

GM 27793

GEOLOGICAL STUDIES OF THE QUEBEC CITY AREA AND OF THE THE ST. LAWRENCE ISLANDS BETWEEN QUEBEC CITY AND MONTMAGNY

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Énergie et Ressources
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Québec 

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Quebec, December 21, 1971.

Pan Canadian Petroleum Ltd.,
National Resources Bldg.,
905 9th Avenue, Southeast,
Calgary,
ALBERTA.

Attention: Mr. C.R. Thomson
District Manager,
Northwest Territory East.

RE:

Geological studies of the Quebec City area and of the
St. Lawrence Islands between Quebec City and Montmagny.

Ministère des Richesses Naturelles, Québec	
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Summary and Recommendations

The Lower Paleozoic rocks of the Quebec City area consist, from north-west to south-east of an autochthonous limestone platform, a para-autochthonous zone of shale and flysch, allochthonous sequences of the Appalachian domain. (see the geological map page 16).

The platform exposures are the Middle Ordovician Trenton limestone and the Utica shale. Nevertheless, a brief study of the polymictic limestone conglomerate observed in various allochthonous sequences of the Appalachian domains suggest that the platform also includes Cambrian and Lower Ordovician limestones. These limestones are somewhere underneath the para-autochthon or the allochthonous rocks. A sandstone of varying thicknesses determines the base of the platform limestone sequence. Some normal faults striking north-east, south-west and with a steep dip to the south-east offset the near horizontal rocks of the platform.

The para-autochthon zone includes Middle Ordovician shale and flysch. The folds observed in that zone are tight near the Appalachian front and progressively disappear going north-west toward the platform exposure.

The allochthonous rocks of the area are Cambrian and Lower Ordovician and could be subdivided into several structural units. Evidence of stratigraphic tops derived from fossils and from primary sedimentary features agree with structural data and demonstrate that the oldest rocks are geometrically the highest strata of the allochthonous sequences. We believe that these

allochthonous rocks have been emplaced in Middle Ordovician time as a series of giant submarine slides. Evidence of these slides is found today in the upper part of the Canajoharie (Trenton) and Lower Utica shale of the para-autochthon and in the Normanskill (Black River) wild-fly-sch of the allochthon.

Hydrocarbons are observed in the platform limestone and in the shaly limestone and the limy shale of the Quebec Promontory "nappe".

In order to determine the surface distribution of the platform limestones and their basal sandstones and of the bituminous rocks of the Quebec Promontory "nappes", the mapping of the St. Lawrence River shores and of its islands, from the Iles aux Loups Marins, west of St. Jean Port Joli, to the Ile aux Basques, west of Trois Pistoles, is recommended.

I also recommend a study of the polymictic limestone conglomerate of the Lower Ordovician formations of the allochthon in order to determine the various limestone facies of the Cambrian and Lower Ordovician platform.

Geology of Quebec City area and of the St. Lawrence Islands between Quebec City and Montmagny.

The main stratigraphic and structural elements of Quebec City area could be subdivided in three north-east, south-east structural zones. That is: north-west to south-east, the autochthon consisting of a Precambrian basement and its cover of Middle Ordovician sedimentary rocks; a para-autochthonous zone consisting of Middle Ordovician rocks; and allochthonous rocks

of the Cambrian and Lower and Middle Ordovician form all the Appalachian rocks of the study area. (see the geological map page 16).

a) Autochthon

The autochthon consists of the Grenville gneiss and its sedimentary cover of Middle Ordovician age; the latter comprises a basal sandstone, the Trenton limestone and the Utica shale. The limestone of a thickness of 600 feet, is lying on a coarse sandstone, of a thickness varying from a foot to more than one hundred feet. It is possible that the platform limestone is much thicker in its southern extension underneath the para-autochthon and the allochthonous strata. Indeed, a primary study of the polymictic limestone conglomerate in the allochthons suggests the presence of Cambrian and Lower Ordovician limestones somewhere underneath the para-autochthon or the allochthonous rocks. The shale sequence of more than a thousand feet thick contains, in its upper part, several beds of graded calcareous sandstone from a few inches to three feet thick, most of the beds being one foot thick.

b) Par-autochthon

The para-autochthon zone occupies that part of the lowlands between the Quebec promontory which extends from Cap Rouge to Cap Diamant and their prolongation on the north-west side of the Island of Orleans and, on the other hand, the Trenton limestone and the Utica shale.

The para-autochthonous rocks consist of shales with, in its upper part, interbedded calcareous sandstone and some thick bands of wildflysch. Tight isoclinal folds, overturned to the north-west, are observed near the Appalachian front in the rocks of Trenton and Utica age. These folds disappear progressively toward the north-west to become almost non-existent in the vicinity of the Precambrian. In the folded part, there are many low angle reverse faults. The undisturbed part is autochthonous, whereas the folded and faulted part has been dragged by the allochthonous "nappes" of the Appalachian domain. Briefly, there is a time transgressive shaly formation of which the internal part (edge of Quebec promontory) has been dragged at the time of the "nappes" emplacement, whereas the external part is autochthonous and in a normal stratigraphic sequence with the Trenton limestone.

c) Allochthon

All the Appalachian rocks of the Quebec City area are allochthonous. The Lower Paleozoic could be subdivided in seven structural units:

- Chaudiere "Klippe"
- St. Henedine "Nappe"
- Victoriaville "Nappe"
- Bacchus "Nappe"
- St. Petronille and Pointe-de-Levy slices
- Quebec Promontory "Nappe"
- Etchemin River wildflysch

The structural units containing the oldest rocks are lying over the

units containing the younger strata. As a matter of fact, the Chaudiere "Klippe", consisting of Cambrian rocks, is the uppermost structural unit of the allochthonous rocks of the Quebec City area. It covers indifferently the Quebec Promontory "nappe" (Middle Ordovician) and the Pointe-de-Levy slice (Cambrian ? and Lower Ordovician). Also, the Cambrian strata at the base of Bacchus "nappes" are lying on Lower Ordovician rocks (St. Petronille and Pointe-de-Levy slices) and Middle Ordovician (Quebec Promontory "nappe").

Therefore, you will see a lithologic and structural description of the allochthon, an historical synthesis and the hydrocarbon possibilities.

Lithologic and Structural Description

Chaudiere "Klippe"

The Chaudiere "Klippe", consisting of Cambrian rocks (Sillery Group) is the uppermost unit of the allochthons. It consists of green, red and grey shales interbedded with graded arenites and rudites in beds of a foot to ten feet thick.

The folds of the flexural-slip type are tight and even overturned toward the north-west in the north-western part of the "Klippe" and relatively open in its south-eastern part. The axial surfaces of the folds have a strike of north 50° east and their axes are plunging at an angle of 20° toward the south-west. The stratigraphic sequence in the north-west part of the "Klippe" is repeated by imbricated reversed faults.

St. Henedine "Nappe"

The St. Henedine "nappe" is located in the south-eastern part of the geologic map of Quebec City area. It consists of green and grey shales with, locally, beds of limestone conglomerate and of sandstone. We consider these rocks to be Cambro-Ordovician.

The St. Henedine "nappe" has been affected by two superposed phases of folding. That is: north-south folds without axial plan cleavage on which have been superposed folds with axial plane cleavage striking 40° east.

Victoriaville "Nappe"

The Victoriaville "nappe" is characterized by the occurrence of argillaceous limestone and highly calcareous sandstone interbedded with bands of green and grey slates. We think that these rocks are of Lower Ordovician age.

As in the St. Henedine "nappe", we notice north-south folds without axial plane cleavage refolded by folds with axial plane cleavage striking north 40° east.

Bacchus "Nappe"

The western part of that "nappe" is in faulted contact with the Quebec promontory "nappe" and the St. Petronille and Pointe-de-Levy slices and, the Etchemin River wildflysch. It is impossible, at the moment, to have an opinion on the nature and position of the eastern contact of that

"nappe". Therefore, the St. Lawrence River Islands, from Islands of Orleans to the Isle aux Coudres and also the strata on the south shore of the St. Lawrence River, from Lauzon to the Boyer River, show identical facies and the same structural style with the type locality of the Bacchus "nappe" on the island of Orleans.

The rocks of that "nappe" have been subdivided in three formations which are, from older to younger, the Anse Maranda, Trou St. Patrice, and La Pointe-de-la-Martiniere formations. The Anse Maranda formation, of Cambrian, consists of shale, mudstone and sandstone, with homogeneous texture and composition, which are locally highly glauconitic. Above, is exposed a sequence of shale with interbedded calcarenite, limestone conglomerate, sandstone and siltstone of the Trou St. Patrice formation. That formation is Cambrian and Lower Ordovician. At the top, the Pointe-de-la-Martiniere formation consists of alternating grey, green and red shales or mudstones containing few beds of limestone conglomerate. This assemblage is Lower Ordovician (Arenig).

The main part of the "nappe" is characterized by tight flattened flexural-slip folds (Ramsay 1967)* and several imbricated reversed faults. In the western part of the "nappe", the fold axes are plunging 22° south. The fold axial surfaces and the fault plane have a dip of 20° east to 90° . East of the Island of Orleans, these structural elements have a strike of 45° and the fold axes plunge toward the south-west at a low angle.

* Ramsay, G.J., 1967 - "Folding and fracturing of rocks" New York, McGraw-Hill Book Co., 568 p.

St. Petronille and Pointe-de-Levy slices

The St. Petronille and Pointe-de-Levy slices are squeezed between the Quebec promontory "nappe" (Middle Ordovician) below, and the Bacchus "nappe" (Lower Ordovician and Cambrian) above.

They are characterized by alternating green dolomitic mudstone and green shale containing beds of limestone conglomerate and calcarenite. These rocks are Lower Ordovician, mostly of the Arenig.

In the Pointe-de-Levy slices, we did recognize two major folds: an anticline and a complex syncline plunging with an angle of 25° with an orientation of 195° . These folds and their parasitic folds are tight and, locally, the hinge lines of the folds have been obliterated by reversed faults. In the St. Petronille slice, isoclinal folds have been mapped, which are overturned to the north-west, and whose hinge lines have been deformed by reversed faults parallel to the axial surface of folds. The fold axes are plunging at 20° in an orientation of 45° .

Quebec Promontory "Nappe"

The Quebec promontory "nappe" constantly forms, in Quebec area, the front of the Appalachian Allochthonous rocks. It consists of Middle Ordovician calcareous limestone and of bituminous shale in beds of one foot to ten feet thick. At the base of the "nappe", there is often a wildflysch. It consists of dark grey shale showing blocks of radiolarian chert, argillaceous limestone, calcareous shale, sandstone and limestone. Most of the blocks are

of Middle Ordovician age (Black River), but some are of the Lower Ordovician (Chazy). It is interesting to note that the fossils found in the blocks are of the Atlantic type and not from the Pacific as expected. In the City of Quebec, these rocks form overturned folds to the west, with an axial surface striking 15° and the fold axis plunging 45° south. In many places, we observed a slaty cleavage parallel to the axial plane of the folds.

Elsewhere, in the area, where the "nappe" is reduced to a few hundred feet, the folds are parallel to the Appalachian front.

Etchemin River Wildflysch

All around the Chaudiere "Klippe" and along many important thrust faults occur some wildflysch of Middle Ordovician age. It consists of chaotic assemblage of:

yellowish and black shales in beds of an inch to two inches thick; blocks of coarse sandstone; blocks of green or brownish silicified mudstone; blocks of green radiolarian chert; blocks of black bituminous shale; blocks of well bedded grey limestone; blocks of dolomitic limestone and siltstone; blocks of green, grey and red shales; and finally, enormous blocks (olistoliths or slivers) of the Lower Ordovician formation.

We think that it is a wildflysch resulting from the emplacement by gravity sliding of "nappes" in a sedimentary basin whereby the nappes on the basin bottom, act as a bulldozer driving the soft sediments into a chaotic assemblage. Also, enormous blocks coming off allochthons slide in the chaotic shales.

The lack of olistoliths of the Chaudiere "Klippe" in the wildflysch suggests that the appearance of the Etchemin River wildflysch is due to the emplacement of the Lower and Middle Ordovician Allochthon prior to the arrival of the Chaudiere "Klippe". No doubt that later on, the emplacement of the latter contributed to the late movements of the "nappes".

Historical Synthesis

We believe the Appalachian rocks of the Quebec City area to be allochthonous and emplaced by gravitational sliding in the Middle Ordovician (Normanskill, Canajoharie and Lower Utica). These hypotheses are based on the following observations:

- The structural units belong to different paleogeographic domains and the uppermost units are made of rocks older than the ones occurring in the lower structural units. This phenomena can be explained only by gravitational sliding due to a progressive stripping of a rising source area.
- The Chaudiere "Klippe" strata are tightly folded and even overturned to the north-west in its western part, whereas, in their southeastern part, the folds are relatively open which suppose an emplacement by gravity sliding.
- The occurrence of Middle Ordovician wildflysch in front of the allochthon in the para-autochthonous zone and below certain "nappes" suggest that the emplacement by gravity of the "nappes" took place in the Middle Ordovician. Let us emphasize that the

wildflysch in the allochthon zone are of Normanskill age (Black River) whereas, in the para-autochthon zone, they are Canajoharie (Trenton) and Lower Utica. Many blocks are lithologically and paleontologically identical to the allochthon strata. They are, we believe, olistoliths coming off from the progressing "nappes" that slide in the sedimentation basin. Other blocks, like the radiolarian cherts having an internal affinity, probably represent "nappes" that have been completely desintegrated into olistostromes and olistoliths. Finally, some calcareous blocks have an Atlantic fauna, which is restricted to rocks located many miles south of the present position of these blocks.

Thus, in Lower Paleozoic time, limestone platforms were followed to the south by an external trough (miogeosyncline) filled with shales, mostly of Lower Ordovician, containing beds of calcisiltites, calcarenites and polymictic limestone conglomerate. The blocks of the limestone conglomerate are of Lower, Middle and Upper Cambrian and also, in some cases, of Lower Ordovician and they, no doubt, represent a sampling of the limestone platform. Indeed, paleocurrent studies show that the calcareous rocks have a northern source (Hubert, 1965)*. It must be emphasized that the beds of calcarenite and limestone conglomerate are graded and have a restricted lateral extent near the platform. Nevertheless, toward the south, they could be followed for many miles along strike. It seems that these calcareous rocks represent turbidity currents following submarine canyons cut in the limestone platforms which were pouring their load into

* Hubert, C., 1965 - "Stratigraphy of the Quebec Complex in the L'Islet Kamouraska area, Quebec". Unpubl. Ph.D. Thesis, McGill University.

the shale trough. In corollary, we deduce that a Cambrian and Lower Ordovician limestone platform exists somewhere under the allochthon rocks. As a matter of fact, in Middle Ordovician times, a subsidence of the platform and a rising of the miogeosyncline have caused gravity sliding of the facies of the latter on the platform strata. That inversion of the paleogeographic relief was probably the effect of normal faults which are still visible on what is left over of the platforms. Nevertheless, we foresee an internal origin for certain facies like the Cambrian rocks of the Chaudiere "Klippe" argillaceous limestone and limy shale of the Quebec promontory "nappe" and the wildflysch radiolarian chert.

Hydrocarbon possibilities

Hydrocarbons are noticed in two formations of the Quebec City area: the Trenton limestone platform, and the limy shale and shaly limestone of the Quebec Promontory "Nappe". Also a summary study of the Polymictic limestone conglomerate of the Pointe-de-Levy and St. Petronille slice and of the Bacchus "Nappe" suggest the presence of Cambrian and Lower Ordovician bituminous (?) limestone somewhere underneath the para-autochthon or the allochthonous rocks. Let us add that Trenton basal sandstone of a thickness of a foot to more than 100 feet could be good reservoir rocks. North of the Island of Orleans, south of Mont. Ste. Anne, the sandstone shows a thickness of 100 feet.

The porosity in the Trenton limestone and in the strata of the Quebec Promontory "nappes" is poor. Nevertheless, the rocks of the Quebec Promontory "nappes" are often brecciated and consequently porous. Also normal faults

have displaced the Trenton sandstone and limestone which in such a case may have a structural porosity.

In order to restore the different facies and the paleogeography of the Cambrian and Lower Ordovician platform detailed studies of the lithology, paleontology and the geochemistry of the limestone conglomerate of the Pointe-de-Levy and St. Petronille slices and also of the Bacchus "nappe" are imperative.

Finally, it must be emphasized that the rocks of the Quebec Promontory "nappes" are in some places very thick and certainly represent possibilities for the discovery of hydrocarbons, mostly gas. The above "nappe" is the first to be emplaced and constitutes the almost constant base of the allochthonous rocks of the Quebec area.

Done J. G. P. 500

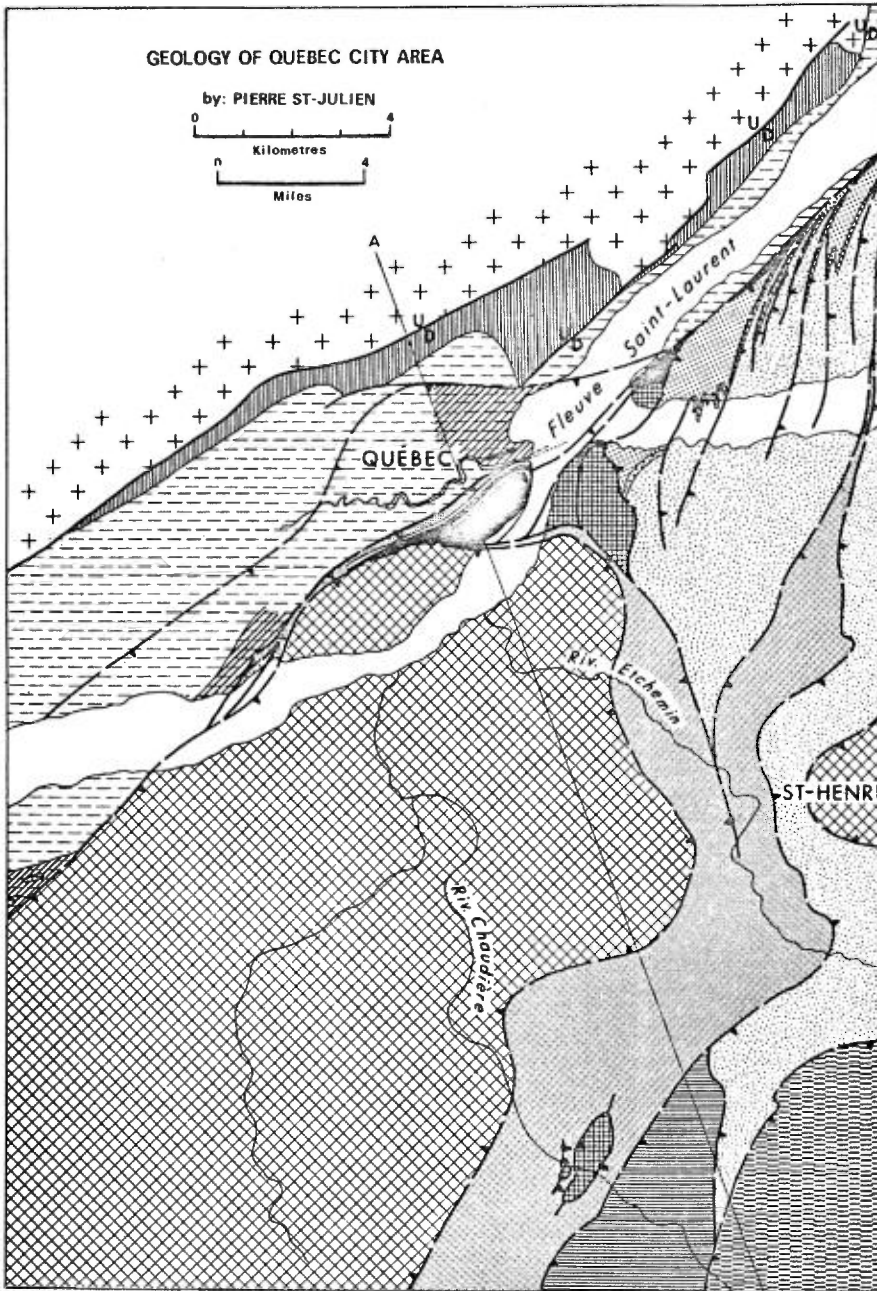
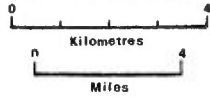
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GEOLOGY OF QUEBEC CITY AREA

by: PIERRE ST-JULIEN



LEGEND

MIDDLE ORDOVICIAN

ST-AUGUSTIN GROUP (Canajoharie - Utica) (Par - autochthon)

Pointe Aubin "Wildflysch"

Shale and flysch

TRENTON GROUP (Autochthon)

Limestone

QUEBEC PROMONTORY "NAPPE"

Argillaceous limestone and calcareous shale of the Quebec City Formation

Citadelle "Wildflysch"

ETCHEMIN RIVER "WILDFLYSCH"

"Wildflysch"

CAMBRIAN (?) AND LOWER ORDOVICIAN

STE-PETRONILLE AND LA POINTE-DE-LÉVY SLICES

Levis Formation: shale, dolomitic mudstone, limestone conglomerate, calcarenite

BACCHUS "NAPPE"

Pointe-de-la-Martinière Formation: red and green shale and mudstone, siltstone

Trou St-Patrice Formation: grey shale, quartzose sandstone, calcareous sandstone, calcarenite, calcisiltite, limestone conglomerate

Anse Maranda Formation: homogeneous shale, mudstone and sandstone locally glauconitic

VICTORIAVILLE "NAPPE"

Argillaceous limestone, calcareous sandstone, grey and green shale

CAMBRIAN

ST-HENEDINE "NAPPE"

Grey shale and limestone conglomerate

CHAUDIÈRE "KLIPPE"

Sandstone and shale

PRECAMBRIAN

GRENVILLE SERIES (autochthon)

Orthogneiss and Paragneiss

SYMBOLS

Geological contact

Thrust fault

Normal fault

1086

