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LACHUTE MAP-AREA, PART II- THE LOWLAND AREA, PART C

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Énergie et Ressources naturelles
Québec

PROVINCE OF QUEBEC, CANADA

Department of Mines and Fisheries

Honourable ONÉSIME GAGNON, Minister — L.-A. RICHARD, Deputy-Minister

BUREAU OF MINES

A.-O. DUFRESNE, Director

ANNUAL REPORT

of the

QUEBEC BUREAU OF MINES

for the Calendar Year

1936

JOHN A. DRESSER, Directing Geologist

PART C

LACHUTE MAP-AREA

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LACHUTE MAP-AREA

Part II.—THE LOWLAND AREA

by H. W. McGerrigle

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LACHUTE MAP-AREA

Part II.—THE LOWLAND AREA

by H. W. McGerrigle

INTRODUCTION

During the course of six weeks, a survey was made by the writer of that part of the Lachute map-area lying between the Laurentian front and the Ottawa river. The purposes of this survey were, first, to provide a map showing the distribution of the various deposits ranging in age from Pleistocene to Recent; second, to determine the present uses of these deposits and, so far as possible, their potential economic value; and third, to provide a basis for comparison between the Pleistocene-Recent deposits of the Lachute lowland area and of an area extending eastward from the Saint-Lawrence to the hill country and the general longitude of Granby. Both of the areas mentioned above were examined by the writer during the field season of 1936. Some attention was given also to the obtaining of information supplementary to that of earlier investigators on the age and physical characteristics of the Palaeozoic sedimentaries in the Lachute lowland area. A brief description of these rocks follows.

PALAEOZOIC

The consolidated rocks of the lowland of the Lachute area are predominantly Lower Palaeozoic sedimentaries. Precambrian rocks rise in the hills immediately east of Saint-Andrews East. They occur in greater area and form more pronounced hills in the Oka mountains (Mont Calvaire). Included in the Oka mountains are exposures of alkaline igneous rock of the Monteregian series and hence Upper Palaeozoic or younger in age. A basic dyke, also referred to the Monteregian series, was observed by the writer cutting the Beauharnois dolomite at Chat island on the Nord river above Saint-Andrews East.

Throughout most of the area, the oldest of the Palaeozoic formations represented, namely, the Potsdam, of Upper Cambrian age, rests on the Precambrian basement in unconformable contact. The Beauharnois formation, of Lower Ordovician age, rests disconformably on the Potsdam and occasionally is observed overlapping that formation and resting directly on the Precambrian. The Upper Chazyan Aylmer formation, of Ordovician age, succeeds the Beauharnois disconformably. One exposure of probable Beauharnois has been noted at Écho lake, about ten miles in from the Laurentian front. This outlier, resting on the Precambrian without the intervention of the Potsdam, shows that the Beauharnois was of greater extent originally than the Potsdam.

Potsdam Sandstone

Exposures of the Potsdam in the present area are rare and usually of small extent. They are practically restricted to the country of Deux-Montagnes, only one exposure to the west of this line, in Argenteuil, being noted by the writer. Ells (1), however, refers to an outcrop of the formation on the south slope of the hill immediately east of Saint-Andrews, and Wilson (2) mentions two small outcrops on the slope of the escarpment marking the Laurentian front about a mile west of Calumet. The formation is best exposed at the Canadian Carborundum property between Saint-Jérôme and Saint-Canut, and on the farms of A. Leroux and A. Giroux, near Saint-Hermas.

The maximum known thickness of the formation was recorded at the Canadian Carborundum property, where 429 feet were penetrated by drilling when the Precambrian basement was reached (3).

The Potsdam consists of white to grey, locally iron-stained, medium- to coarse-grained sandstone and quartzite in beds ranging from a few inches to four feet thick. Bedding is shown by alternating grey to white and bluish-grey layers and occasionally by thin black lines or seams of minerals of iron (Plate I-A). The quartz grains commonly are well rounded and occasionally frosted. Ripple-mark and cross-bedding are common structures and are particularly well shown in the outcrop near Saint-Hermas.

The physical characteristics outlined above apply to the upper 100 feet or less of the formation and show that this part was deposited in shallow water, where it was exposed to the action of rather rapidly shifting and fairly strong currents.

Fossils have not been found in the Potsdam in this area, apart from trails referred to as *Climactichnites* (Plate I-B), and in their absence the formation is correlated on the bases of lithology, stratigraphic position, and actual tracing of beds with the Potsdam of Upper Cambrian age south of the Saint-Lawrence in Quebec and in New York State.

Beauharnois Dolomite

The Beauharnois formation within this area, with the exception of one outcrop, is exposed only to the west of the Argenteuil-Deux-Montagnes county line. It is best seen in the Lachute quarries, in the Nord river at Lachute, and along the bank of the Ottawa river in the vicinity of Cushing.

The thickness of the formation was estimated by Logan (4) at 450 feet in the section between Lachute and Carillon. It is difficult to arrive at an accurate measurement of thickness based, as Logan's estimate was based, on average dip and width of formation, owing to the fact that all

(1) Ells, R. W., *Report on the Geology of Argenteuil, Ottawa and Part of Pontiac Counties, Province of Quebec, and of Portions of Carleton, Russell and Prescott Counties, Province of Ontario;* Geol. Surv. Can., Ann. Rept., Vol. 12, Pt. *J*, 1899.

(2) Wilson, M.E., *Relationship of the Palaeozoic to the Pre-Cambrian along the Southern Border of the Laurentian Highlands in Southeastern Ontario and the Adjacent Portions of Quebec;* Roy. Soc. Can., Trans., Vol. 14, Sect. 4, 1920, pp. 15-24.

(3) Denis, T. C., Que. Bur. Mines, Ann. Rept., 1920, p. 64.

(4) Logan, Sir William, *Geology of Canada, 1863*, p. 115.

three of the Palaeozoic formations have a rolling structure. Thus, dip readings at one place cannot be projected safely for any distance. Drill holes have been put down in the Beauharnois formation at the Carillon dam site, but to depths little greater than 100 feet (1). The formation almost certainly is in excess of 300 feet thick and its maximum thickness probably is between 300 feet and Logan's estimate of 450 feet.

The Beauharnois, locally as well as generally, is a dolomite formation, except for the basal 50 feet or so which consist of dolomitic sandstone and sandy dolomite. Toward the base, the beds are often irregular and locally are strongly cross-bedded. Many of the sand grains are rounded and frosted, and pitting of the grains was noted occasionally. No contact was observed that definitely could be taken as the contact between the Beauharnois and the Potsdam. Rather, the first impression is that one formation is conformable to and gradational into the other. Lithologically, there is gradation. But the presence of much wind-blown material, strong cross-bedding, and local disconformities, suggest a time of very shallow water, if not actual uplift above sea-level, between Potsdam and Beauharnois time. Age determinations based on fossils in other areas suggest that a considerable time interval separates the two formations.

Upward from the base of the formation, the rocks become more and more dolomitic until, about 75 feet from the base, sand occurs only as scattered grains in the dolomite beds. The dolomite occurs in master beds, themselves often thinly stratified, up to three feet in thickness, separated by seams and thin layers of sandy to siliceous, dolomitic shale. The dolomite is light to dark grey in colour, drab-weathering, and finely crystalline. White, grey, and brownish spots of crystalline calcite are common. Occasional beds of small-pebble intraformational conglomerate occur. Mud-cracks and ripple-marks were noted occasionally.

Fossils are rare and poorly preserved within this formation. In 1883, Dawson (2) reported *Piloceras amplum* from Lachute. Ami (3), in 1889, reported *Ophileta complanata* Vanuxem [probably *Lecanospira compacta* (Salter)], *Pleurotomaria canadensis* Billings, and *Hormotoma anna* (Billings) from Lachute, and from a point near Carillon the form *Eurystomites apollo* (Billings). The present writer found several specimens of *Lecanospira compacta*, as well as another form of the same genus, in sandy beds toward the base of the formation. *Lecanospira* also occurs in higher beds along the Nord river at Lachute. Also seen at the latter place were a number of specimens of the genus *Eccyliomphalus*, two small orthoceroid cephalopods, and two small specimens of *Hormotoma*. Close to the level of the Ottawa river, in the front of Cushing, at a horizon about 100 feet from the top of the formation, one bed occurs with a great abundance of ostracods, chiefly of the genus *Leperditia*. None of these fossils, as so far identified, are particularly diagnostic of the age of the formation, except the *Lecanospiras*. These, and particularly *L. compacta*,

(1) Dresser, J. A., *Report to the National Hydro-Electric Company, Limited, Montreal*, December 11th, 1935.

(2) Dawson, Sir William, Can. Nat., Vol. 10, 1883, pp. 1-4.

(3) Ami, H. M., in Appendix to report of R. W. Ells; Geol. Surv. Can., Ann. Rept. Vol. 12, Pt. J. 1899.

show that the formation is the equivalent of the Beauharnois at the type locality south of the Saint-Lawrence, and thus of early Ordovician (Middle Canadian) age.

Aylmer Sandstone and Limestone

The Aylmer formation in the present area has its greatest extent in, and is practically confined to, an area two to four miles wide extending eastward from Grenville village to Chatboro and Watson. While exposures are small and scattered throughout this area, the formation lies close to the surface, being covered by an average thickness of less than five feet of drift. The formation is weakly exposed at Carillon. The best exposures are at Grenville and along the canal and river shore from Grenville down to the old canal near Watson.

The base of the formation and its contact with the Beauharnois can be seen at the Canadian National Railway bridge just below Grenville. Some 25 feet of the Aylmer are shown here in vertical section. The basal two feet consist of interbedded layers of fossiliferous limestone up to four inches thick separated by thin seams of shale. Flattish pebbles of the Beauharnois dolomite occur in the limestone.

The formation has a thickness probably no greater than 50 feet. It consists, in general, of grey and dark crystalline limestones, calcareous and sandy shales, and some sandstone to quartzite beds. The following section was compounded from a number of exposures and for that reason, in conjunction with the shallow and variable dips of the scattered exposures, may be in error as far as the relative position of certain of the beds in the section is concerned. The succession is given in descending order:

9.—Drift.	
8.—Grey, sugary, sandy limestone	4 feet
7.—Coarse quartz sandstone and some small-pebble quartz conglomerate; occasional pebbles or original patches of green shale up to two inches diameter. Beds separated by thin seams of shale	8 "
6.—Green shale in beds up to three inches thick interbedded with quartz sandstone in beds up to six inches. Many of the quartz grains are well rounded and some are frosted and pitted	1 – 2 "
5.—Greenish, thinly bedded, knobby shale	3+ "
4.—Thinly cleaving and thinly bedded, fine-grained, dark-grey limestone separated by seams of shale. Some dove-weathering beds up to four inches thick	3± "
3.—Finely crystalline, grey, drab-weathering limestones in beds up to two feet thick separated by seams and by beds up to one foot thick of dark, greenish-grey, thin-splitting shale. The shaly beds are more common in the lower than in the upper half	20± "
2.—Grey, buff-weathering limestone in beds up to five inches thick separated by seams and thin layers of shale	2 "
1.—Grey, grey-weathering, crystalline limestone in beds up to four inches thick separated by shaly seams. Pebbles of Beauharnois dolomite in the limestone	2 "
	40± feet

Disconformity

a.—Beauharnois dolomite. Grey, brown-weathering, finely crystalline dolomite with vugs filled by calcite, in beds from one-half to one foot thick. The uppermost three feet or so are thinly bedded, ripple-marked, and mud-cracked.

There is no suggestion on this (the north) side of the Ottawa of limestone comparable in thickness, massiveness, and purity to the Aylmer exposed at Ross' quarry south of Chute-au-Blondeau on the south side. The latter has been referred to the upper part of the formation, while the more sandy beds on the north side of the river have been referred to the lower part.

According to Raymond (1), the fossil species common to the Chazy of the Ottawa valley and the Champlain valley are *Camarotoechia plena, C. orientalis, Rafinesquina alternata, Raphistoma stamineum, R. striatum, Leperditia canadensis,* and *Hebertella borealis.* "In the Champlain Valley region, *Camarotoechia plena* is found only in the upper 150 to 175 feet of the section... The two species of *Raphistoma* are usually found more than 300 feet above the base of the section and are most common somewhere about the middle" (1). The range of the other forms mentioned is less restricted. From the above evidence, Raymond concluded that the Aylmer formation would be correlated with the Upper Chazy of the type section. The present writer secured representative collections from several zones within the 50-foot thickness exposed in the area, as well as from the limestones of Ross' quarry on the south side of the river. While these collections have not been studied, *Camarotoechia plena* was noted in abundance in both phases of the formation.

Structure of the Palaeozoic Formations

The Palaeozoic formations of the Lachute area have a gently rolling structure. The dips are low, generally less than 10° and with angles of 3° and 4° common, and they vary more or less in direction and degree from outcrop to outcrop. It is possible that the dips of many of the exposures are initial, while others may be due to slumping. Some of the dips probably are the result of vertical movement, and definite evidence of such movement may be seen at the old locks in front of Watson. Here, an essentially vertical fault has brought about a displacement of at least fifty feet. The fault has a northeast strike (see map) and is marked by a sharp gulley trending northeast from the edge of the Ottawa to the Cushing-Grenville road. The relative movement was downward on the northwest side of the fault, bringing the Aylmer against the Beauharnois.

Judging from the distribution of the formations in the present area and to the eastward, the axis of a broad, low anticline follows a northeast-southwest course from the vicinity of the Saint-Canut quarries, near the Laurentian front, to a point about midway between Saint-Placide and Oka, on the Ottawa river. This was the only major structure recognized.

Economic Importance of the Palaeozoic Formations

The economic use and possibilities of the Potsdam sandstone and quartzite have been discussed by F. F. Osborne (this volume, p. 37). The Aylmer formation within the area has little economic importance.

(1) Raymond, P. E., *The Chazy Formation and Its Fauna;* Carnegie Mus. Ann. Rept., Vol. 3, No. 4, 1906, p. 562.

Some of the beds of this formation have been burned for lime, but this use has long since been given up, for the supply is restricted to relatively thin beds which are not easily attainable.

The Beauharnois formation has been quarried at Lachute and Grenville for building stone, and at Lachute for road metal. It has been employed in the construction of Wilson's paper mill (Plate II-A) and Ayers' woollen mill at Lachute and of several churches and private houses within the area. The presence of shaly layers and seams between the beds of dolomite, and the common occurrence of joints, renders quarrying in this rock relatively easy, and blocks up to two feet thick and four feet wide and long can be secured. The Beauharnois, also, at one time was used as a source of lime for agricultural purposes. Finally, there is the possibility that much of the rock in this formation would be suitable for the manufacture of cement. Examination of drill cores at the Carillon dam site by Dresser led to the following statements and analyses with reference to the potential value of the Beauharnois dolomite at that place as a cement rock (1):

"Analyses of several cores show a composition that may be useful in making cement for the proposed construction.

"Analyses for Comparison

	Cement Rock Montreal	Carillon Drill Holes			Natural Cement Rock Range (11 localities in the U. S.)
		No. 1	No. 4	No. 9	
Silica	13.6	16.05	14.06	18.10	9–19
Insoluble					
Iron and alumina	5.4	10.85	3.19	4.35	3–11
Lime	41.9	35.48	30.87	27.40	23–36
Magnesia	2.5	4.64	13.80	13.56	2–18
Carbon dioxide	35.0	32.80	38.28	36.27	31–40
Loss on ignition					
	98.4	99.93	100.20	99.68	

"In the table, all the 'insoluble' of the Carillon rocks is placed under silica, perhaps making it a little high, and the carbon dioxide content is entered as making up all the 'loss on ignition', which leaves this probably low.

"However, these figures are sufficiently precise for a practical comparison, and appear to show that there are beds of natural cement rock at the Carillon site".

PLEISTOCENE AND RECENT

Pleistocene

Glacial Deposits:

The oldest Pleistocene deposits are unconsolidated sediments of Glacial age. These were formed during the advance and retreat of the ice-sheet that covered this region to a depth of a few thousand feet.

(1) Dresser, J. A., *Report to the National Hydro-Electric Company, Limited, Montreal*, December 11th, 1935. Results given here by courtesy of Mr. J. B. Challies, Secretary, National Hydro-Electric Company.

The oldest of the Glacial deposits is boulder clay. This is a mixture of rock fragments more or less rounded and varying in size from small pebbles to large boulders set in a matrix of clay with some sand. The colour is bluish to greyish. Boulder clay is not abundantly exposed in the area but may be seen in a few places lying directly on the bedrock. This deposit is often encountered in well-drillings, and so, although generally concealed by later sediments, it is probably widespread in the depressions and hollows of the bedrock surface. The boulder clay was formed during the advance of the ice-sheet and was packed in under the ice and hence subjected to great pressure. This has resulted in a very hard, although uncemented, material, and one which gives considerable difficulty in well-drilling operations. The common term, 'hard-pan', is appropriate.

The remaining Glacial deposits of the area were formed during the retreat or northward melting back of the ice-sheet. The most common of the deposits is moraine. Such deposits consist of small pebbles to large boulders in a matrix of sand with some clay. Broadly speaking, there has been little sorting action during the deposition of morainic material, but, in detail, some layering or stratification has developed and usually can be seen wherever the deposits have been opened. Glacial moraine probably was spread as a mantle over the entire area during the melting away of the ice and probably was thickest wherever depressions occurred in the bedrock surface. But, while widely exposed even at the present time, it is to a relatively large extent concealed by later sediments and some of it has been removed by erosion. In general, the morainic material appears where bedrock is close to the present surface forming a mantle seldom more than ten feet thick, although the observed thickness of the deposit varies between zero and 25 feet. This is particularly apparent in that part of the area between Grenville and Saint-Andrews East, where bedrock occurs frequently and where the moraine mantles the bedrock with average depth of less than five feet. Toward the north, between Grenville and Lachute and again between Lachute and Saint-Jérôme, the average thickness of the moraine is somewhat greater, and exposures of bedrock are much less frequent. Morainic deposits are easily recognized by the characteristic occurrence of numerous boulders, either in ridges or spread out over a relatively flat surface. Thus, at Stonefield, boulder fields occur as evidence of the transporting ability of an ice-sheet and of the fact that, during its retreat, morainic material was deposited. In many places, the number of boulders is such as to render the land suitable only as pasturage or as bush land.

Where ridges of moraine occur, their longer axis is generally in an east-west direction or roughly parallel to the Laurentian front. Also, these ridges show better stratification than the flatter and broader areas of morainic material. Hence, these ridges may be recessional moraines resulting from temporary halts in the recession or northward melting back of the ice-sheet. The broader areas of moraine would have been spread out during a steady melting away of the ice and consequent steady release and deposition of the in-frozen boulders, pebbles, and smaller sediment.

Small pits have been opened here and there in the morainic deposits for road material, but the waste occasioned and the effort demanded by the presence of numerous boulders are so regat that these deposits can furnish only purely local needs (Plate II-B).

Associated with the moraines are deposits, usually local, of well stratified gravels. These have resulted from the action of glacial streams, which have picked up and sorted some of the material released by the melting of the ice. Such deposits are known as stratified drift or fluvio-glacial deposits. For the most part, these deposits are shallow, seldom more than ten feet thick, and evidently were formed by small glacial streams issuing from the ice and emptying into a glacial lake or a series of small glacial lakes, with the resultant deposition of sediment in the form of deltas. Several pits are being worked in such deposits, as near the Laurentian front north of Marelan, and a good grade of gravel is obtained, but the deposits are small and can supply only local needs.

Apart from the delta deposits, the stratified drift in this area includes occasional small kames and perhaps one or two eskers. Eskers, typically, are relatively long and narrow deposits of gravel and sand that were formed by glacial streams running either under the ice in tunnels or in narrow, open channels through the ice. A probable example of this type of deposit may be seen on Route 8 highway about three miles northwest of Saint-Hermas. The deposit follows a north-northwest course for about a mile; it is bordered on the east side by a small stream and on the west side is practically beuried bneath Champlain Sea clays. While not exposed throughout its length, it can be traced by the pits that have been opened in it and by slight elevations here and there above the clay. At its north-west end, it merges with a larger deposit that had been opened by the Canadian Pacific Railway Company for ballast and which appears to be a relatively large delta or perhaps outwash deposit (Plate III). The combination of these deposits has yielded a large quantity of gravel and sand for ballast and road material, and the supply is far from exhausted. A second possible esker occurs about midway between Saint-Jérôme and Saint-Canut, immediately on the north side of the Nord river. The occurrence has the characteristic shape of an esker, and to a depth of at least four feet along the top of the ridge the material is small gravel and sand; but the structure of the deposit was not determined. The ridge is about three-quarters of a mile long and follows a northeast-southwest course.

Kames are considered to be closely related to eskers in point of origin and structure, but instead of being long ridges are hummocks or small hills. They are composed of rudely stratified gravel and sand. Possible examples of these, agreeing with the definition of kames in form and having gravel and sand to a depth of at least three feet, occur in the Nord River valley about half way between Lachute and Saint Andrews East.

The stratified glacial deposits in general yield good gravel for road metal, and pits have been opened in the esker and delta gravels in many places in the present area. So far as the writer could determine, the possible kames mentioned above have not been tested, except for the shallow digging done by himself. These deposits merit further attention.

MARINE DEPOSITS:

It has been fairly well demonstrated that the weight of the ice-sheet depressed the surface of the land on which it rested well below the original pre-Glacial height of the surface, and in some regions to several hundred feet below the level of the sea. This depression of the land, combined with melt-waters from the ice-sheet being returned to the sea, caused an invasion of the land by the sea. Records of this post-Glacial or so-called Champlain sea in the nature of marine deposits may be found throughout the lowland areas of Quebec and Ontario as far as the Great Lakes, and down the Champlain valley in New York and Vermont states. In the present area, marine deposits are widespread from the Ottawa river to the Laurentian front, and they occur well back of that front along the valleys of some of the rivers.

The marine deposits are clays, sands, and gravels. These three lithologically distinct deposits cannot be resolved accurately or closely into divisions as far as age is concerned. Topographically, the gravels occur at the highest levels, followed in general at lower elevations by sands and then by clay. Stratigraphically, however, parts of all of these deposits are contemporaneous. For example, beach gravels might be forming at an elevation of 500 feet and at the same time sand at 400 feet and clay at 200 feet. In general, however, the sands overlie the clay directly and thus generally are younger than the clay.

Champlain Clay

Marine clay deposits are widespread in the area and represent the principal sedlment deposited in the Champlain sea. The terms *Champlain clay* and *Leda clay* have been applied to similar deposits elsewhere in Quebec and Ontario. Much of the best agricultural land of this area and of the province as a whole is within areas underlain by Champlain clay. The deposit generally is massive, but here and there well stratified clays occur. The latter consist of layers of clay up to four inches thick separated by thin seams of silt and (or) fine sand. The massive clays, when exposed in section, show many strong, vertical joints. The colour of the clay is bluish and bluish-grey, with occasional beds or bands of brown and reddish-brown. The silty and sandy layers and seams are grey in colour. The best section of theChamplain clay in the area is along the shore of Lac des Deux-Montagnes, below Saint-Placide, where some 25 feet vertically is exposed through a distance of over a mile (Plate V-A). Here the deposit generally is massive, but some stratification occurs locally.

The Champlain clay is exposed from the level of Lac des Deux-Montagnes, 73 feet above the sea, to an elevation of at least 400 feet in the Nord River valley above Saint-Jérôme. Similar clays occur farther up the Nord river in the vicinity of Shawbridge at elevations of between 600 and 700 feet. The similarity to and apparent continuation upward from the undoubted marine clays of the lower levels suggest that the high-level clays also are marine. By far the greatest bulk of the clay lies below the 300-foot level.

The thickness of the Champlain clay varies from one locality to another. In many places in the lowland, it is absent, and again it has

a thickness of only a few feet, as along the course of the du Chêne river. As far as information goes, the maximum thickness is 145 feet, reported from a well on the farm of George Armstrong, two and a half miles south of Lachute.

The Champlain clay constitutes the principal soil in the district. Otherwise, it has been put to no industrial use. It is possible that in some places it could be utilized in brick-making; this possibility, however, was investigated by Keele (1), who did not recommend any particular locality within the area. The nearest locality where brick is, or has been, made is Saint-Lin, in Terrebonne county, Quebec, and at Vankleek Hill in Ontario.

Champlain Sands

The sands of the marine, or Champlain, stage are sometimes referred to as the Saxicava sands and sometimes as the Champlain sands. So far as the present area and report are concerned, some part, and perhaps a large part, of the sands referred to the Champlain sea are actually fresh-water in origin. However, a distinction is made between the sands belonging to the Champlain stage and those formed since the drainage of the area had assumed its present (Recent) stage. The sands described in this section belong to the Champlain stage in the sense that they were formed during the presence of marine waters over the area and also, in some part, after the water had become brackish to fresh but was still in 'flood' relative to present conditions. Thus, no sharp dividing line can be drawn between the Champlain stage of the Pleistocene and Recent time. While we can use these terms to indicate relative time, we do not know when one stage ended and the other began, either from the point of view of actual time or of deposits.

Almost all the sands of the area that are referred to the Champlain stage occur between elevations of 275 and 200 feet. An area of about three square miles of sand, some four miles southwest of Saint-Benoît, lies between 185 and 150 feet above the sea, and in the vicinity of Oka sand occurs as low as 100 feet above sea level. The change from marine to fresh-water conditions may have occurred at about the 250-foot level or contour, and certainly took place before the water dropped below the 200-foot level, for the lowest level at which shells were found in the beach deposits (gravel) was at 260 feet.

The sands are distributed widely but discontinuously in the present area and at first sight do not appear to have any relationship to a definite cause. In general, however, they are closely related with moraine deposits, and evidently were derived from such deposits by wave erosion. It is not unusual to find sand along the upper edge of a terrace and extending back from the terrace-edge for a few hundred to several thousand feet. Such occurrences evidently represent parts of larger deposits that were removed to some extent during the cutting of the terraces. An example of this is on the 210-225-foot terrace crossed by Route 8 two miles northeast of Saint-Hermas. Very rarely is the sand built up in the front of the terrace itself, but such has occurred three miles west of Route 8 on the

(1) KEELE, J., *Preliminary Report on the Clay and Shale Deposits of the Province of Quebec;* Geol. Surv. Can., Mem. 64, 1915, pp. 55-58.

terrace just referred to, near Brown's Gore (Plate IV-A). Here sand occurs on the top level of the terrace and also has been deposited outward to form a built terrace of sand over the clay. The sand is well stratified, cross-bedded, and contains common pebbles of bluish clay in definite bands and a few scattered pebbles of rock (Plate IV-A). Another example is at Oka village, where the 100-foot terrace has been developed in sand.

The Champlain sands of the area are fine to medium in grain, usually angular, and, while quartz predominates, consist of a wide variety of minerals including common feldspar, mica, hornblende, and magnetite. They are well stratified and usually cross-bedded, but in many places their original structure have been modified or destroyed by later (Recent) wind action. The smallness of grain size and the variety and amount of minerals present, other than quartz, prohibit any wide use of these sands. They are used locally by farmers for concrete work, and at one place near Lachute are used in the making of cement tile.

Champlain Gravels

The Champlain gravels of the area are beach and delta deposits. The individual deposits usually are of small extent, but they occur at many places within the area from elevations of 475 feet to 150 feet. No detailed investigation of the gravels in the stream valleys back of the Laurentian front was made by the writer. Wilson (1) describes a probable Champlain delta, three miles west of Dalesville, at an elevation of 735 feet. The gravels at 475 feet constitute a small and poorly marked beach and terrace in the hills two miles west of Saint-Joseph-du-Lac village. The next highest deposit is a delta built into the Champlain sea by a small stream (William creek) flowing from the Laurentians. The delta is three-quarters of a mile east of where the present stream enters the Nord river and is about four miles east-northeast of Lachute. It slopes southward from its highest recognized level of 450 feet to about 200 feet, and has a maximum width of one-third of a mile and length of about one mile. Small gravel pits have been opened in this deposit near its front along the road paralleling the Nord river on the north side.

There may be other delta deposits along the Laurentian front in this area, but if so they are not as definitely identified as the one described. The only other deposit classified by the writer as of delta origin is that along the Nord river at Saint-Andrews, and as this lies between the 150-foot level and the present Ottawa it is classed as Recent and described under that heading.

Beach deposits (Plate IV-B) are relatively common. A notable example is one located two miles northwest of Saint-Joseph-du-Lac. The deposit is backed by a hill of bedrock, now thinly and scatteringly mantled by moralne, and rising to an elevation of about 450 feet. It fronts and overlaps on Champlain clay. The top of the beach deposit is a gently outward-sloping terrace with a maximum elevation of 375 feet above sea-level. This deposit has been opened recently, and well stratified, cross-bedded, outward-sloping gravel with lenses of sand is exposed

(1) Wilson, M. E., *Arnprior-Quyon and Manawaki Areas, Ontario and Quebec;* Geol. Surv. Can., Mem. 136, 1924, p. 14.

in the pit. Marine shells are common. The deposit yields an excellent road gravel, and the gravel and sand are used locally for concrete. A number of smaller beach deposits occur in the area and they yield, in general, a good grade of gravel with relatively little coarse material.

Terraces

After the Champlain sea had endured for a time, the land began rising, with consequent draining away of the marine waters and, later, of the fresh-water lakes and bays that had occupied the lowland. The development of terraces at various levels from 500 feet or higher almost to the present level of the Ottawa river (73 feet) in Lac des Deux-Montagnes shows that the uplift of the land was not a continuous process but an intermittent one. The fact that the lower-level terraces, that is, those between 250 feet and 100 feet, are relatively strong while the higher terraces are weakly developed probably is to be explained in part by the nature and amount of material involved, but it indicates also that the drainage was relatively more rapid in the earlier than the later stages. This latter observation is further supported by the fact that no recognizable deltas occur between the elevations of 450 and 150 feet.

The highest terrace recognized by the writer is at approximately 475 feet. This is two miles west of Saint-Joseph-du-Lac village, among hills rising to between 600 and 700 feet. The best developed and longest terrace has an elevation varying between 210 and 225 feet. It can be followed discontinuously from Calumet to Lachute, whence, with scarcely an interruption, it follows an easterly course to Sainte-Scholastique. This is the terrace so well seen from Route 8 highway in the vicinity of Saint-Hermas village. Other well-marked terraces occur at elevations, respectively, of 200, 185-180, 155, 120, and 110-100 feet (1). The 110-100-foot terrace is the lowest well-marked terrace observed and is best displayed one mile below Saint-Placide where it comes against the shore of Lac des Deux-Montagnes. It is probable that the terraces below 250 feet were formed by freshwater lakes and bays and channels, for marine shells are absent in the beach and bar deposits below that elevation. Thus, the well-marked terraces, all of which were formed in Champlain clay, and whose elevations are given above, probably all were formed after the marine phase of the Champlain stage had given place to a fresh-water phase. The terraces resulted from a gradual wearing away and eating back of a sloping shore through a combination of wave and current action until a cliff had formed. The tops of the terraces are flat or gently sloping. The fronts originally were cliffs such as is shown by the recently formed 110-100-foot terrace at Saint-Placide (Plate (V-A), but these have been modified by later sub-aerial weathering and slumping to less precipitous slopes (Plate V-B).

Recent

The Recent deposits of the area are alluvials, deltas, river and lake bar deposits, and dune sands. Alluvial deposits consisting of sands and

(1) These elevations are approximations, obtained by observations with a Brunton compass from known points.

gravels occur along the course of the present streams. In the Ottawa river, off the mouth of the Nord river, sand and gravel are being deposited in bars tailing off down-stream, and also around the sides and lower end of Ile Carillon. Very little flood-plain material is being deposited along the shores of the Ottawa in this area. Along the Nord river, however, a number of low flats receive flood-plain deposits each year. The deposits are very fine-grained sands with a relatively high percentage of clay, and thus they hold possibilities for use as moulding sand. Such material extends from Canuta upstreams to Saint-Canut, a distance of about five miles. In other parts of the Nord River valley between Lachute and Saint-Jérôme there is considerable development of sand probably deposited by the Nord river when the drainage was at a higher level. Much of this sand has been re-worked by the wind and now shows the characteristic structure (Plate VI-A) and topography of dune sand. The sand here is practically free from clay and, as it is fine to medium in grain and contains many minerals other than quartz, it has little economic use. Flood-plain deposits occur 20 to 50 feet above the course of a small stream flowing from the Laurentian terrain about a mile and a half east of Brownsburg. These deposits are at an elevation of about 400 feet and probably were formed, in part at least, during the Champlain stage. They were at one time the source of fine-grained moulding sand for use in foundries in Lachute.

A large deposit or series of deposits of Recent materials occurs along the lower part of the Nord river. Here, from a point midway between Lachute and Saint-Andrews East downstream to the Ottawa river, gravels, sands, and clay occur. The deposits are not continuous but fill larger or smaller depressions between morainic ridges. Southwest of Saint-Andrews East, some ten acres of ground have been worked in what is known as the 'Government pit' (Ottawa), and the structure of the deposit can be seen in many places. The shape and structure show the deposit to be a delta built by the Nord river into the Ottawa when the latter stood some 50 feet higher than at present. From the front of the delta proper, the deposit slopes to a flat underlain by fine sand with some clay and then falls off gradually to the Ottawa. The shores of the Ottawa river here are marshy, with some sand patches. Since the main part of the delta mentioned above was formed, the Nord river has shifted eastward from one-third to one-half a mile and now passes to the east of the moraine (on which a golf course has been built), whereas formerly it flowed on the west side of the moraine.

The most important deposits, economically, are outside of the area mapped, on Calumet point and adjacent to the point in the Lac des Deux-Montagnes (Figure 1). These are the sands usually referred to as the 'Oka sands'. The sands of Calumet point are a shallow-water, near-shore bar deposit (Plate VI-B) occurring as a broad and relatively low ridge with its long axis parallel to the shore of the lake. The sands are generally coarse and clean, and they consist of a variety of minerals, with quartz greatly predominating and feldspar common. These sands have enjoyed wide use for concrete, and a Canadian National Railway spur-line has been constructed to facilitate transportation to Montreal and other places. The use of dredges in the lake, and the transportation

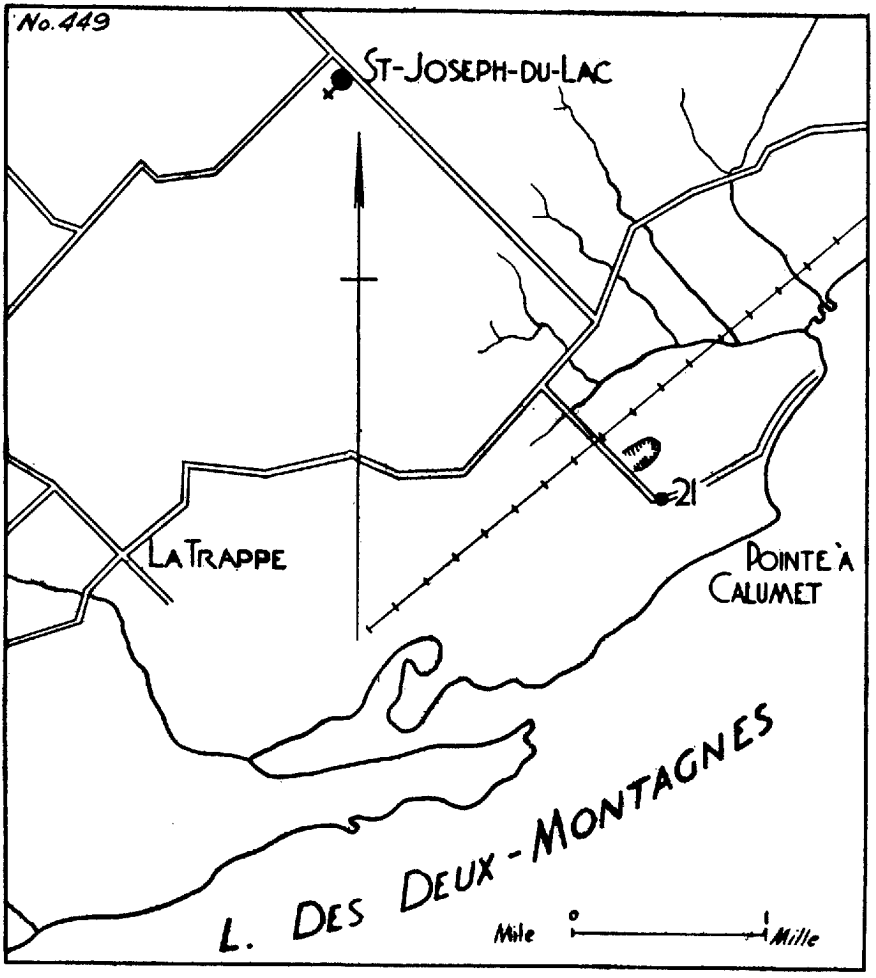


FIGURE 1.— Oka sands, Lac des Deux-Montagnes.

by barge of the sands dredged, has caused a great falling off in the market for the sands of the Point. At the present time, these latter are used locally, with occasional shipments farther afield. The sands on the lake-bottom between the channel and the shore, and those along the shore from Oka to Calumet point, are similar to the sands of the Point but they are interbedded with clay. The interbedding is such as to suggest that the layers are seasonal, the sand being deposited during the summer and the clay during the winter. The water over the deposits of sand and clay is generally too shallow at present for any serious belief that alternating deposition is still taking place on a large scale. It is more likely that the deposits now being dredged were formed while the Ottawa

river stood considerably higher than it does at present. The deposits are being worked by the Consolidated Oka Sand and Gravel Company, Limited.

DESCRIPTION OF PROSPECTS

General

As indicated above, it would appear that the greater part of the sands of the lowland area have little economic value. In general, the fineness of grain and mixed mineralogical composition of the sands, with feldspar, mica, and magnetite common, condemn them for specialized uses. A few developed deposits and prospects of potential economic importance do occur, however. These are described below.

Moulding Sand Prospects

Sample No. 10

Locality: Canadian National Railways gravel and sand pit at Saint-Andrews East; lot 48A, Parish of Saint-Andrews, Argenteuil county.

Description: The sample was taken at the southern edge of the pit. The deposit occurs irregularly below one foot of earth. It underlies an area about 500 feet square and varies in thickness up to one foot; 300 feet to the south, in a smaller pit, the deposit shows as a lens about ten feet wide and up to two feet in thickness.

Remarks: The relatively coarse grain of the sand and its high permeability suggest the possibility of its use for medium-weight castings. The compressive strength is low, however. Sand for local use could be obtained, but the irregular occurrence of the sand would prohibit the production of a large quantity of uniform grade.

Access: Immediately available to highway transportation.

Nearest Foundry: Eight miles to Lachute.

Origin: Delta deposit.

Samples Nos. 13 and 14

Locality: Two-thirds of a mile east of Brownsburg; lot 6, range VIII, Chatham township, Argenteuil county.

Owner: B. Bain, Brownsburg.

Description: The deposit occurs somewhat irregularly from the highway northward for 2,000 feet on the eastern side of a small stream. Its width varies from 50 to 500 feet. Two grades of sand are represented by the samples.

Sample No. 13 represents the northern part of the deposit, having a area of 500 feet by 50 feet and a maximum depth,

under six inches of earth, of one and a half feet. Sand from this part of the deposit formerly was used by the T. McOuat and Son Machine Shop and Foundry at Lachute, but has been supplanted by Albany sand. It is a very fine-grained, light brownish-grey sand, or loam, suitable for light-weight castings. It is indicated that a considerable tonnage of this sand remains. *Sample No. 14* was taken from various places through a length of 1,500 feet and width up to 500 feet in a flat immediately north of the highway. It varies from one to one and a half feet in thickness. This deposit grades northward into the type of sand represented by No. 13. It is a brownish-grey sand and, like No. 13, is fine-grained, but it has a lower clay content and a higher permeability. It probably would be suitable for light to medium-weight castings. While somewhat irregular in occurrence, a large reserve is indicated.

Access: Immediately available to highway transportation.

Nearest Foundry: Three and a half miles to Lachute.

Origin: Flood-plain deposit.

Samples Nos. 16 and 17

Locality: Saint-Canut parish, Deux-Montagnes county. Beginning about two miles east of Canuta and extending eastward for one and a half miles along the southern side of the Nord river are several deposits of sand over clay. Sample No. 16 is from a deposit toward the western end of these occurrences, on the farm of J. Labelle, while No. 17 was taken from near the eastern end, on the farm of M. O'Connor.

Description: The deposits vary in size and shape from small mounds to low ridges up to 1,500 feet long and 50 feet wide. The larger deposits have an average depth, under about six inches of soil, of one and a half feet. The sands are grey, fine in grain throughout, and have a fairly high clay content. It is indicated that they could be used for light-weight castings. A large yardage could be obtained. The largest of the individual deposits, such as those on the properties mentioned above, would yield upwards of 5,000 cubic yards.

Access: Immediately available to highway transportation.

Nearest Foundry: Lachute.

Origin: Flood-plain and natural levee deposits.

Sample No. 19

Locality: On the shore of the Ottawa river; lots 12 and 13, range I, Chatham township, Argenteuil county.

Owners: J. Canning (lot 13); Mrs. J. Owens (lot 12); Grenville.

Description: A small deposit occurring mainly on lot 13 but extending eastward on to lot 12. The deposit is 400 feet long and up to 50 feet wide, with an average depth of about one and a half

feet. The sample is a composite from three test holes. The sand is brown, fine-grained, and has a fairly high clay content. While the sand would be suitable for light-weight castings its use necessarily would be restricted to local needs by reason of the small size of the deposit.

Access: Readily available to highway transportation and to water transportation by means of the Carillon canal and Ottawa river.

Origin: Flood-plain deposit, or delta deposit formed by a small stream flowing into the Ottawa river.

Sample No. 20

Locality: Lot 13, range I, Chatham township, Argenteuil county.

Owner: J. Canning, Grenville.

Description: The moulding sand represented by the sample is restricted to the eastern end of a gravel deposit which, on the adjoining property to the west, has been worked for road material. The sand underlies an area some 300 feet long by 30 feet wide to an average depth of two feet. Thus, less than a thousand cubic yards are available. The coarseness of the sand and its relatively high clay content suggest the possibility of its use in medium to heavy-weight castings. The small size of the deposit implies that its use necessarily would be local.

Access: Immediately available to highway transportation.

Nearest Foundry: Lachute.

Origin: Shore deposit of an earlier and larger Ottawa river.

CONCRETE AND OTHER SANDS

Sample No. 8

Locality: One and a half miles north of Monalea station; lot 4, range II, Chatham township Southeast, Argenteuil county.

Owner: T. Morin, Saint-Philippe.

Description: A pit 450 feet long and 200 feet wide has been opened in a deposit of gravel and sand. The average depth of the pit is five feet. The section consists of three main divisions, given below in descending order:

3.—Slightly earthy gravel with some cobbles..... 2 ft.

2.—Clean, fine gravel, well sorted. This gravel has been used with good results for road surfacing.. 5 ft.

1.—Clean, coarse sand..... 2-4 ft.

The sample represents the clean, coarse sand of the lower part of the deposit. This sand has been used in the construction of highway concrete culverts. It is coarser than the average

of the material known to the building trade as "Oka sand". The reserve of the deposit as a whole is estimated to be in excess of 75,000 cubic yards and that of the concrete sand in excess of 20,000 cubic yards.

Access: Immediately available to highway transportation.

Origin: Probably a delta deposit built during the recession of the Champlain sea.

Sample No. 9

Locality and Owner: Canadian National Railways gravel and sand pit at Saint-Andrews East; lot 48A, Parish of Saint-Andrews, Argenteuil county.

Description: Sample taken from a large lens of sand with a thickness of ten feet. Several lenses of similar sand occur, the total of which would provide an important reserve. The sand is grey in colour, clean, and fairly coarse; it averages somewhat finer than the "Oka sands". It is used locally for concrete work, for which it seems well suited, and would also make an excellent core sand.

Access: Immediately available to highway transportation and railway transportation.

Origin: Delta deposit.

Sample No. 21

Locality: Sand pit at Calumet Point, south of the southwestern limit of the area; Saint-Joseph-du-Lac Parish, Deux-Montagnes county.

Owner: W. Whelan, Calumet Point.

Remarks: The sample was taken for comparative purposes and as being representative of the "Oka sands". The "Oka sands" at present being used for other than local purposes are dredged from the bottom of the Lac des Deux-Montagnes, but they are very similar to the sand of the sample. The sample was taken from the face of a pit located in the western end of a broad ridge of sand that has a length of one-half mile or better and a width up to 1,500 feet. Some 15 feet of the clean, coarse sand represented by the sample overlies finer sand. The latter occurs at about the water level.

While much sand and gravel has been removed from the land deposits at Calumet Point, it is indicated that a very large reserve of good concrete sand still remains.

Access: Immediately available to highway and railway transportation.

Origin: Bar deposit formed in a larger Lac des Deux-Montagnes.

MECHANICAL ANALYSES OF MOULDING SANDS

SAMPLE NO.	Screen Analyses; Percentages U. S. Bureau of Standards Screen Numbers													Grain Fineness No.	Grain Class	Clay Class	Moisture (Tempering) %	Permeability	Compressive Strength	Sintering Point (degrees centigrade)	$CaCO_3$
	On 6	On 12	On 20	On 40	On 50	On 70	On 100	On 140	On 200	On 270	On Pan	Clay Sub-stance	Total								
10	.....	0.12	12.84	58.21	6.21	7.20	2.71	1.86	2.44	0.69	3.02	4.56	99.86	39	7	C	4.5 6.0 7.5 8.1	332 569 323 334	2.0 1.35 2.0 1.25	.....	Nil.
13	.....	.....	.....	0.13	1.22	3.52	3.35	3.71	15.78	7.74	46.32	17.85	99.62	228	1	F	4.8 6.8 8.6 10.4	1.3 1.8 2.3 2.7	7.7 7.8 7.6 9.2	1,075	Nil
14	0.31	0.28	0.51	0.58	0.36	0.90	3.82	7.01	25.85	10.45	40.93	8.86	99.86	212	1	D	5.1 6.2 8.2 9.8	4.1 6.3 8.6 9.8	6.5 7.8 7.3 6.9	1,040	Nil
16	.....	.....	.....	0.05	0.78	2.69	17.20	23.02	20.99	4.72	19.58	10.69	99.72	153	2	E	4.2 5.8 7.9 9.6	6.3 10.8 14.8 15.5	7.0 7.3 6.0 5.1	1,050	Nil
17	.....	.....	.....	0.04	0.17	1.00	11.58	20.30	23.32	5.53	25.49	12.56	99.99	185	2	E	4.8 6.5 8.2 9.4	3.5 5.6 6.0 7.6	7.6 7.8 8.5 7.9	1,200	Nil
19	.....	.....	.....	0.05	0.31	0.76	3.02	9.30	22.76	8.17	42.65	12.47	99.49	219	1	E	4.5 6.4 8.1 9.8	4.2 5.5 6.8 6.7	6.5 6.8 7.1 7.0	1,090	Nil
Pebbles 20	3.50	9.67	16.25	18.02	7.56	4.90	4.78	3.84	5.49	1.92	11.86	12.16	99.95	98	4	E	4.1 6.1 7.8 9.0	35.0 188.4 68.4 115.7	3.5 6.7 5.3 5.0	1,290	Nil

MECHANICAL ANALYSES OF SANDS OTHER THAN MOULDING SAND

SAMPLE NO.	Screen Analyses; Percentages U. S. Bureau of Standards Screen Numbers													Grain Fineness No.	Grain Class	Base Permeability	$CaCO_3$				
	On 6	On 12	On 20	On 40	On 50	On 70	On 100	On 140	On 200	On 270	On Pan	Clay Sub-stance	Total								
1	.....	.....	0.06	0.27	2.30	7.28	37.11	36.54	13.15	1.50	1.02	0.82	100.05	94	4	48	Nil				
2	.....	.....	0.09	1.63	5.09	14.55	43.30	24.39	8.46	0.71	0.80	0.82	99.84	82	4	57	Nil				
3	.....	.....	.....	0.06	1.28	13.15	51.81	25.75	5.01	0.28	0.25	0.46	99.95	79	4	73	Nil				
4	.....	.....	0.01	0.83	11.78	23.08	38.21	19.25	4.53	0.38	0.72	0.76	99.55	73	4	74	Nil				
5	.....	.....	.....	0.05	0.18	6.61	47.54	33.47	9.89	0.93	0.57	0.60	99.84	89	4	60	Nil				
6	.....	.....	.....	0.80	12.91	38.69	41.48	4.43	0.24	0.03	0.80	0.36	99.74	61	5	136	Nil				
7	.....	.....	0.09	2.12	3.30	7.56	39.18	35.37	9.52	0.77	1.17	0.90	99.89	89	4	57	Nil				
8	6.40	42.02	37.38	5.37	0.70	0.98	2.07	1.32	0.74	0.20	1.00	1.57	99.75	16	9	1,500	Nil				
9	0.27	0.39	4.15	50.81	25.06	14.43	2.11	0.50	0.34	0.09	0.48	0.99	99.62	32	7	330	Present	Pebbles caught on screen No. 3 removed before testing			
11	.....	.....	0.05	1.25	3.66	6.50	7.96	39.80	30.85	3.83	5.00	1.00	99.90	121	3	28	Nil				
12	.....	.....	.....	0.92	6.92	25.80	43.07	16.66	4.39	0.31	0.95	0.85	99.87	73	4	58	Nil				
15	.....	.....	0.06	0.49	2.94	14.15	58.47	16.03	4.94	0.64	1.55	0.48	99.75	79	4	67	Nil				
18	.....	0.06	0.45	10.74	29.40	33.13	18.67	4.52	1.16	0.24	1.00	0.64	100.01	54	5	102	Nil				
21	.....	0.05	20.41	51.78	7.97	10.06	6.19	2.00	0.64	0.08	0.12	0.64	99.94	29	8	418	Nil				



A.— Potsdam sandstone near St-Hermas village.



B.— Climactichnites sp. (trail) on surface of Potsdam sandstone bed, St-Hermas.



A.— Wilson's mill, Lachute, constructed of Beauharnois dolomite. The Beauharnois formation traversed by the Nord River.



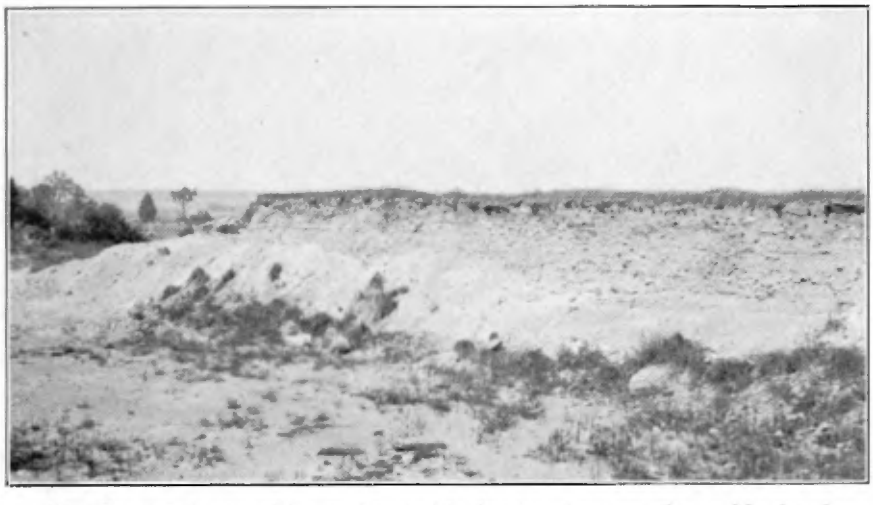
B.— Portion of face of small gravel pit opened in rudely stratified moraine or till deposit.



Northwestern end of gravel pit about four miles east of Lachute; formerly operated by the Canadian Pacific Railway Company for ballast. A Glacial deposit, probably of the outwash type, overlapped to some extent by Champlain deposits.



A.— Sand pit in terrace front near Brown's Gore.



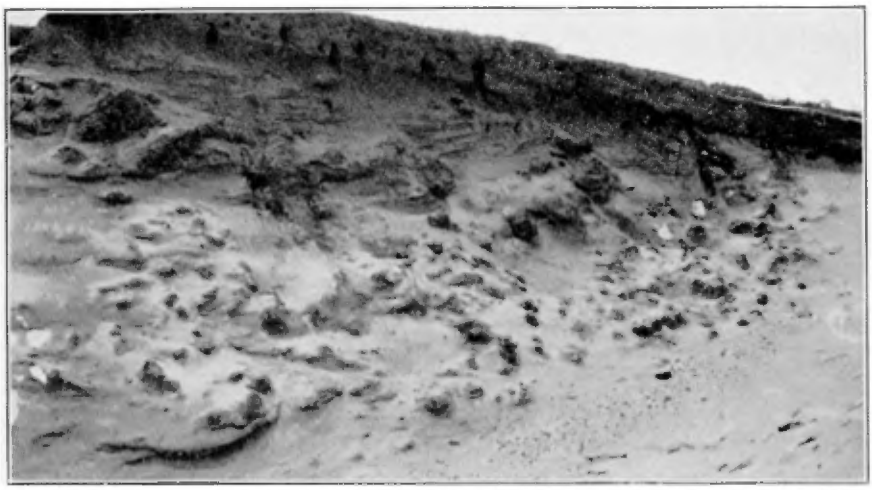
B.— Face of pit opened for road material, showing structure of gravel bach or bear formed in the Champlain sea. More boulders and cobbles here than is usual in a Champlain beach or bar deposit. About three miles east of Grenville and one mile south of Route 8.



A.— Recently formed 110-110-foot terrace with cliffed front. Shore of Lac des Deux-Montagnes; one mile below St-Placide.



B.— Front of 120-foot terrace. Near St-Placide.



A.— Face of natural excavation caused by wind in sand dune. Cross-bedding prominent. Nord River valley, four miles above Lachute.



B.— Pit in late Champlain (or Recent) sand bar formed in larger Lac des Deux-Montagnes. Calumet Point.