcrop noted a single striation makes a deflexion of 45 degrees in its length of 3 feet, swinging from south 50 degrees east to south 95 degrees east. Most of the striæ observed, however, fall into one or two groups (Figure 4). About three-quarters of the six hundred and fifty-five (655) striæ recorded fall in the group which has an average azimuth of 346 degrees, or a bearing of north 7 degrees east, magnetic; and about one-fourth fall in the group having an average azimuth of 298 degrees, or a bearing of north 45 degrees west, magnetic. These two mean directions are found to obtain throughout, the north-south striæ being more abundant and better developed in the northern and central part, and southeast striæ prevailing in the southern part.

These two groups are so distinct that they indicate the two main directions of ice movement over the area, the first set of striæ not being erased completely when the second was made. The intermediate striæ give a partial record of this change of direction. The striæ lying beyond these mean directions may represent the movement of the ice during its early and late stages, when local irregularities in the topography had a more pronounced effect on the direction of movement. Notwithstanding that the two sets of striæ prevail over the district they intersect each

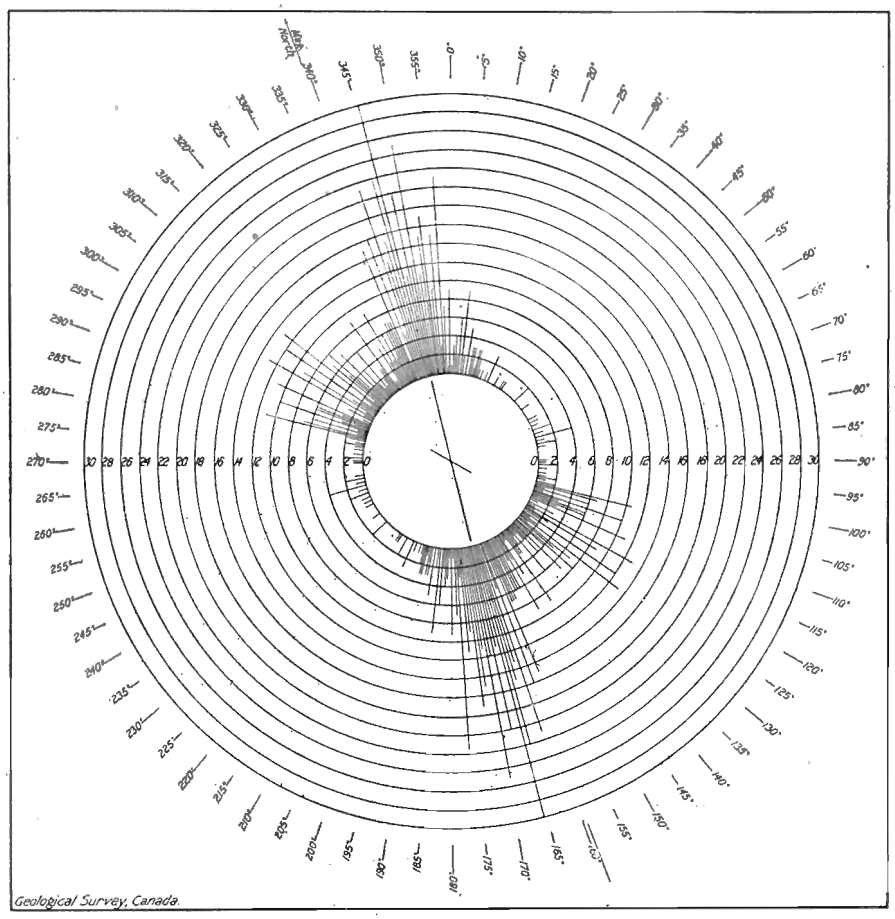

Figure 4. Chart showing plot of 655 observed glacial striæ.

other on comparatively few outcrops. Where they do so, an effort was made to determine which direction was the later, but the data appear to be contradictory.

DIRECTIONS OF MOVEMENT OF ICE-SHEET

There is little doubt that there were at least two general directions of ice movements. The trend of a stria, however, does not alone determine the direction of ice movement, for either of two directions is possible. Accordingly the striæ were examined to see which of the two possible directions was the correct one. The criteria used comprise the forking or splitting of striæ; nail-head striæ; crescentic marking, pocket and gouge phenomena; flutings on rock embossments; abrasion on the distal side of cavities; stoss and lee phenomena on projecting ledges; roches moutonnées, especially on igneous rocks; and plucking phenomena on rock knobs.

In most cases it was impossible to tell whether the striæ were produced by a southward or a northward movement. Of the remaining cases, the striæ of both groups appear to have been developed by southward or southeastward moving ice.

The strongest abrasional phenomenon favouring a southward movement is the igneous rock knob projecting above the flood-plain of Chaudière river opposite Le Rocher post office. This knob was exposed to the full force of ice movement. It is significant that the southern end of this knob is very rugged, as if the face had been formed by the plucking action of the ice, whereas the other slopes show the effects of glacial abrasion.

Although on certain rock outcrops the south and southwestern slopes are more markedly stossed than the north and northeastern, this stossing may have been developed by the ice-sheet advancing from the northwest, a possible direction indicated by the striæ. The evidence as a whole appears to indicate that both ice advances were from the north.

TILL SHEET

Most of the till sheet is uniform in constitution, but at a number of localities, such as Rivière-du-Loup, Gilbert river, and Bertrand creek it is divisible into two parts, which are in places separated by a bed of stratified clay or sand, or in other places grade imperceptibly into one another. The lower till is largely blue, compact, and plastic, and rich in pyrite grains derived from the underlying slates by the grinding action of the ice. The boulders in the drift, largely slates and quartzites of local origin, are in most cases fresh, angular, and polished, and are rarely more than a foot in diameter. Most of the upper till is brown, porous, arenaceous, and friable, and contains very few visible grains of pyrite. As a rule the boulders of the upper drift are larger and more weathered than are those of the lower drift, and a great number of them are of foreign origin.

The above-mentioned differences in the physical properties of the upper and lower tills and their separation in places by stratified deposits

led Chalmers to the conclusion that they represent two distinct sheets, the lower being deposited by the Appalachian glacier, the gathering ground of which lay south of the area, and the overlying being deposited by the Laurentian ice-sheets.

These differences are not sufficient, however, to constitute two distinct sheets. The lower part of the till, having been formed of material carried along at the base of the ice-sheet, would naturally be composed largely of local material and, having been protected from weathering, would preserve its fresh character. On the other hand the upper till, formed largely from material carried along on the surface of the ice-sheet, would contain numerous boulders of foreign origin, and having been exposed to the weather, would, to a large degree, lose its original physical properties. It is often impossible, therefore, to be certain whether the two types of clay belong to two separate glaciations or are different phases of the same sheet. Even if they represent two distinct tills some of the boulders in the two phases prove that both tills are of northern derivation. Boulders of red slate, serpentinized peridotite, and pillow lavas occur in both drifts at localities more than 10 miles south of the most southerly known outcrops of those rocks. As the northward-moving Appalachian ice-sheet would precede the Laurentian ice-sheet, it is difficult to see how these boulders could be found in these localities in the underlying drift which was supposed to be deposited by this glacier.

It is equally difficult to account for the deposits of stratified clay interbedded with till, deposits of which occur as far south as Rivière-du-Loup beyond the southern limits of the area, unless, as postulated by Chalmers, by the complete withdrawal of the Appalachian glacier and the submergence of the low-lying parts of the district. These stratified deposits can be much more easily accounted for by a minor retreat of a southward-moving ice-sheet. With a northward-flowing drainage system it is obvious that during the advance and retreat of ice-sheets from the north, there would be ponding of the drainage waters by the ice barrier, and the development of lake basins. The level of this ponded water would rise to the level of the lowest outlet or divide available, where it would remain stationary until either the outlet was closed by the advancing ice front or a lower outlet was opened by its retreat. The beds of stratified clay and sand were in all probability laid down in these glacial lakes. With the re-advance of the ice these deposits would be buried beneath a later deposit of boulder clay. The minimum extent of the withdrawal of the ice front can be determined approximately from the distribution of these stratified deposits. The distribution of the deposits and the continuity of direction of the striæ suggest that the ice withdrew completely from the area before the re-advance occurred, but the fresh character of all the striæ and the unweathered character of the lower till indicate that the different advances were not separated by any extensive interglacial epoch.

ERRATICS

Although almost all the erratics are of northern derivation a number were apparently derived from localities up to a mile south of their present position. Thus at Doyon creek, boulders of serpentinized peridotite occur,

the most northerly known outcrop of this rock in the vicinity being near Rivière des Plantes. Numerous large erratics of volcanic ash also occur in the neighbourhood of Rivière des Plantes, 1,500 feet north of the most northerly known outcrops of this rock. Similarly in the Thetford map-area, about 50 miles southwest, R. Harvie observed erratics of serpentinized peridotite, lying 5 miles north of the most northerly known outcrops and at much higher elevations than these outcrops. It was partly this distribution of erratics that led Chalmers to postulate his northward-moving Appalachian glacier. This distribution may, however, be equally well explained in other ways. Thus (a) the boulders may have been derived from the north from rock formations concealed by drift, or, (b) the boulders may have been carried north of their present position by streams in pre-glacial times or by floating ice in glacial lakes formed during a retreat of the ice, and subsequently been moved southward by a southward-moving ice-sheet. All the erratics in the map-area that are thought to be of southern derivation are found along the slopes of Chaudière valley. They may have been transported northward by floating ice in late glacial time. In the absence, therefore, of more conclusive evidence the distribution of these erratics does not prove the former existence of a northward-moving ice-sheet.

SUMMARY

There is little to support the view that an ice-sheet moved northward prior to the advent of the Laurentian ice-sheet. Rather, the evidence favours the hypothesis that one or more ice-sheets advanced over the area from the Labrador peninsula. However, during the growth and southward advance of the Laurentian ice-sheet, local glaciers may have formed in the higher parts and have spread for varying distances down the mountain slopes until they finally coalesced with it, and the reverse order of conditions may have taken place during the closing stages of glaciation. In certain parts of this general district—as in the Thetford area—the presence of cirques proves the existence of local glaciers, but within the Beauceville area the altitude was too low for any of these forms to be well developed. Immature forms occur in the vicinity of Round lake at the western border of the area.

UPPER LIMIT OF MARINE SUBMERGENCE

The withdrawal of the ice-sheet and the opening of the St. Lawrence River outlet caused an extensive embayment of the sea far up this valley and those of the tributary streams. The upper limit of marine submergence and the amount and character of crustal warping since the withdrawal of the ice-sheet have been subjects of interest on which there is still a great diversity of opinion, due principally to the faintness with which the upper limit of submergence is recorded, and also to the different criteria employed by investigators in determining this limit. Wave-cut benches and sea-cliffs seldom occur, the main criteria being bars and beaches which in places contain fossil shells of marine species, as Saxicava, Macoma, etc.; and ancient deltas formed at the mouths of streams entering this embayment.

Mount Royal, Montreal, once an island in this Champlain sea, bears evidence of the extent of the submergence; but in spite of the great amount of study devoted by geologists to the Pleistocene of this locality, the upper limit of submergence is still in dispute. Lyell, basing his conclusions on the upper limit at which marine fossils were found, estimated the maximum submergence on the mountain at 470 feet; William Dawson, who attributed the occurrence of foreign boulders to iceberg transportation, held that the mountain was wholly submerged, and he, therefore, put the maximum submergence above 763 feet; Baron de Geer, influenced by a bench and cliff on the northwest slope of the mountain, which he attributed to wave erosion, placed the upper limit at 625 feet; and Chalmers, covering a much larger area, concluded that at the maximum stage of submergence the land stood from 800 to 1,000 feet lower than at present.

Even with the greater exactness of present-day physiographic study there are still great differences of opinion. For many years Goldthwait made a special study of this problem for the Geological Survey and succeeded in tracing what he considered the highest south shore-line of this ancient Champlain sea. He made an accurate determination of the elevation of the gravel beaches from lake Champlain to Gaspe. The highest shore-line was found to rise progressively, from an elevation of 486 feet west of lake Champlain, northeastward as far as the neighbourhood of Quebec, reaching a height of 632 feet about 15 miles southeast of the city. From the projection of a plane passing through these points, the submergence at Mount Royal was estimated to be between 500 and 600 feet, and from local examination it was determined to be 586 feet.

Recently Fairchild made a study of post-glacial uplift in northeastern North America, laying special emphasis on high stream deltas as a criterion for the determination of the amount of post-glacial uplift. His results, which he portrays by a map on which the warping is shown by isobases of 100-foot contour interval, show the upwarping to be in the form of a dome, the centre of which, having an elevation of over 1,000 feet, lies midway between Quebec and James bay, and the outer limit or isobase passes through Sandy Hook, N.Y., and swings in a gentle double curve through Nova Scotia, Cape Breton, and south of Newfoundland. In regard to the submergence at Mount Royal, he agrees with Dawson that the mountain was completely covered, the water standing 50 to 75 feet over the summit.

The extent of the uplift within Beauceville map-area is determined by Fairchild to be between 800 and 900 feet, and in this he is in close agreement with Chalmers. According to Goldthwait, on the other hand, the maximum emergence did not exceed 600 feet. The problem of determining the former vertical and horizontal extent of the marine invasion in this district is somewhat complicated by the fact that in a northward drainage system it is impossible to determine whether certain wave features are the result of glacial lake waters or of marine waters. It was hoped that the clay deposits along the Chaudière valley would indicate whether lacustrine or marine conditions prevailed, but diligent search in these deposits failed to reveal the presence of shells. The absence of shells does not, however, preclude a marine origin of the clays, for conditions may not have been favourable for the existence of marine life.

Some interesting data were obtained from the different elevations of the high deltas built by tributary streams of Chaudière river. At the mouths of most of these streams remnants of former deltas are still to be seen at different heights above the present level of the river. Thus at the mouth of St. Victor river there is an extensive ancient delta, the perfectly level top of which lies at an elevation of 585 feet or about 100 feet above the river level. At the mouth of rivière des Plantes, parts of a smaller delta lie at the same height. Remnants of a delta occur at the mouth of Mill river at an elevation of 570 feet, 90 feet above the river level, and also a broad fan on the east side of the Chaudière at a corresponding height. At the mouth of Gilbert river, an extensive delta has been built, the top of which has an elevation of 565 feet or about 55 feet above the river's present level. Farther south at the mouths of Famine and Pozer rivers, remains of deltas lie at about 550 feet or about 30 feet above river level.

The deltas are composed of stream gravels and are underlain by boulder clay. Their relative elevations indicate a former water-plane which is now tilted upwards to the north about 2 feet to the mile. It is the best marked water-plane recorded in the unconsolidated material, and, if projected, it coincides with the water-plane assumed by Goldthwait to indicate the upper limit of marine submergence. A plane having its datum or zero elevation at Boston, and an elevation of 632 feet 15 miles southeast of Quebec city, passes through the surface of these deltas. The absence of well-defined deltas at higher elevations suggests that this horizon probably marks the upper limit of marine submergence. The conclusions reached are, therefore, in accord with those of Goldthwait.

RIVIÈRE DES PLANTES BASIN

Rivière des Plantes, a southwestward-flowing stream 10 miles in length, enters Chaudière river 5 miles below Beauceville (Plate IV). A mile from its mouth it is joined by its main tributary, Southeast branch, which flows in a northwest (Plate V) direction and which is formed by the union of two streams, Black river and Ste. En Peine creek, a mile above the confluence with the des Plantes. With the exception of the lower mile of rivière des Plantes the stream valleys are wide and deep, and floored to a considerable depth with glacial deposits. The great size of the valleys is much out of proportion to the small streams which at present occupy them.

As indicated above, a marked difference exists between the lower part of the des Plantes valley and the remaining part of the drainage basin. For the lower 3,000 feet the stream meanders across the flood-plain of Chaudière river, which here lies at an elevation of 480 feet. A thousand feet east of the main highway the stream emerges from a gorge cut to a depth of 15 feet in serpentine bedrock. The gorge is 600 feet in length and is terminated upstream by a waterfall of 6 feet. This waterfall, which formerly was about 15 feet, is developed at the contact of intrusive soft serpentine and an underlying resistant acidic tuff. The contact of these rocks crosses the stream at right angles to its course and dips westward with the stream. On the north side of the gorge a short

distance below the falls and approximately 15 feet above the level of the stream, undisturbed oxidized, and cemented gravels of pre-glacial age lie on the bevelled surface of the serpentine.

For a distance of 3,000 feet above the falls, rivière des Plantes flows in a still larger gorge, 150 feet wide, the rock walls of which rise steeply above the bed of the stream to a height of 100 feet, above which the rise becomes much more gradual. The gorge cut in acidic tuff bedrock and floored in places by undisturbed pre-glacial, auriferous gravels capped by boulder clay, thus indicates its pre-glacial age. The present channel of the gorge is paved with boulders of both local and foreign origin, which were derived from the re-sorting of the glacial drift and were left stranded when the finer material was carried down the valley. The present stream channel is much smaller than the gorge and swings from one rock wall to the other. In places the stream in lowering its channel has cut into the rock slope of the pre-glacial valley, the bed of which is 10 to 20 feet lower.

About 4,500 feet east of the main highway the present gorge terminates abruptly against a bank of boulder clay. Here, on the northern side of the gorge, a waterfall of ten steps has a total drop of 60 feet, half of which is in the last two steps (Plate XII). Remnants of two higher steps occur at the upper end of the falls making their former level about 20 feet higher. This waterfall has been formed by the stream cutting across a buried spur of the pre-glacial valley projecting from the north side into the boulder clay with which the Tertiary gorge was filled. Below the falls the stream has succeeded in re-excavating this gorge nearly to its pre-glacial bed. Looking upstream from a short distance below the falls the pre-glacial gorge is seen to continue eastward beyond them, and to be completely filled with boulder clay.

Immediately above the series of waterfalls the valley of rivière des Plantes opens out into a wide, roughly diamond-shaped basin, having its longer diagonal along rivière des Plantes and its shorter a little above the junction of the Southeast branch. Accepting the 700-foot contour as the border of the basin, the length exceeds 8,000 and the width 4,000 feet. Gravel terraces from 635 to 700 feet occur within the basin, and higher terraces in various stages of development and preservation occur along the valleys of the des Plantes and Southeast branch.

The basin has a remarkably level floor of sand and gravel overlying stratified clay. A section exposed in the channel of rivière des Plantes 1,000 feet east of the junction of the Southeast branch is as follows:

	Feet	Inches
Soil	1	
River gravels	2	
Sand and fine gravel	0	6
Fine sand	0	8
Coarse sand	0	8
Gravels	0	8
Finer gravel	0	4
Plastic blue clay	6	

In another section 1,000 feet farther east the gravels are much coarser and the clay layers are much contorted.

A mile south of rivière des Plantes the basin of Southeast branch widens and is connected with the basin of the Chaudière by a broad, drift-filled valley. The nearest outcrops on opposite sides of this valley lie 2,000 feet apart. Within the valley and about midway between the Southeast branch and Chaudière river a divide occurs, whose summit, 770 feet, is approximately the same level as the mouth of Black river one-half mile farther upstream. On the west side of this divide a stream which is much too small for the size of the valley it occupies, flows into Chaudière river, and on the east side a still smaller stream flows into the Southeast branch. Traced farther upstream along Ste. En Peine creek, the valley retains its broad, U-shaped outline across the present drift divide and into the drainage basin of the headwaters of Northwest branch of Gilbert river.

ORIGIN OF THE DES PLANTES BASIN

The wide basin of rivière des Plantes is one of the most conspicuous topographic features. To outline its history it is necessary to go back to at least late Tertiary times. As already pointed out, the Tertiary rivière des Plantes flowed through a narrow gorge cut at least 3,000 feet in length in bedrock of acidic tuff. At the base of the present upper falls this gorge continues eastward beneath the boulder clay. The abrupt termination of the acidic tuff in an escarpment at the upper end of the falls, in line with other exposures of the same rock formation to the north and south, and the occurrence to the east of this escarpment, within and at the border of the basin, of the much less resistant slate and peridotite, suggest that the termination of the Tertiary gorge was not far beyond the upper end of the re-excavated part.

The gorge through the acidic tuff bedrock was formed by the recession upstream of waterfalls developed at its lower end at the contact between a soft serpentine bedrock and the resistant acidic tuff. These falls were developed similarly to the post-glacial falls now present at the same contact. During the recession of the falls upstream and the gradual lowering of the channel in the granodiorite bedrock, the stream above this resistant rock formation was held at a temporary base-level, and thus began to widen its valley through lateral erosion. In this way the wide basin lying in the much softer peridotite is thought to have been formed. Once the falls had receded through the granodiorite, they would soon cease to exist and the basin would be lowered to the new base-level. The presence of oxidized auriferous gravels in the bed of the gorge is taken as indicating that the falls had disappeared completely by late Tertiary time. Whether the Southeast branch drained into the des Plantes at this time, or whether a low divide existed between these two drainage basins, is not known. The great width of the drift-filled valley a short distance below the mouth of Black creek indicates that it was probably a pre-glacial drainage course of the upper part of Southeast branch. Moreover, had the Tertiary Southeast branch, and its tributaries, drained into the des Plantes, the gorge along the des Plantes would probably have been much broader than it is.

The absence of a divide between the basins of Black river and rivière des Plantes may be taken as pointing to the capture of the drainage of one of these streams by the other in late Tertiary times. If rivière des Plantes

captured the drainage of Black river in pre-glacial times, it was after the gorge had been cut through and the channel above deepened to the new base-level. It is conceivable, however, that during the slow cutting-out of des Plantes gorge a small stream worked headward from Black river and captured part of or all the drainage of rivière des Plantes, in which case the latter's channel would be left dry. Surface indications give no clue as to which of these hypotheses is correct. A low rock divide between these two basins may still exist beneath the drift.

GLACIAL HISTORY

During the glacial period marked changes were effected in these drainage basins. With the advance[1] of the ice-sheet from the north there would be a ponding of these northward-flowing waters and in the basins so formed, gravel, sand, and clay would be laid down, and, if not removed by the scouring action of the ice as it advanced over the area, would be covered by a blanket of boulder clay. Within the present des Plantes drainage basin, glacial lake deposits underlying the till were observed only in the des Plantes gorge about 500 feet below the high falls. Here the following section is exposed:

	Feet
Blue till	5
Blue plastic clay with sand lenses	20
Angular gravels with sandy matrix	5
Igneous bedrock (granodiorite)	..

The distribution of boulder clay over this drainage basin was very unequal, being much more pronounced in the valleys lying transverse to the direction of glacial motion than in the valleys lying parallel to it.

POST-GLACIAL HISTORY

The unequal deposition of boulder clay caused many of the pre-glacial drainage courses to be completely filled, and on the retreat of the ice-sheet the waters were forced to find new avenues of escape or were ponded until they did so. Thus the drainage waters at the upper part of Ste. En Peine creek were diverted into the channel of Gilbert river. Downstream, one-half mile below the mouth of Black river, the broad valley lying between rivière des Plantes and Chaudière river, which was doubtless a pre-glacial course of Southeast branch, was partly filled with boulder clay so that the post-glacial drainage of Black river and Ste. En Peine creek was diverted into rivière des Plantes. The pre-glacial gorge of rivière des Plantes was completely filled with drift and the ponding of the drainage waters resulted in a lake until an outlet was cut to drain it. Evidence of this ponding is seen in the deposits of laminated blue clay, already mentioned, exposed along rivière des Plantes. Neither the thickness nor extent of the clay deposit, nor the depth of the lake basin in which it was laid down has been determined. This lake basin was probably a last stage in a series of glacial lakes formed in this valley during the retreat of the ice-sheet. The succession of these lakes is indicated by terraces on the slopes of the basin.

[1]As only one till sheet was to be seen in the exposures examined along the des Plantes and the Southeast branch the discussion of the glacial history of this basin begins with the advance of the last ice-sheet.

These terraces extend up the valleys of rivière des Plantes and Black river, ranging in elevation up to 860 feet. Many of the higher terraces are continuous with those of the main valley of Chaudière river.

As the clay deposits occurring one mile upstream from the upper edge of the gorge lie less than 90 feet above the bed of the gorge, the maximum thickness of this deposit does not exceed 70 feet, and it is probably less than 20 feet. Overlying the clay are beds of sand and gravels. Within the lake basin, as outlined by the 700-foot contour, the maximum observed thickness of the combined sand and gravel beds measures 7 feet, though this thickness increases along the Southeast branch. These beds constitute alluvial fans which were built at the mouths of the streams emptying into the lake basin and which grew until they finally covered the whole bed of the lake.

On rivière des Plantes, just west of the roadway lying 2 miles east of Chaudière river, the underlying clay stratum is locally deformed, the axes of the folds lying normal to the direction of the stream. This folding appears to have been developed by the deposition of stream gravels on the clay stratum by rivière des Plantes. As the gravel fans were being built into the lake basin the weight of the gravel caused a thinning and spreading of the underlying clay bed, which resulted in part of the clay bed being thrust westward toward the centre of the lake basin until finally the excess of bedding had to be taken up by the development of folds. With the progressive deposition of gravels and sand the lake basin finally became full, forming a river flat.

The drainage of rivière des Plantes at this time was across the filled in lake basin, through the col at the west end of the lake, and into the drift-filled valley of the lower des Plantes which it followed to Chaudière river. Along the lower part of rivière des Plantes (with the exception of the part near the outlet of the lake) the post-glacial channel corresponded closely with the pre-glacial course and the stream began the work of re-excavating its pre-glacial gorge. At the outlet of the lake, however, the post-glacial channel of the stream did not correspond with the pre-glacial channel and the stream, after it had cut its way for a distance into the drift, found itself superimposed on the northern rock slope of the pre-glacial valley. As the lowering of the channel in resistant bedrock was much more difficult than in the unconsolidated material, a waterfall resulted. Owing to numerous joint planes in the acid tuff bedrock this waterfall developed into a series of step falls or a "cascade" waterfall.

During the recession of each step across the barrier, the stream above the barrier was held at a temporary base-level, and began to meander in the unconsolidated material and develop a flood-plain. As each rock step receded across the barrier the river immediately lowered its channel in the gravel plain to a level equal to the height of the succeeding rock step, and the development of a new flood-plain was begun, leaving the former flood-plain as a terrace. In this way a series of gravel terraces corresponding with rock steps were formed at 660, 640, and 630-foot elevations. The present falls consist of ten steps spaced over a horizontal distance of about 400 feet, and it is, therefore, highly probable that a series of terraces corresponding to these steps will be developed before the stream channel above the barrier is lowered to the channel below.

CHAPTER VI

ECONOMIC GEOLOGY

PLACER GOLD

GENERAL DISCUSSION

ORIGIN OF PLACER GOLD

The unequal distribution of the gold values in placer deposits, the large size of many of the nuggets, the mammillary form of the nuggets, together with the increase in fineness of placer gold over vein gold, and the occurrence of crystallized gold in numerous placer deposits, has led many observers to the conclusion that the gold found in placers is a chemical precipitate rather than a product of the weathering and disintegration of primary deposits. Although most of these characteristics have been satisfactorily explained without recourse to the precipitation theory, there are still a number of advocates of that view. Experiments[1] have shown that gold may be deposited from chlorine solutions by organic matter such as peat, leather, leaves, cork, petroleum, and wood, and also by metallic compounds and metals. The difficulty, however, does not lie in the precipitating of the gold from solution, but in getting the gold into solution; the presence of MnO_2 being considered favourable if not essential to the solution of gold.[2] It is now generally conceded, however, that precipitation of gold has played an insignificant part in the formation of placer deposits and that gold placers may be considered almost wholly a product of mechanical concentration. This has been firmly established by the fact that the primary deposit has been frequently located by tracing the trail of gold from fine colours through deposits in which it progressively increased in coarseness and quantity until the parent source was crossed, when the values ceased abruptly.

DISTRIBUTION OF GOLD VALUES IN RELATION TO PRIMARY DEPOSIT

The coarse gold as a rule has not travelled far from its original source, but the trail of fine gold may be traced for great distances along stream courses. Unlike the fine gold, which is generally concentrated on the surface of bars or rarely more than a few inches beneath the surface, the coarse gold, once in the stream channel, with each movement that takes place in the gravels works rapidly downward, and unless arrested by a clay stratum soon reaches bedrock. This is so widely recognized that placer gold prospectors always search either the gravels lying directly over the bedrock or the bedrock itself. This enriched zone has been termed the "paystreak" or "paylead". If large nuggets are present they do not travel far after reaching bedrock and as far as known, no large nuggets have been found at any great distance from their primary deposit, unless transported by some other agency than water.

[1]Egleston, T., "The formation of gold nuggets and placer deposits," Trans. A.I.M.E., vol. IX, p. 633.
[2]Emmons, W. H., Min. and Sc. Press, XCIX, 1909, pp. 751–754; 783–787. Trans. A.I.M.E., XLII, 1912, pp. 1–73, and Brokow, A. D., "Secondary precipitation of gold," Jour. of Geol., vol. XXI, 1913, pp. 251–267.

Coarse gold is not necessarily stopped on reaching bedrock, for it moves slowly with the water-soaked gravel mass until finally caught by projections or crevices in the bedrock, or until it finds a lodging place in some protected part of the channel. The slowness with which coarse gold travels in actively eroding streams has been pointed out by McConnell[1] in the case of Hunker and Bonanza creeks of the Klondike district. "The paystreak of the elevated White Channel gravels has been destroyed in places along both these streams. Whenever this occurs the creek bottoms directly opposite the destroyed portions are immediately enriched, showing that the gold, or a large part of it at least, has remained almost stationary during all the time the creeks were employed in deepening their channels from 150 to 300 feet. The horizontal movement in some instances scarcely exceeds the vertical movement. The complementary relationship existing between the creek and the hill pay-gravels has been recognized by the miners, and whenever the creek gravels are lean, pay is confidently expected on the hills, and in the productive portion of the creeks is usually found."

It is not to be inferred that the enriched bottom zone is continuous or uniformly rich. The gold, especially if coarse, occurs in rich pockets, separated often by gravels which are either barren or very poor. The richest zone does not necessarily occupy the centre or deepest part of the channel, but often crosses and recrosses the channel. In some places the values diminish gradually, whereas at others the transition from rich to poor gravels is abrupt. The auriferous zone may be wide or narrow. Owing to the configuration of the channel and the differences in texture and structure of the bedrock, certain parts of the stream undoubtedly favour more than other parts the concentration of gold, but so many factors influence the deposition that each case must be judged on its own merits.

Factors in the Distribution of Values in Placer Deposits

In studying the general problem of the distribution of values in placers, use was made of a laboratory stream, 20 feet in length, having the configuration shown in Figure 5. In addition to the bends, islands, gorges, tributary streams, depressions in bedrock, etc., introduced, riffles representing rock ledges were placed across the stream at different angles from the course and dipping in different directions. The currents set up by these various factors are shown in the upper part of the diagram. In the experiments, galena, garnet sand, and quartz sand of the same mesh were used and the concentration effected was as shown in the lower part of the diagram. Galena, having the greatest specific gravity, was taken as indicating the values in placer deposits, and the concentration effected in the laboratory stream was checked with numerous field observations on the distribution of values in placers.

Texture of Bedrock. The texture of the bedrock is one of the most important factors affecting the localization of the values. If the bedrock wears to a smooth surface, as is the case in granite, serpentine, and soft schists, or if it is covered by a clay stratum, very little of the gold is apt

[1]McConnell, R. G., "Gold values of Klondike high level gravels," Geol. Surv., Can., 1907, p. 15.

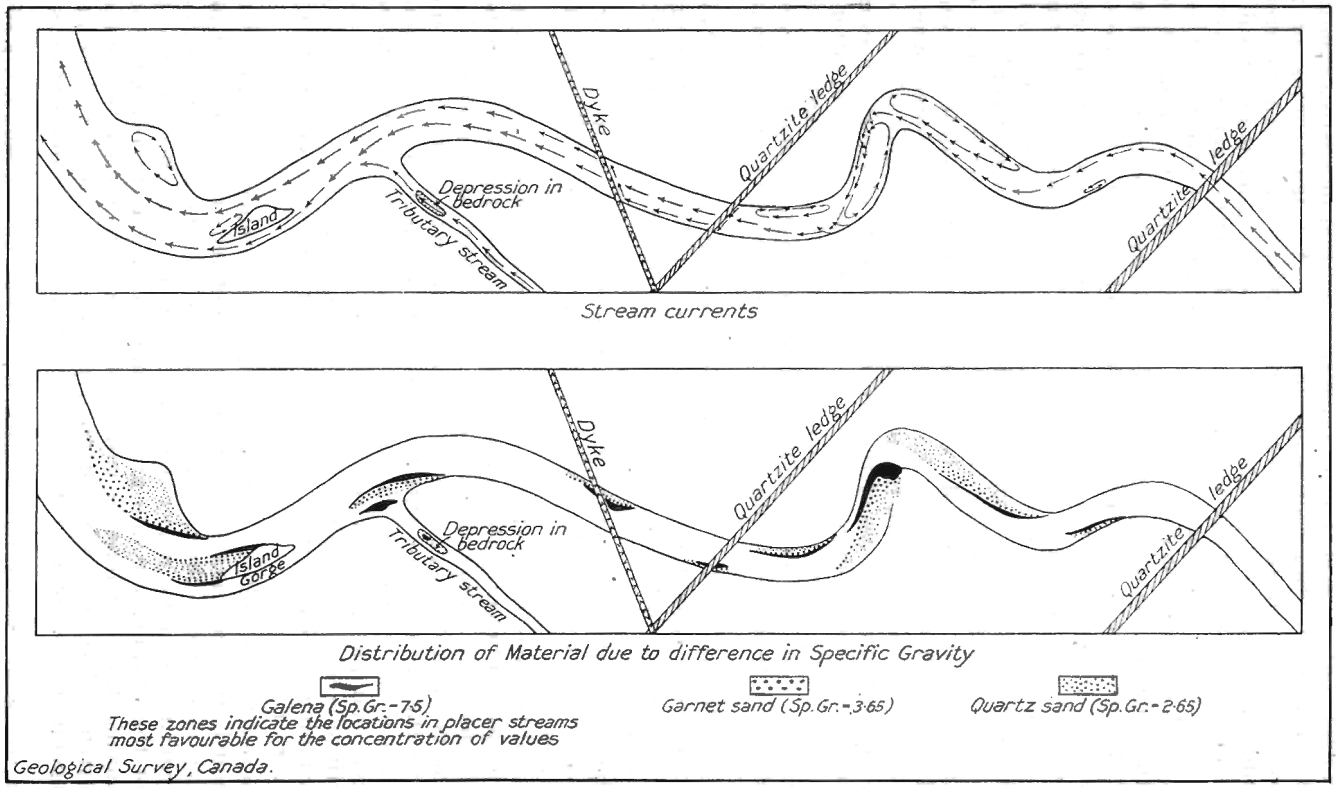

Figure 5. Diagram of laboratory stream showing currents and distribution of material of different specific gravity.

to be caught, but most of it will probably be carried downstream until a more favourable collecting rock is encountered. A rough bedrock, on the other hand, not only makes a better retaining surface, but upward currents are produced which give a jig-like movement to the gravels and result in increased concentration of the values on bedrock. Other factors, however, such as curvature of channel, decrease in gradient of stream bed, etc., may affect the localization of values, and in certain placer streams it was found that the gravels overlying rough bedrock were very poor in values, whereas the gravels overlying smoother bedrock retained their values.

Structure of Bedrock. The structure of the bedrock is also an important factor in gold concentration. Should the bedrock consist of fractured diorite or similar igneous rock, or of tilted beds of slates or quartzites, excellent pockets and riffles exist for collecting and retaining gold. This is especially so if the bedding or structure planes crossing the channel dip with the stream. The gold, being moved along the bedrock, becomes wedged in the riffles and is held there until the rock is weathered, when it works its way gradually down the cleavage, or bedding planes of the rock. In some deposits the crevices of the decomposed slate or schist are so rich that the bedrock has been mined to a depth of 8 feet. This retention of values is so effective that the statement is frequently made that in placer areas characterized by such steeply dipping bedding or schistose planes, the vertical distance the values have travelled exceeds the horizontal distance.

Should the riffles dip upstream they are not so effective. Moreover, values once caught are frequently dislodged through weathering of the rock and may travel a considerable distance downstream before they are again arrested.

When the beds or structure planes strike with the stream the values are moved along the troughs of the bedrock and are generally caught in the crevices.

Should the beds strike at an angle to the stream course, and especially if they project sufficiently above the bed of the channel to deflect the bedrock currents, the values moved along the bottom are deflected down along the bedding or schistose planes and accumulate in the acute angle formed by their intersection with the side of the channel, or if not retained at this place, are carried down along this side until again deflected. Numerous examples can be cited showing that the schistosity of the bedrock with reference to the direction of the stream was of great importance in determining the localization of values, but there are exceptions to this, as to every rule[1].

Cross-section of Valleys. The concentration is richer and, other things being equal, the paystreak is more sharply defined, the more V-shaped the valley is, owing to the restricted area in which the gold accumulates. The exploiting of many placer deposits has been abandoned because the width of the channel was too great to allow of sufficient concentration. The concentration of values in valleys of narrow channels is so common an occurrence that, where well-defined paystreaks in broad valleys have been encountered, they have been interpreted by some investigators as

[1]Spur, J., "Geology of the Yukon gold district, Alaska," 18th Ann. Rept., U.S. Geol. Surv., pt. 3, pp. 300-363.

indicating the position of the bed of a former V-shaped valley which was the younger representative of the present valley[1].

Gorges. Where canyons or gorges occur the effect is to increase the velocity of the stream currents and especially of the bed currents, so that values, having once entered the gorge, are likely to be carried through and deposited at the lower end where the channel widens out, unless on their journey they are arrested by projecting ledges or are caught in crevices on the bed. The formation of such placer deposits at the mouths of canyons is a very common occurrence. In some cases, however, the absence of values in the gorge and the occurrence of high values at its mouth are due to other causes.

Curvature of the Channel. The curvature of the channel is also important. In a straight channel the current is swifter in the middle than near the sides and if no other factors enter into the case, the concentrates would be laid down along or near the middle of the channel. In a curved channel, however, the action is greatly modified, as cross currents are set up, each contributing its part to the localization of the values. On reaching a bend in the channel the stream resists change of course and the central part, having the greater velocity, is least deflected and impinges against the outer bank. In so doing the water displaces the slow-flowing water near the bank which descends obliquely and displaces the slower-flowing water below. This lower water is crowded toward the opposite side, and the water previously near that bank moves toward the centre of the channel as an upper layer. This transfer gives to the current a twisting motion accompanied by the setting up of eddies in adjacent parts of the channel, as indicated by the arrows shown in Figure 5. As the current passes from the outer wall to the inner, the velocity is gradually decreased, and sorting of the material takes place. The result is that active erosion occurs on the outer or concave side of the channel and deposition in the inner side. In this way a gravel ridge is gradually built downstream from the spurs. The heavy material is deposited on the outer slope of this ridge, and the lighter material is carried up over the crest and dropped on the inner slope.

When the ridge reaches a certain height its upward growth is checked by surface currents and it builds toward the inner bank. In experiments with the laboratory stream using galena, garnet, and quartz sand of the same size, the zones of deposition of the different minerals were, at all times, sharply defined.

The greater the specific gravity and the more uniform the size and shape of the particles, the more sharply defined will be the zone occupied by the mineral. Thus, the mineralized zone ought to be much broader in gold placers than in platinum placers, for the gold particles are of a lesser specific gravity and often flaky, whereas the platinum has a greater specific gravity and the particles are of a more uniform size. That such is the case appears from Perret's[2] observations in Russia, in which he states "In broad valley sand especially in curves, platinum follows rich pay

[1]Tyrrell, J. B., "Law of the paystreak in placer deposits," Trans. Inst. of Min. and Met., 1912, pp. 593-613.
[2]Perret, Leon, "Gold and platinum alluvial deposits in Russia," Trans. Inst. of Min. and Met., 1912, p. 661.
Spur, L., "Geology of the Yukon gold district, Alaska, 18th Ann. Rept., U.S., Geol. Surv., pt. 3, pp. 360-363.
Pringle, L. M., "Gold placers of Forty-mile region, Alaska," Bull. 251, U.S. Geol. Surv.
Purington, C. W., Trans. A.I.M.E., vol. 29, p. 6.

streaks in a way similar to gold, but the platinum content taken in the transverse direction decreases more rapidly than does the gold content."

With continued deposition a ridge is finally built across the stream from the inner side of one curve to the inner side of the next curve. With later erosion the part of this ridge crossing the deep channel may be removed, but unless exceptional circumstances intervene, parts of the ridge remain as bars projecting downstream from the bends. These bars occur on opposite sides of the channel, each immediately below the bends where the current flows off at a tangent to the bank. The values in such bars are not distributed uniformly throughout the bar, but are generally concentrated on the outer and upstream borders. Deposits bearing similar relations to bends have been noted by Spur and Pringle in Alaska and by Purington in Russia. The same relation applies to deposits of both coarse and fine gold, except that the fine placer gold is concentrated on or close to the surface of the bar, whereas coarser gold is generally found on bedrock.

Islands. Where islands and gravel bars occur in auriferous channels the concentration of values is along the outer and upstream face of the island in positions comparable to those at bends in the stream channel.

Boulders. Large boulders in a channel set up eddies and protect any material which finds lodgment under or behind them, from further transportation. Consequently, in auriferous channels the areas underlying the large boulders have been favourable spots for the localization of values and are generally noted for their richness.

Pot-holes. Pot-holes seldom pay for the labour of cleaning them out. In certain places small channels leading into the pot-hole are rich, but the gravels of the pot-hole itself are practically barren. The reasons for these abnormal occurrences are not clear.

Change in Gradient of Channel. A decrease in the gradient of the channel causes a decrease in the velocity of the current and an increase in the friction of particles moving along it. This, together with the increase in the width of the channel, is the cause of deposition at the mouths of tributaries, and in placer districts search at these localities for auriferous deposits has frequently proved remunerative. On the other hand, as the gradient of the stream decreases the size of the gold particles transported becomes less and the concentration of values is not so marked. Along the larger streams very little coarse gold is met with, the gold occurring as minute flakes and particles, the average coarseness being about $\frac{1}{100}$-inch in diameter. Owing to the small size of the gold particles they do not concentrate on bedrock and all attempts made at locating a continuous paystreak have proved unsuccessful.

Depressions in Bedrock of Channel. Where depressions occur in the bedrock of auriferous channels the values in many places are concentrated on the downstream or backward slope of the depression, owing, doubtless, to the increase in frictional resistance of the particles moving along the reversed slope of the bedrock.

Flood Conditions. The increase in volume of water and the velocity of the current during flood conditions are apt to destroy completely the concentration which was formerly effected, or so alter the localization of

values as to render it difficult, if not impossible, to determine the position of the paystreak. Frequently during flood conditions a river changes its channel completely. Moreover, if a river be greatly overloaded, sand and gravel are deposited too rapidly to permit of a concentration of the heavy minerals and the alluvium thus formed is generally low in values. When such deposits are re-sorted by stream action, however, the heavier material is gradually concentrated on bedrock unless arrested in its downward course by a stratum of clay.

Effect of Clay Strata. Where clay strata occur in auriferous gravel deposits the upper surfaces are invariably found to be rich in values concentrated from the overlying gravels. In some deposits, as many as seven such clay layers are known to occur, upon each of which lies a layer of auriferous gravel.

General Application of Foregoing Principles to Prospecting

Although too much confidence must not be placed in predictions as to the probable location of values along streams which have not been thoroughly prospected, yet in such prospecting much useless search may often be avoided by the application of the foregoing principles. This is especially so in recent placer deposits, of which numerous examples can be cited supporting the conclusions reached by the laboratory experiments.

The principles are also applicable to buried placers. In prospecting for buried pre-glacial placers it should be remembered that the former streams which deposited the values had characteristics similar to those of present streams, with their irregularities of channel and differences in structure and texture or bedrock. In the pre-glacial channels, as in the present stream channels, certain localities were much more favourable than others for the concentration of values. By taking into consideration, therefore, the configuration of the buried valley, the probable position of the stream within it, the location of spurs, bends, the position of tributary stream junctions, the texture and structure of the bedrock, and other factors above mentioned, the most likely localities for valuable placer deposits may be determined. In glaciated districts, however, the pre-glacial concentration so effected is apt to be completely destroyed by the erosive action of the ice-sheet. This is specially likely should the trend of the valleys be with the direction of ice movement. When the channels lie transverse to the direction of ice movement, the deposits, being protected from the sweep of the ice, are more apt to remain undisturbed, but in such cases the deposition of glacial drift is often so great as to obliterate the configuration of the pre-glacial rock valley, and thus make the position of the paystreak in the buried channel indeterminable. In studying the localization of values in the deep channels care must be taken not to confuse the pre-glacial form of the valley with that resulting from post-glacial stream cutting. Although in most cases the present and pre-glacial channels lie in the same rock valleys, their courses seldom coincide, but are generally found to cross and recross one another many times.

PLACER GOLD DEPOSITS OF BEAUCEVILLE MAP-AREA

GENERAL STATEMENT

Placer gold is the only mineral of economic importance being mined in the map-area. Although the mining at present carried on is on a very small scale, being confined to a few ground-sluicing operations on the northeast branch of Gilbert river and on Meule creek, the former output from the district gives it the unique position of having been the richest placer field in eastern Canada. Fine gold has been obtained from the gravels of almost all the streams belonging to the upper part of this drainage basin, but in only a few streams has it been found sufficiently concentrated to encourage mining on a large scale; the most important streams are Gilbert river, rivière du Loup (just south of the map limits), Meule creek (Plate XIII), rivière des Plantes, and Famine river.

HISTORY OF MINING IN THE DISTRICT

The first indication of placer gold in this district was in 1823 when a nugget was found in Rigaud-Vaudreuil seigniory, near the mouth of Gilbert river. In 1835, a second nugget weighing 1,056 grains was found in the bed of the stream near the same place and this led to further search, which resulted in more gold being found. The finds were sufficiently encouraging to induce the de Lery family, owners of the seigniory on which the discoveries were made, to apply to the Crown for the exclusive mining rights within the limits of the seigniory, which included 71,000 acres and extended for 18 miles along Chaudière river and for 9 miles on each side. These rights were granted in 1846 since which time the mineral rights on certain sections within the seigniory have been leased to various companies and individuals. The attempts made at mining the gravels met with varying degrees of success. The first mining work done was on the lower part of Gilbert river and was confined to shallow placers, but as these became exhausted the gold was followed upstream where mining of the shallow placers led directly to that of the deeper gravels lying on bedrock. These were found to be much richer than the surface gravels and as the news of the finds spread rapidly, hundreds of prospectors hurried to the district. From 1875 to 1885 mining activities on Gilbert river were at their maximum and an average of 500 miners are said to have been employed in the various camps. During this period, gold to the value of almost $2,000,000 was recovered.

Although most of the values were derived from the gravels of Gilbert river, other streams, as rivière des Plantes, Meule creek, and Famine river, contributed gold to the value of many thousands of dollars. Most of these values were recovered from the buried channels and benches of the preglacial streams. Quicksand and water often caused great difficulty in mining the deep gravels. No attempt was made to work deposits more than 100 feet below the surface, and even at this depth many shafts had to be abandoned before bedrock was reached. Unlike the methods now

commonly employed in mining deep channel gravels, where the shaft is sunk in bedrock on one side of the valley and the channel is tapped and drained by means of a drift run from the bottom of the shaft, these deposits were mined by shafts sunk to bedrock in the unconsolidated material composed in descending order of boulder clay, sand, and gravel. Of these deposits the bed of sand, which in places was 35 feet thick and lay about 30 feet below the surface, was the most difficult to penetrate owing to its being saturated with water. In sinking through this sand many of the timbered shafts were so badly crushed in and thrown so much off the vertical by the pressure of the quicksand, that they were abandoned. Notwithstanding these difficulties, the greater part of the deep channel deposits of Gilbert river from near the junction of Caron creek upstream and along the two branches has been thoroughly worked out.

In 1886 there was a marked falling off in the mining operations as one company after the other ran out of pay gravels. A number of companies, however, continued development work, the principal operator being Mr. W. P. Lockwood. In 1900, development work had practically ceased. Little was done during the next ten years. Now and then a few individuals would sink prospect holes and engage in ground-sluicing on a small scale with satisfactory returns.

In 1910, the Champ d'Or Rigaud Vaudreuil Company, a Montreal syndicate, having purchased the mining rights of the seigniory from the de Lery family, began a systematic search for the continuation of the gold leads on the most favourable creeks. The locality lying above the old workings on Gilbert river was selected and for eight months three Empire drills and one Keystone drill were kept in operation, during which time the valley was closely drilled from rim to rim. With the exception of a small block of auriferous gravel 5 feet in thickness and capped by 40 feet of boulder clay, found at the immediate upper end of the old workings, drilling upstream and principally along Northwest branch revealed no trace of any rich deposits. Perhaps no auriferous gravels ever existed along this section of the channel or, perhaps, as is more probable, they were completely removed by glacial erosion, for this part of the valley is in the principal direction of glaciation.

Sufficiently rich values were obtained from prospect pits on the south side of Northeast branch of the Gilbert at the roadway near the eastern border of the map-area, to induce the company to undertake deep mining operations at this point (Figure 6). The prospect pits sunk near the stream showed the bedrock to be only a few feet below the surface, and to slope towards the southeast. Accordingly, at the base of the boulder-clay slope, about 150 feet south of the stream, a shaft was sunk reaching bedrock at a depth of 11 feet. As the surface of the bedrock had a slope of about 6 per cent towards the southeast, and as the boulder-clay bank rose steeply in the same direction, it was considered economy to drift from the bottom of the shaft in the direction of the maximum slope of the bedrock. Along this drift, at intervals of about 30 feet, pits were sunk to locate the bed of the channel and to determine the gold values contained in the gravels. The drift was put in about 360 feet, in which distance eight pits were sunk. The last pit sunk to bedrock was about 250 feet from the hoisting shaft or about 405 feet from the present stream

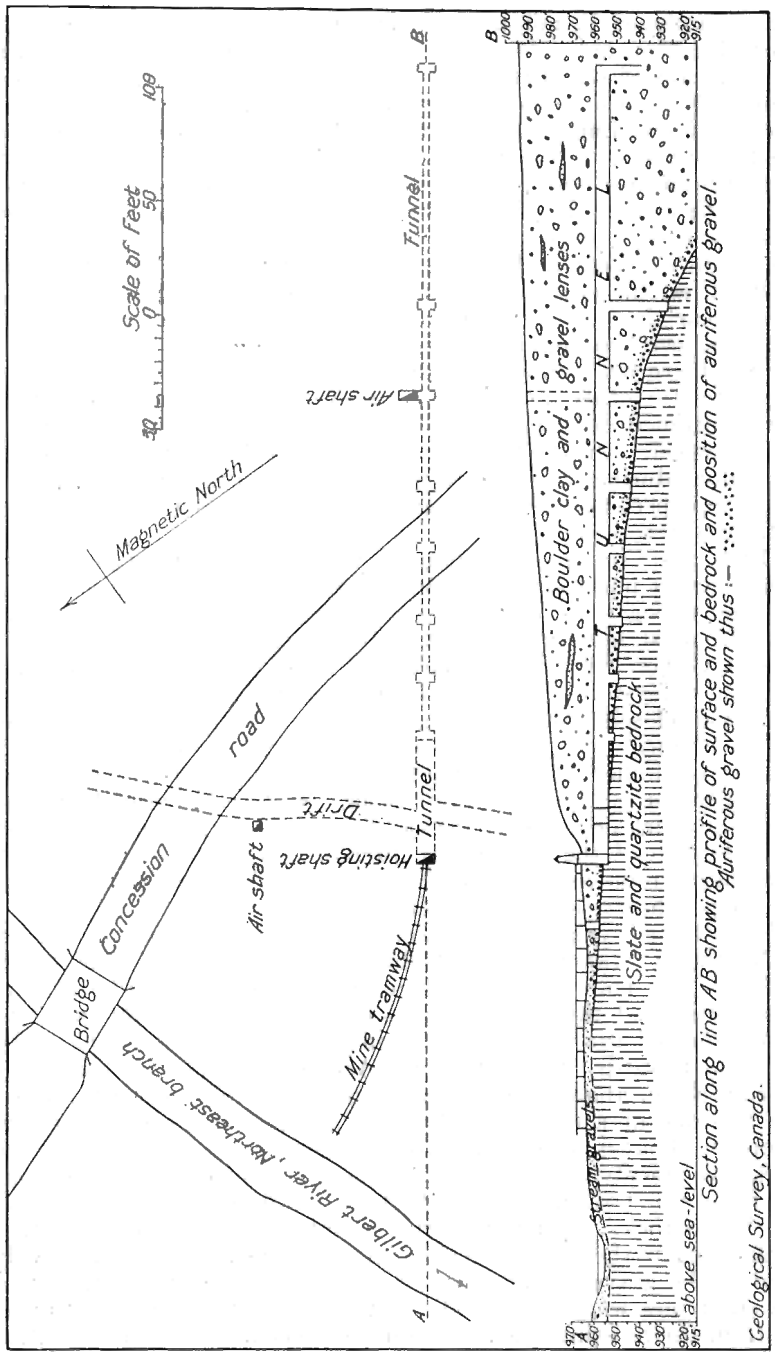

Figure 6. Plan and section of deep workings, Gilbert river.

channel. Bedrock was struck about 25 feet below the bottom of the drift or 30 feet below the stream bed. The bedrock surface was still dipping to the southeast and the angle of slope had increased to about 35 degrees, indicating that the channel was probably not far distant. The total depth of overburden at this point was 47½ feet. About 100 feet farther on, the eighth pit was sunk from the drift, but operations ceased before bedrock was reached. Although no great amount of gold appears to have been recovered from these operations, the values found were sufficiently high to warrant the continuation of the work, and it is unfortunate that operations were terminated before the bed of the buried channel was reached.

Prospecting on Meule creek gave more favourable returns. The early work along this stream had been confined largely to mining the deep channel gravels (Figure 7) lying 80 to 100 feet below the surface, and occurring near the junction with Mill river. A few thousand dollars, however, had been recovered from the gravels overlying the thinly covered rock bench on the south side of the stream 2,500 feet above the junction. Prospecting of this bench above and below the old workings indicated that the pay lead was extensive and the estimated value of the gravels was sufficiently high to induce the company to install an up-to-date hydraulic plant.

Some of the conditions essential—proper dumping room, sufficient grade for sluicing, sufficient values in pay gravels, or sufficient quantity of pay gravels to pay for handling of barren overburden, and an abundant supply of water—were apparently lacking, for operations during 1911 and 1912 were unprofitable and the plant was closed down. The returns, amounting to $30,000, were only a small fraction of the cost of installation of the plant. Since 1912, mining operations have been confined to the work of a few prospectors who generally manage to make fair wages.

As this was the most important hydraulic operation carried on in the province, a brief description is given. For a more detailed description readers are referred to the articles by Mr. Fritz Cirkel[1], consulting engineer of the company, and by Mr. H. A. Bell[2], the two men under whose supervision the plant was designed and installed.

The water required for hydraulicking was brought from lake Fortin, 7 miles distant, by means of 7½ miles of ditches. The ditch terminated in a penstock 275 feet above the level of the pit, to which the water was conducted by means of 2,600 feet of wrought iron pipe. The pipe had a diameter of 18 inches where it joined the intake, and tapered to 15 inches at the pit, where it divided into two branches, each feeding a monitor. One of these monitors was used in cutting, and the other in driving the material into the sluice box. The overflow from the penstock was conveyed to Meule creek, where it was stored in a reservoir made by damming the stream a short distance above the workings. The water thus stored in the reservoir was used in flushing the flume, or "booming", by opening the gate of the reservoir after the material had been driven into the sluice by one of the hydraulic giants. An hydraulic derrick run

[1]Cirkel, Fritz, "Alluvial gold deposits in Quebec," Eng. and Min. Jour., Nov. 25, 1911, pp. 1035–38.
"Hydraulicking in Beauce county, Quebec," Eng. and Min. Jour., 1912, p. 1083.

[2]"Placer mining in the province of Quebec," Min. and Sc. Press., vol. 104, 1912, pp. 727–728.

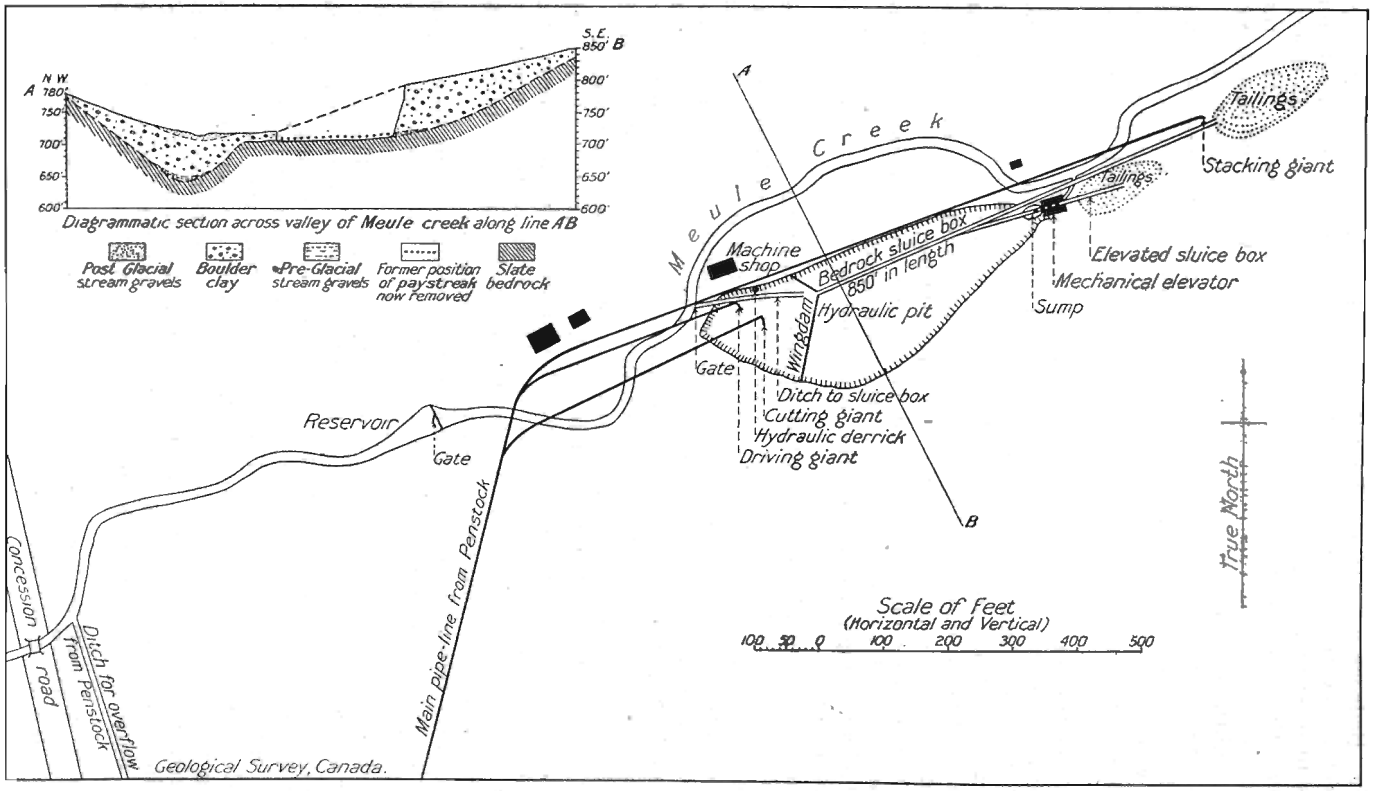

Figure 7. Plan and section of hydraulic pit, Meule creek.

by a Pelton wheel was used for the removal of the large boulders encountered. The sluice box which toward the close of operations had a length of 850 feet was 3 feet by 3½ feet in cross-section, the sides being made of 1½-inch planks and the floor of 2-inch timber. It was riffled longitudinally by a series of five railway rails, each being 20 feet in length and 4 inches in height, placed in a reversed position and spaced with slip blocks. When operations were first begun it was found that after the excess of the water from lake Fortin was used up, insufficient water was available to run more than one monitor, and consequently the work of cutting and driving the material through the sluice box had to be carried on alternately. Owing to the low gradient of bedrock, estimated at 2·35 per cent, the removal of the tailings proved a difficult task, and for this purpose an electric-driven bucket elevator was installed, which raised the material collected in a sump at the end of the bedrock flume to an elevated sluice box, riffled similarly to the bedrock flume. Here the gravel underwent a second washing to catch the fine gold values and the material was discharged on the tailing pile. On increasing the capacity of the reservoir and deepening, remodelling, and repairing the ditch it was found that sufficient water was available to keep three giants in operation, and the third monitor, for stacking the tailings, was installed at the end of the bedrock sluice, thus doing away with the costly operation of raising the material by the elevator. After this giant was installed the mechanical elevator was used only in emergencies when the stacking giant was not serviceable.

No attempt is made in this report to outline in detail the various mining activities carried on along the different creeks of the district. The old workings have long since caved in, so that no access to them is now possible, and the people familiar with the early mining operations have either died or left the country. Consequently any data gathered on this phase of the work would be incomplete, and based altogether on hearsay. Data as complete as could be gathered at the time, on the early mining operations, may be found in the reports of Chalmers[1] and Obalski[2].

Most of the gold recovered has been derived from the deep channel deposits of Gilbert river lying between Caron creek and the junction of Northwest and Northeast branches. The returns from the various workings show that the values were not regularly distributed along the rock bed of the channel, but that some parts were exceptionally rich, and other parts contained little, if any, gold. In many cases the form and location of the paystreak were clearly governed by the configuration of the valley, in the way indicated by the laboratory experiments previously referred to. In other places the configuration of the valley played a less important rôle, the exceptionally rich deposits having been found adjacent to quartz veins traversing the channel. In other parts of the channel, where there was every reason to expect the presence of rich deposits, systematic prospecting carried on by Keystone drill showed that the values were altogether absent.

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[1]Chalmers, R., "Gold mining in southeastern Quebec," Geol. Surv., Can., (N.S.), Ann. Rept., vol. X, 1897; pt. J.

[2]Obalski, J., "Gold in the province of Quebec," Dept. of Col. and Mines, Quebec, 1898.

Very little deep mining has been attempted on the lower part of Gilbert river below the junction of Caron creek. The lowest shaft sunk to the bed of the deep channel was at the mouth of this stream. Bedrock was reached at 97 feet, and from the bottom of the shaft one and one-half ounces of gold were recovered. Unfortunately, owing to the dangerous condition brought about by seepage water and quicksand, the decomposed bedrock could not be removed, nor could all the gold be recovered from its surface, and further development work was abandoned. The collar of this shaft lay approximately 170 feet above the level of the water at the confluence of the Gilbert and Chaudière rivers, 1½ miles farther downstream, giving a fall for drainage of approximately 70 feet in this distance. The section exposed in this shaft, as given by Chalmers, is representative of those obtained in the other shafts along the stream, and is as follows:

	Feet
Loam and river gravel	4
Hard, blue boulder clay	36
Hard grey sand	23
Firm grey sand	10
Gravel and sand	14
Ferruginous sand	3
Auriferous gravel	7
	97

Meule creek has contributed gold to the approximate value of $50,000, all of which has been derived from the lowermost mile of its course. Rivière des Plantes has yielded approximately $10,000 in gold, practically all from the pre-glacial gorge lying below the 80-foot cascade. Work along the other streams has been largely exploratory. On Famine river near Grand falls in the township of Watford, ranges III and IV (a little outside of the map-area), considerable gold has been found, but on the lower part of the stream the exploratory work does not appear to justify further development. The deep channels of Slate creek, Pozer river, and St. Victor river have contributed small amounts of gold, but not in sufficient quantity to induce continued search. The post-glacial deposits at the mouth of rivière du Loup, on Mergermette river, and on a number of the other tributary streams have yielded fair returns, but work on these deposits was discontinued as the values played out. The shallow deposits at Devils rapids on Chaudière river have also yielded a small amount of gold, but never have been an important factor in the output of the district.

CLASSIFICATION OF DEPOSITS

The alluvial gold occurs either along the present stream courses where it is concentrated on or near the surface of the gravel deposits, or along ancient buried stream channels where it is concentrated either near the base of yellow oxidized gravel deposits or directly on bedrock. The recent stream placers, though they have yielded an appreciable amount of gold, are on the whole of little economic importance compared with the ancient stream placers, the principal source of the gold output.

The placer deposits may be classified according to age in two main groups: (a) post-glacial placers and (b) pre-glacial placers. Each of

these groups may be subdivided according to mode of formation into four classes of placers: (1) stream, (2) terrace or bench, (3) river-bar, and (4) alluvial-plain.

OCCURRENCE AND CHARACTERISTICS OF DEPOSITS

Post-glacial Placer Deposits

(1) *Stream Bed Placers.* Most of the gravels occurring in the beds of Gilbert, Famine, Mill rivers, and rivière des Plantes, Slate, Meule, and Black creeks, are at least sparingly auriferous and in some places on rivière des Plantes and Gilbert river the gravels carried high values in gold. These rich localities generally occurred immediately below places where yellow auriferous gravel deposits had been exposed by stream cutting. The values were graded off rapidly on being traced downstream, the coarser, heavier grains having worked their way down through the gravel to bedrock, whereas the finer gold was carried downstream and lodged in some favourable locality in a way that has been indicated in the former discussion. An occasional large nugget has been found on the surface of the stream gravels, but in such cases the nugget is thought to have occurred either close to its original source or to have been transported by some other means than by stream action. The first gold found, a nugget of 1,056 grains, was in the gravel bed of Gilbert river, near its mouth, lying over 80 feet above bedrock, and many other similar finds have been made. The total output from these post-glacial stream bed placers has been small. The occurrences have served more as indications of the presence of rich pre-glacial auriferous deposits than as an important source of placer gold.

(2) *Terrace or Bench Placers.* The surfaces of gravel terraces of Chaudière river, rivière du Loup, Mergermette creek, and many other tributary streams have been found to contain gold in a fine state of division. As in the previously mentioned deposits an occasional large nugget is found in these deposits. On December 5, 1914, on the terrace of rivière du Loup near the mouth of Sample creek, a nugget worth $51 was picked up by Eugene Caron, an 11-year old boy, who was engaged in setting a mink trap. Diligent search, however, failed to reveal further gold. These deposits are only very slightly auriferous and are more of academic than economic interest.

River-bar Placers. The heads of many of the bars, islands, and bends of Chaudière river and rivière du Loup carry fine gold, but as yet no deposits of this type have been found sufficiently rich to be profitably worked. After each period of flood a new crop of colours is found on the gravels at these favourable localities.

(4) *Alluvial Plain Placers.* These deposits are formed as delta or alluvial plain deposits at or near the mouths of the larger streams. Traced upstream they merge into terrace deposits. Of the post-glacial placer deposits they have been the most productive, possibly because they are the only post-glacial deposits that have been worked to any considerable extent. The largest deposit worked was the alluvial flat on the east side of rivière du Loup at its junction with the Chaudière. In 1851-52

the gravels forming a surface layer 2 feet in thickness from an acre of ground were washed along with material from the gravel bank of the river a little farther upstream. The yield was 4,987 pennyweights of gold, worth $4,322. Of this amount 467 pennyweights were in the form of fine dust mixed with black sand and the remainder was in nuggets the largest of which was 127 pennyweights.

Pre-glacial Placer Deposits

The pre-glacial placer deposits, the chief source of the gold, comprise four classes of placers which correspond in mode of formation to the four classes of post-glacial placers just discussed. The main differences between the two groups are age, degree of concentration, and position. The pre-glacial placers bear the same relation to the buried channels that the post-glacial placers bear to the present stream channels. Except where they are exposed by stream cutting or mining operations they are buried beneath a blanket of boulder clay, sand, and gravel. These gravels are frequently separated from the boulder clay by thick deposits of quicksand and stratified clay (locally termed pipe-clay), parts of which at least are pre-glacial. Attempts have been made to exploit all the four classes of buried placer deposits, but the stream bed and bench deposits of the tributary stream, Gilbert river, Famine river, rivière des Plantes, Meule creek, and Slate creek have received most attention. Of these the deep channel deposits of Gilbert river have been the most profitable, having produced over $1,500,000 in gold. The bench and deep channel deposits of Meule creek have yielded the next largest amount, and the bench and deep channel deposits of lower rivière des Plantes rank third. The deposits of the other streams yielded much less.

The pre-glacial auriferous gravels of these streams have an average thickness of 5 feet, but deposits 30 feet thick occur. They differ from the recent stream gravels, which are fresh and loose, in that they are generally yellow, oxidized, compact, and frequently cemented. They are stratified and formed of waterworn boulders, which are generally less than 2 feet in diameter, non-glaciated, and all of local origin. At places underlying the gravels there occurs a layer, a few inches in thickness, of a yellow oxidized clay having the consistency of putty. This material disintegrates with difficulty and is a source of trouble in saving the gold. It is a troublesome sluice-box robber, and has to be closely examined for any gold it may carry.

The values are sometimes disseminated throughout the deposit but are generally concentrated either in the lower part of the gravels on the clay layer or directly on bedrock. In some places where the bedrock is fractured values were found in it at depths of several feet. The gold of these placers is exactly similar to that of the recent placers, except that large nuggets are more frequent. The gold varies from fine dust to pieces the size of a man's hand (Plate XIII). Generally the nuggets are waterworn, but occasionally some of the smaller nuggets show rugged angular outlines. The gold is generally associated with considerable black sand which is especially abundant in those deposits near the serpentine intrusives. This sand consists largely of the iron ore minerals—magnetite, specularite,

hematite, chromite, and ilmenite—but associated with them are pyrite, red and green garnets, rutile, zircon, ottrelite, and corundum. Many of these minerals are foreign to the vicinity of the placers, but whether they are foreign to the entire drainage basins is not known.

ORIGIN OF DEPOSITS

Post-glacial Placers

There are three possible ways in which recent placers might be formed.

(1) By the post-glacial weathering and disintegration of auriferous quartz veins or country rock, either with or without the sorting agency of water.

(2) By the reconcentration of values, derived from the destruction of pre-glacial auriferous deposits, scattered through the boulder clay or fluvio-glacial gravels.

(3) By the dissection and re-sorting by streams of pre-glacial auriferous deposits which had escaped removal by the ice-sheet.

Owing to the comparatively recent disappearance of the ice-sheet from this district post-glacial disintegration of the bedrock or quartz veins is insignificant, so that no deposits formed in this way occur.

A considerable concentration of values has been effected, however, by the re-sorting of glacial drift, so much so, that early students of these deposits and some recent observers considered the drift the principal source of the values. The alluvial plain placers at the mouth of rivière du Loup, the terrace placers of du Loup, and some of its tributary streams of which Mergermette creek is the most important, the river-bar deposits of Chaudière river, and many of the post-glacial stream-bed placers of the auriferous streams have been undoubtedly derived from the reconcentration of values contained in the drift. Strength is given to this opinion by the finding of several large nuggets on the surface of the drift, and in the gravel beds of some of the creeks. It is difficult to see how a large nugget could travel far downstream without sinking through the gravels to bedrock. The fine gold, however, seldom works down into the gravels, but is generally confined to the surface layer. During periods of flood it is carried downstream and becomes lodged in the most favourable localities, where it remains until a later flood carries it still farther.

A number of the post-glacial placer deposits have been formed by the dissection and re-sorting by streams of pre-glacial auriferous deposits which occurred in valleys lying transverse to the general direction of glaciation and which accordingly escaped removal. Examples of placers thus formed are to be found on rivière des Plantes, Gilbert and Chaudière rivers. These deposits occur immediately below the places where the auriferous gravels have been exposed.

Pre-glacial Placer Deposits

Although these deposits have been studied for eighty-five years, very little is known as to the true source of the gold. This is owing largely to the fact that a thick blanket of glacial drift and alluvium conceals the gold-bearing gravels and the underlying bedrock.

Logan and Hunt[1] believed that most of the gold originated in the crystalline schists of the Notre Dame range (Sutton anticline) lying north of the Beauceville area; that the values were derived from the disintegration of these rocks and were disseminated through the superficial deposits, spread over an extensive area lying to the south of their outcrops; and that from these deposits they were subsequently reconcentrated into placers by stream action. This belief was based on (1) the association of minerals of foreign origin with the gold; (2) the waterworn character of much of the gold; and (3) the barren nature of most of the quartz veins in the district. The occasional occurrence of pieces of gold embedded in quartz and the sparingly auriferous character of some of the veins, as at Devils rapids, indicated that some at least of the gold was derived from these veins.

Selwyn[2] regarded the gold as being of local origin, and derived from the destruction of the quartz veins. In his report he states that "the worn and comparatively heavy character of much of the gold does not indicate that it has been derived from distant sources, so much as it has been subjected to repeated and long continued abrasion in the drifts." Most of the geologists and mining engineers who have subsequently studied the deposits agree with Selwyn.

Chalmers[3] though favouring the view that the gold is local in origin and was derived from the quartz veins suggests in connexion with Logan's and Hunt's belief, that, as much of the Palæozoic sediments has been derived from the Precambrian schists it is possible that any values in the schists would be concentrated in zones in the later sediments much as they are in recent placers; and that such a Palæozoic concentration might account for the present unequal distribution of values. No field evidence, however, has been found supporting such a conclusion. Some recent observers[4] still hold to the view that the gold is foreign in origin, basing their conclusion on reasons similar to those advanced by Logan and Hunt. Some hold that it was brought from the north by the Laurentian ice-sheet and still others that it was transported by ice from near lake Megantic.

Although the origin of the gold is still in doubt, the most probable view is that it is local in origin and was derived from the disintegration of the quartz veins. The reasons for this conclusion are:

(1) The stratigraphic position of the deposits. The deposits of the deep channels are found lying close to or directly on bedrock and in many cases are separated from the boulder clay by deposits of gravel, sand, and clay, some of which at least are pre-glacial. The gold, therefore, was not brought to its present position by ice-sheets.

(2) The large size of nuggets and the rough, angular character of many of the smaller ones suggest that little stream transportation has taken place, and favours a local origin.

(3) The presence of quartz with the gold in some of the nuggets, and the close association of rich placers and quartz veins on Gilbert river indicate that the values have been derived from the quartz veins.

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[1]Geology of Canada, 1863, pp. 519, 739.
[2]Geol. Surv., Can., Rept. of Prog., 1870–71, pp. 276–77.
[3]Geol. Surv., Can., Ann. Rept., vol. X (N.S.) 1897, p. 149 J.
[4]Cirkel, Fritz, "Alluvial gold deposits in Quebec," Eng. and Min. Jour., 1911, pp. 1035–38.

(4) The auriferous character of some of the veins and the reported occurrence of visible gold in a vein at Devils rapids point to their being the original source of the gold.

The close association of rich placers and quartz ledges led Chalmers to conclude that lode deposits of gold, of much greater importance than any which have been found, may occur in the district. This condition, however, does not necessarily follow. In a district such as this where the bedding and schistose planes are, either or both, steeply inclined, the gold once caught in the crevices would move very little horizontally but would continue to work down along the crevices as the bedrock surface was lowered. In certain cases it is doubtful if the horizontal distance the particles have moved exceeds or even equals the vertical distance.

The values in the deep placers may have been derived not solely from the destruction of the quartz ledges which formerly continued across the space now occupied by the valley, but also from the erosion of the upper parts of veins which occur throughout the Beauceville series on the uplands and in the valleys. The structure of the Beauceville series and the thickness of the sediments exposed in the folds indicate that several thousand feet of sediments have been removed in the development of the present surface. Consequently the present veins are just the roots of possibly more massive veins which formerly existed. During the gradual lowering of the surface, the veins were disintegrated and eroded, the values were freed from the quartz, and along with the rock fragments were carried into the channels. With continued stream erosion and sorting the values became more and more concentrated in the lower parts of the channels and resulted in the formation of the exceedingly rich pre-glacial placers of the district.

With the advance of the ice-sheet these deposits lying in valleys which trend transversely to the general direction of ice movement were protected from removal but were covered beneath a thick deposit of glacial drift and fluvio-glacial sands and gravels. The deposits lying in channels, the trend of which coincided more or less with the direction of glaciation, were in many cases either completely removed or so disarranged as to be unworkable.

SUMMARY OF CONCLUSIONS

The placer gold deposits of the Chaudière River district comprise post-glacial deposits and pre-glacial deposits, the former occurring at or near the surface; the latter being concealed beneath a blanket of glacial drift and gravels, and lying in most places a considerable distance beneath the present stream beds. The post-glacial deposits are nowhere of sufficient richness to warrant a large expenditure of capital in their development, but some of them may suffice to furnish a livelihood for small groups of miners. The pre-glacial deposits occurring in some of the deep channels, especially those of Gilbert river, Meule creek, and rivière des Plantes, have proved exceedingly rich, and although the easily accessible deposits on these streams are practically exhausted there doubtless remain, both in these and many other buried channels of the district, undiscovered deposits equally rich. It is to these deep-lying deposits that future mining efforts should be directed.

The most satisfactory and inexpensive method of prospecting the deep channels is by means of a Keystone drill. The difficulties involved in the mining operations should be carefully considered before any large outlay of capital is made. Many difficulties peculiar to these deeply buried deposits do not obtain in other placer deposits.

These difficulties comprise:

The great thickness of overburden composed largely of boulder clay and gravels which carry very low values.

The large size of many of the boulders in the drift.

The presence of quicksand and water beneath the boulder clay.

The great depth at which some of the deposits lie below ground water-level.

The low gradient of the present stream channels, making it difficult to obtain sufficient gradient for sluicing or for the disposal of tailings.

The proximity of the deposits to settlements, which interferes with the disposal of tailings.

The numerous floods to which the streams of the district are subjected, resulting in the distribution of tailings causing damage to property.

The lack of sufficient water for hydraulic purposes.

The above-mentioned factors determine the method which must be adopted in exploiting these deposits. Of the various methods employed in placer mining, comprising drifting, dredging, hydraulicking, hydraulic elevating, drag-line scraping, and steam shovelling, drift-mining is usually the most expensive, but it is the only successful method for working these deposits. It involves the handling of a minimum amount of overburden to obtain values either near or on bedrock. The deposits which cannot be worked by some method of drift-mining are not likely to be worked profitably by any other method.

No deep mining has been carried on on Gilbert river below the junction of Caron creek. It is highly probable that the rich values found at Caron creek continue down to the Chaudière, but groundwater and quicksand would make these deposits difficult to mine profitably. The drainage pattern of Gilbert river and the mature condition of its valley indicate that this river was probably the upper part of a stream which formerly flowed southward along Chaudière valley. The deepening of the buried channel to its present depth, and the distribution of the gold along its bed were, in all probability, effected before the change in drainage of the Chaudière from a southeastern-flowing to a northwestern-flowing stream took place, and consequently, values carried down the channel would be distributed along the Chaudière valley to the south and the mouth of the Gilbert rather than to the north of it. The bed of the pre-glacial channel at the mouth of Gilbert river lies possibly over 100 feet below the bed of the channel at Devils rapids. The exploiting of these deposits, therefore, by drift-mining is impossible, and dredging is the only method by which they can be worked. The great depth at which they lie, the barren overburden, and the impossibility of obtaining drainage make the exploiting of the gravels a most difficult undertaking. By dredging, however, the bedrock gravels lying south of the mouth of Gilbert river will probably prove more remunerative than those north of the junction. A condition similar to that of the lower part of Gilbert river obtains in the other tributary streams entering south of Devils rapids, so that working the low-lying deposits is not a very hopeful prospect. The tributary streams north of Devils rapids are characterized by gorges cut in the bottoms of mature

valleys, and exploratory work along these channels has not proved as remunerative as was hoped. However, the upper parts of many of the streams may contain high values, and these deposits will doubtless continue to attract small groups of miners.

QUARTZ VEINS

Hundreds of quartz veins cut the various members of the Beauceville and Caldwell series. They vary from mere stringers to veins having a width of 25 feet. Owing to the drift and timber growth it was found impossible to trace even the largest veins for any great distance, but Mr. Wm. Lockwood, a mining engineer familiar with the early workings, reports that some are more than a mile in length.

The veins are of different ages. Many of the smaller ones were injected into the Beauceville sediments before they were folded, as is indicated by the veins cutting across the rock regardless of direction of schistosity and by their crumpled and brecciated appearance which corresponds with the folding of the rocks. Others, including the largest, are later than the folding to which the Beauceville series has been subjected and lie along the schistose planes in the rock or occur as saddle reefs at the crests of the folds. These veins are frequently lenticular expanding in some places into broad, lens-shaped bodies and in other places pinching to stringers. The schistose planes wrap about the irregularities of the veins. Whether these lenticular forms have been developed by dynamic metamorphism after the veins invaded the schistose planes or are due to the pressure with which the quartz solutions were injected could not be determined.

Mineralogically, the veins fall into two classes, one consisting of veins composed wholly of barren quartz and the other of quartz veins carrying some or all of the sulphides, pyrite, marcasite, arsenopyrite, chalcopyrite, galena, and sphalerite. Assays made in past years either by the Geological Survey, Canada, or by private concerns, indicate that the clear quartz veins are barren, but that the veins carrying the sulphides generally show at least traces of gold. Some of the assays yielded little if any gold, whereas other samples taken close by and assayed by equally reliable persons gave high values. At various times attempts have been made, but always without success, to develop the quartz ledges.

Many assay returns are given in the reports of Hunt, Michel, Chalmers, and Obalski, but little would be gained by repeating them here and those interested are referred to these reports. The writer took samples from numerous veins, but none assayed more than a trace of gold. The only vein in the district in which free gold is said to have been seen occurs at Devils rapids.

PLATINUM

A small amount of platinum was recovered from the black sand concentrates during the early placer operations on rivière des Plantes, but the amount was so insignificant and the price of platinum at that time was so low that no inducement was offered to make further search for the metal. The platinum was, doubtless, derived from the peridotite and dunite rocks

near these workings. As rivière des Plantes and St. Victor river are the only two streams which traverse these basic igneous rocks, the deep channels of these streams are the only ones likely to carry this mineral. A diligent and systematic search in these channels might prove an appreciable amount of platinum.

COPPER

Several small copper prospects occur in the Caldwell volcanic formation, but none of these gives promise of becoming a producing mine. They are more of scientific interest than of economic importance. On Caldwell river, 4,000 feet east of Chaudière river, several quartz veinlets containing small amounts of bornite, malachite, and specular iron occur filling fractures in the Caldwell greenstone. The veinlets vary from $\frac{1}{10}$ to $1\frac{1}{2}$ inches in thickness. They strike north 9 degrees west and dip steeply to the east. The variation in width of the veins is due to slight movement which has taken place in the fractures, resulting in a thinning and swelling of the veins. With the hope that the veins would increase with depth, two shafts were sunk, on opposite sides of the river, reaching depths of about 60 feet, but the results failed to show more than traces of the minerals.

A similar copper prospect occurs 2 miles east of Chaudière river and three-fourths of a mile south of Caldwell river just east of the concession road. Here, the showing of bornite and malachite was much more pronounced than at the other prospects. The copper minerals occur in veins up to $1\frac{1}{2}$ inches thick lying in fractures in the massive Caldwell greenstone. The development work indicates, however, that the veinlets are too few and too small to be of commercial importance.

Chalcopyrite is found in small quantities apparently as primary segregations near the outer edges of the Serpentine intrusive body. All of them, however, are mere mineral occurrences and not of commercial importance.

A thousand feet north of Rivière-des-Plantes post office and just east of the main highway, a small deposit of chalcopyrite occurs at the contact of the gabbro and acidic tuff.

Two miles northeast of Chaudière river and 2,000 feet south of rivière des Plantes, another small deposit of chalcopyrite occurs in the peridotite at the contact of this rock with acidic tuff.

MOLYBDENITE

A molybdenite prospect occurs 600 feet north of rivière des Plantes and 1,300 feet east of Chaudière River road. The deposit consists of flakes, films, and small pockets of molybdenite scattered through a quartz vein developed at the contact of a muscovite granite and a serpentinized peridotite. The contact zone of this granitic intrusion has been changed into a fine-grained, compact, greenish white, massive rock consisting principally of the calcium aluminum garnet, grossularite, along with quartz and chlorite and vesuvianite.

The width of the vein rarely exceeds 1 foot, but varies greatly when followed along the strike. The vein strikes north 18 degrees west mag-

netic, and dips northeast 58 degrees, the granite aplite intrusion forming the south and foot-wall of the vein.

The vein was mined for a distance of 50 feet along the strike, but the molybdenite was insufficient to be of economic importance.

TITANIFEROUS MAGNETITE

Within or near the map limits several deposits of titaniferous magnetite occur, some of which are chrome-bearing. One of the most important occurs about 1,400 feet north of rivière des Plantes and about 2,500 feet to the east of the map limits; several smaller deposits occur on lots 300 and 301, St. Charles range, lying about 1,000 feet north of the junction of rivière des Plantes with the Southeast branch. All these deposits lie at or near the contact of an acidic tuff member and an underlying intrusive peridotite of the Serpentine series. In some places the contact between the two rock types is definite, but at other places there appears to be a gradual transition from the one rock type to the other. Unfortunately the drift and timber growth prevent the contact from being seen except in a few places.

The acidic tuff member is of a dark mottled grey colour, being much coarser grained near the contact of the serpentine than farther away. It is cut by dykes of granite about 1 inch in width. The rock shows distinct banding, probably developed when the rock was laid down. Joint planes in it strike north 52 degrees east magnetic and dip 31 degrees north.

These deposits were reported on for the Department of Mines, Quebec, by Prof. E. Dulieux in 1912,[1] who made a magnetometric survey of the largest deposit mentioned above, which lies just outside the map-area. Prof. Dulieux estimates that the highly mineralized mass is about 70 feet by 25 feet, that it dips steeply to the north, and that it is elongated in a northeast direction, parallel to that of the mineralized belt along which all the other discoveries have been made. These observations accord with those of the writer, and support the view that the deposits are marginal segregations in the peridotite lying along or near the contact of this rock with the acidic tuff member. Prof. Dulieux states "the ore occurs in irregular pockets in the serpentine rock, as a rule the transition from the serpentine is through a kind of rock heavily charged with amber mica against which the mineralized mass stops abruptly. Sometimes, however, there is an imperceptible transition and the originally compact ore changes successively to a serpentine heavily charged with iron grains and then to a normal serpentine." Professor Dulieux notes a great variation in the chemical composition of the iron ore deposit within short distances. Of two samples analysed, taken less than 1,000 feet apart, one was a chromiferous magnetite containing only a small quantity of titanium, and

[1]Dulieux, E., "Preliminary report on some iron ore deposits in the province of Quebec," Rept. of mining operations in the province of Quebec, 1912, pp. 94-100.

the other was a titaniferous magnetite containing no chrome. The analyses referred to are:

	1	2
FeO	53·36	61·36
TiO_2	0·16	16·28
Cr_2O_3	9·86	none
S	0·075	not ascertained
P	0·045	"

The workings on lot 300 are not large enough to determine the form of the bodies, which appear to be lenses from 4 to 10 feet in width lying in granodiorite near the contact with serpentine.

Another prospect shaft has been sunk in an outcrop about 200 feet to the east. The ore in a fresh specimen is compact and of a steel-grey colour, caused probably by crushing. On a fractured surface the un crushed specks are distinctly noticeable, showing up as jet-black, glistening surfaces, giving to the rock a decidedly mottled appearance. The ore breaks with an uneven surface. Due to the crushing, it is in places highly fractured and along these fracture surfaces weathering has taken place. The ore weathers generally to an earthy brown colour, but various shades of green, blue, and brown are met with. The analysis, by Prof. Dulieux, shows it to be a titaniferous magnetite containing—metallic iron 34·70, titanium 12·36. Although the ore is magnetic it attracts the needle only in the immediate vicinity of the deposit.

The other deposit, occurring on lot 301, lies on the south flank of a 720-foot knoll, 1,700 feet due north of the junction of rivière des Plantes and Southeast Branch river. This deposit, though small, is seen to lie along the contact of acidic tuff and underlying serpentine, the contact plane striking northeast, and dipping 64 degrees north.

The contact of the acidic tuff and the serpentine is through about 4 feet of a dark-coloured rock which at a distance resembles ore, but on closer inspection is found to be coloured by ferromagnesian minerals. At the contact of this dark zone are beds of iron ore about 3 inches thick which are cut by cross fractures about 1 foot apart and now appear as thin lenses. That later movement has taken place is evidenced also by the slickensided surface of the serpentine adjacent to the deposit on the south. A sample from a pocket of this deposit analysed—metallic iron 54·77, titanium 1·49.

The limited dimensions of these lenses, their irregular occurrence, and the high percentage of titanium generally present make them of little commercial importance.

LIMONITE

A small deposit of limonite which has been used locally in the making of paint is found on lot 9, Chaussegros range, 3 miles east of Chaudière river and about 1,500 feet south of the first east-west road, south of Gilbert river.

The deposit consists of several bands of limonite, each only a few inches thick, which have resulted from the weathering of ferruginous, dolomitic, acidic tuff. The deposit is too small to be of commercial importance.

SERPENTINE ASBESTOS (CHRYSOTILE)

Irregular veinlets of a yellowish-green serpentine asbestos or chrysotile characterize the serpentine belt, but nowhere sufficiently numerous or large to be of any great economic importance.

Pits have been sunk in the St. Victor River and Rivière des Plantes areas and small quantities of the mineral have been obtained. The best grade of serpentine asbestos came from a shaft 1,000 feet northeast of the junction of rivière des Plantes with the Southeast branch. The veinlets were very numerous and closely spaced and some of them were over half an inch wide. A shaft 60 feet deep proved that the asbestos was not sufficient to warrant further workings.

SOAPSTONE

Soapstone or impure, massive talc is a hydromagnesian silicate having a pale green to white colour and a soft, greasy feel. Due to its heat-resisting properties and its extreme softness this rock has been used in commerce for many years. It is commonly used for firebricks, for paving of furnaces, for laboratory tables, gas burners, crayons, tailors' chalk, etc. Soapstone occurs on the north side of St. Victor river about 2¾ miles west of the Chaudière. The outcrop is a belt about 30 feet in width forming the northern rim of St. Victor River gorge for a distance of 1,100 feet below the lower falls. The rock occurs as a contact zone between an intrusive dunite and a slaty conglomerate and was evidently derived from the dunite by hydrothermal metamorphism by waters accompanying or closely following the intrusion. Numerous veinlets of magnesium carbonate and fibrous serpentine cut through the dunite and the soapstone. In certain parts of the soapstone large, angular, boulder-like fragments of peridotite occur, the schistose planes of the soapstone wrapping about the inclusions, and giving to the rock a bomb-like structure. The peridotite fragments vary from small nodules, the size of a hen's egg, to masses 8 feet in length. As a rule the fragments lie with their longer axis parallel to the foliation of the soapstone and are arranged in belts as if they were part of larger fragments. These masses were evidently torn from the parent peridotite body during a period of faulting and enclosed in a matrix of soapstone. The peridotite fragments being more competent than the surrounding soapstone were able to withstand the pressure which caused the less competent rock to flow around them. Further evidence of the dynamic stress to which these rocks were subjected is seen in the undulating fault plane which is traceable for a distance of over 100 feet along the north side of the intrusive.

The deposit on St. Victor river would be serviceable for the manufacture of many of the products referred to above, but the numerous fractures cutting the rock make it unsuitable for cutting into large slabs or blocks.

MARBLE

The British Canadian Marble Company, Limited, with Mr. H. Bristowe as manager, is quarrying a deposit of red calcite marble, in the Caldwell volcanic formation on the south side of Caldwell river. The marble, which occurs as two parallel beds, 7 and 11 feet thick separated by a 2½-foot bed of red slate, has been traced by means of isolated outcrops for at least 2 miles in a northeasterly direction. It has been exposed by surface stripping for a considerable distance and at a favourable locality a small steam hoist and a channelling machine are operating. The marble, is overlain and underlain by red slates and pillow lavas which are undoubtedly volcanic and there is little doubt that it owes its origin to volcanic agencies. The beds strike north 32 degrees east and dip 75 degrees north. Evidence obtained by a study of the associated volcanic and sedimentary rocks indicates that the formation of which the marble beds are members is overturned. The marble is highly crushed and contorted and contains in places large fragments of slate lying in various directions.

The marble is of little value for architectural purposes, as the limited thickness of the deposit, the brecciated and plicated nature of the beds, the numerous joint planes, and an interbedded slate member render it difficult to obtain sufficiently large blocks for sawing and polishing.

GRANITE

The granite outcropping on the west side of Chaudière river one-half mile west of Le Rocher post office, forms excellent building material. Some years ago the stone for the church and the bridge piers at Beauceville was obtained from one of these outcrops. Recently, however, there has been no demand for the rock, and work on it has been suspended.

CLAYS

Lacustrine and marine clays furnish material for common brick, but are not serviceable for tile or other hollow ware owing to their low plasticity; or for vitrified ware owing to the low temperature at which they soften when being fired. Clay deposits occur at various localities along Chaudière river, on rivière du Loup, Famine river, Bertrand creek, rivière des Plantes, and Doyon creek. At present only one deposit, located in St. George village, is being worked. Here, a pit, over 100 feet long and 8 feet deep, has been opened up and a considerable amount of common brick has been manufactured. The other deposits though not at present being worked will probably be made use of in the near future.

RIVIÈRE DES PLANTES DEPOSIT

The most extensive clay deposit underlies a large part of the broad basin of rivière des Plantes and is exposed along the stream channel 1¾ miles east of Chaudière river. The maximum observed thickness of the clay

was 8 feet, but the base of the deposit was not exposed. The clay is overlain by 3 to 6 feet of stream sands and gravels. It is silty, easily moulded when wetted, and will stand fast drying with a shrinkage of 6 per cent. It burns to a red colour and a porous but strong body at 1750 degrees and is overfired and deformed at 1900 degrees. It is consequently serviceable only for the manufacture of common brick. No attempt has as yet been made to work the deposit.

DOYON CREEK DEPOSIT

A deposit covering about 1,000 feet square occurs on the east side of Chaudière valley near the mouth of Doyon creek at the northern border of the map-area. Five hundred feet east of the main roadway a section exposed on the bank of Doyon creek shows a thickness of 40 feet of clay. The clay varies in colour. Some parts of the bank are decidedly reddish and in other parts the clay is dark blue. This deposit was examined by J. Keele of the Geological Survey, in the course of his investigations on the clay and shale deposits of the province of Quebec, and from his report[1] the following paragraphs are extracted:

"Two samples of clay were selected for testing, one representing the upper 15 feet, the other being an average of the lower 20 feet. No concretions were included in the samples. The upper clay requires 29 per cent of water to bring it to a working consistency. It is fairly plastic and smooth, but is easily made flabby by a slight excess of water. The clay will stand fast drying with a shrinkage of 6 per cent. It burns to a light red colour, and fairly hard border at cone 010, the fire shrinkage being about 2 per cent and the absorption 15 per cent. If heated up to cone 06 the body is denser, but the shrinkage becomes too great. The clay is overfired at cone 03, and softens at cone 1. It would be suitable for common brick made by the soft mud process, and possibly for field drain tile. Owing to its very silty or sandy character the lower clay does not work up as well as the upper. It is low in plasticity, the wet body being flabby and hard to mould. It burns to a pale red, rather soft body at cone 010 with the high absorption of 20 per cent."

"The numerous stony concretions render this clay almost useless and even if these were crushed the lower clay which carries the more concretions is not of much value for brickmaking purposes."

An average sample of this clay bank was submitted to Mr. Keele, the report on which varies little from the above description. It was found to burn to a light red, porous, but fairly strong body at 1750 degrees, and to be overfired and deformed at 1900 degrees.

FAMINE RIVER DEPOSIT

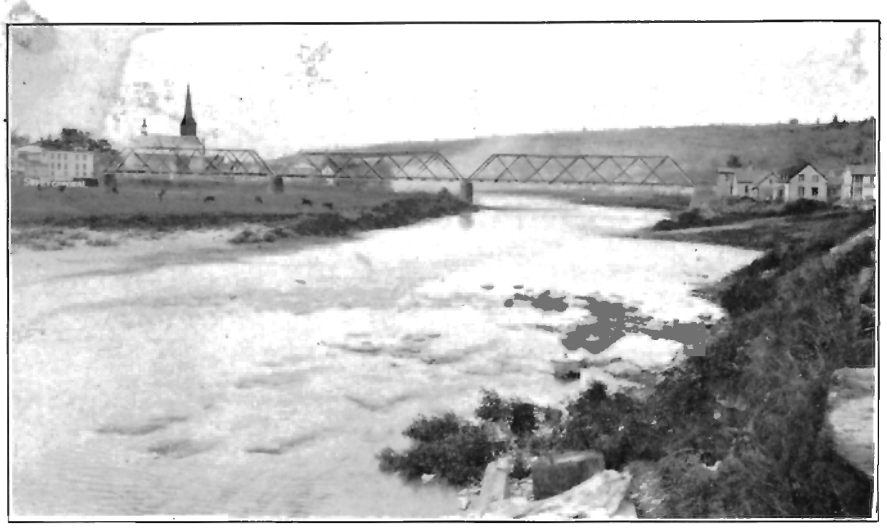
Two clay deposits occur on the north bank of Famine river. One, a greyish blue clay bed similar in appearance to the des Plantes clay deposits, is exposed in a cut bank of a tributary stream one-half mile from Chaudière river, and the other, a white silty clay—termed

[1]Keele, J., "Preliminary report on the clay and shale deposits of the province of Quebec", Geol. Surv., Can., Mem. 64, p. 94.

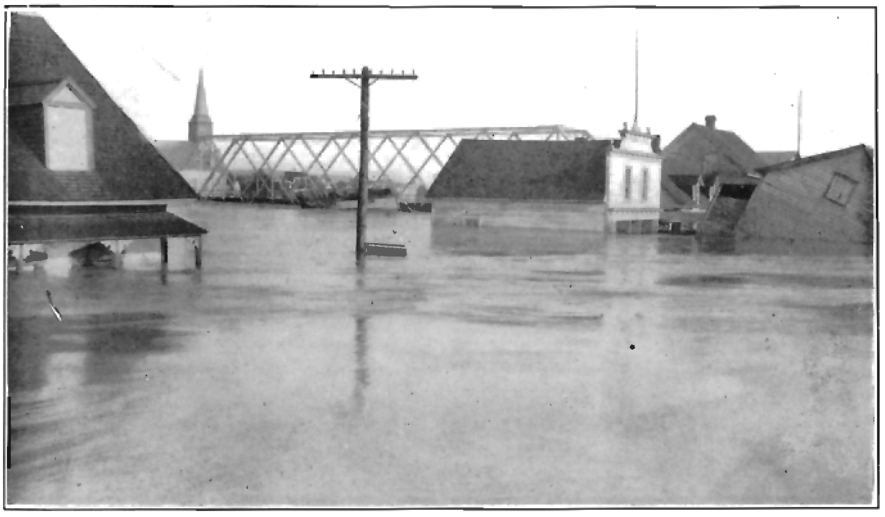
"pipe-clay" by the local miners—is exposed on the north side of Famine river 2½ miles from its mouth. The greyishblue clay deposit, 10 feet thick, overlies a thin bed of compact boulder clay, is capped by stratified gravels, and is undoubtedly post-glacial. The deposit of white, silty clay overlies yellow gravels, and underlies a boulder clay and is apparently of early Pleistocene age. Neither of these deposits is extensive enough to be of any great economic value.

A sample of the grey laminated clay from a 10-foot bed on the north side of Famine river about 2½ miles from its mouth was submitted to Mr. Keele who reports as follows: " This clay is silty in texture, develops a flabby wet body, and has not a true plastic feel. It burns to a bright red, porous body and is only suitable for the manufacture of common brick made by the soft-mud process."

PLATE II



A. Chaudière river, Beauceville, normal condition. (Page 5.)



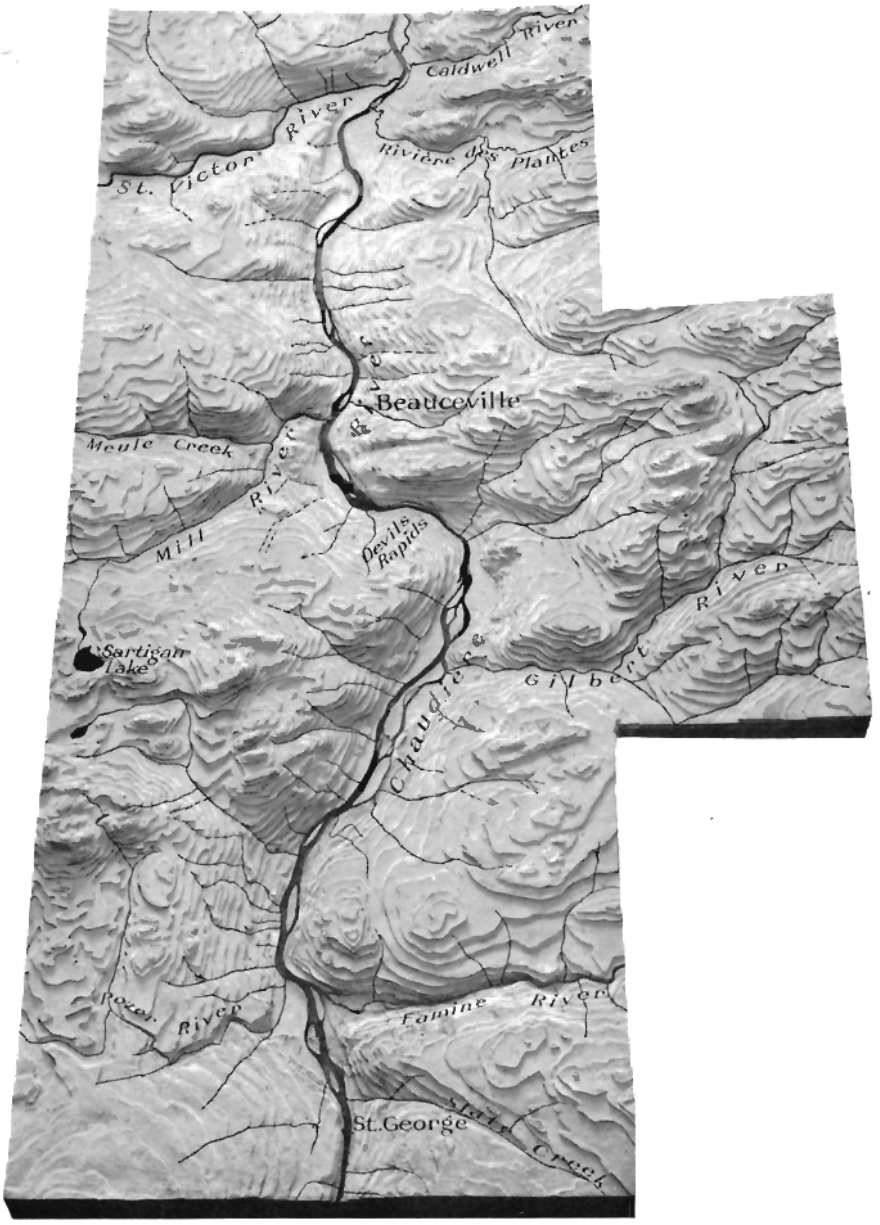
B. Chaudière river, Beauceville, flood condition. (Page 5.)

PLATE III

A. Falls and hanging-valley, Famine river. (Page 16.)

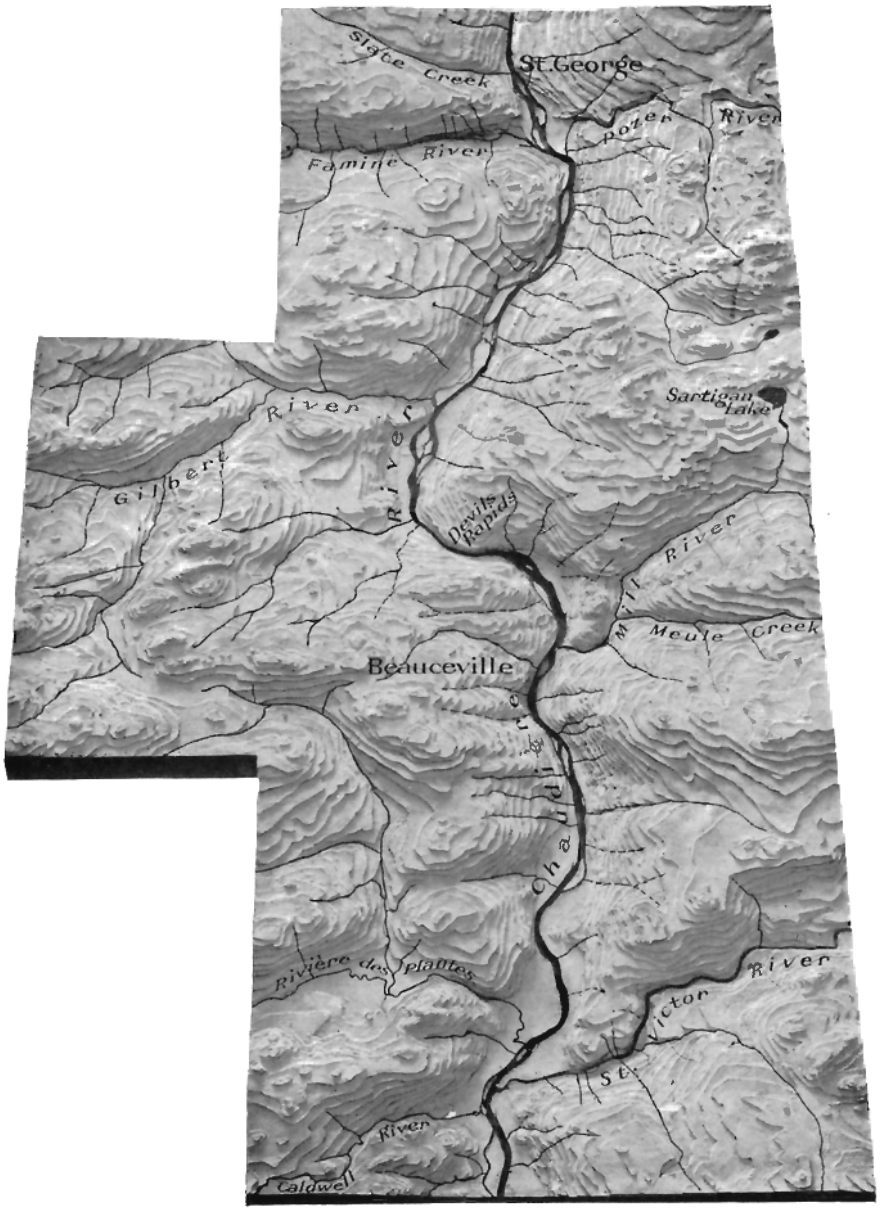
B. Pillow lava, Caldwell river. (Page 22.)

PLATE IV

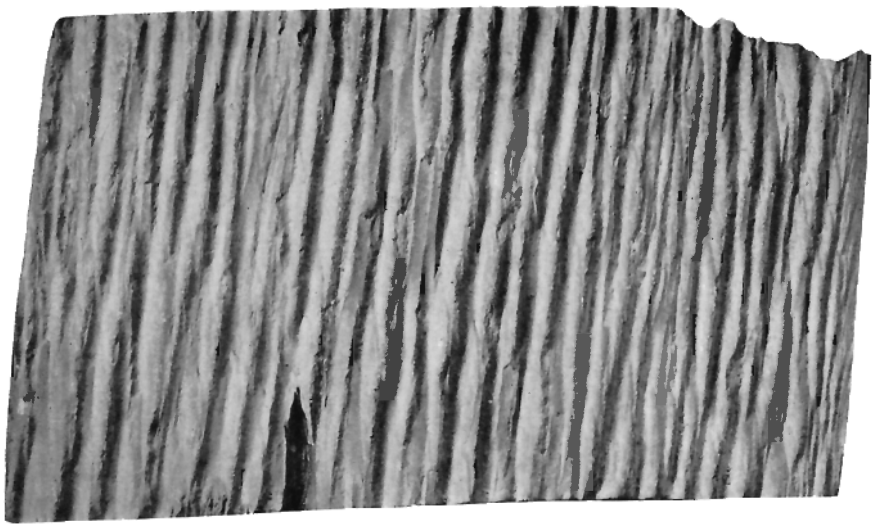


Relief model of Beauceville map-area viewed from southeast. (Page 58.)

PLATE V

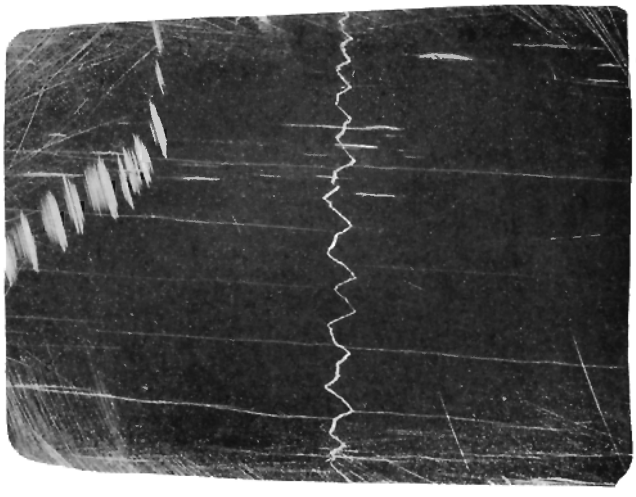


Relief model of Beauceville map-area viewed from northwest. (Page 58.)

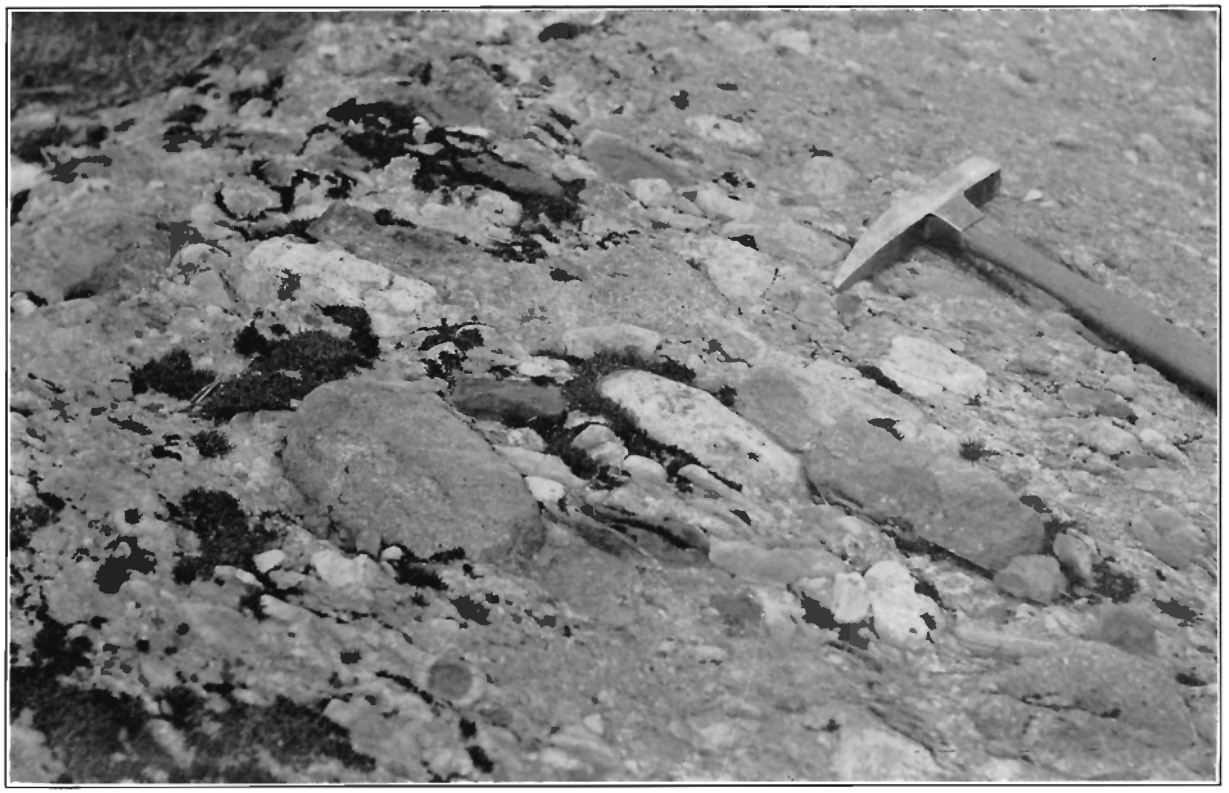


A. End and top veins of fluted surface in slate, Slate creek. (Page 28.)

B. End view of fluted surface in slate, Slate creek. (Page 28.)



C. Sectional trace of fluted surface in slate. (Page 28.)

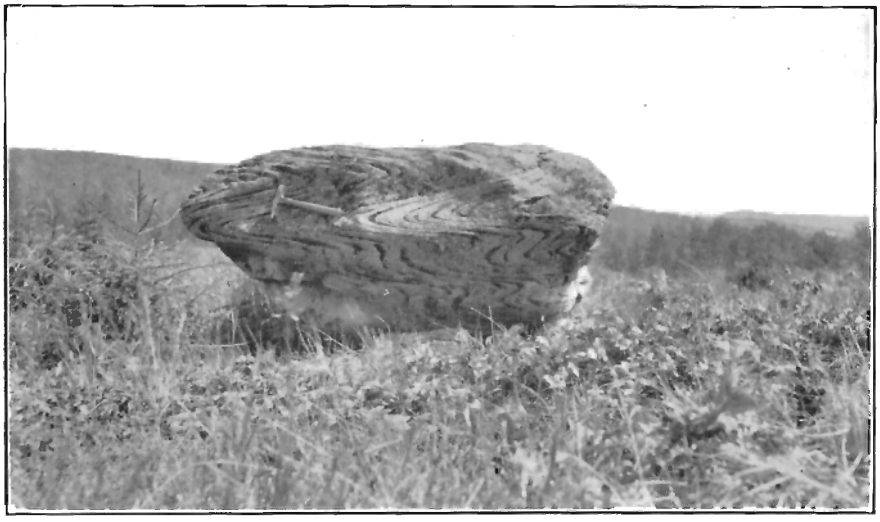


Outcrop of Devonian conglomerate, St. George. (Page 31.)

Outcrop of Tertiary conglomerate, rivière des Plantes. (Page 34.)

PLATE IX

A. Glacial erratic, of basalt breccia, Gilbert river. (Page 36.)

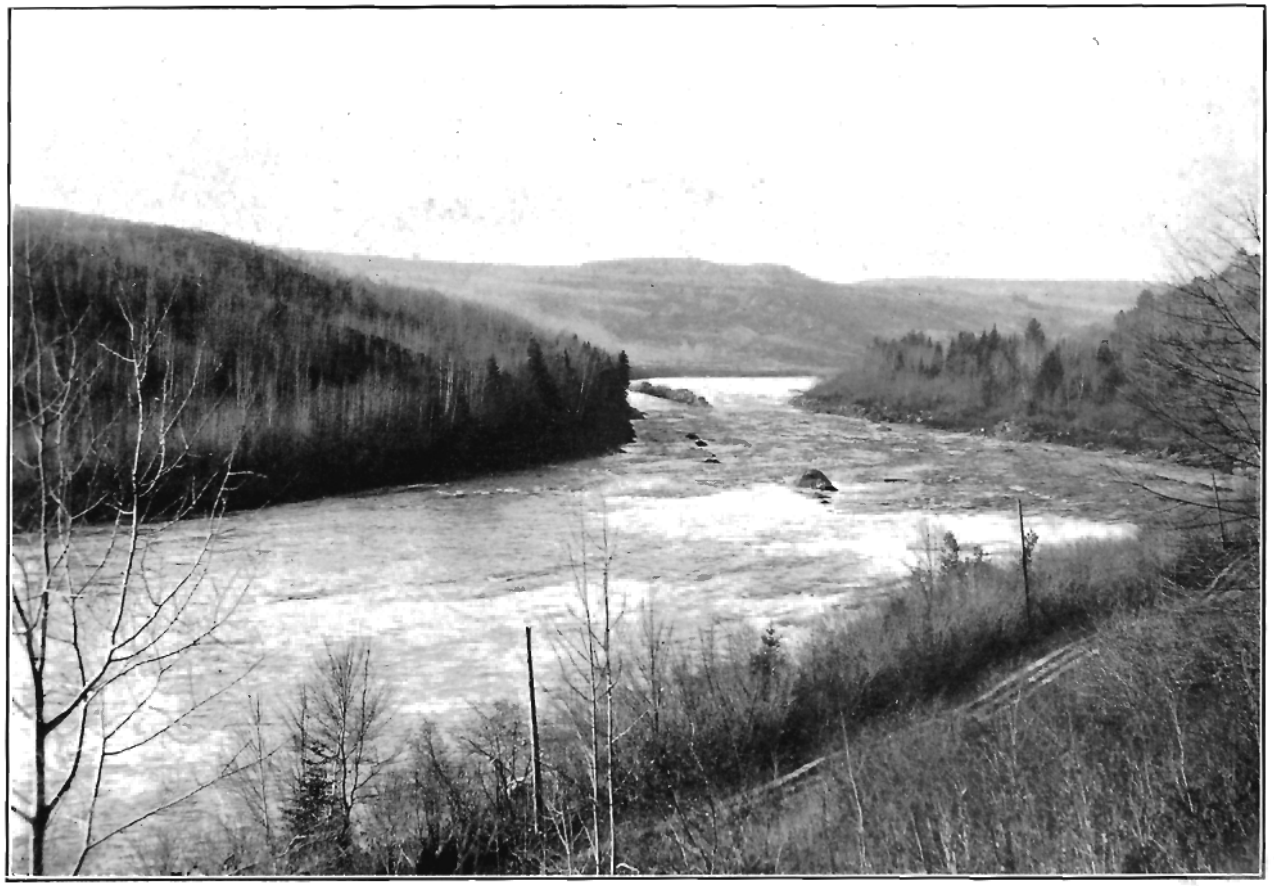


B. Glacial erratic of quartzite schist, Ste. En-Peine. (Page 36.)

PLATE X

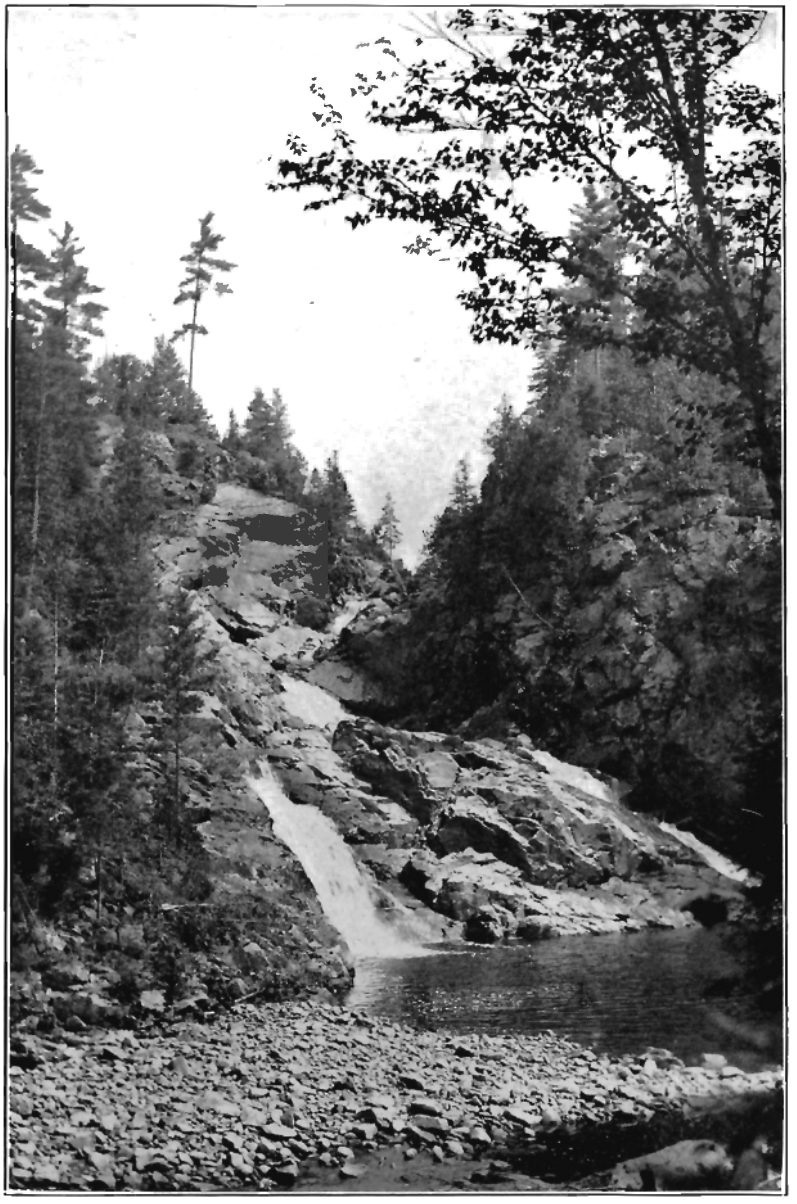
A. Glacial striæ on slate north of Beauceville. (Page 52.)

B. Canoe-shaped striæ, south slope of Famine river. (Page 52.)



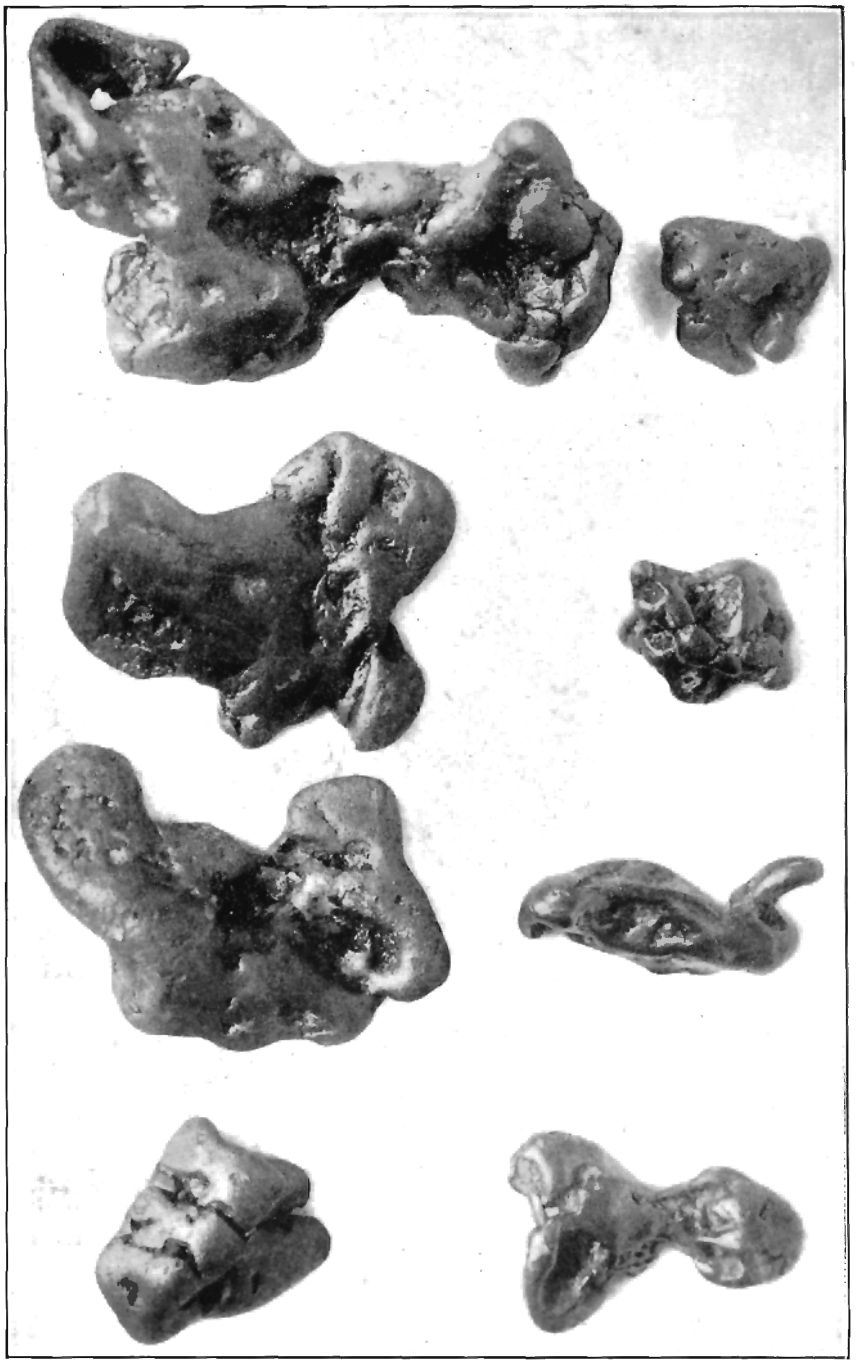
Devils rapids, Chaudière river, looking downstream. (Page 45.)

PLATE XII



Eighty-foot falls, rivière des Plantes. (Pages 7 and 59.)

PLATE XIII



Collection of nuggets from Meule creek. (Pages 70 and 78.)

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