RG 148(A)

PORTNEUF AND PARTS OF SAINT-RAYMOND AND LYSTER MAPS ARES, PORTNEUF AND LOTBINIERE COUNTIES

DEPARTMENT
OF NATURAL
RESOURCES
MINES BRANCH

GEOLOGICAL EXPLORATION SERVICE

PORTNEUF

AND PARTS

OF SAINT-RAYMOND

AND LYSTER MAP-AREAS

Portneuf and Lotbinière Counties

GEOLOGICAL REPORT – 148

T. H. CLARK
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1973

G.R.–148

E R R A T A

GEOLOGICAL REPORT 148

PORTNEUF AND PARTS OF SAINT-RAYMOND AND LYSTER MAP-AREAS

Page	Parag.	Line	Instead of	Read
I	-	-	Silstone	Siltstone
I	-	-	Appalachians	Appalachian
II	-	-	Tectonic	Tectonics
II	-	-	Fold	Folds
III	-	-	boulder on	boulder in
1	1	1	Palezoic	Paleozoic
1	4	2	Clark,1949	Clark, 1949)
6	5	5	northwest-southeast	northeast-southwest
8			Deepskill	Deepkill
9	5	3	Malihercsik	Melihercsik
9	5	3	University Laval	Laval University
14	2	2	include	included
14	2	3	shalow	shallow
15			surface on	surface exposures on
16	3	2	bryozoa	bryozoans
19	2	16	bryozoa	bryozoans
19	3	2	particules	particles
21	4	3	extend from	extend
23	4	3	hemeplicata	hemiplicata
27	2	1	with the crinoidal	with the cream-weathering semi-lithographic lime-stone, crinoids
30	3	1	47 feet of.... east of Neuville wharf	39 feet at the base of the section
32	1	8	Trenton limestone .... is formally	Grondines limestone is lithologically
32	1	16	common in the ...	delete this line
32	1	18	Wittington	Whittington
32	2	1	in respect	with respect
32	2	4	coeval	together
32	2	4	Which	This
32	Table	Left part	Sherman Falls	Lower Grondines (Sherman Fall)
34	16	4.5	Cryptolithus triplesia	Cryptolithus lorettensis
34	16	4.5	Triplecia nuclea	Triplesia nucleus
34	19	1	Shale	Shaly
35	1	1	cristalline	crystalline
36	2	5	are in the quarry	is in the quarry
36	3	4	locality 7	locality 6
37	1	3	cerausus	ceraurus
37	2	1	conodonte	conodont

Page	Parag.	Line	Instead of	Read
37	3	2	lithological identity	stratigraphic allocations
38	3	8	Hallopora spendens	Halłopora splendens
38	4	21	T. cuspydita	T. cuspida
38	4	22	Rhynchotrema increbencens	Rhynchotrema increbescens
38	4	27	Trigrammaria hemeplicata	Trigrammaria hemiplicata
39	3	7	Isoletus gigas	Isotelus gigas
39	4	24	Eurichilina	Eurychilina
39	4	25	Jonesella abscura	Jonesella obscura
39	4	28	Ulrichia binodosa	Primitia binodosa
39	5	3	Cystitis	Cystid
39	8	1	stems	rods
41	1	6	limestone	limestone
42	1	3	add after (limestone)	on left side of the Jacques Cartier River, below Pont-Rouge
42	2	1	member	Member
43	3	1	2-inches beds	2-inch beds
43	3	2	2 inches beds	2-inch beds
43	9	2	1,000	1,000 feet
47	Fig. 5		A The dips are exaggerated and assumed similar	B The dips are exaggerated and assumed similar
48			Bed No. limestone	Limestone Bed. No.
49	9	1	Eurypteride	Eurypterid
49	10	1	Graptolita	Graptolithina
50	2	10	Criptolithus	Cryptolithus
50	3	4	an Utica age	a Utica age
50	4	2	C. Typicalis	C. typicalis
50	5	3	Leptanea	Leptaena
50	6	1	Bécancourt	Becancour
50	6	1	formation names formation Bécancour	formation names Becancour
51	3	10	north	mouth
54	2	7,8	layers of the marked	layers are marked
55	5	6	Flexicalimene	Flexicalymene
55	6	4	Byssonichia	Byssonychia
55	6	6	Colpomya faba pusila	Colpomya faba pusilla
55	7	1		Chambly X
59	5	2	Fig.10	Fig. 4
60	Table	8	C.cf. C. acharenbergi	C. cf. C. scharenbergi

Page	Parag.	Line	Instead of	Read
63	2	2	faunal	fauna
63	4	5	inconspicious	inconspicuous
64	Plate XIII-B	3	S.E.	N.E.
69	1	5	dislocation	dislocations
71	2	6	Deschambalut	Deschambault
72	Fig.8	4.5	There is no signicance to the two patterns of limestone, both belong the Deschambault Formation	The Grondines limestone is down faulted against the Deschambault beds.
74	Plate XV	3	on Trenton shore	on Neuville shore
74	1	17	Figs 10A, 10B	delete
74	1	22	Fig. 9	Figs 10C
78	3	16	miles	mile
79	3	1	suggest	suggests
79	4	19	Sainte-Croix	Sainte-Croix (Plate XVI)
80	Fig 11	1	Gentlefolds	Gentle folds
81	Plate XVI	2	syncline	syncline as exposed a low tide.
84	Plate XVIII	4	(light bands)	(light bands). Photograph taken at low tide
89	1	11	Fig. 14G	Fig. 14 H
89	1	4	walls	walls (Fig 14).
90	3	5	rumors or riches	rumors of riches
91	3	1	quarries	quarried
91	4,5	1	K_2O_3	K_2O
93	7	1	Canada,	Canada. Rept. Prog. 1863, 938 pp.
93	17	1	Wittington	Whittington
94	1	2	---	The well number are those given in O.D.N.R. S-75, Part II.
95	2	1	56-150	57-150

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INTRODUCTION

The Palezoic rocks of the south half of the *Portneuf map-area* were mapped by T.H. Clark in 1944; those of the north half were covered by the same author in 1948. The Precambrian rocks of the area were studied by F.F. Osborne in 1948. The map-area was revisited by Y. Globensky in 1967 and 1968 and several new outcrops, mostly located in recently-dug drainage ditches, were added to Clark's original maps.

In 1948, Clark also visited the *St-Raymond area* and mapped along both banks of the Jacques-Cartier river up to the Precambrian contact. In 1967, Globensky extended the mapping to the east and west limits of this map-area.

In the *Lyster map-area* all of the ground lying northwest of the Sillery Group was mapped by Globensky in 1968.

The present report has been written by Globensky using the manuscript reports of Clark (Clark, 1944, Clark 1949 and his own observations. The section on the Precambrian rocks has been entirely borrowed from Osborne's notes, submitted to the Department of Natural Resources in 1948.

Aerial photographs were available for the 1967-68 work and made possible detailed mapping of the structures visible on the beach at low tide. This led to better understanding of the structural arrangement along the St. Lawrence River. Aeromagnetic and gravity maps were helpful in the recognition of normal faults in the area. The work done by P. St-Julien and F.F. Osborne in the adjacent Chaudière map-area to the east helped considerably in working out the rock distribution and structure in the southeast corner of the area.

Location

The map-area straddles the St. Lawrence River a few miles above Québec City; approximately one third of its area lies to the north of the river, and two thirds to the south. Its position with regard to the neighboring map-areas is shown in Figure 1. It is bounded by latitudes 46°15' and 46°50' north and by longitudes 71°30' and 72°00' west, and covers approximately 728 square miles.

Topography and Drainage

Except for two hilly areas near the northeastern and northwestern corners, the ground north of the St. Lawrence consists of a plain, sloping gently southward and dropping from a maximum elevation of about 300 feet to the St. Lawrence, where it ends in an escarpment 100 to 200 feet high.

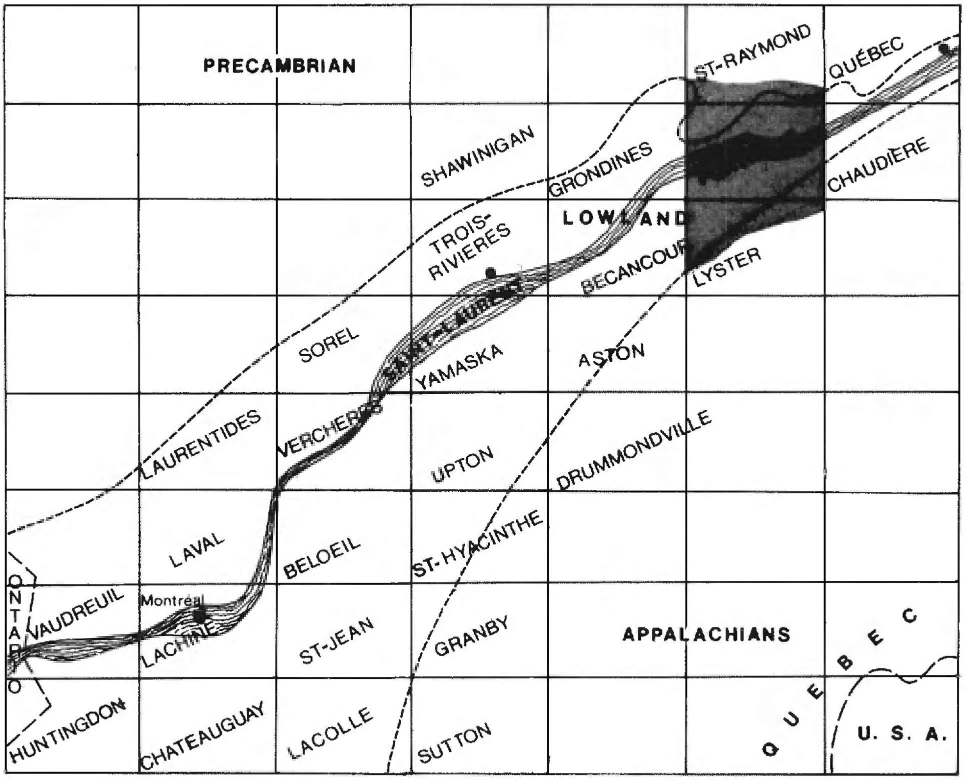


Figure 1 Location of map-area. 6

Flat lands bordering the river are, for the most part, confined to a narrow marginal belt a few hundred feet wide; they are extensive only in the extreme eastern part of the area. The hilly areas referred to are underlain by Precambrian rocks. They rise to 450 and 500 feet, respectively, near Portneuf but are much higher above Saint-Raymond and, in an otherwise monotonous landscape, give the illusion of considerable relief. The Jacques-Cartier river, the only large stream in the map-area, flows for more than half its length through a gorge with precipitous sides up to 100 feet high. The Portneuf river, though much smaller, is important enough to provide power for two factories.

Except for some irregularities near the eastern limits, the area south of the St. Lawrence is a plateau rising gently toward the southeast from the nearly sheer river-side cliffs. The tops of the lowest cliffs, at Bois-des-Hurons, are about 100 feet above sealevel. Downstream, the cliffs rise more and more until a fairly uniform elevation of about 200 feet is reached near Sainte-Croix, and this cliff height continues with some irregularity to the eastern border of the area. The highest part of the plateau proper, 475 feet above sealevel, is in the extreme southeast corner. However, a hill of igneous rock northeast of Saint-Flavien rises above the general surface of this plateau to about 580 feet above sealevel.

The main drainage channel is, of course, the St. Lawrence which is 2 to 3 miles wide at high tide, and contracts to a half these widths at low tide. The Chêne river is the most important tributary stream traversing the area. It was used in the past as a waterway for logging operations. During the summer, it is not navigable even by rowboats because of long shallow stretches and a boulder-strewn bed. Smaller streams abound, of which Huron river and Bourret brook are the largest.

Resources

North of the St. Lawrence, mixed farming is widespread, although the soil is not rich enough to support a flourishing agricultural population. The chief town is Donnacona, at the mouth of Jacques-Cartier river, with its extensive manufacture of wood products. Other lesser wood-product plants are located along Portneuf river. The raw material for these factories is obtained mostly from the country surrounding the upper reaches of these rivers to the north of the Portneuf map-area. There are minor factories in the smaller villages. Besides Donnacona, there are numerous settlements along the St. Lawrence, such as Neuville (formerly called Pointe-aux-Trembles), Les Ecureuils, Cap-Santé, Portneuf, and Deschambault all of which have acquired a reputation as summer resorts. Inland there is no settlement of importance save Portneuf-Station. Immediately north of the margin of this area, on Portneuf river, is Saint-Basile; similarly, on Jacques-Cartier river, there is Pont-Rouge; both are small but important manufacturing centers. Quarries in the Trenton limestone have been opened near Neuville, at Saint-Basile, and west of Deschambault. However, owing to the shift of quarrying activity to Saint-Marc-des-Carrières, just west of the limits of the area, only three quarries are active today.

Excellent market gardens abound along the Lotbinière road to the south of the St. Lawrence. On the whole, however, the soil here is not fertile enough to support a flourishing agricultural community. Nevertheless, farming is carried on by the majority of the population. Small mills and factories are located at Sainte-Croix and at Leclercville (Sainte-Emmélie). The southwestern corner was once largely controlled by the Lotbinière family interests and produced lumber and wood products, chiefly charcoal. In 1967, the estate was acquired by the Provincial Government to become a forestry laboratory. No metals occur, though in a fruitless search for copper several trial pits and one 'mine' have been dug near Saint-Flavien. An asphalt-mix plant, using local sand and gravel, is in operation near Saint-Flavien opposite the Saint-Flavien quarry in the "Bois Franc de l'Ail" concession.

Means of Access

On the north shore of the St.Lawrence, Highway 2 runs northeastward to Québec City, and southwestward to Trois-Rivières and Montréal. A few other roads have been improved, and the process is continuing, but it cannot yet be said that the region is adequately provided with good roads, either as to quantity or quality. Both the Canadian Pacific and the Canadian National railways traverse the area. The abandoned trackway of the Transcontinental railway is still easily followed.

Highway 3 follows the south shore of the St. Lawrence and is the chief through-going means of communication. This road is constantly being improved and doubtless will always be an important highway link between Montréal and Lévis. Route 20, which is part of the Trans-Canada Highway, cuts across the southeastern corner of the area alongside the Canadian National Railway main line. This highway carries fast traffic along the South shore, but may never exert much influence upon the development of this region. Good, poor, and indifferent roads criss-cross the rest of the area, but there are large tracts of timbered land on both sides of Chêne and Huron rivers which lack roads. Only one railroad serves this area. The main Canadian National Railway line from Montréal to Lévis passes through Laurier and Saint-Apollinaire. There is a hightide ferry service across the St. Lawrence from Lotbinière (Vieille-Eglise) to Grondines-Est.

Previous Work

The first serious mention of the rocks of this region was by Logan in 1854, and he summed up his observations in his epoch-making "Geology of Canada, 1863" (pp. 152-156). He gave a remarkably clear account of the distribution of the Trenton and Utica formations. Though he regarded the two tongues of Precambrian rocks to be expressions of anticlinal structures, he recognized dislocations of the rocks on the southeast side of each "anticlinal". Furthermore, he clearly showed the faults on a map which he prepared but which was never published -- and which was later used by Ells with very few changes. Also (pp. 202-203), he gave details of the distribution and character of the Utica shale, and concluded that the "Hudson River" (now called Lorraine) lay in a synclinal axis near Cap-Santé. Until the publication of the detailed work of Laverdière (1935), no improvements upon Logan's descriptions were made.

Following Logan's retirement in 1869, his successor, A.R.C. Selwyn, commissioned R.W. Ells to resurvey that part of Québec bordered on the east and west by longitudes 69° and $74^{\circ}15'$, and on the north by latitude 47°N. (all figures approximate). Research by Ells relating to the Portneuf area was published in 1888. He described the Utica and Trenton along the St. Lawrence shore from Donnacona eastward, adding little to Logan's observations and failing to record the faulted nature of the Trenton-Utica contact at Neuville.

A.P. Low (1893) restated the course of the Precambrian-Paleozoic boundary as it crosses this map-area and gave some details regarding the surface of the Precambrian rocks in Trenton time. He also gave details of the faults bounding the Deschambault and Neuville spurs of Precambrian rock though he was of the opinion that these spurs were high-standing at the time of faulting. Like his predecessors, he assumed that the structure at Neuville was essentially anticlinal, though he supposed that the Utica had been thrust to the northwest over the Trenton. In his description he leaned heavily upon Logan, but brought out much that was new.

Kindle and Burling (1915) referred to the two conspicuous tongues of Archean which indent the Ordovician east and west of Jacques-Cartier river without, however, recognizing the faulted nature of one side of each of these tongues. Keele (1915) published some details regarding the utilization of the Utica shale in brickmaking.

Subsequently, nothing but casual references occur in the literature until 1930 and 1931, when Parks published two reports dealing with the oil and gas resources of the St. Lawrence Lowland. Most of the material in the earlier publication was repeated in the later one. In the latter, he included information on a few wells in Portneuf county. He recognized the Neuville fault, but referred erroneously to the Deschambault anticline. He inserted a non-existent fault east of Deschambault and missed the fault along the west side of the lower Jacques-Cartier river.

Laverdière (1935) reported on the Deschambault area, all of which, except the western corner, lies in the Portneuf map-area. For the first time what, in this present report, is called the Deschambault fault was recognized, correctly mapped, and briefly described. The characteristics and faunas of both the Trenton limestone and the Utica shale are given in some detail.

Goudge (1935) gave details of limestone quarries, and analyses of Trenton limestones from this area.

In 1944, Clark contributed the chapter on the Lowlands for the Geology of Québec, Vol. II (Dresser and Denis,1946), in which there were only generalities based upon previous work. A short regional review of the St. Lawrence Lowland was given by Clark (1947). Clark (1948) reviewed the whole Portneuf map-area, giving some of the salient features of the present report.

In 1954-1955, H.C. Cooke mapped, for the Québec Department of Mines, the east-half of the Lyster map-area, but the report has not been published. In this report, the Normanskill beds were referred to as Utica.

Acknowledgements

The southern part of the area was mapped in 1944 with the assistance of Jean Préfontaine, and the northern part in 1948 with the assistance of H.G. Bassett and Rev. Fr. Roland Sanschagrin O.M.I.

In 1967, the then recently excavated bed of Bourret brook was mapped by F.F. Osborne and assistants. The geology of the southern part of the map-areas was revised by Globensky in 1967 and 1968 with the welcome comments of P. St. Julien and F.F. Osborne, whose work in adjacent map-areas to the east helped in dividing the rocks of the present area into their component parts. To John Riva of Université Laval thanks are due for the identification of several collections of graptolites, without which it would have been well nigh impossible to distinguish between Appalachian and Lowland facies.

GENERAL GEOLOGY

The two hilly areas in the northwest and northeast corners and the extension of these areas in the Saint-Raymond area, are made up of Precambrian gneisses of the Canadian Shield. Elsewhere, the area is underlain mainly by Ordovician sedimentary rocks (limestone, shale, sandstone) of the St. Lawrence Lowland. In the extreme south, there is a northwest-southeast zone, 3 to 5 miles wide, of moderately metamorphosed sedimentary rocks, with accompanying igneous rocks, that belongs mainly to the Appalachian Province. However, as a result of thrusts, this zone includes slices of the Lowland rocks. This zone marks the frontal thrust of the Appalachian mountains or Province - here called the Champlain Thrust but also referred to as the St. Lawrence Fault, the Champlain Fault or, more familiarly, as Logan's Line.

The border between the Precambrian gneisses and the sedimentary rocks of the St. Lawrence Lowland is, in places, a fault; in other places the Trenton or Black River strata lie unconformably upon the older rocks. Except near faults, the sedimentary rocks are approximately horizontal. Where they have been jammed against the Precambrian rocks, or against each other, they may be highly inclined, even vertical. The two hills of Precambrian rocks in the Portneuf area are bounded on their southeast sides by normal faults along which the Trenton limestone and the Utica

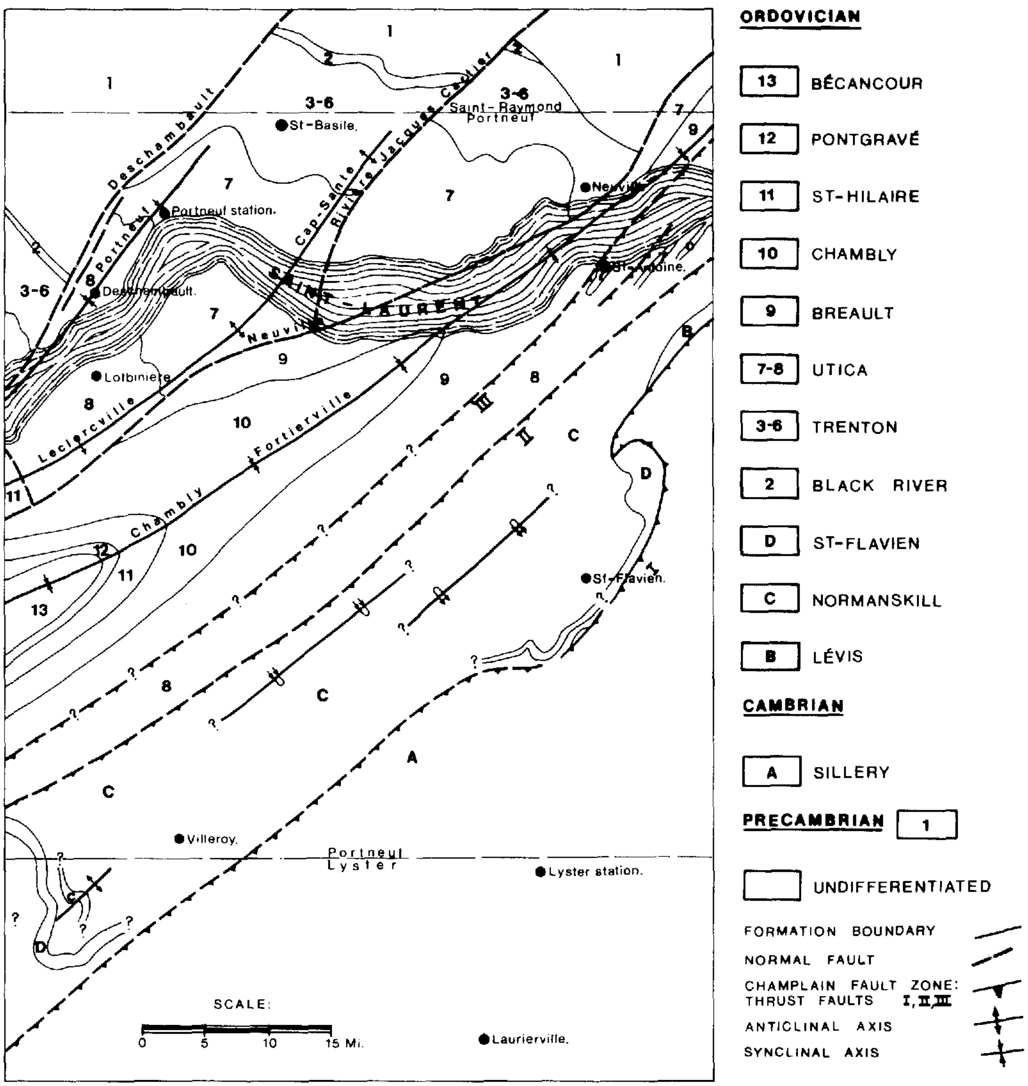


FIGURE 2 – GEOLOGICAL SKETCH OF THE MAP-AREA.

TABLE OF FORMATIONS

	ST. LAWRENCE LOWLANDS					APPALACHIAN			
SYSTEM	SERIES	GROUP	FORMATIONS Members *Zones*	THICKNESS	EQUIVALENTS (North Am.)	SERIES	GROUP	FORMATIONS	EQUIVALENTS (Europe)
ORDOVICIAN	CINCINNATIAN	RICHMOND	BECANCOUR PONTGRAVE	2000' 164'	Queenston Waynesville	CANAJOHARIE		Boulder clay	
		LORRAINE	NICOLET Saint-Hilaire *Pholadomorpha* Chambly *Proetus-Leptaena* Breault *Cryptolithus*	2491' 591' 880' 1020'	Pulaski Frankfort Eden				
	CHAMPLAIN	UTICA	LOTBINIERE Delisle Graywacke strata	400'	Utica			Basalts and gabbros SAINT-FLAVIEN (Normanskill or younger) ?	
		TRENTON	NEUVILLE Grondines *Rafinesquina deltoidea* *Cryptolithus lorettensis* Saint-Casimir DESCHAMBAULT PONT-ROUGE	432' 256' 176' 92' 30'-40'	Cobourg Sherman Fall Hull Rockland	NORMANSKILL	LAURIER	AUBIN BOURRET fault contact	Caradoc
		BLACK RIVER	LERAY LOWVILLE	20'-25'		DEEPSKILL	LEVIS	HURETTE fault contact	Llanvirn Arenig
LOWER CAMBRIAN	WAUCOBAN						STILLERY	SAINT-NICOLAS and SAINTE-FOY undifferentiated	
	Angular unconformity								
PRECAMBRIAN	GRENVILLE SUB-PROVINCE								

shale (both of which doubtless originally covered the whole region) have been let down several hundred feet. The faults continue southwestward beyond the outcrop limits of the Precambrian rocks so that the Trenton limestone and the Utica shale are themselves in places in faulted contact. Minor normal faults affect both the St. Lawrence Lowlands and the Appalachian rocks, and all are affected by a series of thrust faults related to or identical with the Champlain fault. Only one fold of importance can be made out in the northern part of the area (Chambly-Fortierville syncline), though the gentle inclination of the sedimentary rocks results in flexuous contacts undulating across the area from east to west. Northwest of Neuville, along Matte river, the beds form a syncline plunging gently southwest.

The three main controlling features of the area are the Chambly-Fortierville syncline, the Champlain fault zone, and the Precambrian basement (Figure 2). The northern extension of the axis of the Chambly-Fortierville syncline extends from the southwest corner of the area, northeastward to Sainte-Croix and across the St. Lawrence to Neuville. This fold dominates the structure of the Lowland south of the St. Lawrence. Parallel to this axis, and about 3 miles to the northwest, is the Leclercville (Sainte-Emmélie) anticlinal axis, plunging gently toward the southwest, as does the main synclinal axis. The dips on the limbs of these folds are mostly low, 2 to 3 degrees as a rule, although exceptionally they may reach 10 or even 20 degrees. The southeastern part of the St. Lawrence Lowlands consists of very complexly faulted and folded allochthonous Utica and Lorraine rocks. These, plus Normanskill, rocks are the equivalent of the Saint-Germain Complex defined earlier by Clark (1947), which loses its value wherever its component parts can be identified.

The Champlain fault zone in the southeastern part of the area is made up of at least three major faults (I, II and III). Southeast of Fault I, the rocks consist of tightly folded slates and sandstone of the Sillery Group. Dolomitic mudstone and pure limestone conglomerate of the Lévis type occur to the north of Saint-Apollinaire. Between the latter place and Saint-Flavien an elliptical hill, 2 miles across, is underlain exclusively by a basic igneous rock, in part extrusive, in part intrusive. This rock contains sulfides in small amount and was once explored for copper. Other exposures of the same kind of rock occur to the northward. Between Faults I and II, the rocks consist of dark slates, mudstone and green chert of Normanskill age. Between Faults II and III, the rocks are allochthonous Lorraine beds consisting of very much contorted sandy shale and sandstone.

The Precambrian basement exposed in the northern part of the area is broken by normal faults which extend into the Paleozoic rocks of the Lowlands.

PRECAMBRIAN ROCKS

This description is based on mapping done during parts of May and September, 1948, and laboratory work done during the winter 1948-49 by S.J. Malihercsik under the supervision of F.F. Osborne at University Laval.

Gray Gneisses

Most of the rocks exposed within the Precambrian part of the map-area are gray gneisses having the composition of granitic rocks. They were referred to as "Laurentian" on the general map (No. 375) of the region issued in 1890 by the Geological Survey of Canada. "Laurentian" has passed out of use as a formation name, and "gray gneisses" is used here because of the color and the prevalent gneissic structures.

Structures

Where the gray gneisses are well exposed (e.g., in railway cuts), layering is conspicuous. This structure occurs on several scales. In some places, layers of gneiss of uniform character and several feet thick alternate with gneisses of slightly different appearance. Similar layering is present but not easily seen in weathered exposures. On a smaller scale, layers of gneiss rich in light-colored constituents alternate with thinner layers rich in dark minerals to give "layer-cake" gneiss. In some of the darker colored gneisses, light-colored layers up to ¼ inch thick may be seen, and, where these are numerous, a typical lit-par-lit gneiss results.

In many of the gneisses clotting of constituents is found. In this structure, aggregates richer than the bulk of the rock in either light or dark minerals form streaks on the exposed surfaces. The streaks are sections of lens-shaped masses, and the greater dimensions of the lenses are parallel to the layers.

The greater dimensions of the inequant minerals, particularly biotite and hornblende, tend to be parallel to the layers and streaks. The strike and dip symbols on the map refer to the attitude of all three structures which, being in any one specimen parallel to one another, may be used interchangeably for structural determination.

Petrography

Most of the gneisses are gray and medium grained. Some varieties show a greenish cast, although they are predominantly gray. On the weathered surface the general tone is brownish, and there is some etching out of the bands richer in dark minerals.

Pratically all the specimens of gneiss show 15 to 30 percent quartz. The tenor of biotite and hornblende together has about the same range as quartz. A striated feldspar, which is white or slightly greenish, is the most abundant mineral.

Under the petrographic microscope the rocks show a typical metamorphic fabric. The parallel arrangement of mica and hornblende is conspicuous. The quartz and feldspar of many specimens show evidence of breaking after crystallization, but the effects are not conspicuous enough for the rocks to be called cataclastic gneisses.

A noteworthy feature of the gneisses is the calcity (An_{28-33}) of the plagioclase. Potassic feldspar (commonly microcline) does not exceed 8% in common varieties of the gneisses and is absent in many. Where layers and streaks of light colored minerals are abundant, particularly if they are pink, the plagioclase is less calcic, and more potassic feldspar is present than in the normal gneisses. In some thin-sections, the plagioclase contains teardrop-shaped grains of quartz which forms myrmekite. The biotite is a normal variety and in a few specimens it is sufficiently abundant to warrant the term biotite schist. Hornblende of the ordinary variety with a large optic axial angle is found in most of the gneisses. It is accompanied by another amphibole with a much smaller optic axial angle. This amphibole has been referred to as hastingsite, but the optic axial angle is larger and the birefringence higher than the mineral from Ontario originally described under that name. This amphibole, which has been found at many localities in Québec, appears to have formed where there has been metasomatism either in contact zones or in the marginal facies of granites.

The accessory minerals are apatite, sphene, zircon and magnetite. Allanite occurs sparingly and is but slightly radioactive as judged by the alteration around it.

Metasomatism

A coarse and glistening black biotite occurs in layers and veins in the gneisses. From its mode of occurrence and association with pegmatite minerals, it is believed to be the result of metasomatism long after the gneisses were first metamorphosed.

Origin

In the foregoing description, the heterogeneity of the gray gneisses from layer to layer, and within many of the layers, has been emphasized. It is believed that the variation in composition is too great for the gneisses to be deformed plutonic rocks. Some of the more uniform and thicker layers are almost certainly sills of igneous rock that were injected into an older rock, and the two were deformed together. The thin layers of pink granite gneiss in the "layer-cake" and lit-par-lit injection gneisses are certainly of igneous origin. The contrast in color enables their intrusive relationship to the darker gray gneisses to be seen. Furthermore, porphyroblasts of pink microcline are developed in the gray gneisses near some injections and, at some localities, pink gneiss forms masses that are of considerable dimensions although too small to be shown separately on the map. It may be estimated that one third of the gray gneisses are of plutonic origin.

The origin of the remaining two thirds of the gray gneisses is not clear. It is believed, on the evidence of the common occurrence of lenses of light or dark constituents, that part of the series is derived from bedded rocks; in other words, the present rocks are largely paragneisses. In the Laurentian region from Gatineau river on the west to Saguenay river on the east, only one paragneiss-bearing series, the Grenville, has been recognized. In mapping near Shawinigan falls, Osborne (1936) found gneisses that are in many respects similar to the Portneuf rocks. They are below the garnetiferous gneisses, quartzites and limestones of the normal Grenville series, and were called "lower Grenville" to distinguish them from the more characteristic facies of Grenville rocks. The rocks of the lower Grenville at Shawinigan falls are somewhat more basic than the Portneuf gneisses, but the difference may be the result of injection of igneous material into, and metasomatism of, the latter. The presence of the amphibole of low optic axial angle and of myrmekite suggests metasomatism in the Portneuf region.

Part of the Grondines map-area, which joins the west side of the Portneuf map-area, was mapped in 1948. A greater variety of gneisses is exposed there than in the Portneuf area, and includes gneisses that resemble the gray gneisses of Portneuf. They appear to underlie normal paragneisses of the Grenville series containing lenses of quartzite, sillimanite, garnet gneisses and limestone. Farther west in the Grondines area, gray gneisses are exposed at the rapids on Batiscan river above Saint-Narcisse dam. Here, an old structure, apparently derived from original beds, is cut by gneissic igneous material.

The balance of evidence indicates that a large part of the gray gneisses at Portneuf are of *para* origin and derived from rocks equivalent to those lying below the normal Grenville facies at Shawinigan falls and in the Grondines area. The old bedding structures in these rocks formed some of the layers. Considerable material was introduced into the Portneuf rocks both as magma and by metasomatizing solutions. Similar rocks have been called "granitized sediments" or "migmatites", but it is felt that, until further evidence is available, the conventional nomenclature and explanation of origin of the complex should be adopted.

Gabbro

A dike of gabbro 25 feet thick, exposed for 100 feet, occurs north-northeast of Neuville. The dike is dark green and weathers rusty. The microscope shows that it was originally composed of plagioclase feldspar (An_{47-54}) contained within augite. The augite has been much altered to carbonate.

Pegmatite Dikes

Dikes and sills of pegmatite are common throughout the Precambrian here. Few of them are large, and none of the very coarse grained, segregated type of pegmatite was seen. In many localities, the pegmatites appear to be associated with a metasomatism of the gneisses that produced abundant,coarse-grained biotite. In some places, the feldspars actually appear to have developed in the aggregate of biotite.

The pegmatites contain both white and pink feldspar. In some the pink feldspar is dominant. The plagioclase,which is near oligoclase, is commonly white; in some rocks, it is clear and colorless. Muscovite, biotite, and quartz are the other common minerals. Apatite, sphene, zircon, and allanite have been identified as accessory minerals. Molybdenite is found in some places and, at a locality along the abandoned railway line, pits have been sunk to explore the molybdenite that occurs in pegmatite with biotite.

Pink Granite

Pink granite is mapped as a separate unit north of Portneuf Station at the north limit of the map-area. This is an even-grained pink rock with biotite and hornblende. North of Saint-Casimir, in the next map-area to the west, a larger mass of this rock has an alaskitic aspect. The rock forms sills that inject and entrain fragments of the older formation.

PALEOZOIC STRATA

Nomenclature

For nearly a hundred years, until an acceptable usage was summarized by Kay (1937), it had been the custom to refer to the dominant sedimentary rocks found in this area as Black River and Trenton limestones, Utica shale, and Lorraine shaly sandstones (formerly "Hudson River beds"). The succession of Black River, Trenton, Utica, and Lorraine is a common one in the Ordovician of northeastern North America, and at the beginning of this century those terms would have been generally acceptable. However, so finely have they been divided, and so assiduously and, in general, successfully have means for the correlation of their component parts been sought, that it is no longer adequate to use those terms alone. They were at first considered to be formations, i.e. sedimentary rock units more or less lithologically homogeneous. But they are all known now to embrace, within rather narrow limits, a considerable variety of rock types and faunal assemblages. Thus it is proper to think of and to discuss both the changing sedimentation and the ebb and flow of life during Trenton (e.g.) time, and to consider the rocks concerned not as a uniform limestone formation but as the Trenton Group of related constituent parts, the more important of which are today called formations.

Similarly the Utica shale has been subdivided and, remarkably enough, in part correlated with upper Trenton limestones. Lastly, the Lorraine, studied by Foerste (1916), offers little difficulty locally. In the accompanying Table of Formations, both the older names in general use (now group terms) and the newer formational names (see Clark, T.H., 1947) are given.

In addition to numerous outcrops there are the logs of seven deep wells upon which to base details of stratigraphic succession and thicknesses of formations. Summary logs of these wells are recorded in the Québec Department of Natural Resources publication S-75, Part II (1964), and in the Appendix of this report, the complete logs are kept in the Québec Department of Natural Resources (GM-27007) their locations are shown by red circles on the map accompanying that report and the present one.

Their numbers, names and the depth to which they were drilled are listed below:

No. 9	Bald Mountain -- Cap-Santé No. 1	954 feet
10	Bald Mountain -- Cap-Santé No. 2	853 feet
15	Bald Mountain -- Portneuf No. 1	1388 feet
16	Bald Mountain -- Portneuf No. 2	1387 feet
51	Fortierville No. 1	771 feet
69	Imperial Lowlands No. 1 (Leclercville)	3445 feet
72	Imperial Lowlands No. 4 (Lotbinière)	1969 feet

Figure 3 is a correlation chart showing the relationships of the various stratigraphic units. Well 51 is not include in Figure 3 because it was too shalow to reach the Trenton.

Lowlands Formations

THE BLACK RIVER GROUP

Good exposures of Black River Group rocks are found along Jacques-Cartier river. Here there are discontinuous cliff exposures and, at low water, there is a flat as far as midstream composed of calcareous sandstone. The undulations of the beds on the flat prevent reliable measurements, but along the left bank* of the river at about 1,000 feet above the Canadian Pacific Railway bridge at Pont-Rouge (Plate 1A) the following section (table 2) can be built up starting from the top.

On the left bank, the *Tetradium*-bearing, semi-lithographic limestone appears to be of Lowville age. Carter (1957, p. 291), however, assigns the ostracods 7 feet higher in the section to the Leray. It is possible that the sandstone is Lowville and that the overlying limestone is Leray. Because of the uncertainties involved these rocks will be referred to as Black River (Leray and Lowville).

On the right bank of the river, outcrops begin about 1,000 feet above the railway bridge. Black River limestone makes up the lowest 1 foot 10 inches of observable rock, all subjacent beds lying hidden below lowest water level.

Because no sandstone is known on the right bank the beds there exposed probably lie above those on the left bank. If so, the total thickness exposed is 19 feet 8 inches. How much, if any, lies between the base of the section on the right bank and the top of the section on the left bank is unknown, but the total thickness given above should not be increased more than a foot or two. Precambrian rocks outcrop less than ½ mile upstream, and the intervening space is doubtless occupied by both Precambrian gneiss and Black River sandstone. A few feet, at the most, of sandstone should be expected. The total Black River thickness should, therefore, not exceed 25 feet.

*Looking downstream.

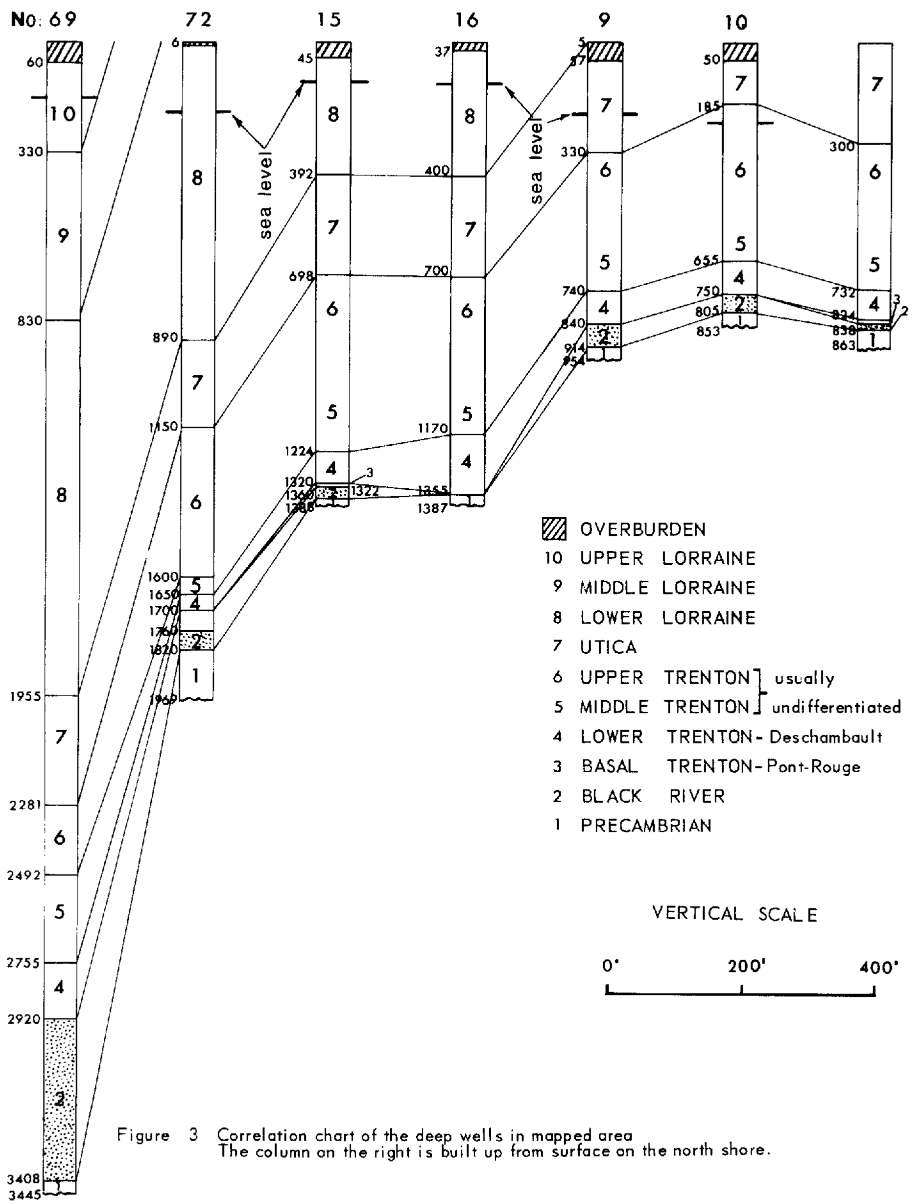


Figure 3 Correlation chart of the deep wells in mapped area
The column on the right is built up from surface on the north shore.

Table 2 - Black River Section along the Jacques-Cartier River

Left Bank

0' 0"	Top of section along cliffs on adjacent river flat
2' 0"	Dark, dense limestone, massive above, thin bedded below
1' 6"	Dark, dense limestone in 4- to 6-inch beds
1' 2"	Bed of dark, dense limestone
1' 3"	Dark gray sandy and shaly limestone
0' 10"	Off-white, pale yellow weathering, semi-lithographic limestone
0' 4"	Pinkish to purplish semi-lithographic limestone
2' 0"	Dark, dense limestone, thin bedded. Ostracods and small gastropods common
0' 6"	White sandstone, prominent
0' 6"	Poorly consolidated shaly sandstone
0' 6"	White sandstone, prominent
1' 9"	Sandstone, light gray, poorly consolidated
0' 6"	Sandstone, dark gray, shaly
0' 10"	Dark gray, shaly sandstone with vertical, finger-sized burrows
2' 0"	Sandstone, light gray, surface rough with molds of burrows One 2-inch bed with large brachiopods which could not be broken out of the rock
0' 8"	Light gray, yellow weathering, semi-lithographic limestone. This is beneath normal water level in the summer and can be seen where the sandstone has been worn away along joints. Even in such cases, the limestone may not be visible because its bed has been recessed by solution. Contains large, ramose *Tetradium*.
1' 6"	Dark, fine-grained, calcareous sandstone, massive. Probably much of the flat is made up of this bed. Base observable section.
17' 10"	

Right Bank

0' 0"	Unconformity with basal Trenton stratum
0' 10"	Medium gray, very finely crystalline limestone. Cherty stringers present. Ostracods very abundant.
1' 0"	Light gray, yellow weathering, semi-lithographic limestone. Cherty stringers in topmost inch only. *Cameroceras alternatum* at base of layer
1' 10"	

The fauna of these beds is a very large one in terms of number of species but only the bryozoa and ostracods are numerous as individuals (Table 3).

Table 3 - Black River fossils, Jacques-Cartier River

ALGAE	TRILOBITA
Buthotrepis sp., cf. *B. succulus*	*Calliops* sp., cf. *C. brevis*
Solenopora compacta	*Ceraurus pleurexanthemus*
PORIFERA	*Encrinurus* sp., cf. *cybeleformis*
Receptaculites occidentalis	*Eoharpes* sp., cf. *E. ottawensis*
COELENTERATA	*Flexicalymene senaria*
Conularia trentonensis	CEPHALOPODA
Foerstephyllum halli	*Beloitoceras agaricus*
Lambeophyllum profundum	*B. cartierense*
Metaconularia sp., cf. *M. ulrichi*	*B. imitans*
BRYOZOA	*Cameroceras alternatum*
Batostoma fertile	*Cyrtorhizoceras rougense*
B. canadensis	*Oncoceras minor*
B. winchelli	*O. orthodonum*
Corynotrypa sp. cf. *C. abrupta*	*Zittleoceras* sp., cf. *Z. clarkeanus*
Monotrypa sp., cf. *M. magna*	CYSTOIDEA
Phylloporina sublaxa	*Amecystis cordiformis*
Prasopora constrictus	*Glyptocystites grandis*
P. sp., cf. *P. contigua*	CRINOIDEA
P. sp., cf. *P. simulatrix*	*Carabocrinus* sp., cf.*C. radiatus*
Rhynidictya exigua	*Cremacrinus* sp., cf. *C. inaequalis*
R. mutabilis	*Cupulocrinus grandis*
Stictoporella angularis	GASTROPODA
Subretopora sp., cf. *S. reticulata*	*Bucania punctifrons*
BRACHIOPODA	*C. montrealensis*
Dinorthis pectinella	*Cyclomena hageri*
Hesperorthis sp., cf. *H. disparilis*	*Hormotoma gracilis*
H. prestonensis	*Lophospira* sp., cf. *L. milleri*
H. sp., cf. *H. carlottina*	*Phragmolites compressus*
H. tricenaria	*Trochonema umblicatum*
Lingula briseis	OSTRACODA
L. rectilateralis major	*Aparchites pembertonensis*
L. sp., cf. *crassa*	*A.* sp., cf. *A. ellipticus*
Oniella paquettensis	*A. trentonensis*
Opikina wagneri	*Bollia simplex*
O. transitionalis	*Briartina modesta*
Parastrophina amoena	*Bythocypris cylindrica*
P. champlainensis	*Eoleperditia fabulites*
Rafinesquina alternata	*E. louckiana*
Sowerbyella curdsvillensis	*Euprimitia macropuncta*
Strophomena filitexta	*Eurychilina reticulata*
S. punctostriata	*Krausella arcuata*
S. youngi	*Leperditella ornata*
Zygospira recurvirostris	*L. rex*

Plate I-A - Black River limestone on right bank of Jacques-Cartier river about 1,000 feet above Canadian Pacific Railway bridge at Pont-Rouge.

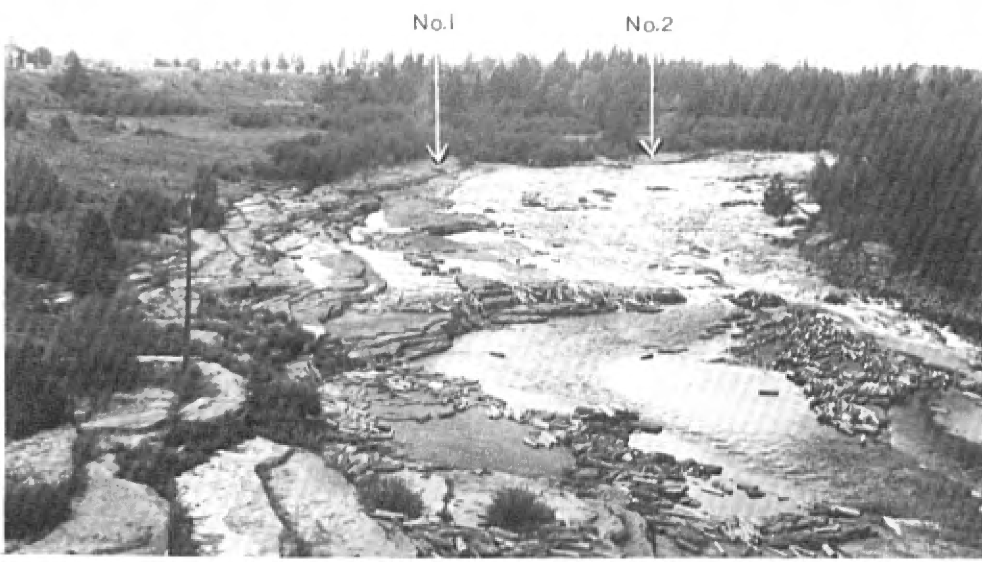


Plate I-B - Pont-Rouge Formation on Jacques-Cartier river, looking upstream from highway bridge. Mostly Pont-Rouge Formation exposed (Precambrian boulder resting in it (arrow No 1) but Black River strata also present (arrow No 2) (See details on plate II-A).

Black River rocks are recorded in the logs of five of the seven deep wells. In all five cases the basal bed resting on the Precambrian is a typical orthoquartzite. In wells 9, 10, 15, and 72, limestone intervenes between the basal sandstone and the Deschambault limestone above. It is not possible to be absolutely sure that this intervening limestone belongs to the Black River Group; it might be part of the Pont-Rouge or an equivalent formation. Because the latter type is spottily developed in the lowlands, and the Black River widespread, Black River is the more logical choice.

THE TRENTON GROUP

General Description

The limestones of the Trenton Group are everywhere easy to recognize. Though there are many different petrographic types, a general similarity allows them to be distinguished from the other sedimentary rocks of Ordovician age. They are almost everywhere dark gray on the fresh surface, with commonly a bluish tint; the lower limestones are more likely to be lighter in color, and some have a yellowish or brownish cast. They weather to gray, buff or yellowish gray, or more rarely to dove-blue. Here, also, the lower beds are exceptional in that they alone are characteristically light gray on the weathered surface. In grain, they range from almost lithographic to coarse, the latter type being common in the lower beds and upper parts. In the lower part the beds are apt to be thick, (more than 4 inches), whereas in the middle and upper parts of the group thin bedding is the rule, and beds of 2 to 4 inches predominate. Shale partings, rarely more than an inch thick, are more abundant in the upper parts of the section. In the lowest part, shaly limestone beds up to 6 inches thick are thickly strewn with bryozoa. The shale partings rarely yield fossils, contrary to the usual rule.

Chert is common in the upper part of the group as discrete particules from about ½ inch in diameter to 1 inch across, and as nearly continuous masses making virtually a bed of chert. It also occurs as finely disseminated grains, for the most part sub-macroscopic. These grains, though they may not be easily visible, betray their presence by imparting a hardness and a toughness to the limestone which it would not otherwise possess. One tendency of the middle and upper beds is to weather into a rubbly mass, so that individual beds appear to be broken up into 'pebbles'; thus, many exposures look superficially like limestone conglomerate. True limestone conglomerate layers of sedimentary origin are rare.

The limestones of the entire group are petroliferous to some extent. Almost any sample yields an oily odor when freshly broken and, especially in the lower part of the section, actual droplets of petroleum may be freed from the rock by breaking it. Numerous black seams, not necessarily related to bedding, are interpreted as hardened petroleum residues.

Fossils are commonest in the lowest beds. Bryozoan mats in the 6-inch shaly limestone beds have already been referred to. In the middle and upper parts of the section, most of the beds are barren or practically so. Here and there a layer, thick or thin, may be crowded with fossils, almost all of which belong to a few species of brachiopods.

Surface Distribution

Although the limestones of the Trenton Group are exposed in wide areas near Deschambault and continuously along the shore at Neuville, and also along the banks of Jacques-Cartier river, nowhere is there a continuous section of this group from its base on the Precambrian to its contact with the Utica. The gaps in the section are particularly marked in the lower part. In the Deschambault area, except for a few scattered outcrops along Lachevrotière river, only the lower part of the Trenton Group is exposed. Along Jacques-Cartier river the lower and upper parts are well shown but are in fault contact, with the intervening parts of the section eliminated. The Neuville area provides the best information on the Trenton Group in the map-area.

The correlation of the Trenton rocks is as follows:

Table 4 - Correlation of the Trenton Strata

FORMATIONS Members *Zones*	THICKNESS (in feet)	LOCATIONS	APPROXIMATE EQUIVALENTS	
			NEW YORK	MONTREAL
NEUVILLE				
Grondines	326'	Neuville shore	COBOURG	TERREBONNE
Rafinesquina deltoidea				
Cryptolithus lorettensis			SHERMAN FALL	MONTREAL
St-Casimir	106'	Neuville shore Railway cut	-	-
DESCHAMBAULT	92'	Railway cut Fields and woods	HULL	DESCHAMBAULT
PONT-ROUGE	14'	Jacques-Cartier river	ROCKLAND	ROCKLAND

Pont-Rouge Formation

From 800 feet above the C.P.R. bridge at Pont-Rouge to just below the bridge, step like exposures of Pont-Rouge limestone are well shown along the right bank of Jacques-Cartier river (the section on left bank is almost inaccessible). The dips are almost in complete harmony with the gradient of the stream. The section is in table 5 as follows:

Table 5 - Section of the Pont-Rouge Formation

0'	0"	Top of section, below railroad bridge.
1'	6"	Gray-weathering, crystalline and dense limestone beds, largely obscured by sewage.
3'	7"	Mostly fine-grained, crystalline limestone with minor amounts of shaly limestone. Bedding irregular. Fossils abundant, especially *Receptaculites*.
4'	2"	Alternating, fine-grained, crystalline limestone, and off-white, semi-lithographic limestone (the latter 2 to 3 inches thick). One 3-inch layer can be followed virtually the whole length of the outcrop. Some of the semi-lithographic beds are crowded with fossils, and most of these beds are covered by a 1/8-inch layer of shale.
0'	8"	Light to medium gray, partly crystalline limestone in thin (2") beds. A large block of Precambrian granite-gneiss rests with its base within this limestone.
1'	3"	Light greenish gray, fine-grained, crystalline limestone. Cherty stringers abundant and irregular.
1'	5"	Medium gray, faintly greenish, fine-grained, crystalline limestone. Cherty stringers closely follow the bedding. Unconformable contact with Black River beds.
12'	7"	

Sinclair (1945) collected extensively from these beds, and after an analysis of the fauna concluded that they were of earliest Trenton Rockland age; in this Flower (1945) concurred after a study of the cephalopods. Interestingly enough, in five localities, limited developments of basal Trenton limestone occur below the Deschambault and rest upon Black River formations: 1) here at Pont-Rouge, 2) in the Sainte-Anne beds on Sainte-Anne river, 3) in Fontaine beds on Lard river northeast of Trois-Rivières, 4) in the Ouareau Formation near Joliette, and 5) in an unnamed 10-foot unfossiliferous development at Montréal. These are listed and discussed by Clark (1959, pp. 16-17).

Deschambault Formation

Jacques-Cartier River

The beds resting directly upon the Pont-Rouge Formation are exposed discontinuously as far as the northern border of Portneuf area, where exposures on both sides of the river extend from down to the White

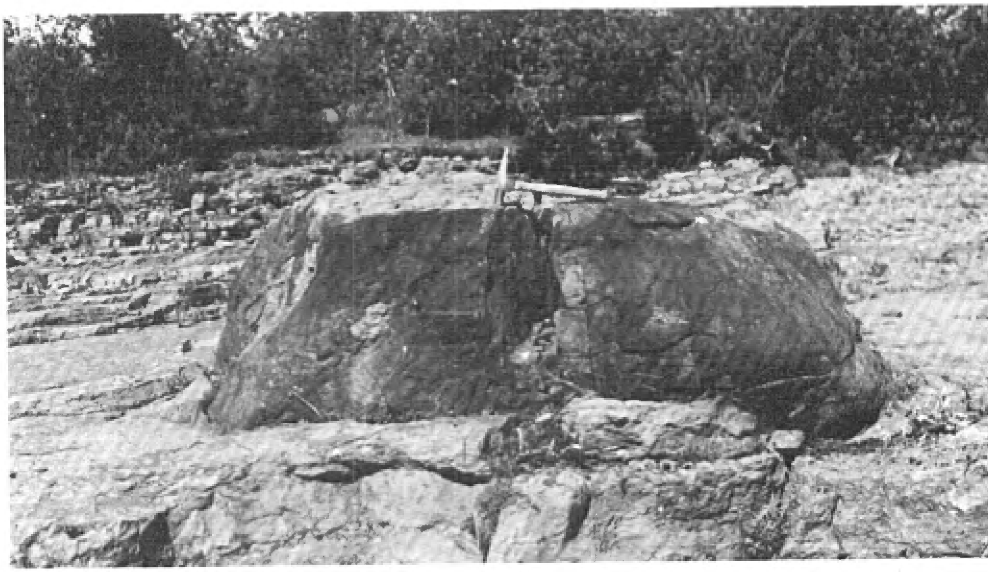


Plate II - A - Pont-Rouge Formation at Pont-Rouge. A Precambrian boulder in Lower Trenton limestone. See Plate 1-B for exact location (arrow #1).

Plate II - B - Deschambault Formation. Gorge of Jacques-Cartier River. Looking downstream 1,000 feet below White bridge.

bridge which spans the stream in the middle of the sharp horseshoe bend, and thence as far downstream as the power house at the end of the bend. The Deschambault beds, which maintain much the same characteristics throughout this stretch, are here cut off by a fault (Plate XIV), and are brought up against the uppermost 93 feet of Trenton of Cobourg age. Between this fault and the northern border of the map-area about 70 feet of beds can be measured foot by foot, which, together with an estimated thickness of 16 feet of inaccessible beds along the lower part of the gorge, makes a total thickness of 86 feet. This corresponds well with that of 92 feet at Neuville and indicates that very few feet of this formation have been cut out by faulting.

Throughout this stretch, the limestone is crystalline, fragmental, and crossbedded, with a faint brownish cast (more marked in the streak than on a fresh surface) and with a distinctly oily odor when broken open. The uppermost beds are well supplied with bryozoan mats up to 6 inches thick made up of a complex of *Hallopora splendens* var. *clarki* set in a somewhat shaly matrix. These mats are separated by their own thickness, more or less, of normal, gray crystalline limestone.

Jacques-Cartier river is no exception to the general rule that rivers cut steep-sided gorges in the Deschambault limestone wherever possible, forming spectacular dalles along the belt of outcrop of the formation from Joliette to Neuville. This feature can be well seen from White bridge. A path down the steep left bank reaches the river exactly opposite the lower power house, and within a thousand feet of this spot, the dalles, the upper part of the Deschambault Formation and also of the Grondines Member, the fault separating these two units, and the basal Utica beds are all splendidly displayed.

The fauna of the available part of the Deschambault limestone along this river is in table 9, locality 1. The abundance of *Parastrophia hemeplicata*, together with the presence of *Phragmolites compressus* and *Bumastus milleri*, indicates a close faunal relationship with the Deschambault beds of the Neuville railway-cut section.

Deschambault

North and west of Deschambault, Trenton limestone is widely exposed in pastures and woods. No section is more than 10 feet thick, and no means are available for building up one continuous section. On the southeast, these beds butt against the Deschambault fault and are, in many places, brecciated along the contact (details of this are given under Structure).

With hardly an exception, the beds exposed here belong to the crystalline Deschambault Formation. Shale partings and interbeds are common, and are in most places thickly studded with a ramose bryozoan, probably *Hallopora splendens* var. *clarki*. Fossils abound in the limestone, but the fauna is not abundant in number of species. *Parastrophia hemiplicata* is the most characteristic element, and it is abundant. The complete list is given in table 9, locality 2.

These beds are everywhere petroliferous to some degree. In some, oily matter oozes out of cavities in the freshly broken rock, and many seams and fossil cavities are filled with a black bituminous petroleum residue. Most beds have an oily odor when struck, whether they show traces of petroleum or not.

One interesting detail of sedimentation deserves to be mentioned. The Deschambault Formation limestone about ¾ mile north of Paré is exposed in a series of small mounds up to 100 feet across (most are much less) and a few feet high (rarely 6 feet, usually 2 to 4 feet). Subsoil drainage tunnels radiate outward from their summits. Although there are fossils in this limestone (particularly a large pelecypod too poorly preserved to be collected), there is nothing that can be interpreted as a reef structure. The mounds are too regular to be erosional remnants, nor is there any evidence of any form of erosion which could isolate the thickly crowded humps. It is probable that they are the result of some selective localization of limestone deposition not understood. Sauvageau's quarry was developed almost entirely in one of these mounds. The composing rock is in no way different from that of the normal Deschambault.

Neuville

One and a half miles northeast of Neuville wharf in the Canadian National Railways cut, there is a ¼ mile cut in Trenton limestones. Northwest of its northeastern end, and beginning about ¼ mile from the track, there are many low exposures of limestone in fields and woods, in general dipping toward, and below, the southeastern end of the cut. Precambrian rocks outcrop a few tens of feet farther north.

These lowest (locally) Trenton beds are coarsely crystalline, fragmental, crossbedded limestones, light gray where fresh or weathered, and with a faint brownish streak. They emit an oily odor when freshly broken. These are the characteristics of the limestones of the Deschambault Formation of Early Trenton age, so well displayed in several quarries at Saint-Marc-des-Carrières, formerly a part of Deschambault village. This section is illustrated on Plate III.

The thickness of the beds exposed in the fields, measured along a line from close to the supposed Precambrian boundary to the northeastern end of the cut, and based upon prevailing dips and strikes, is 63 to 74 feet (the average, 68 feet is used below). Rocks identical, lithologically and faunally, to those in the pastures make up the lowest part (24 feet) of the cut (see Correlation Chart, Table 4), and there may well be no stratigraphic gap between the two developments. In that case the thickness of this limestone formation is 92 feet.

Although no contact with the Precambrian rocks was seen, an outlier of Precambrian granite-gneiss occurs within the area of Deschambault limestone just beyond the border of the woods. This is the only such occurrence observed along the Precambrian-Paleozoic boundary in the area.

The local fauna of this limestone is not extensive, but is quite characteristic, and is indicated in Table 9., locality 3.

Neuville Formation

Above the Deschambault limestone, the Trenton falls into a fairly consistent pattern of thin- to thick- bedded (½ inch to 6 inches) limestone beds separated by relatively thin shale interbeds. The limestone is, for the most part, dense (in the lower part semi-lithographic) with only a few crystalline beds. On the whole, the formation is poor in fossils, though here and there individual beds carry great numbers, particularly trilobites and brachiopods. Displayed in small part in the railway cut and in large part along the Neuville shore, the name of the formation is most appropriately chosen.

The Neuville Formation is here divided into two members, the Grondines above and the Saint-Casimir below. The Grondines includes limestone on the St. Lawrence shore upstream and downstream from the Neuville wharf, and is characterized by a greater amount of shale in the interbeds. The Saint-Casimir includes rocks along the Neuville shore downstream from the wharf and the Neuville Formation in the C.N.R. railway cut. It is characterized by its greater content of semi-lithographic limestone. (The actual contact is about 600 feet downstream (east) from the wharf). Both member names are taken from localities in the adjacent map-area to the west.

Saint-Casimir Member

Neuville

Lying upon the uppermost beds of the Deschambault Formation in the railway cut 1½ miles northeast of the Neuville wharf (see Table 6 and Plate III-B) is a succession of 67 feet of limestone, which, unlike the Deschambault, is thinly bedded, rarely crossbedded, and very rarely coarsely crystalline. Several beds approach lithographic limestone in

Plate III- A - Contact between Deschambault Limestone (below the hammer) and Saint-Casimir Limestone. Railway cut 1½ miles NE of Neuville wharf.

Plate III- B - Saint-Casimir Limestone section, Same locality as in A.

Table 6 - Section of the St. Casimir Member and of the Deschambault Formation

Total thickness		Unit thickness		Lithological Description
90'	9"			Top section. Southwestern end of cut.
90	9	4	0	Cream-weathering, very fine grained, almost lithographic limestone, very finely bedded, and in places crossbedded. Shale partings common. The individual beds are rarely more than 4 inches thick. In the descriptions given below this type will be designated by the letter Y
86	9	1	0	Crystalline limestone alternating with the crinoidal and other fossils common. Huge *Isotelus* and translucent rods, common on the Neuville shore, are present here.
85	9	10	9	Y with shale partings.
75	0	6	0	Y alternating with crystalline fragmental rock. Minor unconformities occur at almost every inch.
69	0	2	9	Irregularly bedded, fine-grained, crystalline, fragmental limestone interbedded with Y. Above this horizon Y predominates.
66	3	0	6	Y.
65	9	1	9	Irregularly bedded light and dark limestone, with one inch of Y.
64	0	6	9	Medium- to fine-grained crystalline limestone in beds 1 inch to 2 inches thick with ¼- to ½-inch shale partings. A one inch thick bed of Y.
57	3	2	0	Unevenly bedded miscellaneous types of limestone.
55	3	11	9	Fragmental crystalline limestone interbedded with lesser amounts of Y., the latter never more than 6 inches thick.
43	6	1	6	Fine-grained and muddy limestone, in 1-inch to 2-inch beds.
42	0	4	6	Coarsely crystalline limestone, crossbedded. *Prasopora* and crinoids at 40 feet.
37	6	6	0	Crystalline limestone and Y. interbedded.
31	6	0	9	Finely and evenly bedded limestone and medium-grained crystalline limestone interbedded.
30	9	6	9	Medium- and coarse-grained limestone, crossbedded.
24	0	0	3	Lowest Y.
23	9			TOP OF DESCHAMBAULT FORMATION BASE SAINT-CASIMIR MEMBER, NEUVILLE FORMATION.
23	9	11	6	Fine-, medium-, and coarse-grained crystalline limestone, crossbedded.
12	3	0	6	Very fine grained limestone.
11	9	1	3	Very coarse,crystalline limestone, crossbedded *Prasopora* and *Rafinesquina* very common.
10	6	1	6	Very finely bedded, fine-grained limestone in beds up to 1 inch thick.
9	0	9	0	Coarse- and fine-grained crystalline limestone. *Prasopora* common.
0	0			BASE OF EXPOSED SECTION.

texture. Although there is a regional dip to the southwest the dips are not constant and the beds undulate in places. Moreover, the beds dip away from the railway slightly on both sides, so that the track runs along the axis of a minor anticline. A bed by bed description of the entire section is given in Table 6.

Between the western end of the railway cut and the beach at Neuville, there are numerous exposures of yellowish weathering dense limestone, separated, however, by such distances that, in the absence of consistent dip, no section can be built up of them. Continuous exposures begin on the Neuville shore about ½ mile east of the Neuville wharf, but, in their eastern part, where they are close to the Neuville fault, they are so contorted that no reliable section can be built up. There are no great difficulties in constructing a section if one starts at a point near sealevel about 1,700 feet east of the wharf and proceeds upstream. The western end of the railroad cut is just about 250 feet above sealevel. The distance between the two points in a straight line is approximately 6,500 feet, and this measurement is almost exactly along the direction of dip. These controls indicate a dip of 2.2 degrees which is in harmony with the average of the dip measurements made on the abundant gutter exposures along the highway between the cut and the Neuville wharf. With some reservations with regard to accuracy in detail, we may therefore assume that the highest bed of the railroad cut and the lowest bed of the measured section along the Neuville shore are at approximately the same horizon stratigraphically.

The fauna present in these strata is indicated in Table 9, locality 4.

Lachevrotière River

Somewhat farther southwest than the area occupied by the bulk of these rocks, there are two localities where limestones of a less characteristically crystalline variety may be seen. First, along the new road leading from Paré to Saint-Marc, and about ½ mile from highway 2, there are two roadcuts of cream-weathering, almost lithographic limestone with shale partings. Fossils are few, but include *Dalmanella rogata*, *Prasopora simulatrix*, *Platystrophia amoena*, and abundant crinoid stems. It is entirely likely that these beds are to be correlated with the upper beds of the railroad cut at Neuville.

Along Lachevrotière river, limestones are exposed immediately below the wooden dam less than ¼ mile above the highway. These are thin bedded, fine grained and crystalline, with interbeds of shale rich in bryozoa. Immediately below the dam, fossils are more abundant, *Prasopora*, *Sowerbyella*, *Dalmanella*, and *Isotelus* being common. Still

Plate IV - A -(Grondines Member) near the Neuville fault. View looking east from Neuville wharf.

Plate IV - B - (Grondines Member) at the Neuville section looking west from Neuville wharf. Trenton Limestone.

higher upstream where a sharp bend brings the river within 500 feet of the road, 7 feet of limestone, in beds up to 6 inches with shale partings up to 1 inch thick, is poorly exposed. Of these beds along the river, the bryozoan beds probably are to be correlated with the Deschambault Formation, whereas those farther upstream probably belong to the Saint-Casimir Member. The strata are much disturbed along the lower part of Lachevrotière river (dips up to 37° and strikes boxing the compass) so that their apparent anomalous position can be assigned to structural complications.

Still farther to the southwest, in the extreme corner of the map-area, there are a few exposures of limestone which are in effect the beginning of almost continuous roadside exposures that stretch for miles along the road to Grondines in the Grondines map-area. Fossils are very scarce, but every indication suggests that these beds belong to the upper part of the Saint-Casimir Member, and the lithology is similar to that along the Neuville shore.

Grondines Member

Neuville

With the exception of 47 feet of brownish, semi-lithographic limestone immediately east of the Neuville wharf (Pl. IV-A), the whole section of Trenton rocks exposed along the Neuville shore belongs to the upper or Grondines Member (Pl. IV-B, V-A) of the Neuville Formation. This consists of dark gray limestone, for the most part dense with both semi-lithographic and crystalline textures comparatively rare, and abundant shale interbeds (Plates V-B, VI). Much of the dense limestone is referred to in the accompanying stratigraphic analysis as chemical; this is an interpretation based upon its uniformly fine grained texture, but it is quite possibly an extremely finely divided granular rock. Wherever subaerial weathering is effective the rock breaks down into a rubbly mass resulting from a partial separation of the limestone layers into small blocks which give the appearance of pebbles (Plate III-A). This is the characteristic appearance of this member inland. Pale blue or gray chert is disseminated throughout practically the entire section, particularly toward the top. The topmost few inches, in contact with the Utica shale, contain abundant finger-sized fragments of a straight cephalopod, unidentifiable because in virtually all cases only the living chamber and, at the most, three camerae are preserved. This peculiar occurrence is characteristic of the top of the Trenton elsewhere in this and adjacent map-areas.

The Grondines Member can be correlated with the Montreal and Tétreauville Formations of the Montréal area, and also with the Sherman Falls and Cobourg elsewhere. It is impossible at present to determine where to draw the line between the equivalents of the Montréal and the Tétreauville

Plate V- A - Trenton limestone (Grondines Member) at Neuville. Looking west. Thickly bedded units.

Plate V-B - Trenton limestone (Grondines Member) at Neuville. Looking east. Thinly bedded units.

formations. Certainly, the *Cryptolithus lorettensis* zone, 10 to 20 feet above the base of the Grondines Member is to be correlated with the Montréal Formation. *Rafinesquina deltoidea*, a species elsewhere characteristic of Cobourg rocks, first appears a few tens of feet above the *Cryptolithus* zone and has been identified as high as 160 feet above that zone. In the adjacent Grondines area, *R. deltoidea* and *Cryptolithus lorettensis* occur in the same bed, and *R. deltoidea* occurs throughout most of the overlying Trenton. The Trenton limestone section at Neuville is formally identical to the Upper Trenton (Cobourg) of the Trenton type section of Trenton Falls, New York, except that the Neuville section contained an abundance of a new form of *Cryptolithus*, *C. lorettensis* which is morphologically more advanced and thence is younger than *C. tesselatus*. *C. tesselatus* is the characteristic trilobite of the basal Trenton of New York, base of the Sherman Fall limestone to which it is also restricted. *C. tesselatus* is absent from the Neuville section but *C. lorettensis* is very common in the Lower Cobourg up to now, *C. lorettensis* is known to be common in the Upper Trenton of the St. Lawrence Lowlands in the areas close to Québec City (Wittington, 1968, Bertrand and Lespérance, 1971).

The Saint-Casimir Member limestone appears, in respect to its New York equivalent, the Sherman Fall, to be reduced in thickness considerably. *R. deltoidea* species has been reported in the Grondines map-area as being coeval with *Cryptolithus lorettensis*. Which tends to reduce even more the thickness of the Sherman Fall.

Table 7 - Grondines Member Correlation

Trenton Fall Section	Neuville Section
Cobourg Ls. *Rafinesquina deltoidea*	Grondines (Cobourg) *Rafinesquina deltoidea*
Sherman Fall Ls. *Prasopora orientalis* *Cryptolithus tesselatus*	Sherman Fall Ls.• *Cryptolithus lorettensis* *Prasopora orientalis*

The complete stratigraphic section along the Neuville shore is as follows (Table 8). Beginning at the top (west at Delisle Point) and proceeding downstream.

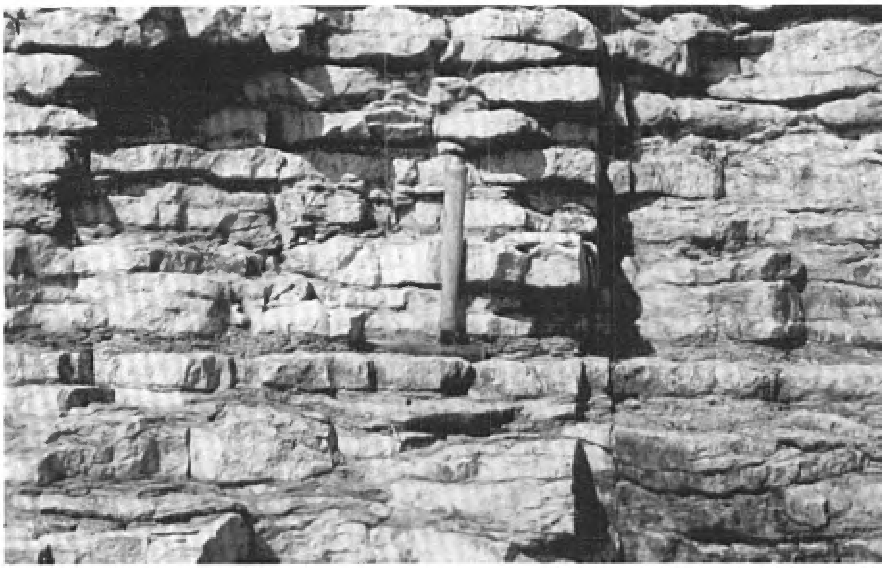


Plate VI - Interstratified limestone and shale - Grondines Member.

Table 8 - Section of the Grondines and St. Casimir Member on the Neuville shore.

Total thickness		Unit thickness		Lithological Description
364'	9"			TOP OF THE GRONDINES MEMBER
364	9	0	9	Rubbly weathering limestone. Cephalopod fragments abundant.
364	0	32	0	Cherty limestone, shale partings common.
332	0	20	0	Dark shaly limestone in 2- to 4-inch beds with 1-inch shale partings.
312	0	14	9	Ditto, but shale partings 1 inch to 3 inches.
297	3	0	6	Lithographic limestone. This is rare in the upper part of the section.
296	9	12	9	Dark limestone in 2- to 4-inch beds with 1-inch shale partings.
284	0	3	10	Rubbly weathering limestone, in beds up to 2 inches.
280	2	0	2	Light gray, coarsely crystalline limestone.
280	0	4	2	Dark, crystalline, rubbly weathering limestone, both thick and thin bedded.
275	10	14	4	Impure limestone, weathering to a very rough surface. *Rafinesquina deltoidea* common.
261	6		6	Pure chemical limestone in beds of 1 inch to 1½ inches.
261	0	5	3	Impure limestone in beds 2 to 6 inches thick.
255	9	2	3	Dark limestone weathering to very rough surface.

Table 8 (continued)

253	6	6	6	Thick-bedded limestone, beds up to 8 inches, shale partings inconspicuous.
247	0	15	3	Shaly limestone with thin beds of shale. Pure limestone beds are rare. The wide flat with the bathing float is at the top of this thickness.
231	9	8	9	Chiefly chemical limestone with some rubbly weathering, impure limestone forming small cliff. This latter contains one single 21-inch bed.
223	0	9	0	Chiefly chemical limestone. This forms the flat in front of the hotel.
214	0	16	0	Thick- and thin-bedded limestone, with shale partings up to 3 inches. Becomes somewhat more thin bedded toward the top, with shale partings rarer. Burrows common. *Rafinesquina deltoidea* and *R. alternata* very common in some beds. Neither chemical nor pure crystalline types noticeable. This forms a prominent 15-foot cliff.
198	0	23	6	Mostly thin-bedded limestone poorly exposed on the beach.
174	6	1	0	Brecciated layer. Beds above and below unaffected.
173	6	6	6	Nearly pure chemical limestone, with thin shale partings. Very wide surface at top, sloping west.
167	0	4	6	Impure crystalline limestone, shaly, flaky weathering.
162	6	10	0	Almost pure chemical limestone, with a few shale partings.
152	6		9	Dark gray lithographic limestone.
151	9	10	9	Impure limestone in 2- to 3-inch beds, with brown-weathering, 2-inch shale partings.
141	0	3	0	Hard, cherty limestone, splintery fracture.
138	0	4	2	Hard, cherty limestone in 2- to 3-inch beds; one 6-inch shale bed.
133	10	3	6	Rubbly weathering, impure limestone with 1- to 2-inch shale partings.
130	4	2	9	Dark, impure, very fine grained, rubbly weathering limestone in 2-inch beds. Very fossiliferous. Well exposed at top of beach at low tide. Not well seen where washed by tide. *Cryptolithus tripleca nuclea and Ceraurus pleurexanthemus lorettensis* especially abundant.
127	7	3	1	Heavy-bedded limestone in 6-inch beds. Rubbly appearance probably due to original deposition.
124	6	3	8	Almost lithographic limestone in 2- to 3-inch beds with 1- to 2-inch shale partings.
120	10	1	2	Shale limestone with *Cryptolithus*. Base of the *Cryptolithus lorettensis* zone of the Grondines member.
119	8	1	0	Missing.
118	8	2	5	Thin-bedded, finely crystalline, gray limestone.

Table 8 (continued)

116	3	1	3	Coarsely cristalline, gray, fossiliferous, thick-bedded limestone.
115	0	3	0	Missing.
112	0	1	8	Dark gray, crystalline, rubbly weathering limestone.
110	4	1	7	Missing.
108	9	1	8	Missing.
107	1	19	1	Brownish, lithographic limestone, with very thin, shaly partings. Here and there thin, crystalline beds with fossils.
88	0			BASE OF SECTION WEST OF WHARF. TOP OF SECTION EAST OF WHARF
88	0	4	3	Medium to dark gray, chemical limestone.
83	9	5	3	Thick - (6") and thin-bedded (2") shaly limestones with shale partings. Some lithographic beds here.
78	6	2	6	Dark shaly and crystalline limestones.
76	0	7	0	Same, with interbedded lithographic and fine-grained limestones.
69	0	9	0	Heavy beds of fine-grained limestone.
60	0	8	0	Thin-bedded limestone, deeply weathered.
52	0	11	0	Heavy-bedded limestone.
41	0	1	10	Alternating limestone and brown shale in beds 2 to 8 inches thick.
39	2			BASE OF GRONDINES MEMBER. TOP OF SAINT-CASIMIR MEMBER.
39	2	7	2	Mostly dark gray, fine-grained, crystalline limestone, with lesser amounts of brownish limestone.
32	0	1	11	Dark gray, fine-grained limestone, crystalline.
30	1	6	8	Almost lithographic limestone, with a few ½-inch bands of crystalline limestine.
23	5	8	11	Dark, very fine grained, crystalline limestone, with a few beds of lithographic limestone.
14	6	2	0	Lithographic limestone with a few shale partings.
12	6	12	6	Dark, fine-grained, crystalline limestone.
0	0	0	0	BASE OF MEASURED SECTION. 1,700 feet E. of Neuville wharf.

Fauna of Grondines Member, as shown on the Neuville shore is indicated in Table 9, locality 4.

About 1½ miles north of Neuville village, and along a poor road to Pont-Rouge, a small stream has been dredged to provide better drainage. The rock thrown up by the dredge is, in places, exceedingly fossiliferous, and belongs to the base of the Grondines Member (as shown by *Cryptolithus*). *Rafinesquina deltoidea* is extraordinarily abundant in the higher beds, and *Ceraurus* is common throughout. These beds are geographically and structurally in the correct position, for the *Cryptolithus* horizon on the Neuville shore. The fauna from this locality is indicated in Table 9, locality 4.

Saint-Basile

A few outcrops of Trenton rocks occur near Saint-Basile railroad station, chiefly along Portneuf river. These beds belong to the base of the Grondines Member, as suggested by their abundant and characteristic fauna, (Table 9, locality 5). The best place to see these strata are in the quarry of "Ciment Québec Inc.". At the top of the section in the quarry of Ciment Quebec Inc., there is a considerable increase of shale beds, which may indicate an approach to the top of the Neuville Formation and to the Trenton-Utica boundary. Another good exposure of the Grondines Member is situated immediately below the highway bridge over the Portneuf River southeast of Saint-Basile. An outcrop situated upstream on the same river contains an abundance of *Rafinesquina deltoidea*.

Jacques-Cartier River

South of the fault at the lower power house, the beds are almost all thick-bedded chemical limestone, in which fossils are very scarce. In the 93 feet exposed, the species indicated in Table 9, locality 7 are present. Of this list, *Rafinesquina* sp., cf. *R. deltoidea* and *Cyclospira bisulcata* are indicative of an upper (Grondines Member) horizon in the Neuville Formation. This 93-foot layer of limestone lies directly under the Utica shale, and details of the contact (Plate VII-A) between the two types are deferred until the latter is described.

* * *

The only other places of any importance where the limestone of the Trenton Group may be seen are along the southeast side of the northern part of the Deschambault fault. Between Portneuf and Deschambault stations, railroad cuts along the abandoned Transcontinental Railway and stream exposures show this rock in a few patches. West of Portneuf-Station and also at Deschambault-Station, it was once quarried for lime.

Paleontology

The entire fauna of the rocks of the Trenton Group is fairly large. Nevertheless, a few species predominate. In the Deschambault beds, *Parastrophia* is everywhere common. In the Saint-Casimir Member, *Prasopora* is characteristic and is abundant in places. In the Grondines Member, *Ceraurus, Flexicalymene, Leptaena, Triplesia, Rafinesquina,* and *Sowerbyella* occur in most exposures. In the upper part of the Grondines *Sowerbyella* is the only common species.

A study of conodonte distribution in the Trenton limestones of Neuville has been published (Globensky and Jauffred, 1971) previous to the writing of this report.

Table 9 gives the list of fossils collected at the above mentioned sites and their lithological identity.

Subsurface Distribution

Each of the six deep wells gives a complete section of the rocks of the Trenton Group. In well 16, the Trenton rests on the Precambrian, but its development probably is complete. Along the Neuville shore, the separation of Upper from Middle Trenton is difficult even with the help of fossils, and in well cores and cuttings this difficulty is much greater. Hence, only in Well 69 was such a subdivision made. The Lower Trenton Deschambault Formation is fairly easily recognized, and though outcrop measurements show it to maintain a fairly constant thickness of 90 feet, the thickness in the logs, in numerical order, is 100, 95, 96, 185, 165 and 50 feet. A check of the logs of Wells 69 and 72 reveals no reason to change the record. Well 16, however, shows typical Deschambault cuttings down to 1,275 feet, i.e. a thickness of 105 feet, which is "normal" for the formation. From 1,275 to 1,315 feet, the limestone is in part dense, gray rather than buff, and should more properly be considered sub-Deschambault. Whether this limestone belongs more properly with the Pont-Rouge Formation or the Black River Group cannot, in absence of diagnostic fossils, be determined, but, the Pont-Rouge Formation does not have the widespread extent of the Black River beds, and a tentative alignment of this 40-foot thickness of limestone with the Black River Group is preferred. Below 1,315 feet increasing percentages of sandstone occur along with the limestone and suggest the limestone-sandstone interbedding of the Black River beds at Pont-Rouge.

Correlation

Enough has been said already to indicate the equivalency of the Deschambault Formation, as well as the Neuville Formation with its Saint-Casimir and Grondines members, with the subdivisions of the standard Trenton section. There remain two observations: first, with regard to the upper part of the Grondines Member *(Rafinesquina deltoidea)*, its relation to and correlation with parts of the Utica Group will be discussed after the Utica has been considered below; secondly, within the

Table 9 - Trenton Group Fossils

Localities	Strata and Localities							
Jacques-Cartier River (White bridge) 1 Deschambault 2 Neuville (Railroad) 3 Neuville (shore) 4 Saint-Basile 5 Jacques-Cartier River (power house) 6	DESCHAMBAULT			NEUVILLE				
				St-Casimir (Lower)	St-Casimir (Upper)	Grondines		
	1	2	3	3	4	4	5	6
SPONGES								
Receptaculites oweni		X						
Sponge spicules						X		
COELENTERA								
Conularia sp.	X				X			
BRYOZOA								
Arthrostylus obliquus	X					X		
Prasopora simulatrix	X	X	X	X	X			
P. simulatrix var. *orientalis*	X		X	X	X	X		
P. constrictus	X							
P. neuvillensis								
P. elegans			X					
P. insularis			X			X		
P. sp., cf. *P. triserialis*			X					
Hallopora spendens	X		X					
H. subplana	X		X					
Pachydictya sp., cf. *P. triseratus*	X							
P. acuta		X	X					
Batostoma sp., cf. *winchelli*			X					
Rhinidictya mutabilis			X	X				
Nematopora ovalis						X		
Mitoclemella mundula						X	X	
Mitoclema wilsoni								
Corinotrypa ulrichi				X	X			
BRACHIOPODA								
Lingula sp., cf. *L. cobourgensis*	X							
L. trentonensis				X				
L. riciniformis					X			
Trematis terminalis	X			X	X	X	X	
Platystrophia amoena	X	X					X	X
Dalmanella rogata	X	X	X	X	X	X	X	X
D. whittakeri						X		
Dinorthis browni	X							
D. pectinella	X	X		X				
Sowerbyella sericea			X			X		
S. punctostriata	X	X	X	X	X	X	X	
Rafinesquina alternata	X							
R. geniculata						X		
R. sp., type *geniculata*						X		
R. sp., cf. *R. deltoidea*								X
R. deltoidea						X		
R. mucronata						X		
R. subtrigonalis							X	
Parastrophia hemiplicata	X	X	X					
Triplesia nucleus	X		X	X	X	X	X	
T. cuspydita						X		
Rhynchotrema increbencens	X	X		X	X	X	X	
Zygospira recurvirostris	X	X	X	X	X	X	X	X
Cyclospira bisulcata						X		
Orbiculoidea sp.		X						
Plaesiomys iphigenia		X						
Trigrammaria hemeplicata		X						
Leptaena sp., cf. *L. affinis*			X			X		
L. rhomboidalis						X		
Conotreta rusti					X			
Pholidops sp.						X		

Table 9 (continued)

	1	2	3	3	4	4	5	6
GASTROPODA								
Phragmolites compressus	X		X					
Cyrtolitidina sp.		X						
Sinuites cancellatus						X		
Archinacella sp.						X		
Hormotoma sp., cf. *H. gracilis*			X					
Hormotoma gracilis				X	X			
CEPHALOPODA								
Oncoceras			X					
Endoceras proteiforme						X		
Orthoceras sp.						X		X
TRILOBITA								
Bumastus milleri	X				X	X		
Calyptaulax calderi	X							
Flexicalymene senaria	X	X	X	X	X	X	X	
Ceraurus pleurexanthemus	X			X	X	X	X	
C. dentatus		X						
Odontopleura sp.	X				X		X	
Isoletus gigas						X		X
Isotelus sp.				X	X	X		
Isotelus iowensis					X	X	X	
Remopleurides sp.					X			
R. canadensis								
Cryptolithus lorettensis						X	X	
Diacanthaspis sp.						X	X	
OSTRACODA								
Leperditia ornata	X	X						
Tetradella sp.	X							
T. lunatifera			X			X	X	
Bythocypris cylindrica	X		X	X		X	X	X
B.? granti			X	X				
Leperditella sp.						X	X	
Primitia sp., cf. *P. obesa*			X				X	X
P. obesa		X						
Primitia sp.							X	
Primitiella ulrichi								X
Tallinella sp.								X
Schmidtella incompta		X	X		X			
S. latimarginata			X					
S. umbonata		X	X					
Aparchites mundulus		X	X					
A. trentonensis			X					
A. sp., cf. *A. ellipticus*						X		
Krausella arcuata		X						
K. sp., cf. *K. arcuata*			X					
Hallatia particylindrica			X					
Bollia subaequata			X					
Briartina modesta			X					
Ceratopsis milleri			X				X	
Eurichilina recticulata			X					
Jonesella abscura			X					
Dicranella sp.							X	
Ctenobolbina sp.							X	
Ulrichia binodosa				X	X			
ECHINODERMATA								
Lepidocoleus jamesi					X	X		
Daedalocrinus sp.						X		
Cystitis plates				X	X	X		
Crinoïd fragments						X		
GRAPTOLITHINA								
Climacograptus sp.						X		
Diplograptus sp.							X	
ANNELIDA								
Arabellites hamatus						X		
INCERTAE SEDIS								
Translucent stems				X	X	X	X	

Portneuf map-area there is no representative of the Rockland (basal) Formation of the Trenton, but on Jacques-Cartier river, within the Saint-Raymond area the Pont-Rouge Formation is correlated with reasonable certainty with the Rockland beds of Ottawa area (see Table of Formations p. 8).

UTICA GROUP

Lotbinière Formation

Distribution

From Delisle point just west of Neuville village westward to half-way between Jacques-Cartier and Portneuf rivers, the St. Lawrence shore is almost continuously bordered by flats and cliffs of Utica shale. East of Neuville, it occupies the shore for about ½ mile (but is highly disturbed) before giving way to the shales and sandstones of the Lower Lorraine Formation toward the eastern margin of the map-area. Inland from the shore the shale can be seen along many streams, and particularly well along Jacques-Cartier river where several miles of cliffs nearly 100 feet high are made up wholly of this rock. There are a few exposures along Portneuf river and its tributaries. Immediately east of both the Neuville and the Deschambault faults this shale, highly disturbed in many places, can be seen in contact, or nearly so, with Precambrian or with Trenton rocks. Its stratigraphic contact with the Trenton limestone can be seen very well at two exposures near Neuville, and also on Jacques-Cartier river.

South of the St. Lawrence, the Utica shale is exposed near Platon point and Saint-Antoine-de-Tilly. From Platon point westward the shale is magnificently displayed in nearly vertical cliffs, mostly more than 100 feet high, along which the entire formation except, perhaps, the lower 50 feet or less can be examined inch by inch. We propose the term *Lotbinière Formation* for this development and the Lotbinière shore as the type section.

Lithology

Most of the Lotbinière Formation is dark brown or dark gray (rarely black) shale. There are some beds of fine sandy material especially in the upper part. It is petroliferous almost throughout, some beds emitting a much stronger odor when first broken than do any of the Trenton limestones. Here and there, with no special stratigraphic horizon, there is dark brown, bituminous shale, lighter in weight and less obviously stratified than the rest of the formation. The normal shale weathers to some shade of light gray, whereas the bituminous rock weathers to a dull, light to medium brown. Throughout, the formation contains medium gray, dense limestone beds, up to 10 inches thick, which weather pale yellow or pale orange. They are usually made up of a series of beds 2 to 3 inches thick, closely associated, and separated by normal argillaceous shale. A peculiar development at the base of the formation is described below.

Jacques-Cartier River

The basal part of the Lotbinière Formation is best seen where it is in contact with Trenton limestone 1,000 feet or so below the power house at the lower end of the horseshoe bend in Jacques-Cartier river (Fig. 4-A). There, Trenton limestones can be followed along the bank of the river downstream from a point opposite the power house at the foot of the path descending the river bank. Some 93 feet of these limestone can be measured, A.C.D.- Fig. 4, the upper part of the section forming a prominent bench (C). Below the bench, and usually covered by water, there is an irregular layer of brown-weathering shale (B), ranging in thickness from 6 inches to 5 feet. The shale is almost black where fresh, and does not break readily along the bedding planes. It contains thin, buff-weathering limestone beds, and yields a few graptolites referable to the lower Utica of New York. However, it is succeeded by 30 inches of typical, heavy-bedded, Trenton limestone, (C), with a characteristic shelly fauna, and this in turn by 36 inches of Trenton limestone in 2 inches beds separated by 1 inch to 2 inches of shale, (D). Weathering has separated the last-mentioned limestone beds so that they have the appearance of boulders in a conglomerate, and no layer is continuous along the bedding plane, (Plate VII-A) as exposed, for more than 6 inches. The shale interbeds yield a small graptolite fauna, and the limestones contain a few Trenton fossils. Above this thin-bedded Trenton comes the Utica, but not in its characteristic development at the base. This consists of about 30 inches, (E) of alternating brown shale and 2-inch beds of pure gray, almost lithographic, yellowish weathering limestone. This zone contains sparse, characteristic Lower Utica fossils. Above it lies the normal Utica Shale, - thin bedded, dark gray where fresh, light brownish gray weathering, with thin beds of buff-weathering limestone, (F). These shales are here exceedingly fossiliferous, as they are in the two other places (see below) where the basal portion of the Utica can be examined.

Neuville

At the two localities near Neuville the Trenton-Utica passage is somewhat different. First, at the west side of Delisle point, and secondly, in the road cut on Route 2, 1.3 miles west of Neuville wharf (Fig. 5). At both localities the uppermost Trenton limestone is rubbly weathering and full of cephalopod fragments 2 to 4 inches long. This is succeeded by 5 to 6 feet of the basal Utica gray platy limestone in continuous beds separated by shale interbeds, E-Fig. 5. This is followed by typical Utica shale, (F-Fig. 5). Buff-weathering limestone beds occur within the Utica shale at irregular intervals. In fact, the shore west from the point showing the contact is characterized by 20 or so small points, well shown at low tide, each of which is held up by a buff-weathering limestone band in the otherwise easily weathered Lotbinière shale.

We propose to call the basal few feet of the Lotbinière Formation, consisting of platy limestone beds with shale interbeds, the Delisle

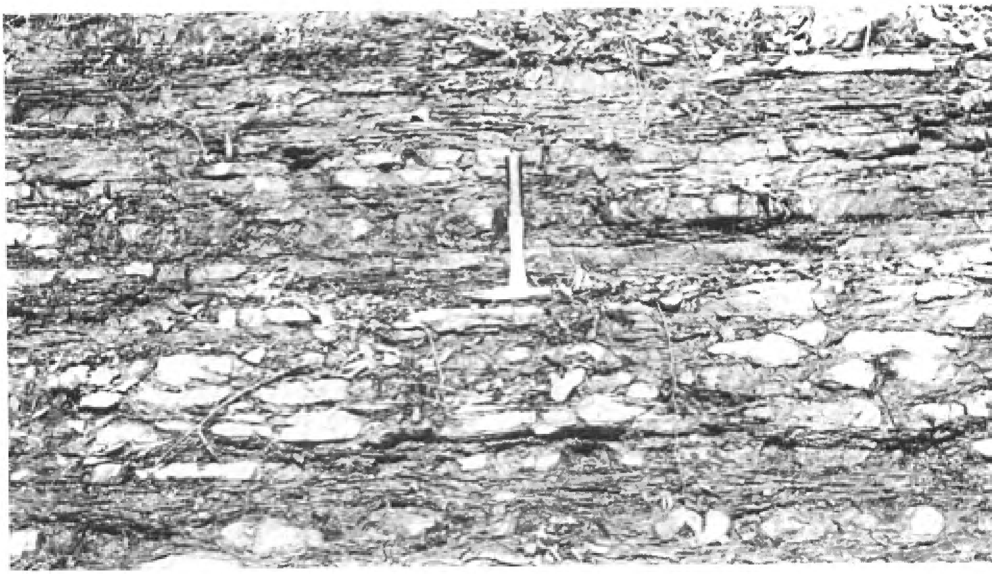


Plate VII -A · Hammer head rests on contact between basal part of even-bedded Utica shale and upper part of rubbly bedded Trenton limestone

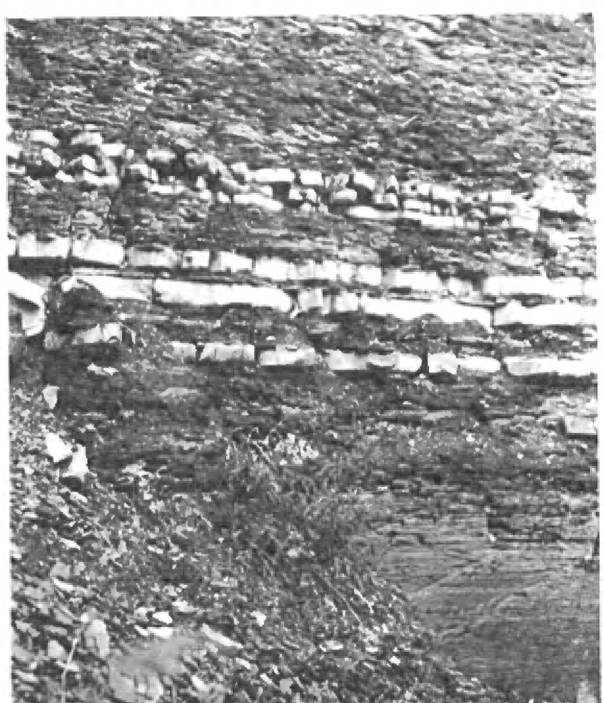
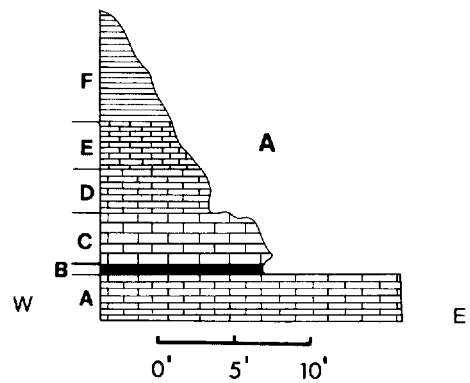


Plate VII-B - Delisle member of Lotbinière Formation in creek flowing south close to Utica-Trenton contact about 1 mile west of Neuville.

F The lowest part of the Utica shale in continuous section. Buff-weathering limestone beds present: 20'0".

E Alternating beds of brown shale and continuous 2-inch beds of gray, almost lithographic limestone, yellowish-weathering. Utica formation: 2'6".

D Trenton limestone in 2-inches beds separated by 1-inch to 2 inches beds of shale. The limestone beds are broken as if by weathering: 3'0".



C Typical heavy-bedded Trenton limestone with shale partings 1 inch to 2 inches thick: 2'6".

B Very dark brown shale, weathering light brown. One buff-weathering bed. Utica fossils: 1'6".

A Top of continuous section of Trenton Limestone.

A.E.F. : Same lithology as above.

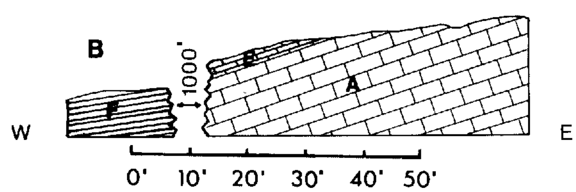


Figure 4 - Sections illustrating the passage Trenton-Utica

A - Left bank of the Jacques-Cartier River at about 1,000 south of the power Station.

B - North side of route 2 at 1.3 miles west of the Neuville wharf.

Plate VIII-A - Utica shale in cliff 1 mile west of Platon point.
Note buff-weathering calcareous sandstone layers.

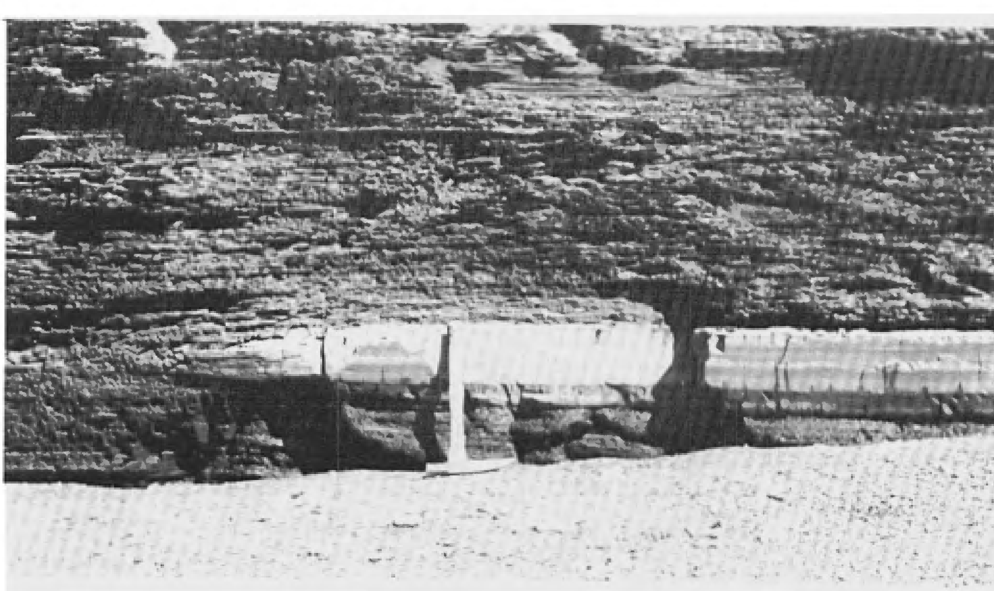


Plate VIII-B - Close up of buff-weathering calcareous sandstone
layers shown in A.

Member, taking the name from Delisle point on the St. Lawrence shore a mile upstream from the Neuville wharf, where the member is well shown. It is equally well exposed at the two other localities referred to.

On the south side of the St. Lawrence, from Lotbinière village to Platon point, and to a lesser degree for some distance downstream, there are practically continuous exposures of a soft, shaly rock ranging from a nearly pure "claystone" to siltstone. Nowhere in this succession are there any typical sandstones. The "claystones" are, of course, without apparent grain and disintegrate readily into platy fragments, ¼ inch or more across. These fragments rain constantly from the cliff face, offering, however, no menace to the observer. The siltstones are obviously micaceous, but no other mineral grains can be seen even with a strong lens. The presence of abundant quartz is indicated by the fact that much of this rock will scratch steel. Whereas the "claystones" are typically almost devoid of bedding planes, the siltstones are everywhere finely bedded in layers 1 mm. or more thick of various textures and shades of gray and purplish gray. It was this characteristic which earned these beds the field designation of 'variegated beds'. Associated with these ordinary types are two remarkably different ones. First, apparently grading into the argillaceous types there are several horizons of dark brown, bituminous shale. Secondly, interstratified throughout the whole formation there are, at intervals of 5 to 25 feet or more, beds of buff- to orange-weathering, fine-grained, magnesian limestone, in some of which there is so much fine-grained quartz sand as to justify the designation calcareous sandstone. These stand out sharply wherever the formation is exposed on a cliff or beach. The minimum number of these sandstone beds can be seen from a section of the cliff face from Platon point to Hydrographic Station 29, as shown in Figure 7 *a*. Flattened, circular, calcareous concretions up to 3 feet in diameter and 1 foot thick are common in a few horizons high up in the formation.

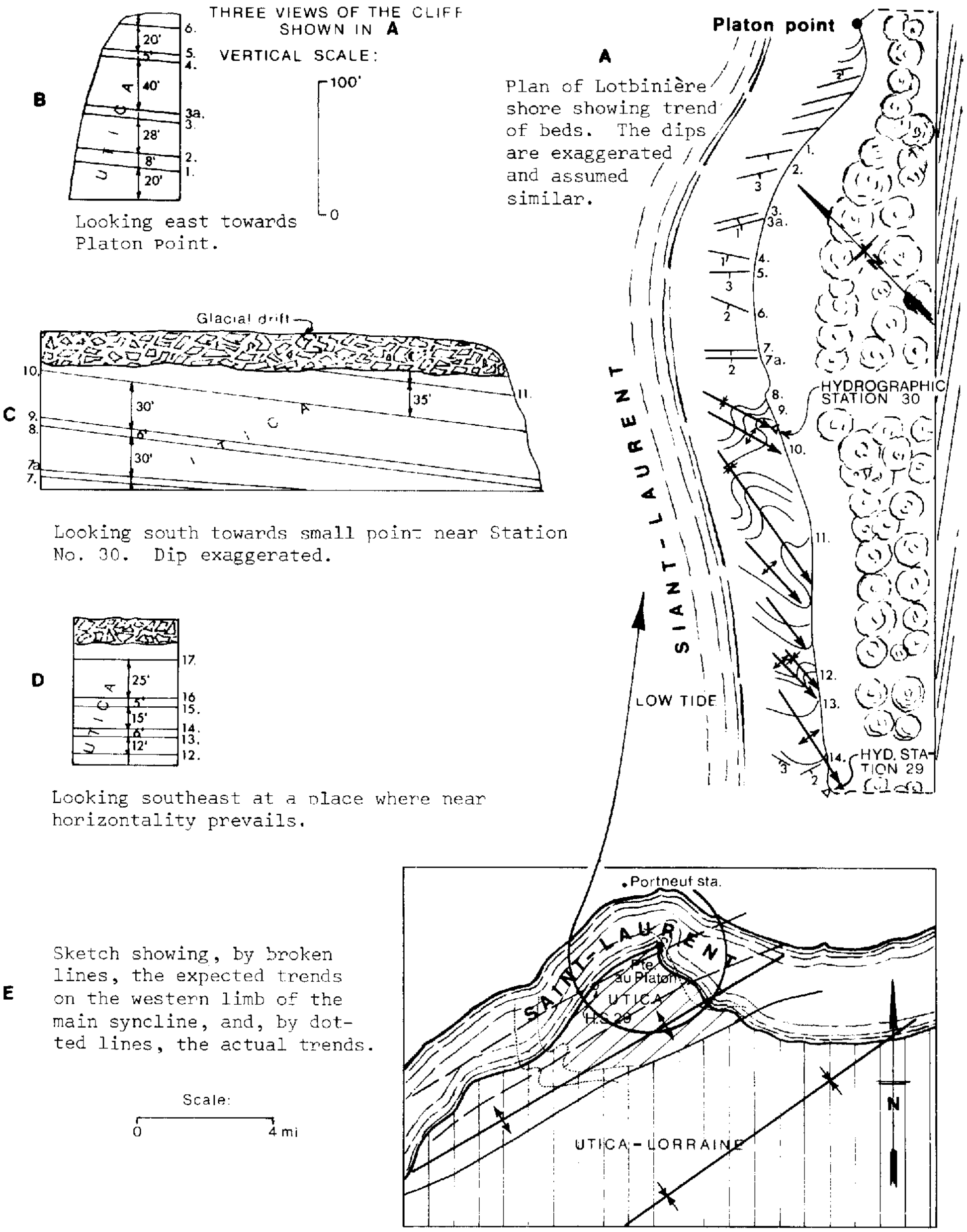
The Lotbinière Formation is in discontinuous exposures from Platon point downstream toward Sainte-Croix. Inland, the streams north and south of La Ferme cut through these rocks. Several folds, some of which are overturned, and thrust or low angle reverse faults characterize the structure of this area.

Thickness

Fortunately four of the deep wells penetrated the entire thickness of the Lotbinière shale. The correlation chart (page 15) shows a considerable variability in the thickness of this formation, ranging from 334 feet in Well 69 to 260 feet in Well 72. That this formation, which transgressed and replaced the Trenton limestone, should be irregular in thickness is to be expected. In the five Bald Mountain - Batiscan wells (Nos. 3, 4, 5, 6 and 7 in S-75), 30 miles west southwest of Well 9, the thickness ranges from 330 to 355 feet. Thus, the local logs suggest that the Lotbinière Formation is 300 feet thick on the average.

Plate IX-A - Large concretion in Utica shale.

Plate IX-B - St. Lawrence shore at low tide, at Saint-Antoine-de-Tilly.
Utica shales on tidal flat.



B. Looking east towards Platon Point.

A. Plan of Lotbinière shore showing trend of beds. The dips are exaggerated and assumed similar.

C. Looking south towards small point near Station No. 30. Dip exaggerated.

D. Looking southeast at a place where near horizontality prevails.

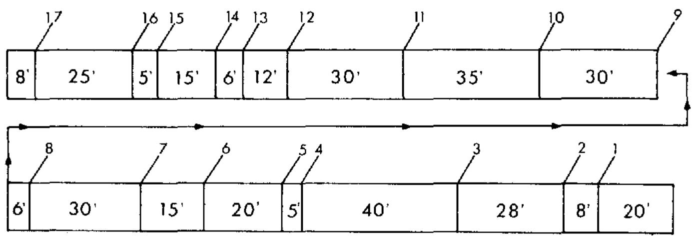
E. Sketch showing, by broken lines, the expected trends on the western limb of the main syncline, and, by dotted lines, the actual trends.

Figure F - PLAN AND SECTIONS OF UTICA-LORRAINE STRATA ALONG THE SHORE AT LOTBINIERE.

The situation along the Lotbinière shore southwest from Platon point is shown in Figure 5. The interbedded magnesian limestone layers were numbered and their thicknesses, as well as those of the shales, were measured or estimated, with the result shown below. Trigonometric calculations involving distances and dip angles are not wholly reliable, partly because of variations of the strikes and of the low-angle dips.

Bed No. limestone

Thickness intervening shale



Total thickness of shale	338	feet
Total thickness of limestone beds	12	feet
Total thickness of formation	350	feet

The 30 to 40 feet of fossiliferous shale at the base of the formation, as seen on the north shore, does not show in the section along the Lotbinière shore and should lie below the lowest shales exposed at Platon point. Hence the figure of 350 feet worked out as the thickness of the shale along the Lotbinière shore, is a minimum, and it should be increased by 30 to 40 feet. Nevertheless, 380 to 390 feet is too great a thickness to be compatible with that shown by the well logs. The thickness of many of the shale beds was estimated in cases where inaccessibility made such a course necessary. Also, no account could be taken of the effect of ever-present folding, shown by the pattern of outcrop at low tide (fig. 5A). Few of these complications show in the vertical cliffs, yet their effect must be to exaggerate the thickness as given. Hence, a thickness of 300 to 350 feet is more in accord with reality.

Paleontology

Fossils are abundant, and consist essentially of graptolites. The only common inarticulate brachiopod is *Leptobolus insignis*. *Triarthrus* sp. is also common. The buff-weathering limestones are well provided with graptolites (*Climacograptus typicalis* and *C. spiniferus*), and the bituminous shales contain, in addition to all of the above forms, *Dicranograptus* sp., cf. *D. nicholsoni* and *Geisonoceras*. The graptolites are abundant in exposures of the Lotbinière Formation on both sides of the St. Lawrence. In outcrops and in well cores the lowest bed of shale is in most cases composed of a mass of fossil fragments ("débris bed" of our field notes). A complete list from the formation on both shores of the St. Lawrence follows:

Table 10 - Utica fossils (Lotbinière Formation)

COELENTERATA	
Glyptoconularia splendens (Hall)	
BRYOZOA	
Atactopora maculata	
BRACHIOPODA	
Pholidops sp.	*Dalmanella* sp.
Leptobolus insignis	*Sowerbyella sericea*
Trematis ottawensis	*Rafinesquina ulrichi*
Lingula sp.	*Camarotoechia* sp.
GASTROPODA	
Archinacella sp., cf. *A. patelliformis*	*Oxydiscus* sp.
CEPHALOPODA	
Geisonoceras tenuistriatum	Brevicone cephalopod
ANNELIDA	
Serpulites angustifolius	
TRILOBITA	
Triarthrus eatoni	*Isotelus* sp.
Odontopleura sp.	*Ceraurus pleurexanthemus*
Flexicalymene senaria	
OSTRACODA	
Bythocypris cylindrica	*P. ulrichi*
Primitiella unicornis	*Ctenobolbina* sp.
MEROSTOMATA	
Eurypteride fragment	
GRAPTOLITA	
Dicranograptus sp., cf. *D. nicholsoni*	*O. ruedemanni*
Orthograptus amplexicaulis	*Climacograptus typicalis*
O. quadrimucronatus	*C. pygmaeus*
	C. spiniferus
INCERTAE SEDIS	
Cornulites sp.	

With the exception of the graptolites, *Leptobolus insignis*, and *Geisonoceras tenuistriatum*, all of the above were collected exclusively from the basal beds within 30 to 40 feet of the Trenton. At least half of these are identical with, or very closely related to, species common in the underlying Trenton. It is as if the incoming mud eliminated most of the life forms of the Trenton sea, but a few hardier ones survived long enough to be represented in the lower Utica shales. Most of the 'hangovers' from the Trenton are dwarf forms, though some, like *Camarotoechia* and *Isotelus*, are fully as large as their Trenton predecessors.

East of Saint-Antoine-de-Tilly, in the zone of complexely folded and faulted Utica-Lorraine rocks, the following graptolites were recovered from Utica-like lithology and are of Lower Utica age (identified by J. Riva, 1967, personal communication): *Dicranograptus* sp., cf. *D. nicholsoni* , *Orthograptus quadrimucronatus*, *Climacograptus typicalis*, *C. spiniferus?*

Correlation

The presence of *Dicranograptus* sp., cf. *D. nicholsoni* in fair abundance in the basal beds on the Neuville shore indicates that the beds containing it are Lower Utica. Also, the general fauna points to an affinity with the lower part of the Utica shale of New York. This has its implications with regard to the classification of the Trenton formations. Except in a very few places the replacement of limestone by mud did not begin until Upper Trenton (Cobourg) time. Hence it is appropriate to assign the uppermost part of the Trenton, of uncertain thickness, to the lower part of Cobourg time. The presence of *Rafinesquina deltoidea* and *Criptolithus lorettensis* in the Neuville shore rocks and *Cyclospira bisulcata* in the uppermost beds of Trenton age in the Jacques-Cartier gorge is the only available faunal evidence corroborating this conclusion.

Graywacke, siltstone and shale

On the south shore of the St. Lawrence River, between St-Antoine-de-Tilly and Aubin Point, rocks are exposed with a lithology similar to the rocks of the Lorraine Group (graywacke, siltstone, shale) but their fossil content (graptolites) indicates an Utica age. These rocks are, in general, very much disturbed, as indicated by the numerous vertical dips, and are separated by faults from the Lotbinière formation.

The graptolites found in this zone and identified by John Riva are the following: *Climacograptus* sp. *C. Typicalis* Hall, *C. spiniferus* (Rd) and *Orthograptus quadrimucronatus*. The two following fossils were also identified: *Sowerbyella sericea* and *Cryptolithus bellulus*.

LORRAINE GROUP*

Nicolet Formation

In 1916, Foerste divided the rocks of the Lorraine Group into a number of zones on the basis of their faunal content as follows: *Pholadomorpha*, *Proetus*, *Leptanea* and *Cryptolithus* zones. In general terms, the first represents the Upper Lorraine, the middle two the Middle Lorraine, and the lowest the Lower Lorraine. A more complete discussion of this question is given by Clark (1964) for the Yamaska-Aston area where the name "Nicolet River Formation" is given to the entire Lorraine development, divided into the Saint-Hilaire, Chambly, and Breault members and corresponding very closely to the faunal grouping given above. In the present

* The previously used formation names formation Bécancourt River, Pontgravé River, and Nicolet River, have been modified in this report to Bécancour, Pontgravé, and Nicolet in accordance with a general policy of the geological Services.

area, all the Lorraine belongs to the Breault Member except for a few Chambly Member exposures along Chêne river, and in a cliff about a mile east of Sainte-Croix on the St. Lawrence shore. It is presumed that the Saint-Hilaire is present south of Chêne river, near the western limit of the map-area.

Breault Member

The rocks of the Breault Member consist mainly of soft, thin-bedded shales with some limestone and sandstone, and are at least 1,000 feet thick.

Apparently the rocks of this zone grade upward into the Chambly Member of the Nicolet Formation, from which they are distinguished lithologically by the absence of an abundance of thick sandstone beds, and faunally by the presence of *Cryptolithus* and *Triarthrus*, and also by an abundance of *Dalmanella*. From the underlying Lotbinière Formation, into which they also grade, they may be distinguished lithologically by their higher sand content and the absence of the buff-weathering calcareous beds so characteristic of the latter. They can be readily recognized in only two places. First, along Chêne river from just above the seigniorial mill bridge downstream to the north of the river, and along the shore of the St. Lawrence to Lotbinière village. The second locality is along the St. Lawrence shore for a mile or so east and west of Sainte-Croix. Between Saint-Antoine-Est and the eastern edge of the map-area, the highly folded and faulted rocks along the St. Lawrence shore and along Méthot brook belong in part to the Breault Member and in part to the Lotbinière Formation.

Near Sainte-Croix, both east and west of beds of the Chambly Member referred to above, there are strata containing the normal meager fauna of the *Cryptolithus* zone. A composite list of the species identified from exposures $1\frac{1}{2}$ miles west, and $2\frac{1}{2}$ miles east, of Sainte-Croix is shown in table 11 locality 5.

Thus, with the exception of one pelecypod, all the identified species fit into the *Cryptolithus* zone. However, several species persist into the higher Lorraine, and even into the Richmond. Similar beds, with a smaller but similar fauna occur along the stream bed one mile east of Joly.

The other main locality for these rocks is from a mile above the seigniorial mill bridge on Chêne river downstream to Leclercville (Sainte-Emmélie), and along the south shore of the St. Lawrence downstream to Lotbinière. A note regarding the inclusion of these beds within the Nicolet River Formation is pertinent here. Within the Portneuf map-area, the lowest part of the Nicolet Formation is a group of shales and sandstones, usually devoid of the thick "clean" sandstone beds which characterize the rest of the Nicolet Formation. These beds (containing graptolites, *Triarthrus*, *Chonetoides*) are virtually devoid of *Cryptolithus* and were previously separated from the Nicolet Formation and named the Leclercville Formation. Subsequent investigation, however, has shown that this separation is not justified, and that these so-called Leclercville beds are actually the lower part of the Breault Member and possess the physical and faunal characteristics given above. Lacking both the thin "clean" sandstone beds of the upper part of the Breault Member, and the buff-weathering calcareous beds of the underlying Lotbinière Formation, these lower Breault beds present a monotonous series of thin-bedded shaly sandstones and sandy shales. Like the underlying Lotbinière beds, they disintegrate readily upon exposure. This is not a characteristic of the rest of the Breault or of the Chambly Member.

The rocks exposed along Chêne river between the mill bridge and the mouth have the characteristics given above. Peculiarly, the only graptolites found (about half-way between the two bridges) were in thin-bedded sandstones, not in shales as is usually the case. According to the structural interpretation of the observed attitudes, the width of outcrop of the beds exposed along the river here is 3,432 feet, which, with an assumed average dip of 3 degrees, gives a thickness of 180 feet.

Throughout the exposures along Chêne river fossils are exceedingly rare and poorly preserved. They included graptolites and fragments of brachiopods (probably *Dalmanella*).

Downstream along the St. Lawrence from Leclercville (Sainte-Emmélie), shales and shaly sandstones outcrop along the beach at Bois-des-Hurons, but except for fragments of *Dalmanella*, these beds yielded no fossils. Similar unsatisfactory traces occur in the sandy shales in the stream bed southwest of Vieille-Eglise. From the latter locality, exposures are almost unbroken along the shore to Lotbinière village and consist of shales and thin-bedded sandstones with a few thick sandstone beds. The last, near Lotbinière church, carry current markings, flute casts, burrows, etc., and a fragment of *Cryptolithus*. The only places where these rocks are obviously fossiliferous are 2,500 to 4,000 feet below the beacon at Vieille-Eglise, where limestones and slabby sandy shales contain the fossils indicated in table 11, locality 2.

Except for the *Cryptolithus*, such a fauna might be found at any horizon within either the Chambly Member or the Breault. This is one of the pieces of evidence hinted at by Foerste, who suggested that the Lorraine fauna was being held in readiness in some nearby basin and was fed out to this region wherever the environmental conditions allowed and supported it. Not until Chambly time did this fauna as a whole become well established.

In the eastern part of the map-area north of the St. Lawrence, shaly rocks are exposed here and there along the shore from Neuville eastward. At about 1½ miles in a straight line from Neuville wharf these shaly rocks are identical with the Lorraine on the south side of the St. Lawrence. The exposures along Roches river also belong to the Lorraine Group. The shales in the railroad cut ½ mile east of Les Ecureuils station are more sandy than usual but not enough to make one suspicious of their Lorraine affinities.

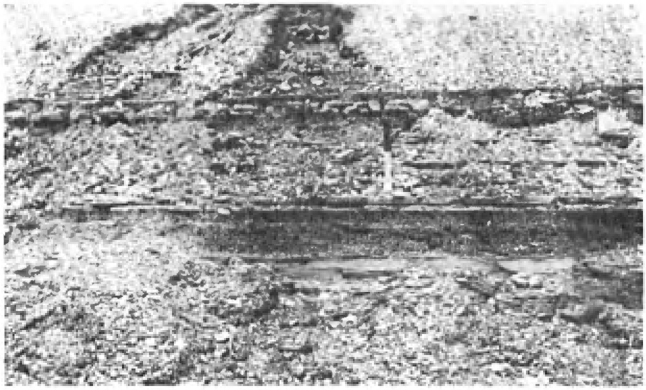


Plate X-A - Lower Lorraine shale, ½ mile north of La Ferme.

Plate X-B - Middle Lorraine shale (Chambly member) and thick sandstone beds. Pont-Noir, Chêne River, 6 miles above Leclercville.

Plate X-C - Close-up of thickly bedded sandstones of the Chambly member.

The shales along the shore are dark and micaceous, and contain thin, sandy layers; the shaly sandstones are less dark, and contain small bits (1-3mm.) of various kinds of shaly rocks, together with greenish fragments of unknown affinities. Fragments of a plicated articulate brachiopod are abundant in some layers and also some brims of *Cryptolithus*. The same kind of lithology is abundant along the Saint-Antoine shore and in creeks there that drain into the St. Lawrence. The exposures along Roches river and the other river to the southeast, show only sandy shales. The fair degree of folding suffered by the beds along the shore and Roches river, with dips up to 22°, indicates that the Lorraine was depressed along open synclinal axes in many places. To the east, beyond the limits of this map-area, Lorraine beds are common. In conformity with the succession on the south shore of the St. Lawrence, these Lorraine strata belong to the Breault Member of the Nicolet Formation.

Chambly Member

Exposures of this member occur in two localities. The first is along Chêne river, from 3 miles below to a mile above the mouth of Bois-Clair river. The exposures farthest upstream can be seen immediately above and below a steel bridge (Pont Noir) 2 miles southwest of Saint-Edouard (Rivière Bois-Clair). There, a series of soft clay shales, sandy shales and sandstones, with a few thin beds of limestone, appears along the right bank of the river. The sandstone is very irregularly bedded, and many layers of the marked with both fine and coarse ripples. The lower surfaces of many of the thicker beds of sandstone show, in reverse, the structures or irregularities usually referred to as current mark, flute casts, etc. These indicate long periods of quiet mud deposition interrupted occasionally by strong current disturbance during which the upper surface of the mud was deformed, and then covered by sand. The latter preserves, vicariously, a record of the irregularities that affected the mud layer. This exposure is easily reached, and, for that reason, it is unfortunate that its dip is anomalous. All of the exposures farther downstream have a southerly dip in accordance with their position on the northwestern limb of a southwesterly plunging syncline. The beds visible from the bridge all dip to the north, an aberration due no doubt to a local disturbance of the otherwise orderly arrangement of the beds. Fossils are common in some layers; the composite list for this locality is given in Table 11, locality 3.

Most of these species are fairly long ranging ones, yet the emphasis falls upon the *Proetus* zone of the Chambly Member. Although the numerical preponderance of *Proetus* Zone species is slight, the absence of *Cryptolithus*, *Triarthrus*, and *Leptaena* rule out the possibility that these beds are in the *Cryptolithus* zone or even the lower part of the *Proetus* zone. Similarly, because the common and easily distinguished species *Pholadomorpha pholadiformis* is absent, these beds are probably not so high as the zone of that name. *Proetus* itself is present only as fragments, and for great thicknesses absent altogether. In sum, a position in the middle or upper part of the Chambly Member is indicated.

Table 11 - Lorraine fossils

Localities	Strata					
			LORRAINE			
Ste-Croix 1 Vieille Eglise 2 Chêne River 3 Bois Clair River 4 Ste-Croix East and West 5	TRENTON	UTICA	Breault	Chambly	St-Hilaire	RICHMOND
ANNELIDA						
Serpulites sp. (4)						
BRYOZOA						
Numerous species (3,4,5)	X	X	X	X	X	X
BRACHIOPODA						
Sowerbyella sericea (2,3,4)	X	X	X	X	X	X
Rafinesquina alternata (1,2,3)	X	X	X	X	X	X
Strophomena cf. *planumbona* (3)				X	X	X
Dalmanella sp. (1,2,4,5)						
Catazyga sp. (1,2,4,5)						
Leptaena moniquensis (1,2,5)			X	X		
Lingula sp. (5)						
Platystrophia sp. (2)						
GASTEROPODA						
Clathrospira subconica (3)	X	X	X	X	X	X
Lophospira sp. (3,4)						
Pterotheca pentagona (4)				X		
Liospira micula (5)	X	X	X	X	X	X
Sinuites cancellatus (2,5)	X	X	X	X	X	X
Bellerophon sp. (5)						
TRILOBITA						
Isotelus sp. (3)						
Proetus (fragments) (3)				X		
Cryptolithus bellulus (2,5)			X			
Triarthrus huguesensis (5)			X			
Ceraurus pleurexanthemus (5)	X	X	X	X	X	X
Flexicalimene sp. (5)						
PELECYPODA						
Cuneamya scapha brevior (3)				X	X	
Ctenodonta borealis (3,4)			X	X	X	
Whitella cf. *obliquata* (3)						X
Byssonichia radiata (1,3)			X	X	X	X
Lyrodesma sp. (3)						
Colpomya faba pusila (3)			X	X		
Modiodesma modiolare var (1,3)						
Cymatonota recta (4)				X	X	X
Modiolopsis anodontoides (1)				X		
Orthodesma pulaskiensis (1,5)				X		
Clidophorus praevolutus (5)				X		
C. planulatus (5)			X	X	X	
Byssonychia hyacinthensis (5)			X			
Cymatonotus pholadis (5)			X	X	X	
INCERTAE SEDIS						
Cornulites sp. (3,4)						

Half a mile downstream, small and poor exposures of sandstone with abundant *Whitella* sp., preserved only as fillings of the interior, occur on the right bank. Still farther downstream, immediately below the mouth of Bois-Clair river, other exposures of shale and sandstone yield no definite information as to the exact age of the beds. However, about a mile below the Bois-Clair river, cliff exposures begin along the right bank and extend for about ¼ mile. They contain the fauna listed in Table 11. locality 4.

Here, also, the evidence favors a position within the *Proetus* zone. No other fossiliferous exposures occur until near the seigneurial mill bridge, 2 miles above Sainte-Emmélie. Here, all the rocks belong to the *Cryptolithus* zone.

The second locality where fossils characteristic of the Chambly Member occur is in a cliff exposure about a mile east of Sainte-Croix along the St. Lawrence. There, for about ½ mile, sandstone beds identical with those along Chêne river abound with fossils, mostly, however, not helpfully diagnostic because poorly preserved. A list of those identified is given in Table 11, locality 1.

Again, the evidence for a Chambly Member age is convincing, and it would appear that, as with the beds under Pont Noir, the number of forms found in the *Cryptolithus* zone indicates that the lower part of the Chambly Member is here represented. The structural implications inherent in the recognition of these Sainte-Croix beds as belonging to a horizon higher than the *Cryptolithus* zone is discussed below under "Structure". In passing, it may be noted that both east and west of these sandstone exposures there are shales with *Cryptolithus*, thereby indicating a synclinal structure along the shore east of Sainte-Croix.

RICHMOND GROUP

Although the Becancour Formation is shown as occurring in the southwest corner of the map-area, no exposures have been seen. Because of the known distribution of the Bécancour and lower formations in adjacent parts of the Bécancour and Lyster map-area, and its recognition in the core of Fortierville Well 1 (No. 51 in S-75), the probability of its presence in the Portneuf map-area is of a high order.

As with the Bécancour Formation, there are no exposures of the Pontgravé Formation here, though its presence as a band within the Chambly-Fortierville syncline is called for by the regional stratigraphic sequence.

Appalachian Formations

SILLERY GROUP

Slates and Sandstones

Scattered irregularly around and between Saint-Apollinaire and Saint-Flavien, there are exposures of purple, red, gray, green, and black slates and shales, together with gray sandstones of various grain sizes. These, on the basis of lithology, presumably belong to the Sillery Group so extensively developed a few miles to the northeast in the Chaudière map-area. No fossils were discovered in these rocks in the Portneuf area, though 10 miles northeast the characteristic Sillery brachiopod, *Botsfordia pretiosa*, is common in black and gray shales. Some good road-cuts were made along Highway 20, in 1943, and were mapped then; most are now covered.

The slate is, in most exposures, red; black and gray colors are next in importance. Very rarely can the original bedding be seen, except at contacts between slate and sandstone.

The Sillery sandstone presents a great variety of expressions. It ranges from black through green and gray to white, and from fine to coarse and even to conglomeratic. Nevertheless, it is everywhere quartzose, and dominantly so in the fine-grained varieties. Mica and some sort of a ferro-magnesian mineral are to be seen in most specimens but feldspar is rare. One mile northeast of Saint-Flavien hill, there is a reddish sandstone made up largely of decomposed feldspar and some quartz. Flakes of slate occur in some fine-grained sandstones but are more common in the coarse-grained rocks. Most of the sandstones consist of quartz grains so closely packed together that there is little room for matrix. None of the sandstone is calcareous. Clear quartz makes up the bulk of the rock, though milky grains occur in places in equal quantities.

The coarser sandstones and fine-grained conglomerates are not common. They can best be seen in parts of an extensive exposure near the four corners a mile south of Marigot. Quartz grains and pebbles up to ½ inch in diameter make up about half of the visible fragments. The rest is composed of pieces of slate, cherty material and, rarely, limestone. This type is essentially the same as that used in the walls of Québec.

One mile west-northwest of Saint-Apollinaire and immediately south of the road, a fine-grained sandstone is in contact with basic intrusives. The sedimentary rock here has been metamorphosed so as to resemble fine-grained marble, though its peculiar appearance may be due in part to weathering.

Along the Bécancour River, from Lyster Station to Bourbon, there are numerous outcrops of massive, medium to coarse-grained Sillery sandstone, which is greenish on a fresh surface. Most of the beds dip strongly toward the south-east. Sillery sandstone beds can also be observed interbedded with black and red slates, north and northeast of Dosquet.

LEVIS GROUP

Hurette Formation

North of Saint-Apollinaire a half-oval area about 2 square miles in extent rises from the general plateau level of 300 feet to a height of more than 400 feet. Within this area the rocks are notably different from the Sillery described above. They consist of gray shales and greenish gray mudstones (for the most part dolomitic, buff-weathering, and sandy) with interbeds of sandstone and black shale. Though these rocks show cleavage, it is not so dominant as in the red and black Sillery shales and slates. Like the latter rocks, these dolomitic rocks dip southeast. On both sides of the road one mile northeast of Hurette, on land belonging to Albert Moreau, loose blocks of limestone conglomerate occur in abundance sufficient to indicate the truth of Mr. Moreau's contention that limestone forms the bedrock at this place. In fact, he stated that his well penetrated 55 feet of pure limestone. Also, 1½ miles north-northeast of this spot there is a small but prominent hillock where limestone was once quarried for lime, but where no exposure can be seen today. Three-quarters of a mile to the northeast, about 1,000 feet beyond the NW -SE road, there is a spot on the southeast slope of the hill where limestone and limestone conglomerate boulders are abundant. The pebbles range up to 2 inches in diameter, and none was observed to be fossiliferous. No actual exposure was seen here.

These three occurrences presumably betray the presence *in situ* of the Hurette Formation, and calcareous shales are likely to be the accompanying rock. A thorough search of these rocks failed to yield any fossils, except the one mentioned below, although Ells, in his Northeast Quarter map (1888), shows the symbol for fossils where these calcareous rocks occur. He does not record what fossils were found, nor the exact locality.

Only one fossil was discovered. On the Moreau property, one piece of limestone has large *Maclurites logani*, which is characteristic of the Corey Formation limestone of the Philipsburg section. This formation is considered to be the equivalent of the upper part of the Lévis Group.

LAURIER GROUP

Bourret Formation

The Bourret Formation of the area is composed of three distinguishable units:

1 - black shales or slates with interbeds of buff-weathered, bituminous, argilaceous limestone; ochre-weathering dolomite and sandstones; and local beds of limestone conglomerate;

2 - black, sooty, green, gray, and brownish red shales or slates and mudstones with interbeds of dense rusty brown and orange dolomite and limestone;

3 - thick sandstone beds interstratified with black shale and breccia.

Rocks of Unit No.1 are best exposed on Bourret brook, about 4 miles northwest of Saint-Apollinaire (Fig. 10), and, from this section, the name of the formation is derived. A detailed description of this section (see Map No. 2 in pocket) was made by M. L'Heureux and J. Tessier, in 1966. It is well exposed also at Issoudun, Laurier-Station, on branches of Huron river about a mile north of Laurier-Station, and on Ormes river. Unit No.2 is best seen on one branch of Bourret brook, about 3 miles northwest of Saint-Apollinaire, and on Bourret brook itself but much farther upstream at about 1½ miles northwest of Saint-Apollinaire. It is also present on the shore of the St. Lawrence near the eastern edge of the map-area. Generally the rocks of the Bourret Formation have been considerably deformed, and particularly those of Unit No. 2.

Rocks of Unit No. 3 are best exposed in the Léon Lambert Quarry, on the southwest flank of a hill 2 miles north of Saint-Apollinaire. It is composed mainly of sandstone in beds up to 6 feet thick (Plate XI-A) with interlayers of sedimentary breccia and of black shale. The sandstone is generally coarse grained, medium gray to greenish buff, and composed largely of quartz with fragments of other rocks, the commonest of which is a green shale. The shale contains Normanskill graptolites, is thinly bedded and black and, in places, carries thin (1 mm.), brown-weathering, white, siliceous beds. Its lower contact indicates a reasonable continuity of deposition with that of the sandstone, but its upper boundaries are usually unconformable. One characteristic of this sandstone which sets it apart from the Sillery sandstone is its calcareous cement. A fine-grained calcareous sandstone is widely distributed over the hill carrying the quarry.

The only fossils recovered from the Bourret Formation are graptolites. A careful examination of the fauna by J. Riva (1967, personal communication) revealed that it contains Appalachian forms, quite different from those of the Lowlands. However, *Climacograptus caudatus* is found in both terrains. Moreover, the lithology and the degree of deformation of the rocks are characteristic of the Appalachian terrain. Therefore, the Bourret Formation most probably is part of Normanskill age terrains of the Appalachian Province.

Table 12 - Bourret Formation Fossils

Bourret Brook (Osborne & Riva, 1966)	1				
Laurier-Station (ditch near highway 20).......		2			
Ormes River (¼ mile from highway 20)			3		
Ormes River (3 miles W. of highway 20)				4	
Lambert Quarry					5
Climacograptus modestus	X				
C. cf. *C. eximius*	X				
C. cf. *C. acharenbergi*	X				
C. sp.	X			X	
C. bicornis		X		X	
C. caudatus			X		
Cryptograptus tricornis	X	X			
Dicellograptus gurleyi	X				
D. sextans var. *exilis*	X				
D. sextans		X			
D. sp.				X	
Dicranograptus sp., cf. *D. rectus*	X				
D. rectus		X			
D. ramosus		X			
D. sp.					X
Glyptograptus euglyphus	X				
Leptograptus flaccidus mut. *trentonensis*	X				
Nemagraptus exilis	X				
Orthograptus calcaratus var. *incisus*	X				
O. calcaratus			X		
Retiograptus geinitzianus	X				
Pseudoclimacograptus modestus		X			
P. parvus					X
P. sp.				X	
Lasiograptus mucronatus		X			

Aubin Formation

The Aubin Formation is composed of hard, green, cherty beds (silicified siltstone or tuff), of different types of well-bedded lithographic limestone, of black calcareous mudstone, of wildflysch and of red mudstone all of Normanskill age. The matrix of these units is, however, of a Canajoharie age. Moreover, we find in this formation few calcarenite and calcareous sandstone blocks of a Canajoharie age. This formation is exposed on the southern St. Lawrence shore at the eastern edge of the map-area (Plate XII-A). It forms a point on which the cherty beds are well exposed.

Plate XI-A - Lambert's quarry, 2 miles NE of Saint-Apollinaire. Normanskill (Bourret Formation, Unit No.3) sandstone, dark shale and breccia.

Plate XI-B - Blocks and bed remnants in Bourret slate. Normanskill contorted unit on Petite Rivière du Chêne 1,000 feet east of Highway 49.

Plate XII-A - Aubin Formation (Unit 3) - Point Aubin on south shore of the St. Lawrence about ½ mile west of the eastern limit of the area.

Plate XII-B - Anticline in Aubin Formation ½ mile west of extreme edge of south shore of St. Lawrence in Portneuf map-area. Looking east.

WILDFLYSCH
(Canajoharie)

At low tide at Aubin Point, is present a rock band of wildflysch type e.g. a band composed of calcareous sandstone and calcarenite blocks in a calcareous mudstone matrix. This band stretches inland toward the southwest.

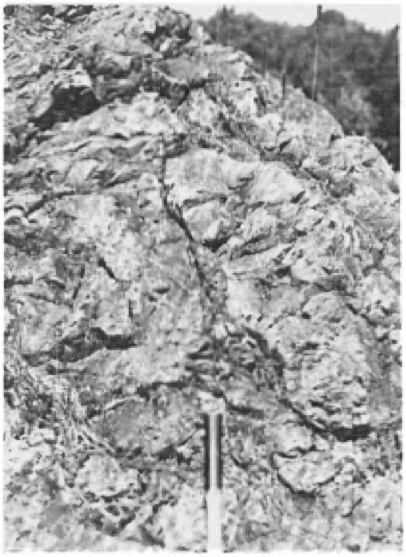
This wildflysch band contains a graptolite fauna which can be correlated with the *Corynoides americana* faunal of New York, of a lower Canajoharie age.

At Aubin Point, these rocks lay aside another wildflysch band of Normanskill age (Aubin Formation) but with a matrix of Canajoharie age.

IGNEOUS ROCKS

In many places in the southeast corner of the map-area, southeast of the Champlain Fault, there are dark, basic, igneous rocks. These are in part extrusive, in part intrusive. They may stand in bold relief, as in the ridge 1 mile north of Saint-Apollinaire, or they may be inconspicious, as in low roadcuts along Highway 20. The best development of these rocks is 3 miles northeast of Saint-Flavien, where an oval hill, a mile more or less long and wide, is thickly strewn with exposures and boulders of a basic rock showing many extrusive characteristics, and which has been explored for copper. None of these igneous rocks is known northwest of the Champlain Fault.

Many of the exposures on the Saint-Flavien hill are obviously of volcanic origin. The southernmost of these occurs behind a schoolhouse at a road corner 2 miles east-northeast of Saint-Flavien. The rock is a dark gray (almost black), amygdaloidal and porphyritic, basaltic type. The phenocrysts are mostly of augite, up to 2 mm. across; the amygdules are of calcite and range up to 8 mm. in diameter. The groundmass consists of finely crystallized black minerals which cannot be differentiated in the hand specimen. On the hill proper a variety of rock types occur. Near the old "mine", there is much quartzose and cherty rock, together with some crystalline limestones. Chalcopyrite and copper carbonate are common on the "mine" dump. A quarter-mile southwest of the "mine", normal types of igneous rocks are exposed. Here the calcite-filled amygdules are so closely spaced as to make up at least one quarter of the surface area of the rock. The rock is too finely crystalline for the identification of minerals without the microscope. It is dark to almost black with, in places, a reddish cast. Effervescence under hydrochloric acid is general throughout. At several places, especially ¼ to ½ mile southwest of the old mine, pillow lava structure is well developed. The rock of the pillows is a finely crystalline, dark greenish gray diabase; ophitic texture is plainly shown on the weathered surfaces. In this type of rock Saint-Flavien Quarry Inc. was in operation (800 tons daily) until November 1967. During



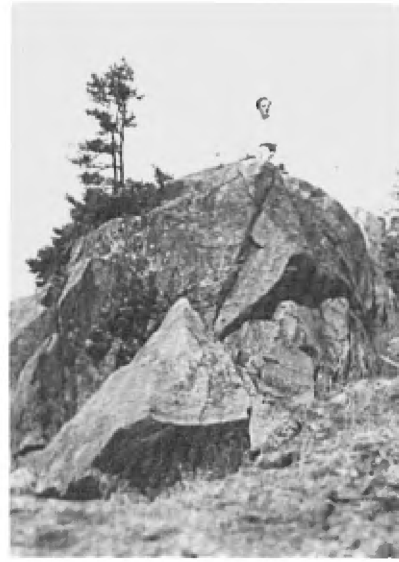


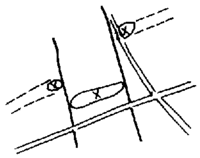
Plate XIII - A - Pillows in diabase (4 miles NE. of Saint-Flavien).

B - Part of the long dike, 1½ miles N. of Saint-Apollinaire Looking SE. Sillery slate on right.

the summer of 1968, all the machinery was dismantled and the quarry closed.

Logan's description of these rocks is worth repeating (1863, pp. 241-242):

> "... at St-Flavien ... red shales occur, underlaid by a band of amygdalodal diorite, ... (which is) between a quarter and half a mile wide, and limestones occur both at the summit and at the base of the band, which in those parts appears to be of a concretionary or conglomerate and brecciated character, being composed, particcularly at the base, of rounded and angular masses of amygdaloidal diorite, varying in diameter from two inches to two feet. Many of these appear to be calcareous, and much of the rock is red. The interstices among the masses are filled with calcspar, which is transversely fibrous toward the walls, and encloses crystallized quartz in the centre. This band is highly cupriferous, and ores of copper occur both in the beds, and in veins or lodes which cut them; the bearing of the veins, however, being with the strike. The ore in the beds is copper pyrites, large masses of which have been met with associated with the limestones at the top. The veins, in addition to copper pyrites, hold the variegated and vitreous sulphurets. In one spot, native copper occurs in small masses in the conglomerate at the base of the diorite, and the whole band has a striking resemblance to some of the rocks of the upper copper bearing series of Lake Superior."

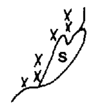


A

Plan of exposures of diorite dike near road intersection one mile NW. of St-Apollinaire, showing dislocation by faults.

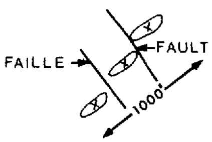
E

Northeasternmost of three knobs of diorite on northern side of Highway No. 20 1½ miles SW. of St-Apollinaire, showing an inclusion of Sillery slate.



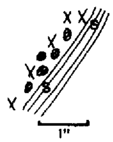
F

Same location as E; slate-diorité contact.



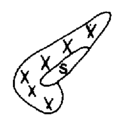
B

Plan of exposures of ridge upheld by diorite dike 30 feet thick.



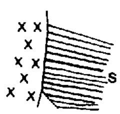
G

Brecciated contact south of Highway No 20, 2 miles SW. of St-Apollinaire.



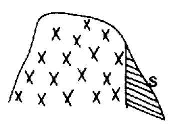
H

Detail of contact in diorite. 1 mile due north of St-Apollinaire.



C

View of contact along east side of dike in B.



D

Another view of contact in B.

I

Intrusive contact on bank of Bourret brook one mile WNW. of St-Apollinaire.

Figure 6- Sketches of St-Flavien igneous rocks, showing their faulting and intrusive contacts.

S = Sillery X : diorite

Elsewhere, the igneous rock appears only as actual or presumed dikes. They are everywhere crystalline and usually ophitic; nowhere are they vesicular or pillowed. In many places they have obviously metamorphosed the adjacent sedimentary rocks, such as can be well seen a mile northwest of Saint-Apollinaire. It is fair to assume, therefore, that these rocks are all intrusive (for details of intrusive contact, see Fig. 6 *c-i*). One of the most interesting exposures is in a long ridge that extends for more than ½ mile southwestward from the border of the map-area about 2 miles north-northeast of Saint-Apollinaire (Fig. 6 *b*). In this ridge the rock is an ophitic diabase, with a grain ranging from almost aphanitic to a facies with crystals nearly ½ inch long. Field identification of plagioclase, hornblende, and augite can be made almost throughout. No sulphides were noticed except for inconspicuous and minute masses of pyrite. Northwest of Saint-Apollinaire there are three exposures of the same sort of rock (Fig. 6 *a*). It is very likely that these are, in fact, parts of the dike that upholds the ridge just described; only one small offset would be demanded to allow this. Another offset would link up the three hillocks of diabase just west of the new boulevard 1½ miles southwest of Saint-Apollinaire. One of the coarsest grained examples of these rocks is in a group of exposures 1½ miles northwest of the Saint-Flavien hill. Here the rock is composed dominantly of augite.

The Saint-Flavien igneous rocks are found close to Sillery rocks or in contact with Normanskill mudstones or slates at Drummondville, Plessisville, southwest of Princeville, southwest of Saint-Agathe, at Saint-Apollinaire, south of Joly, northwest of Bourbon and at Saint-Malachie. Closely identical rocks overlie the Sillery at Acton Vale, probably with an angular unconformity. At Drummondville, volcanics are interbedded with dark slates containing numerous graptolites of Normanskill age (Middle Ordovician). Hence a Middle Ordovician or later age is indicated here.

TECTONIC

Three main structural features dominate rock distribution in the area. First, the Paleozoic-Precambrian contact; second, the northern continuation of the Chambly-Fortierville syncline; and third, the zone of thrusts forming the western boundary of the folded rocks of the Appalachian mountain-built terrane. They will be described under the general headings dealing with the Precambrian-Paleozoic contact, with the faults and with the folds.

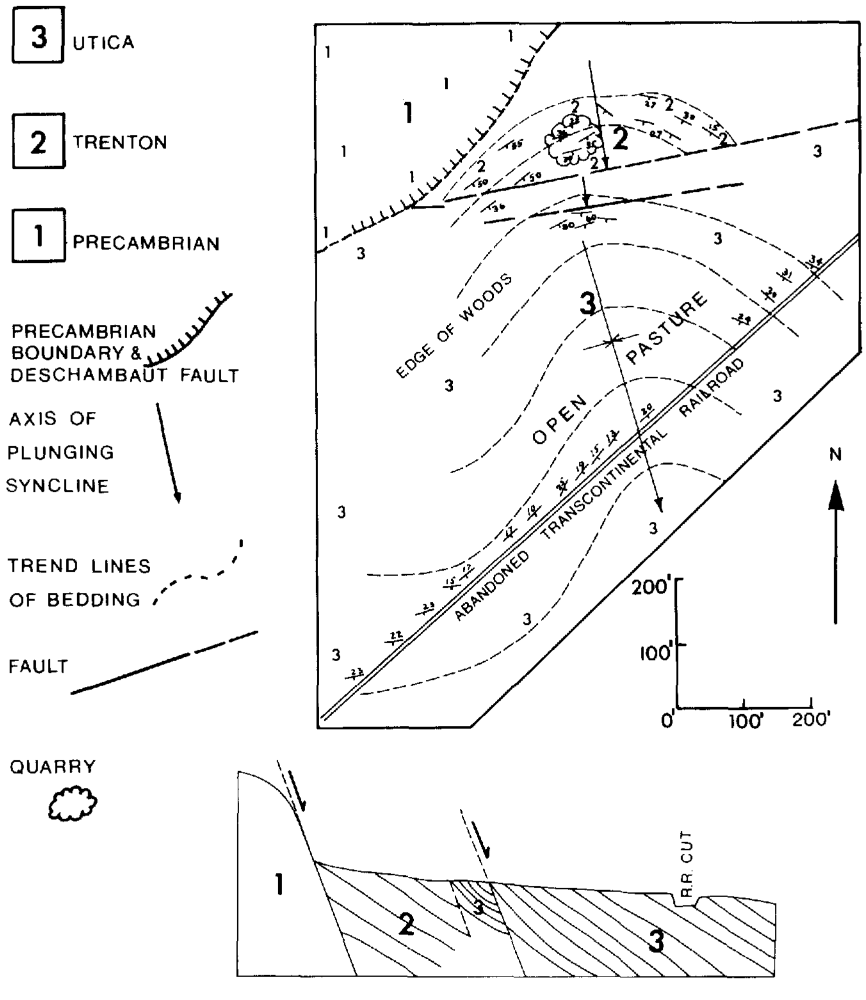
Paleozoic - Precambrian contact

The structural arrangement of the rocks near the northern part of the Portneuf map-area is, on the whole, fairly simple. A series of sedimentary rocks, 900 to 1,000 feet thick, rests unconformably upon the Precambrian basement. They have been deformed by gentle folding, and in one or two very restricted areas by severe crumpling. In addition to their sedimentary contact with the Precambrian, they have been faulted down against the older rocks along two major breaks, involving displacements of several hundred feet. In a few places the sedimentaries have been faulted within themselves, independently of the Precambrian basement, at least as far as surface indications are concerned Figure 7 is a typical example.

Although these two groups of rocks are presumably in sedimentary contact northwest of both the Deschambault and the Neuville faults, only in the latter case do exposures indicate it. North of Deschambault there is a broad area of Precambrian flanked on the southwest by nearly flat Lower Trenton beds. Presumably these Trenton strata lie upon the Precambrian but the closest the two series come is 2,500 feet (Deschambault-Station). Moreover, the distributional pattern of the exposures in this region indicates only in a most general way the direction of the contact. The relationship is clearer in the fields northeast of the old Neuville station and northwest of the Neuville fault. There, the proximity and distribution of Precambrian and Lower Trenton outcrops, the latter essentially flat, show that the contact runs northwesterly from near the railroad track. Nowhere, however, can the actual contact be seen. Within the largest exposure of the Deschambault limestone in this locality there is a small boss of Precambrian, which indicates that the old Precambrian, surface was at least somewhat irregular. This is the only Precambrian outlier so far found in this map-area.

From a regional point of view, the sedimentary contact between Precambrian and Paleozoic rocks should be more or less parallel to the St. Lawrence. However, it is approximately at right angles to the expected trend. A rough survey of the southern part of the Saint-Raymond map-area showed that the contact toward the west is arcuate and curves around into the valley of Jacques-Cartier river, returning to a more or less normal direction on the western side of that river. The same relationships probably exist along the course of Sainte-Anne river in the Grondines map-area, and in the area to the north. These irregularities in the course of the contact may be a reflection of an irregular topography at the beginning of Trenton time. Not until these basal irregularities, with a relief of a few tens to possibly 200 feet, had been eliminated, by filling up of low areas so that an even sea floor resulted, could the beds become more nearly horizontal and continuous. This theory has interesting physiographic implications. One logical conclusion would be that both Jacques-Cartier and Sainte-Anne rivers are located upon initial embayments in the old, early Trenton shore line. However, it is more probable that the pre-Trenton surface was approximately flat, sloping southeastward slightly, but that the Deschambault and Neuville faults tilted this surface so that it sloped slightly down to the southwest.

FIGURE 7



PLAN AND SECTION OF THE ROCKS EXPOSED ONE MILE DUE WEST OF PORTNEUF STATION. THE PRECAMBRIAN ESCARPMENT HERE IS STEEP AND HIGH. THE DIPS OF THE UTICA SHALE SHOULD HAVE BEEN SHOWN TO DECREASE TOWARDS THE SOUTH. THE SECTION IS TAKEN APPROXIMATELY ALONG THE SYNCLINAL AXIS.

Figure 7 - PRECAMBRIAN - PALEOZOIC CONTACT

Faults

Normal Faults

The two most prominent normal faults (the Deschambault and the Neuville) are north of the St. Lawrence. They are essentially similar in attitude and development and both trend more or less northeast-southwest. Along both, the southeast side dropped down several hundred feet, and both have about the same dip. Several minor dislocation also are present, most of which are described below.

The Deschambault Fault

This fault is recognized by much the same evidences as characterize the Neuville fault. Beginning a little more than 2 miles west of Saint-Basile railway station, and extending irregularly southwestward, this fault can be traced by the juxtaposition of Precambrian, Trenton and/or Utica in situations which rule out sedimentary contacts. For the first 5 miles southwest from the northern border of the map-area, only Trenton limestone is observed in near contact with the Precambrian. Thence to near Belle Isle river, only Utica shale occurs on the downthrown side, with the exception of the limestone at Deschambault-Station. As with the Neuville fault, to the north the Utica shale is in contact with the Precambrian, whereas farther south, from Deschambault-Station to Belle Isle river, it is in contact with Trenton beds.

Near the northern border of the map-area, the trace of the fault can be closely approximated where exposures of Precambrian and Trenton limestone are separated by not more than 200 feet. The Trenton limestone there strikes 65 degrees and dips 27 degrees south, both measurements being abnormal. No more exposures of Ordovician rocks occur for 3½ miles toward the southeast, and the contact is assumed, arbitrarily, to follow the base of the Precambrian highland, and, more specifically, to lie parallel to, and just to the northwest of, the abandoned Transcontinental Railway track.

At Deschambault-Station, fairly strongly tilted Trenton limestone has been actively quarried for the production of lime in the past, and, though Laverdière (1935) showed this outcrop to be a tongue of undisturbed Trenton, it is much more likely to belong to the downfaulted mass. Its attitude favors this hypothesis as does its much greater resemblance to sedimentary types of the Neuville Formation than to those of the Deschambault Formation. In two places along the tracks, Precambrian rocks occur within a few hundred feet. To the east of the cross roads, Utica shale is common in the fields and the streams. The discordances between the attitude of the Utica shale, of the Trenton limestone, and of the direction of the Precambrian-Paleozoic boundary can only be explained by presupposing the existence of a fault zone affecting all three rocks.

Southwestward from Deschambault-Station, the fault follows a course of about N.40°E., passing along the base of a low hill composed of Trenton limestone and finally crossing Belle Isle river, after which all trace of it is lost. Laverdière showed the exact trace of the fault at the mill where the river crosses the road running northwestward to Saint-Julien. Along the base of the hill just referred to, the Trenton limestone stands up in relief against the Utica shale precisely as it does along the Neuville shore. The limestone escarpment dips 60 to 65 degrees, and in several places a breccia of limestone fragments, up to 2 to 3 feet thick, is plastered to the face of the escarpment (Fig. 8). Though the Trenton limestone rarely dips as much as 20 degrees, and commonly ranges between horizontal and 10 degrees, the Utica shale in the fields and drainage ditches to the southeast dips from horizontal to vertical. In strike, both limestone and shale agree with the strike of the fault.

This fault is not known beyond Belle Isle river. No evidence of it can be seen on the south shore of the St. Lawrence where, in the Grondines area, there are no exposures. Because the Utica shale is in places faulted against the Precambrian, the displacement must be at least 524 feet (the thickness of the Trenton). This figure is a minimum, but it is not possible along this fault to be as definite as it is along the Neuville fault. In all probability the two faults are comparable in amount of displacement.

At Portneuf-Station (Fig. 7), the railroad runs through a long cut of Utica shale, with Trenton limestone occupying part of the territory between the track and the steep Precambrian escarpment to the northwest. The limestone here had at one time been quarried in part at least for lime, the remains of small lime kilns being still visible. Apparently, only Trenton limestone lies against the Precambrian. It is possible that beyond, and to the southwest of, these exposures the Utica shale is in contact with the gneiss. The Utica occurs not only in the cut, but also in the fields and woods to the northwest, and its contact with the Trenton must be a fault, - this is shown by the lack of harmony between the attitudes of the two sedimentary series, because the fossils of the Trenton point to a Neuville age, and because of the lack of the lower beds of the typical Utica development. Thus, it is probably the high degree of susceptibility to weathering which prevents the Utica from being exposed where it would normally come into contact with the Precambrian immediately southwest of these exposures. The lack of sedimentary rock exposures for more than 3 miles to the northeast is possibly due to the presence, under the overburden, of Utica shale.

The Portneuf-Station Fault

Some 2 miles due west of Portneuf are the sites of Wells 15 and 16 (Fig. 3, S-75, Part II). As the Trenton-Utica boundary lies ½ mile northwest of the sites, the wells should normally have started in Utica shale. Instead, the logs of these wells show Lower Lorraine shale down to

392 and 400 feet, respectively. Because there is no appropriate dislocation of the Utica-Trenton boundary or of the Deschambault fault, the situation calls for a strike fault between the well sites and the nearest Utica outcrop. Such a fault, continued northeastward, would pass through Portneuf-Station, from which it takes its name. The vertical movement is in the same sense as along the Deschambault fault, and involves 400 feet of Lorraine and some 200 feet of Utica. Thus, 600 feet is a reasonable displacement figure.

It is, of course, probable that the Portneuf-Station fault is closely related to the Deschambault fault, and may be a branch of the latter. If so, then the total movement along this fault zone can be measured directly from the dislocation of the Precambrian surface. This lies 1,360 feet below the surface (el. 128') at the well site, and 225 feet above sealevel northwest of the Deschambalut fault, which gives a net differential of 1,457 feet. To this must be added an unknown vertical thickness of Precambrian rock stripped by erosion off the present exposures. If we allow about 50 feet as a minimum thickness so eroded the movement comes to about 1,500 feet.

On the aeromagnetic map, these normal faults, in which the northwest side has moved up in relation to the southeast side, are easily detected. The Precambrian basement, being closer to the surface on the northwest side of these faults, produces magnetic anomalies which are readily seen on the map.

Jacques-Cartier River Power-house Fault

This fault has already been alluded to (p. 23). It crosses the river at a very narrow spot, and can be seen well on both sides (fig.9, plate XIV). It strikes N.55°E. and dips 65 degrees SE. All of the Saint-Casimir and most of the Grondines members of the Neuville Formation are eliminated by this fault, which therefore represents a movement of at least 400 feet, and probably not much more. Its extension on either side of the river cannot be determined. It is, in reality, a pair of faults, the more northerly being responsible for marked drags in the adjacent rocks, whereas the more southerly (at least on the east side of the river) is marked by a brecciated zone more than 1 foot thick.

Three miles due north of Donnacona, Utica shales exposed in the abandoned Transcontinental Railway track strike about N.30°E. and dip 25°SE. Less than ¼ mile away, Trenton limestone exposed in track gutters and in adjacent fields strike similarly, but dip only 2 degrees. This relationship suggests a fault, but is not proof of one. However, about 2 miles along the strike of the beds to the south-southwest, where a small stream plunges to Jacques-Cartier river, the Utica shales have the abnormally high dip of 20 degrees. Positive evidence of faulting can be seen in the cliffs bordering the river. It is reasonable to assume that the two localities were affected by the same fault.

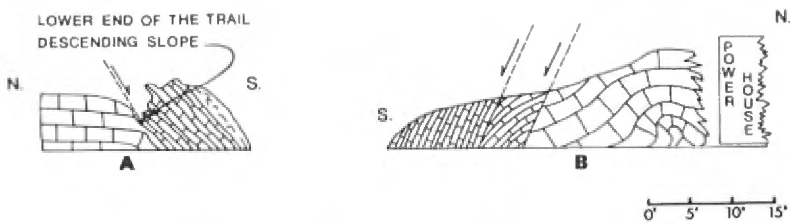


Figure 8 - DIAGRAMMATIC VIEWS LOOKING RESPECTIVELY EAST AND WEST ACROSS THE JACQUES-CARTIER RIVER AT POWER HOUSE BELOW HORSESHOE BEND A MILE SOUTH OF NORTHERN BORDER OF THE PORTNEUF MAP-AREA. THERE IS NO SIGNIFICANCE TO THE TWO PATTERNS OF LIMESTONE, - BOTH BELONG THE DESCHAMBAULT FORMATION.

Plate XIV - Fault in Grondines limestone opposite power-house on Jacques-Cartier river.

The Neuville Fault

From the point where Roches river enters the map-area near its northeast corner, this fault extends southward (S.20°W.) for about 2 miles before changing to a southwest course (S.40°W.) and holding that direction until it enters the St. Lawrence. Throughout this length, movement along the fault has brought together rocks of different formations. For the first 1½ miles Precambrian rocks lie to the northwest of the break and Utica shales to the southeast. Within a hundred feet or so of the fault, the Utica beds commonly dip 55 to 65 degrees to the southeast. For the next 1½ miles there are no exposures on the southeast side, but for the last mile or so Trenton limestone occupies the western side and Utica shale the eastern.

Because the refusal of most investigators of this region to recognize the faulted nature of the contact between these different formations, it may not be amiss to quote Logan's description of the occurrence. On pages 155 and 156 of his *Geology of Canada* he records his observations as follows:

> "A great development of limestone occurs at Pointe aux Trembles (modern Neuville). The fossils ... show the rock to belong to the Trenton formation, ...(which here) folds over the Pointe aux Trembles * anticlinal. ..
>
> "On the south-east side of the anticlinal, the dip is more precipitous than on the north-west, and the strata on that side are broken and let down by a fault. The position and course of this dislocation are plainly seen on the beach at and near a spring ..., where strata of the Utica formation are brought against those of the Trenton without any of that interstratification of calcareous and argillaceous layers which indicates the passage from the one to the other. The course of this dislocation, in its continuation, strikes the south-east side of the Bonhomme Mountain; and near the line of division between Pointe aux Trembles and St-Augustin, the Trenton formation is wanting, and the Utica shales come in contact with the gneiss. ... A considerable distance farther on (beyond the Portneuf map-area), a narrow strip of Trenton limestone becomes interposed between the shales and the gneiss both rocks being tilted up to a high angle as they approach the gneiss."

It is difficult to understand why the concept of an anticline, which Logan mentioned but did not describe, has persisted, whereas the concept of a fault, so clearly revealed by Logan, did not germinate.

* Now Neuville.

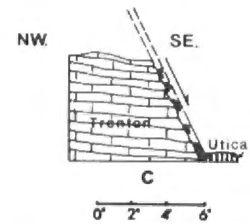
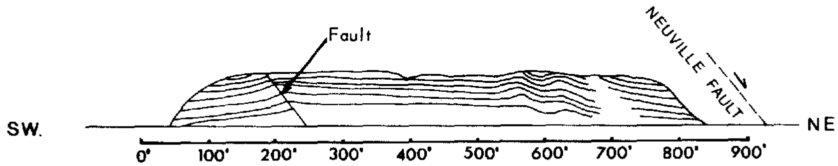


Figure 9 -

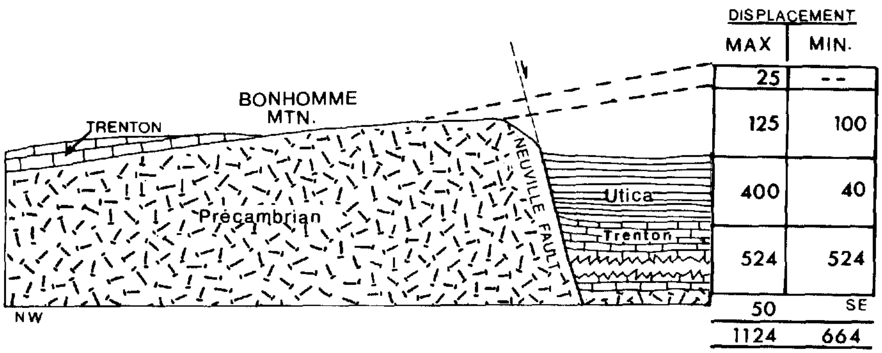
Diagram showing relationships along Neuville fault 1.5 miles due west of Neuville village.

Plate XV - Neuville fault, striking about N.40°E., separating Trenton limestone and Utica shale on Trenton shore.

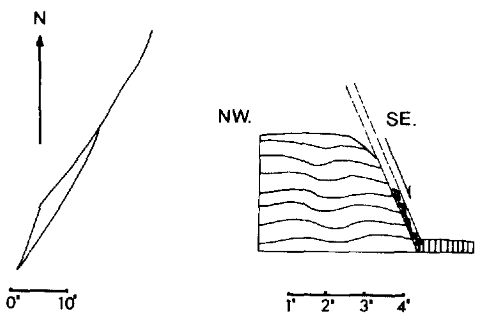
Nowhere along the northern part of the Neuville fault is the actual contact between the Utica and the Precambrian visible. However, gaps of not more than 30 feet, together with the steep dip of the shale, rule out the possibility that the contact might be a normal sedimentary one. Farther south, along the shore of the St. Lawrence, Utica shale and Trenton limestone are in actual contact, and this relationship can be followed, more or less continuously, for 1,000 feet along the beach at low tide (Fig. 10C). There the Trenton limestone forms a low escarpment, 2 to 6 feet high, which dips to the southeast at angles of 60 to 65 degrees (Plate XV). Intensely contorted Utica shale occupies the beach flat, and nowhere stands up in relief. The buff-weathering bands lie brecciated and disrupted within the shale mass in such confusion that it is not possible to reconstruct their original distribution. The Trenton limestone is also much disturbed along the fault, but less so than the shale. For 200 feet or so northwest of the fault the limestone is thrown into a series of folds, with minor dislocations, that make building a continuous section impossible (Figs. 10-A, 10-B). Not until a point along the beach is reached some 100 feet west of where the fault passes is it possible to treat the limestone as a stratigraphic succession. This is where the Neuville Shore section recorded on Table 8, P. 33. One of the most interesting details observed along this fault is a smear of brecciated limestone over the face of the fault in some places (Fig. 9). The blocks are of all sizes up to a foot across. This brecciated zone is rarely more than 2 feet thick, and usually less than a foot.



A- Section of Trenton limestone along C.N.R. track, 1½ mile N E of Neuville wharf showing faults and undulations.



B- To illustrate how maximum and minimum vertical displacement along the Neuville fault can be estimated. Length of section about 3 miles.



C- Plan of details of Neuville fault on beach 1,500 feet NE. of Neuville wharf. For each component fault the movement of limestone was the same - East side down

Section across Neuville fault. Same location as A. The fault breccia is rarely more than a few inches thick. Note the undulating Trenton limestone and the vertical Utica shale.

Figure 10 – Sketches of Neuville fault.

No identification of any horizontal component in the movement was seen. There are no slickensides, and, of course, no laterally disrupted beds. Hence, it has been assumed that the displacement was vertical, or nearly so. A measure of the amount is difficult to determine accurately (Fig. 10B). Along the northern part, the Utica has been dropped down to lie alongside the Precambrian, and the elimination here of the Trenton alone indicates a movement of 524 feet. This is a minimum, and could be increased if we knew the horizon within the Utica which has been brought against the Precambrian, and if we knew how much of the Precambrian has been removed by erosion. As for the first modification, nowhere along the fault do we find any evidence of the lower 40 feet of the Utica which, because of its abundance of fossils, can be easily recognized. This raises the minimum to 564 feet. As for the erosion of the Precambrian, we can attack that problem as follows:- If we assume that before faulting the beds were essentially horizontal, and reasonably widely distributed, then the base of the Trenton would have covered the lower part of Bonhomme mountain (the spur of Precambrian). From the present sedimentary contact northeastward the present Precambrian surface has a dip of 2 degrees, which is only slightly less than the dip of the Trenton limestones. Probably, therefore, the basal Trenton limestones rested on the top of the Precambrian spur, which has an elevation of 450 feet today. The Utica shale is found at elevation of 350 to 325 feet. Hence, we must add another 100 to 125 feet to our minimum estimate, which now becomes 664 feet. If we adopt the maximum figures, the movement becomes the sum of 524, 125, and 400 feet (maximum thickness of Utica), i.e. 1,049 feet.

Neither of these estimates takes account of possible erosion of the Precambrian surface upon which the Trenton limestone may have rested. Now at 450 feet, there may have been an additional 25 feet of Precambrian there, before erosion was able to attack the Precambrian consequent upon the removal of the Trenton; nor have we taken into account the effect of the highly inclined Utica beds along the fault itself. Actually, the drag along the fault has resulted in the observed Utica today being at a higher elevation than is the horizontal Utica a few hundred feet away. The correction might be 10 to 50 feet. If we use these figures, the minimum becomes 664 feet and the maximum 1,124 feet.

Logan plotted the course of this fault to the northeast. The continuation in that direction, however, lies outside the limits of this area. Southwestward, it enters the St. Lawrence river, and no trace of it is found until at a point on the south shore opposite Donnacona where Lower Lorraine shales dipping steeply south-southeast are followed along the shore to the northwest by Utica shales with low dips, for the most part to the southwest. Its continuation toward the west must pass between Turenne and the site of Well 72 (see map and S-75, Part II). The log of this well, disregarding 6 feet of overburden, starts in Lower Lorraine shale and continues in that formation for 884 feet (see log, Appendix). Without the evidence from the log of this well the site would be considered to lie on the southeastern limb of the Cap-Santé anticline, and hence should show Utica shale at the surface. Still farther to the southwest, the only evidence of this fault is in the abnormally high dip of the Lower Lorraine shale farthest upstream along Chêne river. This high dip is taken to be a reflection of drag along the fault. The minimum amount of movement near the site of Well 72 is 884 feet. Rough calculations indicate that probably little more than 100 feet of Utica would be found immediately northwest of the fault, so that it is in order to consider that the movement here is about 1,000 feet, a figure in harmony with the calculated movement near Neuville.

The Sainte-Emmélie Fault

The positioning of this fault, like that of the southwestern part of the Neuville fault, is based on the anomalous presence of Upper and Middle Lorraine strata in Well 69 (S-75, Part II). The site of this well would normally have been considered the southwestern continuation of the Lower Lorraine rocks on the northwest limb of the Cap-Santé anticline. Scarcely a mile intervenes in the direction of plunge between the outcrops of Lower Lorraine along Chêne river (el. approx. 50 feet) and the site of the well (el. 168 feet). Through this distance about 250 feet of Lower Lorraine beds would normally be distributed, so that the top of the Lower Lorraine or possibly the basal beds of the Middle Lorraine should occur 118 feet below the well site. Instead, the Lower - Middle Lorraine boundary comes in 830 feet below the surface at the well site, and so a movement of 712 feet is indicated. The aeromagnetic map of this region shows a northwest-southeast trend of crowded isogams which is taken as the basis for the direction of this fault as shown on the map. The extensions of this fault beyond the limits of the Portneuf area are unknown. This is the only known major fault in this area, the strike of which does not conform in general with that of the Neuville fault.

The Champlain Thrust

The Champlain Thrust is the third great structural control in this area (the second is reviewed later in this report). Whether a single fault (as is widely conceived) or a complex fault (as we interpret it), its general effect in the Province of Québec has been to bring Cambrian and Lower Ordovician Appalachian rocks against and over Upper (or Middle and Upper) Ordovician Lowlands rocks.

This thrust was first postulated by Logan (1863) to explain the abnormal relations between the Appalachian and Lowlands rocks. He described the fault as follows (pp. 233-234), illustrating his idea with a diagram (cross-section, Montmorency to Orleans island) which needs little improvement to day: "... an overturn anticlinal fold, with a crack and great dislocation running along its summit, by which the group is made to overlap the Hudson River formation ... The dislocation ... comes upon the boundary of the province, in the neighborhood of Lake Champlain. From this, it proceeds in a gently curving line to Québec ...". And, on page 241, he wrote: "... the dislocation reaches the opposite side of the river, a little above St. Nicolas church; and here the red and green shales, ... underlying the Sillery sandstones, constitute the strata which lean against the Hudson River beds."

Ells (1889, p. 15K) wrote: "On the south side of the St. Lawrence, two miles above the wharf at St-Nicolas, ...the contact between the gray, sandy shales and sandstones of the Lorraine and the red, green and black shales of the Sillery formation is well seen both on the beach and in the cliff. The beds along the line of fault for several yards are much crushed, but the general dip of the two series is 65^{o}-90^{o}.". And, on page 17K, he wrote: "From the fault above St. Nicolas the line of contact there described between the Lorraine and Sillery formations extends apparently in a direct line, as indicated on the geological map, 1866, to the Becancour River, where it is seen about fourteen miles above the mouth". This distance given by Ells should be doubled.

Raymond (1913) showed in detail the course of part of this fault, and later Parks (1929) gave further details. However, there was very little information regarding the precise trace of the fault along its supposed course through Québec until the recent work of the Québec Department of Natural Resources. Its intersections with the St. Lawrence shores shortly above Québec City are well known. Thence, southwestward, its position in the Portneuf map-area can be placed between Normanskill on the east and Utica-Lorraine on the west. Thus, starting from the rear of Québec City the Thrust goes southwesterly to the north shore of the St. Lawrence at Cap-Rouge, where it can be well seen at low tide. Crossing the river, it comes upon the south shore 2½ miles west of Saint-Nicolas church and enters the Portneuf map-area 1½ miles south of Hydrographic Station 38. Thence, it follows a curving line, concave to the southeast, as far as the second road intersection southeast of Les Fonds. From here it presumably goes southwestward, passing ½ mile east of Laurier. Throughout this 14 miles stretch in the Portneuf map-area, there are no exposures along its course, which in the southern part may be as much as ½ mile out in either direction as traced on the map. In the Chaudière map-area, it dips to the southeast at a low angle.

In the Portneuf map-area, the Champlain Thrust cannot be referred to as a single fault as is usually done. Rather, it is a series of thrust faults which have brought a band of allochthonous rocks in contact with those of the Lowlands. This allochthonous band is composed of several slices which contain Sillery, Lévis, Bourret, Aubin and Utica-Lorraine types of rocks.

In the Saint-Nicolas map-area to the east, a series of thrust sheets or slices is also present, and the rule here is "the older the slice the younger its rocks". Here we find Lower Cambrian (Sillery Group) rocks resting on Lower (Lévis-Lauzon Group), Middle and even Upper

Ordovician (Utica-Lorraine Groups) rocks; Lower Ordovician rocks resting on Middle and Upper Ordovician; and Middle Ordovician rocks resting on Upper Ordovician rocks of the Utica-Lorraine type which cover the northeastern part of the Chambly-Fortierville syncline. In the Portneuf area, the same principle can be applied since we have Lower Cambrian (Sillery Group) rocks resting on Lower (Lévis Group), and Middle (Normanskill Group) Ordovician rocks; Lower Ordovician rocks (Lévis Group) resting on Middle Ordovician (Normanskill Group) and Upper Ordovician (Utica-Lorraine Groups) rock. There is also the Saint-Augustin slice (containing Utica-Lorraine complexly folded) which rests on the northeastern flank of the Chambly-Fortierville syncline.

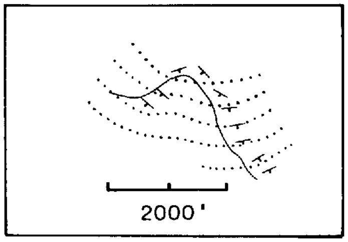
Poorly preserved graptolites found in the Lorraine unit of this slice are similar to the graptolites of the Canojoharie shale (Riva, 1969, personal communication). This will be further investigated when better preserved graptolites are available.

Folds

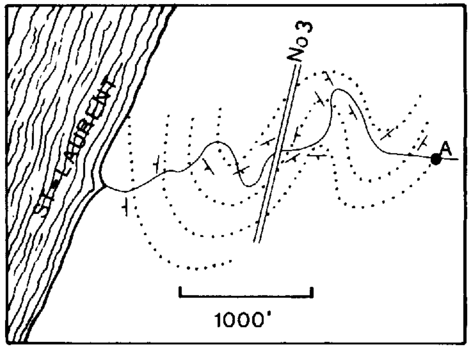
The general trend of the beds in the area suggest a large open fold plunging southwest. This major fold is the northern extension of the Chambly-Fortierville syncline. It is accompanied to the east and to the west, by a series of smaller anticlines and synclines whose axes are more or less parallel to its axis. The most important of these secondary structures is the Cap-Santé anticline (extension of the Leclercville anticline). There are also some isoclinal folds that were formed when thrust faulting took place to the east.

Chambly-Fortierville Syncline

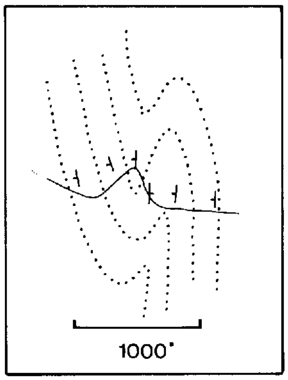
In the northeastern corner of the Bécancour map-area (Fig.1), outcrop of the Bécancour Formation almost pinches out. It is probable that some of the Bécancour actually crosses into the Portneuf map-area. Evidence of this is provided by the log of a deep well drilled within the Lyster map-area (Fortierville No. 1, Q.D.N.R., S-75, Part II, p. 51, 1964), in which Bécancour beds were cut down to 180 feet below the surface. Direct evidence of the synclinal structure in the Portneuf map-area is given by the distribution of beds of the Middle Lorraine (Chambly Member) in relation to the distribution of the underlying Breault Member; this distribution indicates that the beds concerned form part of the northeastern end of a southwesterly plunging syncline. There is, however, one peculiar development. The easternmost exposure of Chambly Member beds on Chêne river agrees with the rest perfectly in its lithology and its fauna, but it dips northeast. Although other interpretations are possible, we consider this as a result either of a minor axial wrinkle within the main fold, or drag along a northeast-southwest fault with a downdrop to the northwest. No such faults are known in this area, but they do occur farther southwest, especially near Montréal. The synclinal axis cuts the shore of the St. Lawrence close to Sainte-Croix. Thick sandstones of the Chambly Member are found in the cliffs, dipping southwest and flanked on both sides by *Cryptolithus*-bearing strata of the Breault Member.



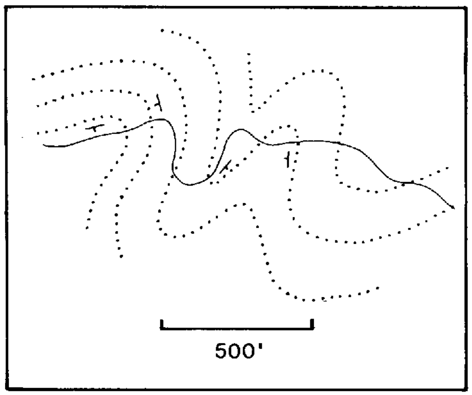
A–Stream at La Ferme highway No3
(see bloc A on the map)



B–Lower part of the stream entering the St-Laurent
north of La Ferme (see bloc B on the map)



C–Same stream as in B
but 1-1/2 miles above
(see bloc C on the map)



D–Upstream of point A in figure B
(see bloc D on the map)

FIGURE 11– GENTLEFOLDS IN THE LOTBINIERE SHALE (Utica)

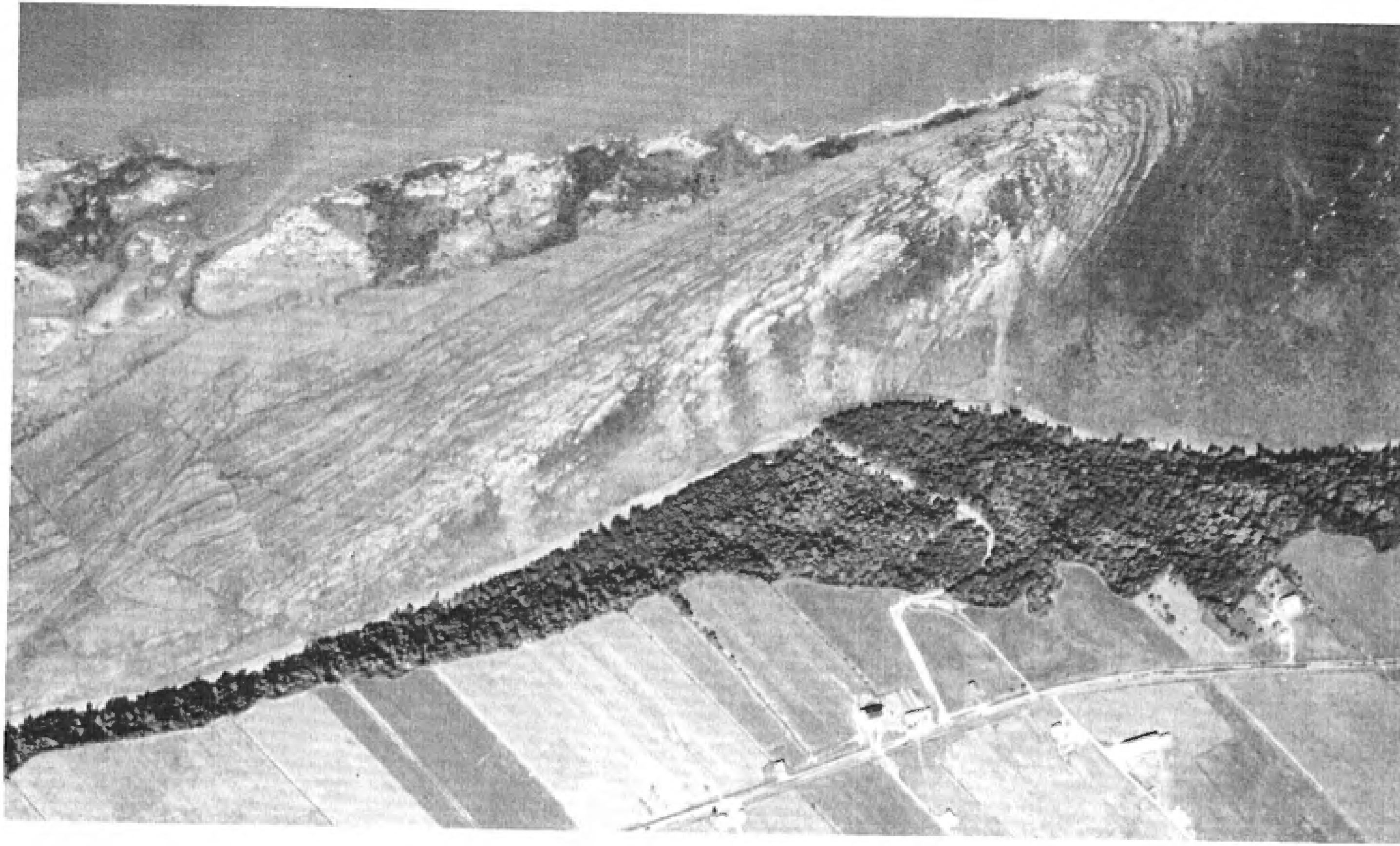


Plate XVI - South shore of the St. Lawrence at Sainte-Croix-Est, showing the nose of the Chambly-Fortierville syncline.

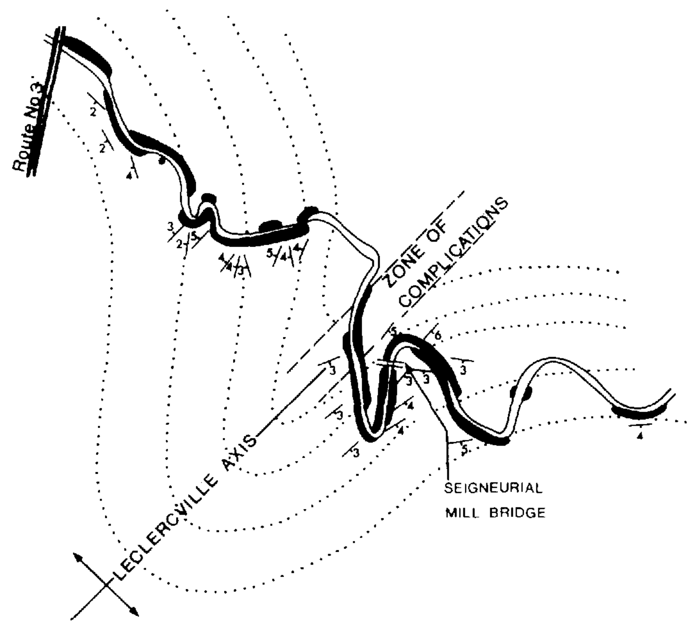


Figure 12 Map of lower part of Chêne river from mouth to point 2 ½ miles (straight line) upstream. Shows the gentle undulations indicative of the Leclerville axis.

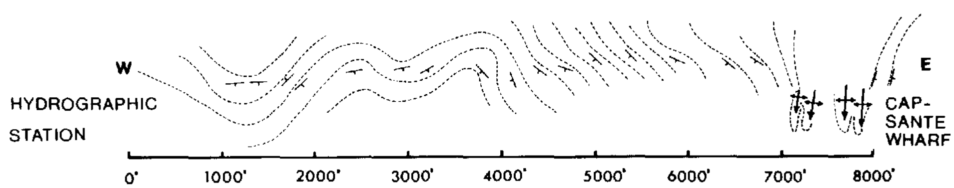


FIGURE 13–SKETCH SHOWING ATTITUDES AND PRESUMED TREND LINES OF UTICA SHALE AS EXPOSED ALONG THE NORTH OF THE ST. LAURENCE WEST OF CAP - SANTE WHARF NOTE THAT ALL PLUNGES ARE IN THE SAME DIRECTION. THERE IS ONE ANOMALOUS DIP NEAR WESTERN END OF SECTION.

At the eastern limit of the map-area, the northeastern continuation of the Chambly-Fortierville syncline can be seen near Roches river, east of Neuville. The attitudes of the Lorraine beds show the presence of a syncline whose axis crosses Roches river in a northeasterly direction at the point where this river intersects Highway 2.

Cap-Santé Anticline and other secondary folds

Plotting of the attitudes of the beds exposed along the streams flowing into the St. Lawrence northeast of Lotbinière (Fig. 11) show that a few subsidiary wrinkles complicate this western limb of the main fold. The most important of these is the Cap-Santé anticline, whose axis can be traced to the east of Cap-Santé and on Chêne River (Fig.12) near Leclercville. This anticline is the northern extension of the Leclercville anticline.

The effects of the Cap-Santé anticline can well be observed along the north shore of the St. Lawrence. The rocks involved in this folding are the Utica shales immediately west of the Cap-Santé wharf; these shales have abnormal dips reaching up to 10^{o}, and the folds (Fig. 13 and plate XVII) are accompanied by very small visible faults. This tectonic is also found on the east side of the wharf but more pronounced, especially near the axis of the anticline where folding is more intense. The dips get higher as we get closer to the west side of the Jacques-Cartier river. To east of the same river, the dips are low but the shales have yielded to pressure which resulted in numerous normal faults accompanied by drag folds. This tendency to fracture on the flanks of open folds (Plate XVIII) is not a favorable indication of the ability of the rock to retain oil or gas.

Plate XVII - At Cap-Santé, west of wharf. Anticline and syncline in Utica beds.

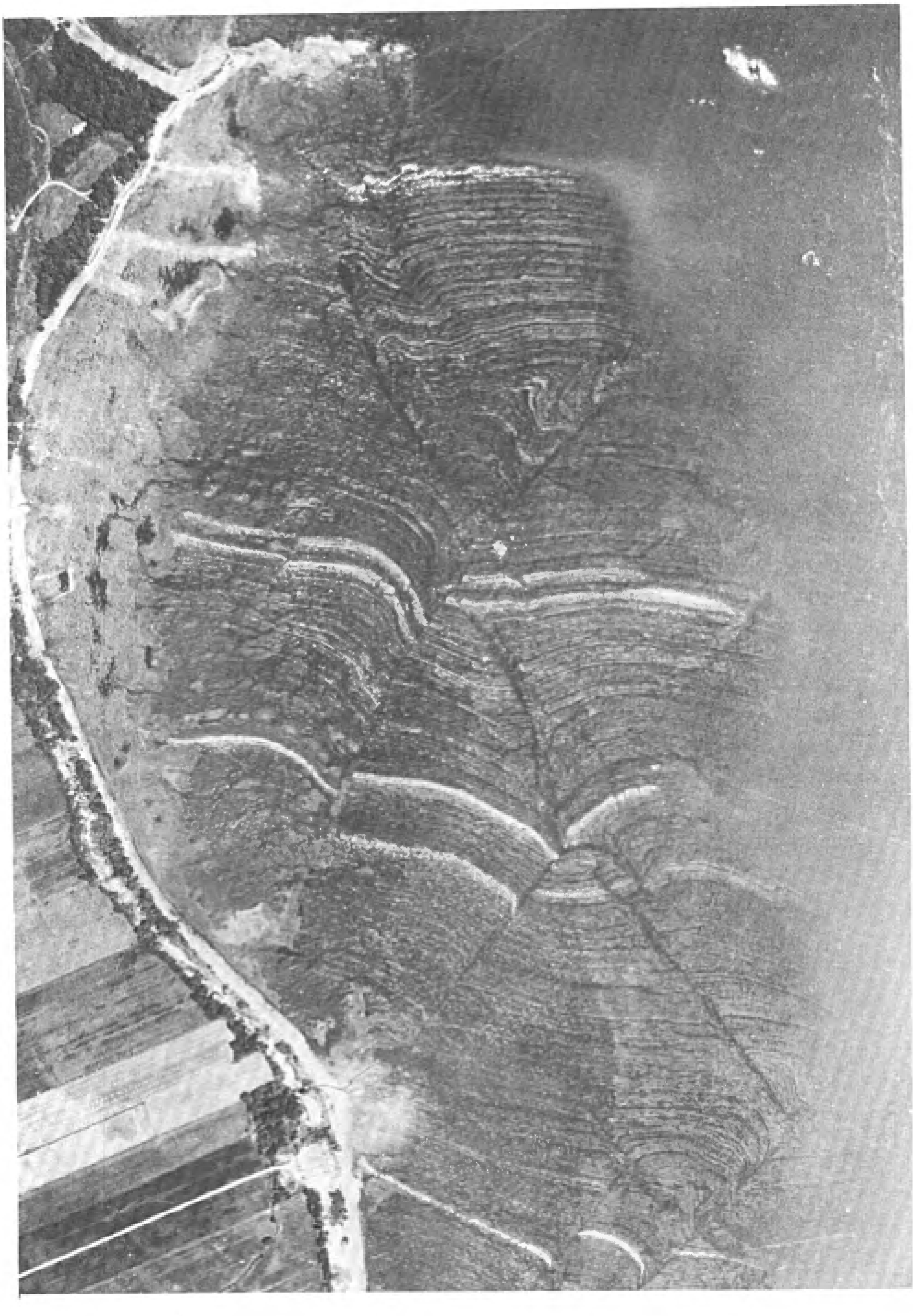


Plate XVIII - North shore of the St. Lawrence, halfway between Les Ecureuils and Neuville, illustrating the conjugate fault system in Utica shale (dark) with interbeds of limestone (light bands)

Isoclinal folds

As the Appalachian frontal series of thrusts is approached, the beds become more and more intensely folded. In general, it may be said that, more than 6 miles from Thrust III, the dips of the Lorraine beds are almost invariably less than 10 degrees, whereas within $1\frac{1}{2}$ miles of this thrust the dips are almost invariably more than 10 degrees; also between Thrust III and Thrust II, isoclinal structures are the rule. Illustrations of a few such structures are given in Fig. 14.

Observations along the south shore of the St. Lawrence from the eastern border of the area westward for about a mile reveal a complex of rocks in which there is an alternation of Canajoharie, Normanskill, Lorraine and Utica. The lithologic observations made here are as follows:

0 feet - St. Lawrence shore at eastern edge of Portneuf map-area. Proceeding upstream.

600 " - *Canajoharie*. Black, bituminous, fissile shales, with grapto lites; scattered small exposures from 0 to 600 feet.

1030 " - *Canajoharie*. Heavy-bedded sandstone and conglomerate (pebbles up to 2").

1145 " - *Canajoharie*. 2-foot sandstone bed, widening eastward to 6 feet of conglomerate, similar to that at 1,030 feet. Pebbles up to 3 inches, well rounded.

1180 " - *Aubin Formation*. Brecciated dark gray beds with hard, green, cherty layers.

1800 " - *Aubin Formation*. Hard flinty shales, bluish gray with greenish and brownish beds, forming point near Hydrographic Station 37. No fossils seen. Rarely break along stratification. Small but well-marked anticline at 1,700 feet. Considerable crumpling in some layers. The same type of rock occurs on the tidal flat, where some beds have graptolites. The beds along the shore are interpreted as Lorraine beds slightly metamorphosed by faulting.

2000 " - Foot of road near eastern border of map-area.

2010 " - Stream, not shown on map.

2500 " - Soft gray shales with several intercalated beds of fragments of green rock. Probably indurated Lorraine.

3600 " - Coarse, light gray sandstone, some layers conglomeratic

3650 " - *Utica*

3700 " - *Utica*. Soft, solid, bituminous shale, with graptolites.

4000 " - *Utica*. Soft and hard, greenish, flinty shale; well-stratified.

4150 " - *Block of Normanskill*. Thin-bedded, well-stratified limestone and shale, intensely crumpled.

4250 " - *Block of Normanskill*. Red shale and slate, fissile and chunky breaking with soft and flinty, black and gray shale and some dove-gray limestone..

4450 " - *Utica*, or possibly *Lower Lorraine*. Dark shale.

6410 " - *Lower Lorraine*. Soft, crumbly, sandy shale. Beyond this locality nothing but definetely Lorraine and Utica beds occur as far as Saint-Antoine.

In this sequence Wildflysch (Canajoharie) rocks contains blocks of green chert of Aubin Formation (Pl. XII), and blocks of dolomitic mudstone, of ribbon limestones, and of red shales (probably also Normanskill).

Southeast of Fault III, isoclinal folds overturned toward the northwest and plunging generally toward the southwest are present in the Utica-Lorraine complex (Pl. XIX-A). Also there are some slivers of folded Normanskill (Aubin Formation, Bourret Formation) in this complex (Pl. XIX-B and XX). These folded bands of the Lowlands type of rocks plus the Bourret Formation could well represent what has been called elsewhere the Saint-Germain Complex (Clark, 1964a).

The more or less uniform strikes and dips are in accord with what is usually found in the Saint-Germain Complex, where incompetent beds have been regionally deformed by an overriding slice and have therefore assumed a rough regularity of structure of which the main characteristic is isoclinal folding with the axis plunging steeply toward the southeast. This gross structural feature extends along the shore to Saint-Antoine, beyond which point the folding, though intense, is not isoclinal. As a consequence, high dips to both northwest and southeast are common. Sainte-Croix-Est is a critical point structurally because to the east the minimum dip is 30 degrees, whereas to the west dips of more than 8 degrees are exceptional. Moreover, west of Sainte-Croix-Est, the strikes are no longer predominantly northeast, as should be the case in a uniformly and tightly folded region where the beds are almost everywhere parallel to the axial planes of the folds. Instead, and because the folds are open, the dips "migrate" around their ends.

Plate XIX-A - Anticline in Utica-Lorraine Complex, between Saint-Antoine-de-Tilly and Aubin Point.

Plate XIX - B - Anticline in Normanskill on Petite Rivière du Chêne about 1,000 feet east of Highway 49.

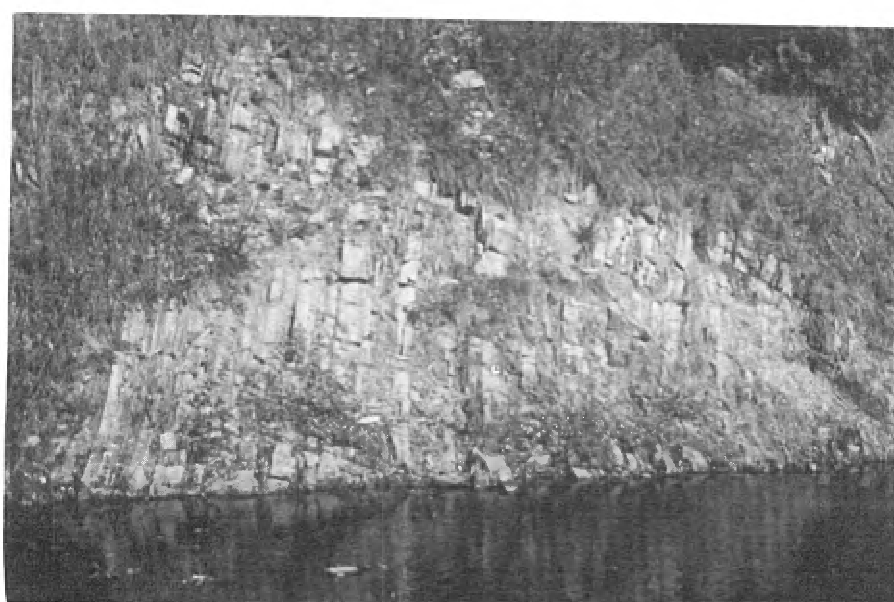
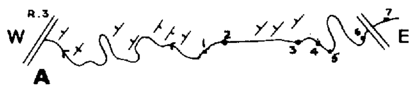
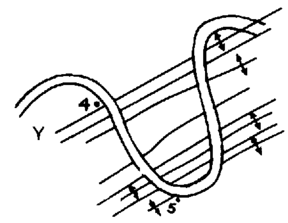


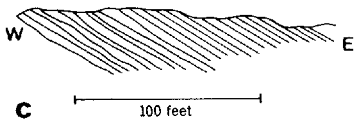
Plate XX - Nearly vertical Bourret calcareous argilite and slate on Henry river close to road going west from Joly.



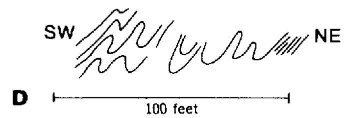
Map of Bourret Brook from bridge east of Les Fonds to highway No 3.



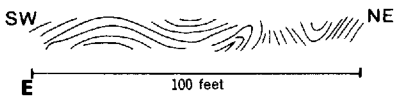
Enlargement of part of Bourret Brook between points 4 and 5 on figure A showing closely crowded fold axes.



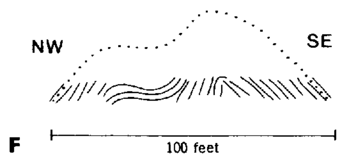
Thrust faults in right bank of Bourret Brook 200' above the bridge east of Les Fonds Location 7 in figure A.



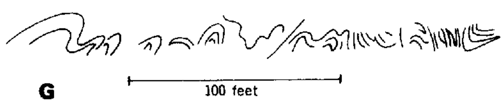
Complications along the right bank of Bourret Brook 500' below bridge east of Les Fonds Location 6 in figure A.



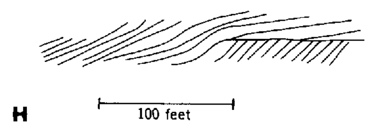
Complications along the right bank of Bourret Brook Two anticlines and two synclines in Bourret formation Location 5 in figure A.



Contorded anticline in shale and limestone Location 4 in figure A.



Complications in Bourret formation Location 2 in figure A.



Shale showing gradation from flexure to overthrust Location 1 in figure A.

Figure 14 PLANS (A and B) AND SECTIONS (C to H) ILLUSTRATING FOLDS IN SHALE OF BOURRET BROOK NEAR LES FONDS.

A peculiar feature near Les Fonds is outlined below. From near the wharf, a road ascends to the plateau top and, in about a mile, crosses Bourret brook. Downstream, the brook makes several sharp hairpin turns, flanked practically all the way by rock walls. Anticlines and synclines may be seen along these walls, some extending from one bend to another. The beds on both flanks of the main anticline consist of Lorraine type rock of Utica age; true Utica occurs in the centre. About half way between the road mentioned above and Highway 3, a remarkable flexure-fault can be seen on the north bank of the brook. There the beds change from a simple tilted condition on the southwest through a monocline to an actual fracture toward the northeast (Fig. 14q). The fracture is actually a thrust fault developed along a nearly horizontal surface. It would appear that the rocks were securely anchored at the northwest part of this section, and that pressure applied from the southeast at the northeast end was sufficient to fracture the beds as indicated, thus producing a rotational thrust movement. Complications abound in the shales in this section.

ECONOMIC GEOLOGY

Petroleum and Natural Gas

Although both the Trenton limestone and the Utica shale have generally an oily odor when freshly broken, no record exists of any findings of oil in commercial quantities in the area. The same applies to gas, with the exception of a well which produces gas on the Convent property at Neuville, where it was once used for lighting purposes. In many instances, droplets of oil ooze from freshly broken Deschambault limestone, and black coal-like seams traverse the limestone in several places. Both the oil and the "coal" have excited local curiosity, and more has been expected of these phenomena than they deserve. The "coal" is solidified petroleum residues.

The Utica shale is everywhere bituminous. Some layers are strongly odoriferous, and it is possible to detect an oily odor while walking alongside many cliffs of this rock. Analyses made by the Québec Department of Natural Resources showed only a trifling amount of hydrocarbons, however.

In 1956, 1957, 1958 and 1964, seven deep wells were drilled in the present area in search of oil or gas. These are listed in Québec Department of Natural Resources Publication S-75 as numbers 9,10,15,16,51,69 and 72. Summary logs of these wells are given below in Appendix. The complete logs are filed with the Department of Natural Resources (GM-2700). A correlation chart showing the formations cut in six of these wells, all except 51, is given in Fig. 3. None of the wells produced commercial amounts of gas or oil. Wells 10 and 72 were barren. In 9 and 15, gas was tapped in the Middle Trenton, and oil appeared in the core at various horizons in the Deschambault and Black River formations. Well 16 had shows of gas in the Lower Lorraine, Upper Trenton, Deschambault and Precambrian, and traces of oil in the Deschambault. In Well 69, gas was found in the Utica, Upper Trenton and Deschambault.

If any generalization can be made, it is that gas occurred most commonly in Trenton horizons. Unfortunately, the finding of commercial quantities of oil or gas seems not to be favored by either experience or geologic indications.

Copper, Molybdenum, Radioactive Minerals

The Black River "mine", on land owned by Mr. Stanislas Desrochers, 4 miles east of Saint-Flavien Parish, 1,600 feet from the public road on Range Bois Franc de l'Ail, was explored for copper but there is no record of any successful extraction of ore. This was in the 1860's, and has been a constant source of rumors or riches in copper ever since.

The Portneuf Mineral Corporation prospected for molybdenite in Precambrian rocks in range II, lots 290, 291, 293, 293-A and 524 of Deschambault Parish and on lots 184, 185, 185-A, 187 and 658 of Notre-Dame-de-Portneuf Parish, but nothing was found of commercial value. A smaller exploration program was carried out on the land of Narcisse Perron, lots 301, 304, 305, 306, 3rd concession, Deschambault seigniory, Portneuf county, for copper and molybdenite but without results. Mica in pegmatites has also attracted some attention.

According to Shaw (1958), four holes were drilled in 1953 on lot 331, Concession III, Notre-Dame-de-Portneuf parish, Portneuf Seigniory, on the Gaudry property, in search of radioactive minerals. Uranophane, autunite, thucolite, and a heavy, unidentified radioactive mineral were found. The best assay was 0.1% U_3O_8 along 5 feet of core.

Agricultural Lime, Cement

Lime was formerly produced in a number of local kilns: one at Deschambault and one at Pont-Rouge, particularly. Now it comes from only the Gauthier Frères mill at Neuville, with a capacity of 1,500 tons a day.

Nearly all the Trenton limestone has a lime-producing potential (see Analyses 1 and 2), and the Deschambault limestone is rich enough in $CaCO_3$ to support a chemical industry.

At Saint-Basile, cement is produced by Ciment Québec Inc. This mill has a capacity of 29,000 97½-lb. bags a day. Most of the cement goes to the Montréal market.

Building Stone

The Portneuf area abounds in good deposits of first-class building stone. However, since the industry moved west to Saint-Marc-des-Carrières, all such production ceased here. The Portneuf area could easily supply the needs of any of the large Canadian cities from its store of Trenton limestone alone.

The Utica shale is not itself a good building stone, but, in a few places, it contains several beds of splendid, fine-grained limestone which breaks into rectangular blocks 2, 3 or 4 inches thick.

Some Precambrian gneiss has been quarries in this area. The church and one or two houses at Saint-Gilbert were built of gneiss from a nearby quarry. The cost of opening a quarry in the Precambrian gneiss would probably be prohibitive today.

Stone of Neuville, Québec

Analysis 1 - Drolet Property

Hole No. 9

Casing Core	SiO_2	K_2O_3	CaO	MgO	Loss	Total
0'-10'	1.36	0.62	53.66	0.79	41.94	98.37
10'-20'	1.09	0.56	54.05	0.47	42.64	98.72
20'-30'	0.96	0.44	54.21	0.62	42.50	98.73
30'-40'	2.32	0.98	53.35	0.68	41.90	98.23
40'-50'	1.20	0.86	53.90	0.63	41.94	98.53
50'-60'	12.16	4.28	44.44	1.12	35.74	97.74
60'-70'	4.92	3.04	49.95	0.87	39.44	98.22
70'-80'	60.86	7.34	15.21	1.30	12.16	98.87
80'-87	85.30	6.30	2.38	1.06	2.34	97.38

Analysis 2 - Darveau Property

Hole No. 10

Casing Core	SiO_2	K_2O_3	CaO	MgO	Loss	Total
0'- 6'	2.00	0.98	53.11	0.97	41.90	98.96
6'-16'	1.90	0.70	53.66	0.59	42.12	98.97
16'-26'	2.36	1.14	52.64	0.65	41.68	98.47
26'-36'	0.90	0.58	54.13	0.54	42.44	98.59
36'-46'	2.08	1.02	52.93	0.72	41.52	98.29
46'-56'	14.48	3.14	44.13	1.10	35.16	98.01
56'-67'	21.82	4.44	38.06	1.31	31.88	97.51

Holes drilled by Canada Cement Co. Ltd. in its Neuville Property.

Road Material

With the Saint-Marc-des-Carrières quarries producing all the crushed stone the local region requires, there is little need to utilize the nearly inexhaustible supply of Trenton limestone in the northern Portneuf area to produce this material. However, the Gauthier brothers at Neuville produce crushed stone for local use and, in March, 1968, "Pavage Frontenac Ltée" of Québec, opened a new quarry at Neuville. On the south side of the St. Lawrence, a quarry (St-Flavien Quarry Inc.), about 3 miles northeast of Saint-Flavien, was in operation until November, 1967. Road material has been taken in the past from the sandstone north of Hurette, on Mr. Lambert's land.

Gravel is in short supply in the area north of the St. Lawrence. In the most northern parts, particularly on the Precambrian uplands, the glacial drift can be screened, in places, to give a fairly satisfactory road material, for enough clayey component remains with the sand to make a good binder. In the area south of the St. Lawrence, sand is widespread, but is generally too clean to be a good road material. River sand and gravel are common in the southeastern corner. Also, there are numerous ridges of nearly pure quartz sand, presumably old dune ridges paralleling post-glacial shore lines. An asphalt mix plant is in operation 3 miles northeast of Saint-Flavien, using local sand.

At Pont-de-la-Noreau, a small industry has developed in the past, sifting post-glacial shells from sands, to be sold for chicken grits, driveways, etc.

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APPENDIX

SUMMARIES OF LOGS OF WELLS BORED IN THE AREA

No. 9

Company: Bald Mountain Oil Co.

Name of well: Bald Mountain-Cap-Santé No. 1

Location:

Lot:	102	Ground Elev.:	219 ft.
Concession:	I	R.F. Elev.:	221 ft.
Parish:	Cap-Santé		
County:	Portneuf		
Coords:	Approx. 0.7 mi. NW of Highway 2; 200 ft. from Cap-Santé — St-Basile road.		
Spudded:	Apr. 5, 1957	Driller:	Logan Bros.
Completed:	May 20, 1957	Type of Rig:	Diamond Drill
Result:	Dry Hole		
Water:	42',55',84',558'-560'		
Gas Indications:	647', 662'		
Oil Indications:	736',763'-764',792.5',803',805',887'-887.5'		

SUMMARY LOG: T.H. Clark, 1959

Depth below Surface - feet	Formation	Description
0 - 5	OVERBURDEN	
5 - 57	LOWER LORRAINE	Dark gray, finely micaceous shale, 92% Thin sandstones beds up to 3", 8% of core
57 - 325	UTICA	56-150 Dark gray, soft shale, finely color banded, slightly calcareous. Oily odor; oil in fractures. Silty bands up to 6", 4% of core 150-235 Dark brownish gray shale, finely color banded, hard, calcareous. A few thin sandstone beds. Silty beds up to 6", 8% of core. Oily odor, oil in fractures 235-325 Dark, soft, fissile shale. Siltstone beds 8% of core
325 - 330	LOWER UTICA	Dark gray to black shale, calcareous. No siltstone. ¼" trilobite debris bed at base
330 - 500	UPPER TRENTON	Dark gray, dense to crystalline limestone and dark gray shale. Bedding mostly irregular. Limestone: shale 46:54 above, 78:22 below
500 - 630	UPPER AND MIDDLE TRENTON	Lithology as above. Middle Trenton fossils present
630 - 751	MIDDLE TRENTON	Dark gray, dense limestone, a few 1" crystalline beds. Shaly partings common. Limestone: shale 85:15
751 - 840	LOWER TRENTON (Deschambault)	Faint brownish gray crystalline limestone. Shale never more than 5%. Bryozoan mats occur from 822 to 839
840 - 914	BLACK RIVER	Dark brownish gray, dense to fine-grained limestone, with interbedded gray sandstone. Limestone beds contain *Phytopsis* 904-914 Coarse-grained sandstone, some quartz conglomerate, pink feldspar grains
914 - 954	PRECAMBRIAN	Biotite gneiss and pink quartzite

No. 10

Company: Bald Mountain Oil Co.
Name of well: Bald Mountain-Cap-Santé No. 2

Location:

Lot:	210	Ground Elev.:	236 ft.
Concession:	Pincourt	R.F. Elev.:	238 ft.
Parish:	Cap-Santé		
County:	Portneuf		
Coords:	200 ft. from W. LL., 200 ft. from S. LL.		
Spudded:	Aug. 7, 1958	Driller:	A. Dubé
Completed:	Dec. 10, 1958	Type of Rig:	Cable
Result:	Dry Hole		
WATER:	30'-62',380',655',725',800'		

SUMMARY LOG: T.H. Clark, 1959

Depth below Surface - feet	Formation	Description
0 - 50	OVERBURDEN	
50 - 185	UTICA	Dark gray shale, light brown streak calcareous. Graptolites common
185 - 655	UPPER & MIDDLE TRENTON	Limestone, dark gray, mostly dense to very fine grained, 70% to 95% of samples Shale dark gray to brownish gray, non calcareous, 5% to 30% of samples 535'-Possible boundary between Upper and Middle Trenton.
655 - 750	LOWER TRENTON	Light buff limestone, dense to fine-grained Shale less than 5%
750 - 805	BLACK RIVER	Medium dark limestone, dense to fine-grained. Shale, dark gray, up to 10%
805 - 855	PRECAMBRIAN	Quartz-biotite rock

No. 15

Company: Bald Mountain Oil Co.
Name of well: Bald Mountain-Portneuf No. 1

Location:

Lot:	3	Ground Elev.:	129 ft.
Concession:	I	R.F. Elev.:	131 ft.
Parish:	Deschambault		
County:	Portneuf		
Coords:	¼ mile SE of C.P.R. right of Way		
Spudded:	Feb. 18, 1957	Driller:	Logan Bros.
Completed:	Apr. 2, 1957	Type of Rig:	Diamond Drill
Result:	Dry Hole		
Water:	300', 420', 952'		
Gas Indications:	937'-940',976',1071',1122',1199',1237',1274'		
Oil Indications:	1225', 1260'		

SUMMARY LOG: T.H. CLARK, 1959

Depth below Surface - feet	Formation	Description
0 - 45	OVERBURDEN	
45 - 392	LOWER LORRAINE	Very dark gray shale, with 1" beds of light sandstone. A few silty beds. Oily odor. Shale: sandstone
392 - 698	UTICA	Dark gray to black shale; a few calcareous siltstone beds 1" - 2". Oily odor
698 - 800	UPPER TRENTON	Dark gray, fine- to coarse-grained crystalline limestone. Dark gray shale. Irregularly interbedded.
800 -1224	MIDDLE TRENTON	Dark gray, dense to fine-grained limestone. Dark gray shale. Bedding regular to irregular.
1224 -1320	LOWER TRENTON	Light to medium gray, brownish, crystalline limestone. Shale less than 1%. Oily odor 1268-1280 mat of bryozoa.
1320 -1322	ROCKLAND	Dark gray, fine-grained crystalline limestone and pale greenish gray sandstone
1322 -1360	BLACK RIVER	Limestone, fine-grained to lithographic 1322 - 1325. Sandstone, limestone and a little dolomite, all mostly black. 1325 - 1360
1360 -1388	PRECAMBRIAN	Pink biotite gneiss

No. 16

Company: Bald Mountain Oil Co.
Name of well: Bald Mountain-Portneuf No. 2

Location:

Lot:	3	Ground Elev.:	128 ft.
Concession:	I	R.F. Elev.:	130 ft.
Parish:	Deschambault		
County:	Portneuf		
Coords:	100' S. of Bald Mountain – Portneuf No. 1		
Spudded:	Apr. 22, 1957	Driller:	McMaster & Sons
Suspended:	June 1, 1957	Type of Rig:	Cable
Result:	Dry Hole		
Water:	Fresh at: 37', 406'-408'; Salty at: 1352'		

Gas Indications: 83' 352',700'-705',1240'-1245',1347'

Oil Indications: 1313',1338'

CARNET DE SONDAGE SOMMAIRE: T.H. CLARK, 1958

Depth below Surface - feet	Formation	Description
0 - 37	OVERBURDEN	
37 - 400	LOWER LORRAINE	Dominantly dark gray shale; lesser amounts of gray siltstone
400 - 700	UTICA	Predominantly dark gray to black shale; a little shaly buff-gray limestone
700 - 1170	UPPER & MIDDLE TRENTON	Mostly medium gray, fine-grained limestone, with dark gray dense and medium gray crystalline limestone in lesser amounts. Shale 10%
1170 - 1355	LOWER TRENTON	1200-1315 Predominantly light to medium gray crystalline limestone; very little dense limestone. Shale 4% 1315-1350 More than half light gray quartz sandstone. Limestone 41%; Shale 1%
1355 - 1387	PRECAMBRIAN	Biotite gneiss

No. 51

Owner: Goyette
Name of well: Fortierville No. 1

Location:

Lot:	17	Ground Elev.:	226 ft.
Range:	IX	R.F. Elev.	228 ft.
Parish:	St-Jean-Deschaillons		
County:	Lotbinière		
Spudded:	Sept. 15, 1943	Driller:	Connors Drilling Co
Completed:	Nov. 5, 1943	Type of Rig:	Diamond Drill
Result:	Dry Hole		
Water:	263', 266', 418'		
Gas Indications:	771'		

SUMMARY LOG: T.H. CLARK

Depth below	Formation	Description
0 - 70	OVERBURDEN	
70 - 180	RICHMOND	Bécancour
180 - 771	RICHMOND	Pontgravé

No. 69

Company: Lowlands Exploration Ltd.
Name of well: Imperial Lowlands Leclercville No. 1

Location:

Lot:	24	Ground Elev.:	168'
Range:	Village St-Michel	R.F. Elev.:	170'
Parish:	Ste-Emélie de Lotbinière		
County:	Lotbinière		
Seigniory:			
Coords:	310' from E. LL., 813' from N. LL.		
Spudded:	June 22, 1956	Driller:	Stubble & Stubble
Completed:	Oct. 20, 1956	Type of Rig:	Cable
Result:	Dry Hole		
Water:	Fresh at: 26'; Salty at: 3043'		
Gas Indications:	2276', 2389', 2940', 3042'		

SUMMARY LOG: T.H. CLARK, Jan. 1959

Depth below Surface feet	Formation	Description
0 60	OVERBURDEN	Sand and clay
60 - 330	UPPER LORRAINE	Shale, light to medium gray. Lesser amounts of light gray siltstone, light gray, very fine-grained sandstone.
330 - 830	MIDDLE LORRAINE	Shale, medium gray, micaceous; lesser amounts of medium gray siltstone, medium gray very fine grained sandstone
830 - 1955	LOWER LORRAINE	Shale, medium dark, lesser amounts of medium gray siltstone, medium gray, very fine grained sandstone
1955 - 2281	UTICA	Shale, black
2281 - 2492	UPPER TRENTON	Limestone, medium to dark gray, fine grained; shaly limestone; buff and gray dense limestone; shale
2492 - 2755	MIDDLE TRENTON	Limestone, buff dense; shaly limestone; very little shale
2755 - 2920	LOWER TRENTON	Limestone, crystalline, light to med. gray; shaly limestone;
2920 - 3408	LOWER TRENTON and/or BLACK RIVER	Sandstone, almost pure quartz, grain averaging .5 mm. Mostly white, also gray, buff and green Shale present near base.
3408 - 3445	PRECAMBRIAN	Biotite-quartz foliate

No. 72

Company: Lowlands Exploration Ltd.
Name of well: Imperial Lowlands No. 4 Lotbinière

Location:

Lot:	557	Ground Elev.:	209'
Range:	Saint-Jean-Baptiste	R.F. Elev.:	212'
Parish:	Saint-Louis de Lotbinière		
County:	Lotbinière		
Coords:	99' from W. LL., 400' from N. LL.		
Spudded:	Sept. 16, 1957	Driller:	Meier & Shaw
Completed:	Nov. 9, 1957	Type of Rig:	Cable
Result:	Dry Hole		
Water:	38'		

SUMMARY LOG: T.H. CLARK, Jan. 1959

Depth below Surface-feet	Formation	Description
0 - 6	OVERBURDEN	
6 - 895	LOWER LORRAINE	Dark to medium gray shale: light gray, fine-grained sandstone and light to medium gray siltstone in minor amounts
895 - 1150	UTICA	Black shale. Calcareous beds at base
1150 - 1650	UPPER & MIDDLE TRENTON	Dark gray, dense and shaly limestone; lesser amounts of crystalline limestone and of shale
1650 - 1700	LOWER TRENTON	Crystalline limestone; a little dense limestone, and very little shale
1700 - 1820	BLACK RIVER	1700-1760 Dark gray, dense and slaly limestone predominates at top; quartz-rich sandstone at base, 1760-1820
1820 - 1969	PRECAMBRIAN	Biotite - quartz - orthoclase gneiss

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