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MONTMORENCY FALLS

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QUEBEC DEPARTMENT OF NATURAL RESOURCES

Honorable Paul-E. Allard, Minister

MINES BRANCH

Photo O. F. Q.

MONTMORENCY FALLS

by

R. Bureau and J. Riva

Geological Services

Quebec
1968

P.G. 3

Cover photo:

MONTMORENCY FALLS ***(274 feet high)***

On the right, Ordovician shales dip toward the St. Lawrence river. In the background, Montmorency Falls flows over a cliff made up of Precambrian gneiss. Above the falls, Ordovician (Trenton) limestones lie horizontally.

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FOREWORD

The Geological Services of the Quebec Department of Natural Resources are preparing a series of non-technical pamphlets on the geology and geologic history of many parts of the Province. This series is intended to introduce to residents of the Province and to tourists some of the fundamentals of the long geologic history through which particular areas, and the Province as a whole, have passed before the present landscape or scenery was produced. Great lengths of time and great changes as time moved on are the essence of geologic history.

The description of each area is accompanied by illustrations of the main features of both the land forms and the geology.

The photographs in this pamphlet are by the Geological Services of the Quebec Department of Natural Resources unless specifically acknowledged.

PAUL-E. GRENIER,
Director of Geological Services

Quebec, 1968

MONTMORENCY FALLS

One hundred feet higher than Niagara Falls

Montmorency Falls is situated between Courville and Boischatel on the north shore of St. Lawrence river, some 8 miles northeast of Québec City. It was named by Samuel de Champlain in 1608 in honor of Charles de Montmorency, admiral of France and Brittany, viceroy of New France.

Although not as magnificent as Niagara Falls Montmorency is more than 100 feet higher, the rough waters of the river falling down a 274-foot cliff before they reach the St. Lawrence. The discharge has been appreciably reduced since a dam was built in 1885 to produce electric power for Québec City.

Swift waters

The head of Montmorency river is in the Laurentians, north of Québec City. From there it flows about 20 miles in a narrow valley, in places through a succession of rapids and cascades between fairly high hills of Precambrian rock. Upstream from l'Étang-du-Moulin, the river-bed is made up of Precambrian gneiss* but the banks are boulders overlain by clay and sand deposited in the former Champlain sea.

Symbol * refers to an explanation in the glossary.

Photo No. I — Canyon cut into the Trenton limestone by Montmorency river upstream from the dam. This part of the river is now completely flooded.

Natural steps

Downstream from l'Étang-du-Moulin *(Photo No. 2)*, the river dug its bed through softer sedimentary* rocks, such as limestone* and shale*, but cut only a few feet into the underlying gneissic rock. In this area, a fairly deep canyon was dug by the erosive work of the river waters. Horizontal rock strata, overhanging in places, may be seen on the shores. The benches or levels so formed are known as " natural steps ". *(Photo No. 1)*. Unfortunately, the steps were flooded in large part when the water level was raised by the dam, but it is still possible to see them between the top of the falls and the dam. The east bank of the river here may be reached by several trails.

No swallow hole

For a long time a swallow hole was believed to exist at the base of the falls. However, it was proved by observations of frog-men in 1959 that the maximum depth is 55 feet and that there is an average of 35 feet in other parts of the basin (cf. *L'Action Catholique,* Nov. 28th and Dec. 21st, 1959).

Under the ice

All land forms may be explained by their geological history. To account for the presence of Montmorency Falls, we have to go back thousands of years. The last continental ice retreated from the St. Lawrence valley about 11,500 to 12,000 years ago. The ice-sheet* referred to was thousands of feet thick and similar in appearance to those presently covering Antarctica and Greenland. Four times during the last million years, most of Canada was covered by such ice-sheets.

And now, the sea

As the ice melted, the valley was invaded by the waters of the Atlantic Ocean and so the Champlain sea was formed. This came about because the weight of the thick ice had depressed the land relative to sea-level. So, at this time the whole St. Lawrence valley was occupied by an interior sea. Fossils* of animals that lived in this sea have been found at present altitudes of 400 feet at Québec City and 570 feet at Montréal. The Champlain Sea reached a point 100 miles beyond Ottawa in the Ottawa valley and extended almost to Kingston and to the south end of Lake Champlain. The whole area between the Appalachians and the Laurentians was covered by this sea.

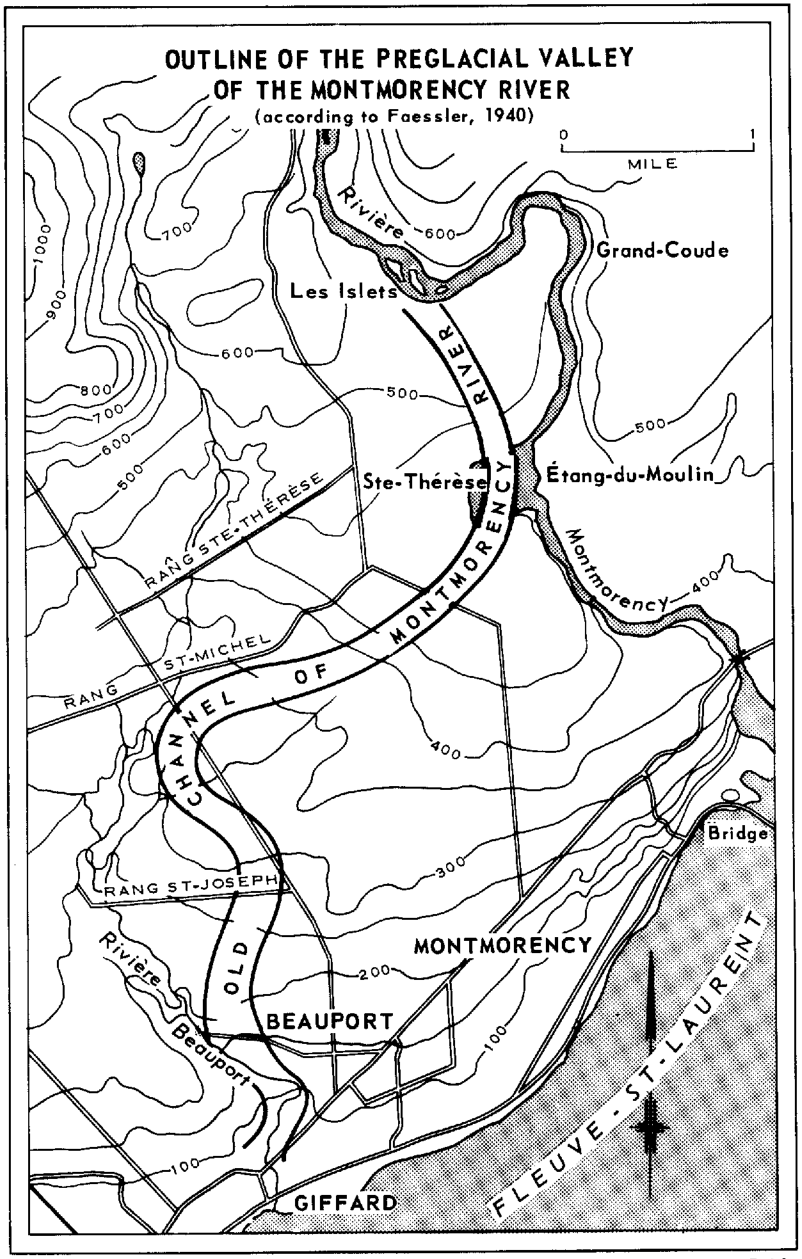

FIGURE 1

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If such changes, geologically quite recent, are hard to accept it may help to know that the St. Lawrence river below Québec City spreads some miles beyond its channel and that its waters are salty as far up as the northeast end of Orléans island. In other words, the shore of the St. Lawrence below Québec City is still flooded by Atlantic waters.

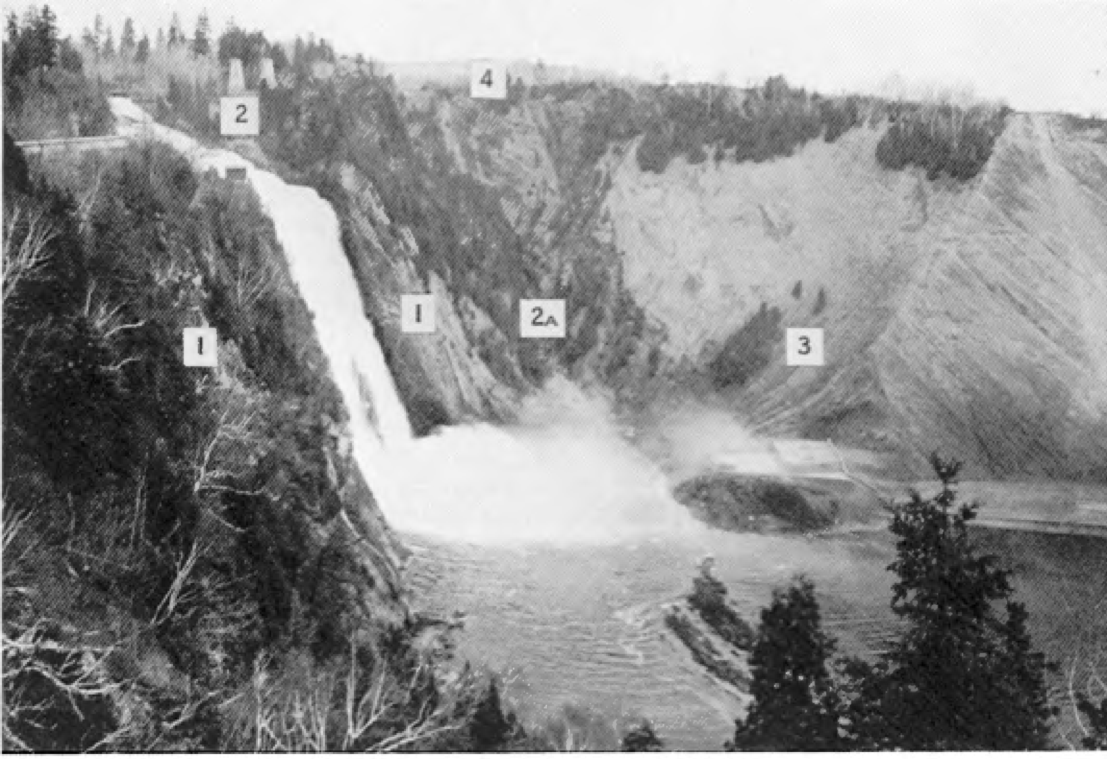
Evidence of the presence of Champlain Sea waters at Montmorency Falls may be seen along the crest of the cliff, east of the falls *(see site 4, Photo No. 2)*. Here, at an elevation of 200 feet, marine fossil shells may be found in gravels that mark the position of a former seashore.

Change in course

Prior to the glacial period, the course of the river was much different, as was established by Faessler in 1940 *(Fig. No. 1)*. The river entered the St. Lawrence 3½ miles to the west, at Giffard, along the present valley of Beauport creek. It was forced out of its preglacial valley by a barrier of glacial debris left by the retreating ice sheet and had to develop a new course in order to reach the St. Lawrence.

At that time, the river banks, made up of Ordovician *(see Geologic Time Table)* shaly rocks, were approximately along highway No. 15, in front of the falls. Within a few thousand years the cutting action of the river through these soft rocks hollowed out the amphitheatre now seen in front of the falls.

When the river encountered the Precambrian* gneiss, a harder rock, erosion was slowed down considerably and the river bed was maintained at a higher level. Literally the gneiss holds up the falls, and the falls are the result of different rates of erosion between two different rock types, one being soft, the other hard.



[Photo by Roland Coulombe]

Photo No. II — Geological view of Montmorency Falls.
(from the observation post at Maison Montmorency)

1 - Precambrian gneiss which constitutes the fault-plane cliff.

2 - Horizontal strata* of Trenton limestone above the falls.

2a - Inclined strata of the same Trenton limestone, below the falls.

3 - Sandy shale Trenton-Utica (Ordovician) overlying the limestone.

4 - Unconsolidated material, partly made up of Pleistocene sand, containing marine shells.

Earthquake

Another important factor in the development of the falls is a fault* which parallels the present cliff and extends at least 27 miles, from Giffard to Cape Tourmente. This fault, which is later than the Ordovician rocks, resulted in a downward movement of about 500 feet of the rock mass on the St. Lawrence side. The effect of the fault is illustrated by the cross-section *(Figure No. 2)*. The steep dip of the rocks at the base of the falls was caused by friction or dragging along the fault.

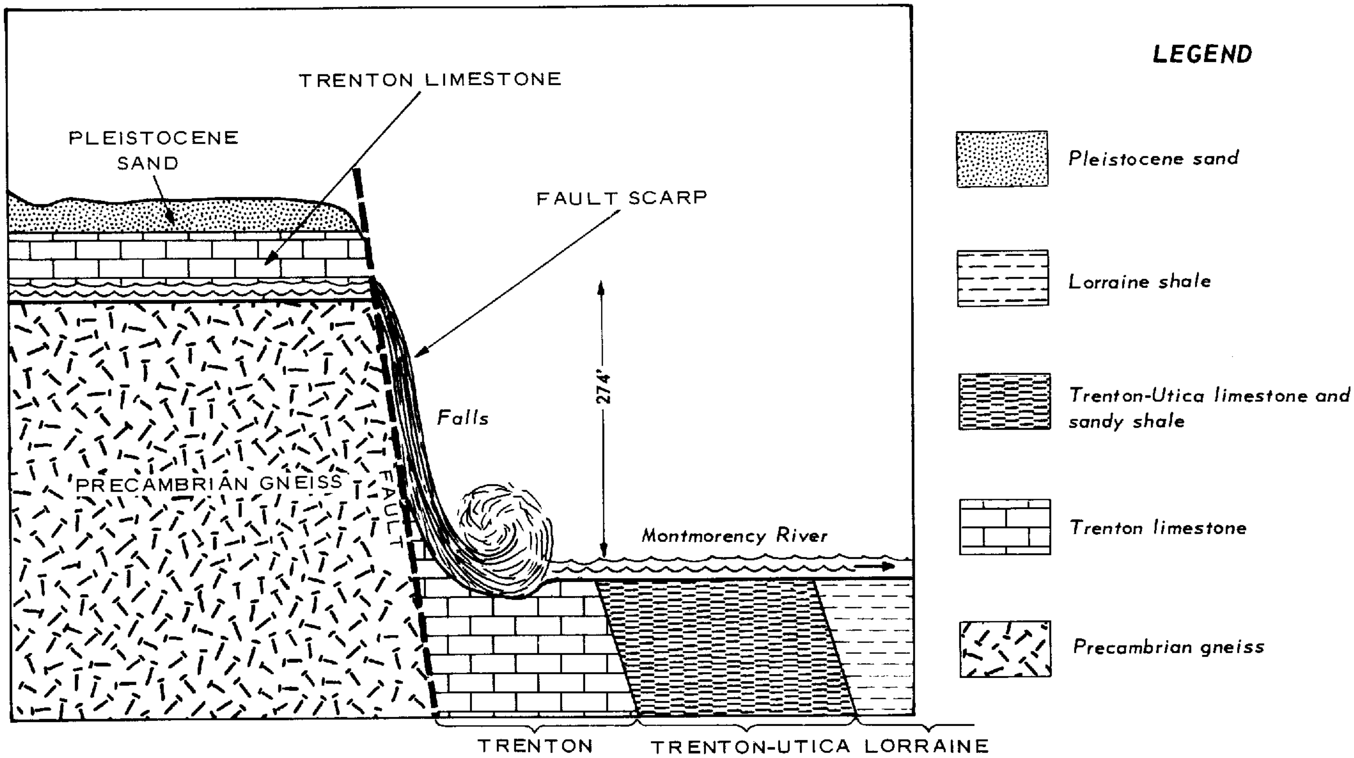
Similar, still active faults are the prime cause of earthquakes of the present time.

Potholes

To this point, we have dealt with two quite different types of rock which have been eroded by the action of the river : the Precambrian gneiss and the Ordovician sedimentary rocks*. The gneiss may be seen in the upper part of Montmorency river and, also, on a low ridge about 500 feet upstream from the bridge above the falls *(Fig. No. 3)*. At this place, which can be reached easily by a trail, "potholes" may be seen in the gneiss. These are circular cavities formed in the bed of rough-water rivers or at the base of falls by the wearing action of sand and pebbles caught in a whirling movement. The potholes were cut prior to the deposition of the Ordovician rocks because they are still partly filled with Ordovician (Trenton*) limestone. Gneiss outcrops at a few places on the east bank of the river, upstream and downstream from the bridge.

Life remnants (fossils)

The gneiss and the Ordovician rock formations are separated in time by several hundred million years. The former



SCHEMATIC SECTION IN GEOLOGICAL FORMATIONS AT MONTMORENCY FALLS

FIGURE 2

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lacks fossils, whereas the latter contains a wide variety. Fossils, when studied along with those from other areas, help to correlate the formation in which they occur. This is why we know we are dealing with rocks from part of the Ordovician known as "Trenton". Moreover, some of the fossils indicate that the temperature of this Trenton sea was much warmer than that of our present northern seas. These fossils (calcareous algae*) may be seen a short distance upstream from the falls on the east bank of the river. The algae are fossilitized in their position of growth directly on the Precambrian gneiss that was the sea floor of the Ordovician sea.

Several other types of fossils such as brachiopods and trilobites* *(see plate I)*, gastropods*, pelecypods*, cephalopods etc... are found in the Trenton rocks on the west side of the crest of the falls *(see site 2, photo No. 2)*. The younger Lorraine* rocks in front of the falls *(see site 3, photo No. 2)* contain graptolites* and trilobites.

On the following plate are illustrated the most common fossils found in the rocks of the area and brief comments on the various types.

All fossils illustrated in this booklet range from ¼" to 2" in size, except for the cephalopods which may reach a few feet.

Photographs of fossils were taken from various sources.

(1 to 6) TRILOBITES

Amongst the most common fossils in the Trenton limestone are the trilobites, a type of extinct arthropod*, which characterized the Paleozoic. These rather small animals first appeared some 600 million years ago and dis-

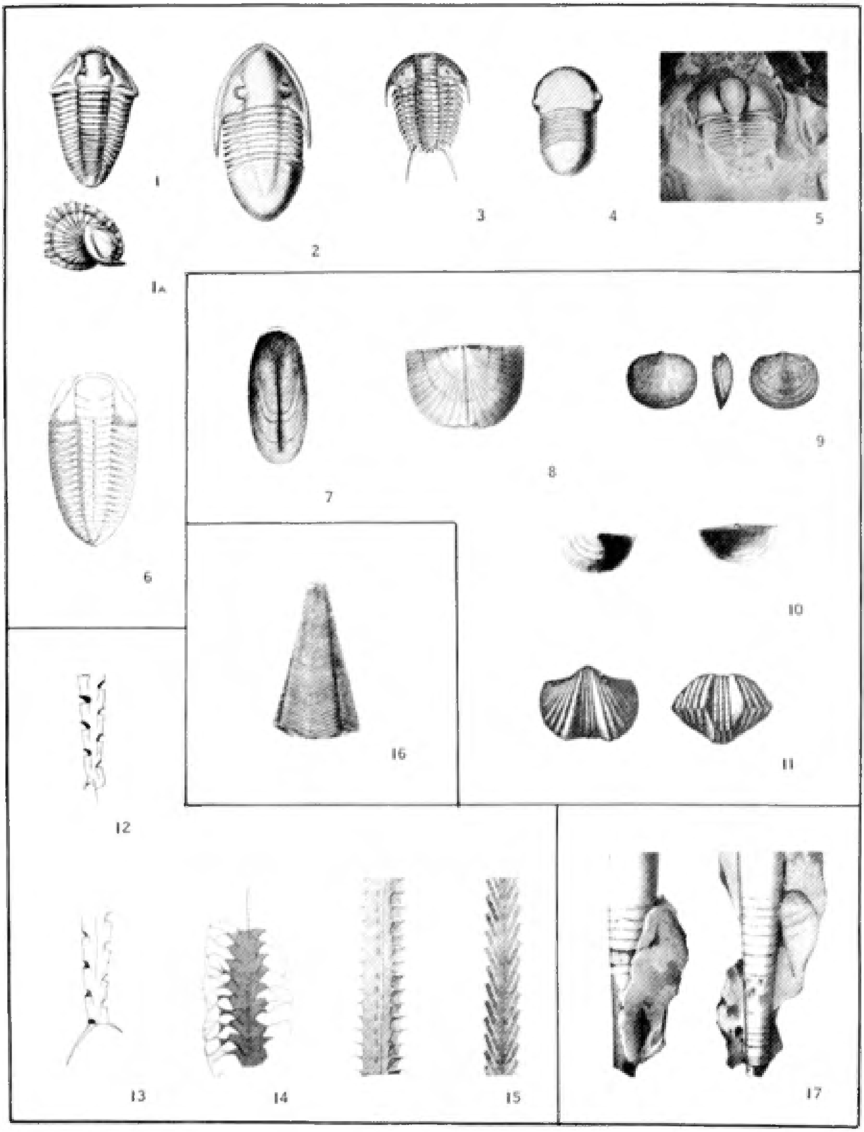

PLATE I

PLATE 1

(Caption)

Trilobites:

1. - *Flexicalymene senaria* (Conrad)
1a - Enrolled specimen
2. - *Isoletus gigas* DeKay
3. - *Ceraurus pleurexanthemus* Green
4. - *Bumastus* sp.
5. - *Cryptolithus tesselatus* Green
6. - *Triarthrus beckii* Green

Brachiopods:

7. - Inarticulated brachiopod of the Linguloid group
8. - *Rafinesquina* sp.
9. - Dalmanellacea brachiopod
10. - *Sowerbyella* sp.
11. - *Platystrophia* sp.

Graptolites:

12. - *Climacograptus typicalis* Hall
13. - *Climacograptus spiniferus* Ruedemann
14. - *Neurograptus* sp.
15. - *Orthograptus quadrimucronatus* Hall

16. - *Conularia trentonensis* Hall
17. - Cephalopod, Orthocone type

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appeared about 270 million years ago. The horse-shoe crab* is the present-day animal form most alike the trilobites.

(7 to 11) BRACHIOPODS

Brachiopods are small variable-shaped animals composed of two unequal valves. Approximately 30,000 fossil forms

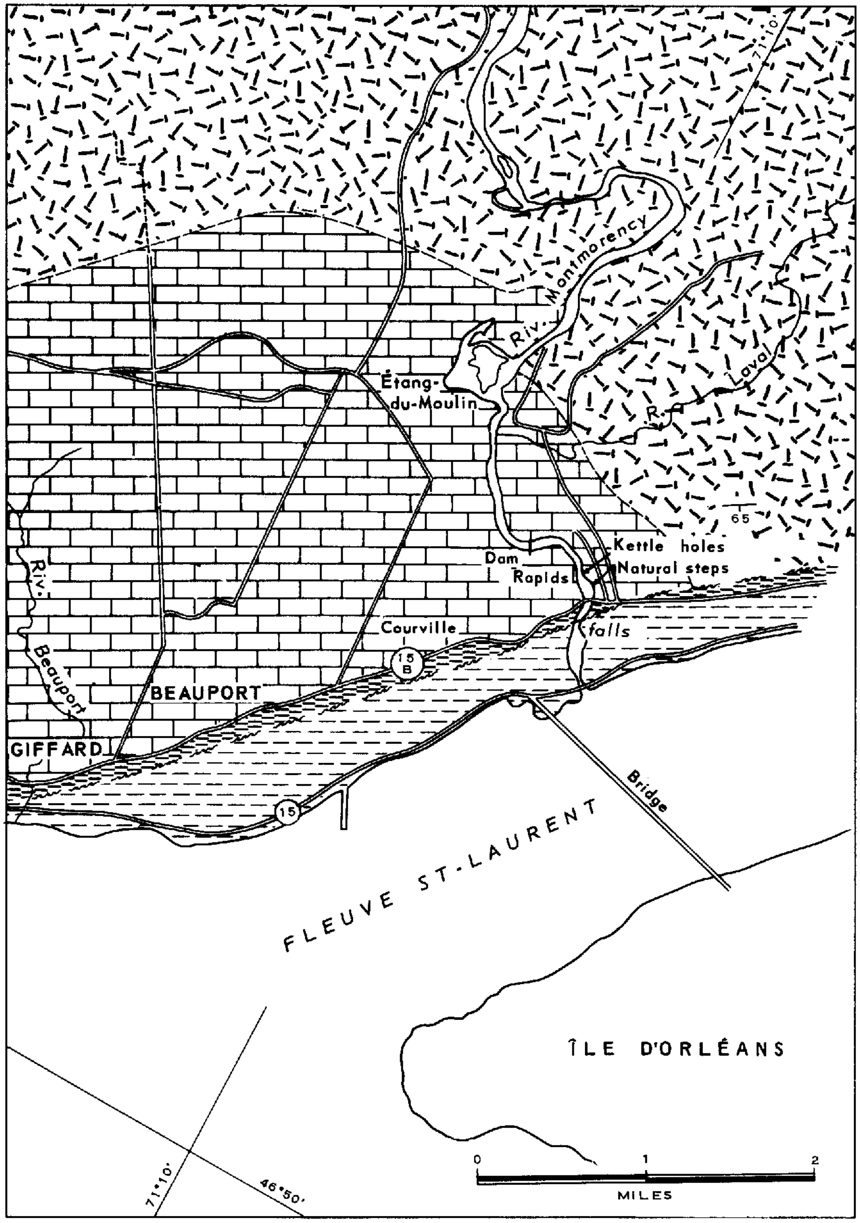

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FIGURE 3

LEGEND

ORDOVICIAN

Lorraine shale

Trenton-Utica limestone and sandy shale

Trenton limestone

PRECAMBRIAN

Gneiss

Approximate contact

Fault

65 *Dip*

GEOLOGY OF THE MONTMORENCY FALLS AREA

(according to Putman, 1945)

R. Bureau and J. Riva, 1967

FIGURE 3

of brachiopods have been found but only 200 are known to be living now. They appeared at the beginning of the Paleozoic, about 600 million years ago.

(12 to 15) GRAPTOLITES

Finely indented imprints, which resemble pencil marks, were left on the surface of some sedimentary rocks by the delicately shaped graptolites. These are organisms grouped in colonies. They lived through the Lower and Middle Paleozoic only, and so disappeared some 300 million years ago.

(16) CONULARIIDS

Conulariids are strange sea animals which have evolved from the Ordovician time (450 to 500 million years ago) and lasted into Jurassic (150 million years ago). They developed to the shape of a pyramid or an empty cone. The external part of partitions has a herring-bone structure with various patterns.

(17) CEPHALOPODS

Cephalopods are sea mollusks. They are known as fossils since the Cambrian, or for some 550 million years. They were most abundant in the Ordovician and declined in number till after the Denovian, more or less 350 million years ago. From then on they changed their shape, and by Mesozoic times had reached their maximum development. The squid, cuttle-fish, octopus, and nautilus (devil-fish) are present-day forms.

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Geologic Time Table

(after Arthur Holmes, 1960)

ERA	PERIOD		(Numbers in parentheses refer to millions of years)
	Recent		Post last great glaciation - 10,000 years to Present Age of Man
Cenozoic *(70)* Age of Mammals, Birds, and Modern Plants	Pleistocene		Ice Age (1) — 1,000,000 years to Present.
	Pliocene	(10)	
	Miocene	(14)	
	Oligocene	(15)	
	Eocene	(30)	
Mesozoic *(155)* Age of Reptiles (dinosaurs etc.)	Cretaceous	(65)	Age of reptiles (dinosaurs eg.)
	Jurassic	(45)	
	Triassic	(45)	First flowering plants.
Age of Vertebrates and Land Plants	Permian	(45)	Extinction of trilobites and certain corals.
	Carboniferous	(80)	Age of Amphibians Age of Plants
Paleozoic *(373)*	Devonian	(50)	Age of Fishes
	Silurian	(40)	Corals, brachiopods (now rel. rare), cephalopods.
Age of Invertebrates and Marine Plants	Ordovician	(60)	Graptolites and trilobites (now extinct), brachiopods, cephalopods.
	Cambrian	(100)	Fossils common, most invertebrate classes present. Trilobites were the dominant animals.
Precambrian (4,000 to 600)	Beginning of life. — Single-celled forms found as well as algal remains (seaweeds etc.), worm burrows, rare shelled invertebrates, sponge spicules, jelly fish? — All evidences of life are very scarce.		
Pre-Precambrian (? 5,000 to 4,000)	Development of the Planet Earth and of its geologic crust.		

GLOSSARY

Algae

Simple marine plants, without roots or stems, which produce their own food. Some fossil forms in the Trenton limestone at Montmorency Falls.

Arthropods

Group of crustacea to which belong crabs, insects, scorpions, etc.

Limestone

Sedimentary rock, of various colors but usually gray, common in the St. Lawrence Lowlands. It may be formed by accumulation at the bottom of the sea, and solidification (lithification) of shells or skeletons of animals. There are several types and some are used in the building industry. The limestone at Montmorency Falls was deposited in an Ordovician-age sea.

Fault

Rupture, fracture in rocks of Earth's crust with movement of one side (wall) relative to the other.

Fossils

Animal or plant remains, or signs of their presence, preserved in rocks.

Gastropods

Animals so-called because they crawl by means of a fleshy disk situated on the ventral side of the body.

They have a distinct head provided with two tentacles, and a spiral shell. Aquatic and terrestrial forms are known. Gastropods first appear in Cambrian time *(see table of geological times)*. The Trenton limestone contains several types. More than 35,000 species are now living, and approximately 15,000 are known in fossil form.

Glacier

Snow converted by its quantity and weight into ice. Under the effect of pressure the underlying layers become plastic so that the glacier can spread away from its source. We are referring here to a continental glacier or ice-sheet which spreads over wide areas. The latest period of glaciation is known as Pleistocene and extends from two million years ago to our time. The topography of the province of Quebec was considerably modified by the action of ice sheets.

Gneiss

Gneisses underlie large areas in the Laurentians. They are metamorphic (i.e. altered) rocks characterized by a banded structure which results from the parallel arrangement of the various mineral types. The color varies according to the component minerals.

Ice-sheet

See glacier.

Horse-shoe Crab

Fairly large marine animal somewhat similar in shape to trilobites. Living specimens may be seen at the Quebec Aquarium.

Lorraine

See Utica.

Nautilus

Marine mollusk, highly developed, known since Paleozoic times. Still lives in the waters of Pacific Ocean near the Philippines and Indonesia.

Pelecypods

Pelecypods are aquatic animals, most of them marine, the body of which is enclosed in a shell composed of two valves that are tied by a ligament and hinged together. The word "pelecypod" refers to the "hatchet" shape of their foot. Pelecypods are known since Ordovician times. Many species known under the generalized names of clams, mussels, scallops, oysters, etc. exist today.

Precambrian

Geological era which began with the appearance of the solid crust on the earth, more than 4 billion years ago. In Canada, the large area underlain by Precambrian rocks is known as the Canadian Shield. It circles Hudson's Bay and extends to the Labrador coast. Its edge follows the St. Lawrence estuary to Cape Tourmente and at Montmorency Falls is marked by a cliff.

Sedimentary rocks

Rocks originating from accumulation of sediments, and characterized primarily by the fact that they are layered or stratified (cf. strata).

Shale

Layered rock made up of very fine grains (muds). According to their composition they may be argillaceous, bituminous, sandy, etc.

Sediments

Any settling (of rock fragments or particles, organic remains, products of chemical reactions) in water or in the open air.

Strata (or bed)

The smallest unit of sedimentation in sedimentary rocks. It is differentiated by its composition or physical properties.

Trenton

This name refers to Trenton Falls in the state of New York where the geological formation by this name is typically represented. The limestone which constitutes this formation underlies a large part of the St. Lawrence Lowlands. Fossils are numerous and date the Trenton as middle Ordovician in age.

Utica and Lorraine

Two rock formations, Middle and Upper Ordovician in age respectively, overlying, and therefore younger than, the Trenton. They are made up of shale and sandstone. The shale is calcareous, argillaceous and locally bituminous. It contains numerous graptolites, trilobites and other fossils.