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PRELIMINARY REPORT ON BELOEIL AREA, SURFICIAL GEOLOGY, L'ASSOMPTION, BOURGET, VERCHERES, ST-HYACINTHE, CHAMBLY AND ROUVILLE COUNTIES

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PROVINCE OF QUEBEC, CANADA

DEPARTMENT OF NATURAL RESOURCES

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GROUNDWATER, GAS AND PETROLEUM BRANCH

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# PRELIMINARY REPORT

ON

# BELOEIL AREA

## SURFICIAL GEOLOGY

L'ASSOMPTION, BOURGET, VERCHÈRES, ST-HYACINTHE, CHAMBLY AND ROUVILLE COUNTIES

BY

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## INTRODUCTION

The Beloeil area is in the St. Lawrence Lowlands east of Montreal and lies between latitudes 45°30' and 45°45' and longitudes 73°00 and 73°30' (National Topographic Sheets 31H/11). It includes parts of the city of Longueuil and the towns or villages of Charlemagne, Repentigny, Boucherville, Varennes, Ste-Julie-de-Verchères, St-Hubert, St-Bruno, Beloeil, St-Hilaire and several smaller villages.

The area is covered by a network of rods spaced from 1 to 2 miles apart except for a forested region north of Mont St-Bruno. The principal highways are Routes 2, 3 and 37 along the St. Lawrence river, Routes 21 and 47 along Richelieu river, Route 9, which crosses the southern part of the area from west to east, and Route 12, which crosses the eastern part from northwest to southeast.

## TOPOGRAPHY

The Beloeil area is in the St. Lawrence Lowlands, a broad plain developed on relatively undeformed rocks of early Paleozoic age. The Lowlands were flooded by the late Pleistocene Flandrian (Flint, 1957, p. 262) transgression of the sea, known here as the Champlain Sea, and a thick mantle of marine sediments conceals most of the bedrock surface.

Much of the Beloeil area is flat, but gentle slopes ranging from 10 to 30 feet per mile extend back as far as 5 miles from the St. Lawrence river and 3 miles from the west side of the Richelieu river. The altitude of the plain in the Beloeil area ranges from about 50 to 140 feet above sea level. In the south two prominent hills, Mont St-Bruno and Mont St-Hilaire, with maximum altitudes of 715 and 1,350 feet respectively, rise abruptly above the plain.

## DRAINAGE

The area is drained toward the north by the St. Lawrence and Richelieu rivers. Most of the small streams follow former sub-parallel channels abandoned by the early St. Lawrence and Richelieu rivers, or are in artificial channels. The drainage has a crude trellis pattern.

## BEDROCK GEOLOGY

The bedrock geology of the area was mapped by T.H. Clark (1955). Precambrian metamorphic and igneous rocks are assumed to underlie the Paleozoic rocks, which are known from borings and widely scattered outcrops. About 5,000 feet of Ordovician rocks overlie about 100 to 200 feet of Cambrian rocks. The Cambrian formation is the Potsdam sandstone. The Ordovician rocks are sandstones, shales, limestones and dolomites. Rocks older than Trenton do not outcrop in the Beloeil area. The outcrops are mainly rocks of Utica, Lorraine, and Richmond ages. The Monteregian hills (Mont St-Bruno and Mont St-Hilaire) are nephline syenite and essexite accompanied by minor differentiates (tawite). According to recent K-Ar ratio dating (Fairbairn, Faure, Hurley, Pinson, 1961), these intrusives were emplaced in Cretaceous time. Ages based on paleomagnetic studies also seem to agree with the radiogenic dates (Larochelle, 1962).

## SURFICIAL DEPOSITS

### Stratigraphy

The Pleistocene deposits of the area are subdivided into two groups: those of Wisconsin age and earlier, and those of Recent age.

On the evidence of palynological studies and radiocarbon dating, Terasmae (1959) suggested "that the Champlain sea episode in the St. Lawrence Lowlands may be in part contemporaneous with the Two-Creeks interval, and hence the St. Narcisse readvance can perhaps be correlated with the Valders (?) substage". Gadd and Karrow (1959) demonstrated that the Valders ice sheet "advanced from the highland into the marine basin to form the St. Narcisse moraine".

By radiocarbon dating, the deepest submergence of the Champlain sea has been set at about 11,300 years before the present (Flint, 1956).

The Champlain sea interval is here considered to be contemporaneous with the Two-Creeks and Valders, and also contemporaneous with the Flandrian (Flint, 1957, p. 262) eustatic rise of sea level in late Pleistocene time.

# Table of Formations

| | | | | |
|---|---|---|---|---|
| Quaternary | Pleistocene | Recent | | Bog deposits<br>Bouldery sand in low ridges<br>Low terrace sands: alluvial and deltaic deposits<br>High terrace sands: medium-grained, fluvial, unfossiliferous sand, some silt |
| | | Wisconsin and earlier | Valders and Two-Creeks | Champlain Sea gravels and sands: mainly shore deposits, containing fossiliferous beds<br>Champlain Sea clays: some definitely marine, some presumably lacustrine; local variations common<br>(e) brown to light brown clay with silty layers containing fresh-water species<br>(d) reddish brown,almost red, silty clay, no fossils<br>(c) blue-grey clay with sand partings: marine fossils<br>(b) blue-grey, silty clay, massive or locally layered, containing marine fossils<br>(a) blue-grey clay, some organic matter, containing marine fossils |
| | | | Mankato and earlier | Medium-grained, reddish brown sands (do not outcrop)<br>Reddish brown, sandy, usually calcareous till, overlain in a few places by interbedded reddish grey silts and reddish brown clays |

## Description of Deposits

(Numbers refer to map-units)

### 1) Till

The oldest glacial deposit exposed in the area (Map-unit 1) is a dusky red (10R3/2, 4/4 Munsell system), sandy, usually calcareous till. Till forms the surface around the mountains and in areas west of Mont St-Bruno. In deep bore holes the till has been inferred only from the relative resistance to drilling and by the reddish brown material that adhered to the auger. The red colour of the till is due to its original constituents and not to weathering processes.

### Interbedded Silts and Clays (Included in Map-unit 1.)

In a few scattered exposures, generally calcareous, compact, interbedded reddish grey silts and reddish brown clays overlie the till. In one place, they are folded, probably as a result of slumping rather than glacial readvance. These silts and clays are generally about 5 to 6 feet thick, except in one place just south of the map-area, where a test boring penetrated 25 feet of similar laminated silts and clays, without passing through them. These deposits are found only west and southwest of Mont St-Bruno and southwest of Mont St-Hilaire. They may have been deposited in glacial lakes in re-entrants formed in the retreating ice margin where glacier flow was obstructed by the mountains.

### Reddish Brown Sands (Do not outcrop; not shown on map.)

Medium-grained, reddish brown sands underlie the clay in one bore hole on the north side of Mont St-Hilaire. No exposures were seen, but similar occurrences of sand below marine clays are known in other localities in the Lowlands; this sand may be a useful aquifer.

### 2) Champlain Sea Clays

The clays generally rest on the reddish brown till. The greatest thickness known from borings is 140 feet. Marine fossils were found in some exposures; in other exposures, the clays are assumed to be marine because marine fossils occur elsewhere at similar altitude. At the top of the clay section, some fresh-water fossils were found in clay that may have been eroded and redeposited by the early St. Lawrence river.

Five types of clays are locally recognizable, but they cannot as yet be mapped as separate units. They are:

a) A blue-grey clay, containing specks and blebs of black, odoriferous organic matter, presumably seaweeds. It was observed at Boucherville and in borings in the central part of the area. It contains marine fossils tentatively identified as *Macoma balthica*, *Yoldia arctica* and *Hiatella arctica*. The minimum observed thickness was 15 feet.

b) A blue-grey generally silty clay ("glaise bleue"), usually massive, and very slightly calcareous. It is locally layered and contains the same marine fossils as type (a). The layering is due to differences in grain size and water content. This is the most abundant clay in the area and probably is locally thicker than 100 feet.

c) A blue-grey clay, containing sand partings and grading upward into sand. This clay immediately underlies the high terrace sands and is 4 to 10 feet thick. The sandy layers are generally 1 cm. thick. They are fairly regular in thickness. The same fossils have been observed as in (a), though they are less abundant.

d) A reddish brown, almost red, silty, non-calcareous clay, which was exposed in utility excavations at Boucherville only at one site, above (b) and below the low terrace sands. Its thickness ranges from 0 to 2 feet. It seems to pinch out away from the St. Lawrence river. No fossils were observed in it. In the base of the overlying fluvial sands are shells tentatively identified as Lampsilis siliquoidea, a fresh-water species.

e) A brown to light brown clay with interbedded silty layers. Where sands are not present, this clay forms the top 4 to 6 feet of the clay section in many places throughout the area. The silt and clay laminae are 1 to 2 cm. thick. The brown colour seems to be mainly due to oxidation. Pelecypod shells found in them were tentatively identified as Macoma balthica and Sphaerium sp., the latter a fresh-water shell. These shells in association suggest a shallow estuarine environment.

3) Champlain Sea Gravels and Sands

Champlain Sea gravels and sands are mainly shore deposits. These deposits range from sand to gravelly sand to boulder gravel, and are locally as much as 30 feet thick or more. They occur mainly on the slopes of the mountains. They generally display very distinct cross-bedding on a large scale, including foreset beds, dominantly coarse sand, and topset beds, which comprise pebble to boulder gravel. These features form marine-built terraces.

A few small beach ridges composed of well-rounded pebble gravel occur on the lower slopes of the mountains, especially on the north sides. The map-unit also includes small areas of material of probably glacial origin, small areas of water-worked till and some small areas of gruss (igneous rock decomposed to a loose granular material) and angular slide rock, generally of pebble to cobble size. Areas of bedrock around the mountains are also included in Map-unit 3. The marine gravels contain fossiliferous beds.

The following shells were tentatively identified: Miatella arctica, Mya truncata, Mya arenarea, Macoma balthica, Macoma calcarea, Mytilus edulis, Astarte borealis, Balanus sp. (probably crenatus).

Mya truncata is generally found in growth position on top of or in a layer of reworked till, at the base of the shore deposits.

4) High Terrace Sands

Gadd (1960) used this term to describe sands deposited by the early St. Lawrence river between the 100- and 275-foot altitude in the Bécancour area. The upper limit in the Beloeil area is 200 feet. The sands blanketed parts of the Lowlands, and channels have been eroded through this blanket and into the underlying clay, leaving areas of sand on higher ground.

The sand is generally brown and of medium grain size. It is generally less than 10 feet thick. Mica flakes are abundant. A layer of grey silt, between 0.5 and 1.0 foot thick, commonly occurs between the sand and the underlying clay. In some places the silt is interbedded with thin layers of grey clay. There is a gradational sequence upward from clay to silt to sand, which materials were deposited in a fluvial environment, proof of this being their current bedding. Locally the upper layers have been reworked by wind.

Boulders (Included in Units 2 and 4)

Cobbles and boulders are abundant on the surface of clay in the southern and eastern parts of the area and commonly underlie the high terrace sands. It is not yet feasible to show their distribution on the map supplementing this report. The stones between the sands and clays are generally in or just below a matrix of poorly sorted sand and clay with sparse pebbles. Some of the larger stones appear to have pressed down and deformed the clay beds. The stones are distributed in extensive but irregular patches and they consistently occupy the same stratigraphic position.

This kind of deposit may have originated by ice rafting (mainly river ice), or by the fluvial erosion of clay containing relatively few stones or, again, by transport as the bed load of a river.

5) Low Terrace Sands

This term was used by Gadd (1960) to describe mainly alluvium of the modern St. Lawrence below the 75-foot contour in the Bécancour area. In the Beloeil area, low terrace sands comprise mainly sand with minor clayey sand and silt below an altitude of 75 feet, and include boulder concentrations found on many of the islands in the St. Lawrence. A deltaic deposit, comprising at least 15 feet of medium brown to grey sand, lies southwest of Repentigny.

Deposits probably related in part to Unit (5) have been mapped under the following headings: glei (5a), glei and water-worked till (5b), and cobble and boulder sand of problematic origin (5c).

5a) Glei

A surface deposit of a sticky clayey material, ranging from a dark bluish grey to a light brown colour and locally mottled, occurs where bedrock is very close to the surface and where drainage is poor. Commonly a concentration of angular fragments of the underlying bedrock occurs at the base. This sticky material is called glei by pedologists, and has been mapped separately because in many places it is about 2 feet thick. Presumably the parent material of these deposits is partly of fluvial origin.

5b) Glei and Water-worked Till

Unit (5b) is similar to Unit (5a), but contains scattered patches of till-like material and a lag concentrate of cobbles and boulders. Small concentrations of beach material and alluvium were found in two places. Where this unit exists, the bedrock is usually within five feet from the surface.

5c) Cobble and Boulder Sand of Problematic Origin

Two deposits that resemble till more than alluvium have been mapped as Unit (5c). These consist of stony angular material of cobble size, mixed with some medium to fine sand. They rest on clay. Their texture is generally loose but locally compact. East of the Richelieu river, 12 miles north of St-Hilaire, these deposits are located at the top of a scarp cut in clay. The scarp is about 20 feet high, and the capping of angular material protected the underlying clay from erosion.

The situation of these deposits along the Richelieu river suggests a fluvial origin, but a glacial origin is not precluded.

6) Bouldery Sand in Low Ridges

Ridges of undetermined origin are shown on the accompanying map as Unit 6. These ridges, from 3 to 7 feet high and between 100 and 200 feet wide and slightly sinuous, are generally sub-parallel to the St. Lawrence river. The tops of the ridges usually contain angular to subrounded boulders in a matrix of sand. The boulder content decreases with depth. Clay layers are interbedded with lenses of sand below approximately 4 feet; boulders were not observed below this depth. The clay in them is slightly compact. The ridges rest on clay. Their branching pattern resembles that of a river system. They may represent river channel deposits that have positive relief, owing to lowering of the surface of the clay by shrinkage consequent upon desiccation.

7) Bog Deposits

Bog deposits are mainly brown fibrous peat generally less than 10 feet thick. The most extensive bogs are in depressions in former channels. Pollen studies and radiocarbon dating planned for the future will yield information on the ages of these channels.

## PLEISTOCENE HISTORY

A tentative Pleistocene history of the Beloeil area is as follows: in pre-Two-Creeks time, ice moved southwest across the Beloeil area and deposited a reddish brown, sandy, calcareous till. The ice then retreated and the area south of Mont St-Bruno and Mont St-Hilaire may have been occupied by a glacial lake (Glacial Lake Frontenac). Further glacier recession admitted the sea to the region, about 11,400 years ago. The early glacial lake and marine waters winnowed the fines from the upperpart of the till, left lag concentrates and, in a few places, blanketed the floor of the basin with red sands. Marine clays were then deposited. The earth's crust, relieved of the load of glacier ice, rose isostatically causing the relative position of sea level to fall. Eventually the area became part of an estuary in which the water was fresh or slightly brackish. During this phase, sand carried by the ancient St. Lawrence and Richelieu rivers was deposited downstream from Mont St-Bruno and Mont St-Hilaire as high terrace sands. Subsequently, the modern St. Lawrence river first flowed in a braided pattern and then, narrowing down in successive steps, gradually formed its present channel. Bog deposits formed in parts of these channels since they were abandoned. Most of the channels are now occupied by underfit streams.

## APPLIED GEOLOGY

### Groundwater

#### Bedrock Aquifers

Most of the bedrock in the Beloeil area is not permeable, except where joints, bedding planes, faults and solution openings permit the rapid movement of water. Several bedrock aquifers yield salt water. Bedrock formations of the area do not generally yield any great quantity of water, but locally they supply domestic needs. Presumably the porous Potsdam sandstone could yield large quantities of water, but to the knowledge of the writers there are no records of wells penetrating this formation.

#### Glacial Drift Aquifers

The till and the red sand overlying this till form aquifers capable of supplying domestic needs in the area. The till contains sand lenses that yield water, though the supply of water from them is highly variable.

#### Marine Clays

The marine clays locally supply small quantities of water for domestic use, especially the upper clays that have interbedded silt-rich layers. Some farms are supplied only by clay aquifers which are tapped by using open pipes sunk to a depth of about 25 feet. These wells have a very slow rate of recharge. Several wells in clay have yielded saline water. On many farms, small reservoirs have been excavated in clay; these reservoirs store water from rain or seepage through the silty layers. The water thus collected is used for stock. Gas occurs in clay in some places. The gas is highly inflammable and is a hazard in well-drilling.

### Marine Sand and Gravel and Fluvial Sand Aquifers

The large bodies of gravels and sands surrounding the two mountains yield much groundwater. These materials are generally very permeable and rain water percolates down to the base where it emerges as spring water. Fluvial sands, though generally less than 10 feet thick, are potential aquifers.

## ENGINEERING GEOLOGY

### Construction Material

Large quantities of sand and gravel are concentrated around the mountains and are currently used as road material and concrete aggregate. Several types of bedrock, especially the Lorraine shale (Goyer quarry), the nepheline syenite (east side of St-Hilaire) and an acidic sill (Varennes quarry), are crushed and used as construction material.

### Foundation Problems and Embankment Stability

The marine clays in the Lowlands are sensitive (Crawford, 1961); if disturbed their strength decreases by a factor of 8 to 100 and they flow. The natural water content of the marine clays in many cases exceeds their liquid limit. A height of about 50 feet seems to be a limiting value for the height of scarps cut in clays: higher scarps are susceptible to the earth-flow type of landslides. No evidence of landslides was observed where scarps are less than 30 feet high. The average slope angle in these cases varies from 10 to 15°. Along the St. Lawrence, waves produced by ships undermined the banks and have contributed a great deal to the retreat of the shoreline in some places. Escarpments in sands have natural slopes ranging from 30 to 35 degrees.

### Seismic Velocities

A hammer seismograph was used to outline the bedrock topography. The velocities of different types of material encountered in the area are given in Table 1.

Wherever the velocities were measured in clay, the top layer, generally partly desiccated, was observed to have a velocity of 700 to 1,000 feet per second. The underlying layer has a velocity of 4,000 to 4,500 feet per second.

Table 1

Seismic Velocities (ft./sec.) of Various Materials in the Beloeil Area

| Material | Velocity Range |
|---|---|
| High terrace sand | 800 ft./sec. |
| Upper (brown) partly layered clay | 700-1,000 ft./sec. |
| Grey marine clay | 4,000-4,500 ft./sec. |
| Till, normal | 1,800-2,400 ft./sec. |
| Bedrock: Lower Lorraine shale | 7,000-9,000 ft./sec. |
| Igneous rocks | 16,500 ft./sec. |

## Brick-making

No brick factory is active in the area today. A detailed study of the mineralogy of the clay should, however, be made with respect to the suitability of this commodity for brick-making.

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