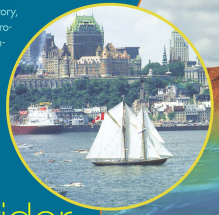
Québec Geoscape

A billion years of history . . .

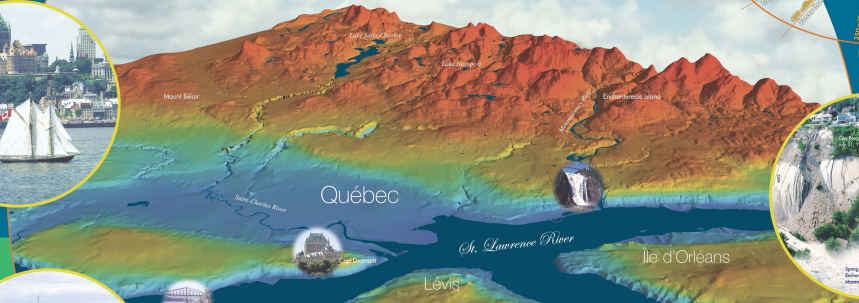
Founded atop cap Diamant, Québec surveys the St. Lawrence River and offers an incomparable panorama, where past and present meet. The first city established in the New World, Québec is a World Heritage Site where visitors can wander through historic districts dating back to the birth of the colony, or explore further afield and marvel at the magnificent natural settings in the immediate vicinity of the city. Located at the junction of three major geological provinces, the Québec region is the product of a tumultuous billion-year history. Some of the most beautiful features of the region remain as a legacy of this history, which has also produced an environment that can be subject to the whims of nature.

Montmorency Falls: a geological fault
Jacques Cartier River valley: a glacial trough



An extraordinary geological heritage

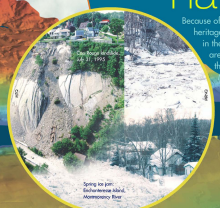
Tourist attractions that bear witness to a spectacular geological past: the disappearance of oceans, the formation of mountains, the passage of glaciers...



Once upon a time...

The whims of nature

Because of their geological heritage, certain locations in the Québec region are more prone to the vagaries of Mother Nature.


Cap Rouge landslide, Jul. 31, 1995
Spring ice jam: Sainte-Anne Island, Montmorency River

A vital corridor

The St. Lawrence River is one of the largest navigable rivers in the world. It flows through a rocky valley partially filled with the deposits of an ancient postglacial sea.

The cliffs and stairs of Québec connect two distinct geological provinces and straddle one of the most important faults in eastern North America: the Logan Fault.

Upper TOWN
Lower TOWN

rocks are part of our history

Each of the major geological domains of the Québec region is a rich source of building stones and, ever since the French regime in the seventeenth century, builders have made extensive use of all of them.

LE QUÉBEC SECOUÉ
LE SEISME DE NOVEMBRE A SURPRIS LES EXPERTS
SOLEIL
5,2!
Une vieille faille s'est «réveillée»
QUAKE PERIL HERE MOST REMOTE: QUEBEC HAS A "FAULT LINE"
À Rivière-du-Loup UN VENT DE PANIQUE
LE GOUVERNEMENT SE DIT PRÊT À AIDER

The earth quakes under Québec

Many of the earthquakes that have been felt in Québec were centred in the region, but it is the more powerful events that have occurred in the Charlevoix and Saguenay areas that are responsible for the city's classification as a moderate earthquake risk zone.

www.cgq-qgc.ca/english/geoscape/qc

Québec Geoscape
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Pascale Côté, Aicha Achab, Yves Michaud
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Québec Geoscape

A billion years of history...

A vital corridor

WHY IS IT WHERE IT IS?

The position of the St. Lawrence valley is dictated by the location of an ancient system of normal faults. The St. Lawrence rift system formed some 600 million years ago, in the Precambrian, during the break-up of a supercontinent that led to the formation of the Iapetus Ocean, the forerunner of the present-day Atlantic.

Released from the burden of the glacier but still isostatically depressed as a result of its weight, the Québec region is flooded by the Champlain Sea to an elevation of 230 m.

Québec gradually rebounds, and the Champlain Sea recedes. The first two high points on île d'Orléans emerge at an elevation of about 120 m.

As the area continues to rebound, the sea becomes a river. At an elevation of about 60 m, numerous channels develop around the higher points of land.

The course followed by the present-day St. Lawrence River is the product of a long history of tectonic, glacial, and marine events.

THE STORY OF AN EPHEMERAL SEA

The current location of the river is an artefact of the most recent period of glaciation. After the ice melted, the postglacial Champlain Sea occupied the St. Lawrence valley for thousands of years. As the sea receded, the river bed was gradually established in the glacial materials left behind. About 9500 years ago, the Québec promontory was an island surrounded by two channels. The north channel, now the site of Québec's Lower Town, gradually dried up as the land rebounded. Today, the river and the tidal stream flow entirely along the ancient south channel.

A LAYOVER ON THE FLATS

Many of the flats that border the St. Lawrence estuary, such as those at Cap-Tourmente and Montmagny, are made up of vast accumulations of muddy sediment left behind after the retreat of the postglacial sea. These tidal mudflats are an ideal environment for the growth of bulrushes, a plant whose roots are an essential part of the diet of migrating snow geese.

A GATEWAY TO DEVELOPMENT

In 1608, when Champlain decided to establish a colony at the site of present-day Québec, it was because of the many advantages afforded by the geography of the location. From a strategic point of view, the Québec promontory offered an excellent natural defence. Because of the narrowness of the river, the passage of every ship could be monitored from the shore. From an economic point of view, the river was also a natural gateway to the interior of the continent, guaranteeing access to the fur trade. Because of its location between the estuary and the river, Québec has long been a transshipment point from marine transportation to rail and river systems, a factor which has contributed greatly to its growth and to its development as a major seaport.

The narrowing of the river inspired the Amerindian name for the city, 'Québec', witch became a part of history and means 'where the river narrows.'

GSC

Sir William Logan founded the Geological Survey of Canada in 1842 and was its director for 27 years. He was the first person to study the fault that now bears his name.

Upper TOWN Lower TOWN

A MAJOR GEOLOGICAL FAULT

When you climb from the Lower Town to the Upper Town of Québec, you move from the St. Lawrence Platform into the Appalachian Orogen. The boundary between these two geological provinces, or the northern edge of the Appalachians, is the Logan Fault, which can be followed along such streets as Arago, côte de la Pente-Douce, and boulevard du Versant-Nord. It is the main structure in a series of thrust faults that stretches from Lake Champlain in southern Quebec to the Gaspésie, and passes through Cap-Rouge, Sainte-Foy, Québec, and île d'Orléans. The Logan Fault represents a fracture in the Earth's crust. The fracture plane is shallowly inclined. Slabs of rock were transported along the fault in thrust sheets that were pushed toward the northwest as part of continental collision leading to the formation of the Appalachians. Also referred to as 'Logan's Line,' this fault has been inactive for hundreds of millions of years.

The deformation structures typical of the Appalachian thrust sheets are clearly in evidence at chute de la Chaudière.

THE APPALACHIANS IN QUÉBEC

The rocks of the Québec promontory are part of the Appalachian Orogen. This chain of mountains extends from Newfoundland to Alabama and was built up over a period of 250 million years. Along the côte Salaberry, the côte d'Abraham, and boulevard Henri IV, and up the stairs of the Lower Town of Québec, you rise through the thrust sheets, moving from one geological environment to another.

Every day, thousands travel along boulevard du Versant-Nord and its bike path, which follow the Logan Fault.

STEEP SLOPES ...

When mountains form, collision-generated tectonic forces push against rock materials already in place. Imagine a bulldozer at work.

... A SET OF SHEETS

As all this thrusting takes place, materials break, fold and stack up. The result is an accumulation known as a thrust sheet or nappe

An extraordinary geological heritage

Québec is situated at the junction of three separate major geological domains or provinces. These rocky assemblages, ranging from 450 million to one billion years in age, are partially overlain by unconsolidated sediment (clay, sand, and gravel) that developed during the Quaternary, the current period of geological history. Today's landscape was generated by the collision and break-up of tectonic plates and refined by erosional processes.

Grenville Province

Province	Era	Rocks
Grenville	Precambrian	igneous, metamorphic

THE CANADIAN SHIELD AT QUÉBEC: THE GRENVILLE PROVINCE

The Grenville Province is a subdivision of the Canadian Shield, and it is here that the oldest rocks in the region are found. These rocks are the deep roots, uncovered by erosion, of a chain of mountains that formed between 1500 and 900 million years ago. At that time, Laurentia, the ancestor of the Canadian Shield, collided with other continents now dispersed across the surface of the Earth. An imposing, Himalaya-type mountain range grew out of this collision. The rocks of the Laurentians contain deformation and metamorphic structures that tell the story of those tumultuous times.

J.-L. Lethiec — J. Sylvain

Nine hundred million years ago, Mount Sainte-Anne was part of a mountain range that resembled the present-day Himalayas.

St. Lawrence Platform

Province	Era	Rocks
St. Lawrence Platform	Paleozoic	undeformed sedimentary

THE LOWLANDS: THE ST. LAWRENCE PLATFORM

At the end of the Precambrian, about 600 million years ago, the region around Québec was located near the Earth's equator. Part of the Grenville mountain range subsided in a long trench known as a rift. Over time, the trench gradually widened, giving birth to an ocean. From 600 to approximately 460 million years ago, the Earth's crust remained relatively stable in the Québec region, as sediments accumulated on the platform along the edge of the continent. The landscape at the time probably resembled that of the present-day Atlantic coast. The fault at Montmorency Falls, where the rocks of the Grenville Province come into contact with those of the St. Lawrence Platform, is thought to be a remnant of this time.

Five hundred years ago, the rocks of the St. Lawrence Platform formed in a tropical sea. At that time, the region was located at a much milder latitude.

Appalachian Orogen

Province	Era	Rocks
Appalachian Orogen	Paleozoic	deformed sedimentary

THE APPALACHIAN OROGEN: THRUST SHEETS

From 460 to about 380 million years ago, a major tectonic upheaval produced another chain of mountains: the Appalachians. Laid down along major breaks in the Earth's crust, thick sequences of rocks were carried over several tens of kilometres and overrode the St. Lawrence Platform. Then, once again, erosion resumed the inexorably slow work of demolition. The Québec promontory, most of île d'Orléans, and the entire south shore of the St. Lawrence are part of the Appalachian Orogen, although the first hint of mountainous terrain only appears about 40 km to the south.

About 450 million years ago, the Upper Town of Québec and the areas of Sainte-Foy, Sillery, and Cap- Rouge resembled a present-day alpine landscape.

... and the Quaternary

Period	Unconsolidated
Quaternary	gravel, sand, clay

THE QUATERNARY: A PERIOD OF GLACIATION

Between 1 800 000 and 10 000 years ago, several periods of glaciation took place, each burying almost all of the northern part of the continent under an impressive buildup of ice. The slow movement of ice sheets (continental glaciers) helped flatten and erode the mountains and plateaus of the Grenville Province and the Appalachian Orogen. The most recent of these glaciations ended about 10 000 years ago. Many of the valleys and rivers of the Québec region are the legacy of the advance, retreat, and melting of these continental glaciers. About 12 000 years ago, at the height of the deglaciation process, the continent was still isostatically depressed owing to the weight of the ice sheet. As a result, an arm of the Atlantic was able to invade the St. Lawrence lowlands, and the Champlain Sea was born. The sediments left behind by this postglacial sea led to the development of the best farmland in the St. Lawrence valley.

M. Morency

Eighteen thousand years ago, the entire region lay under a thick layer of ice similar to the Antarctic ice sheet.

rocks are part of our history

THE GRANITES OF THE GRENVILLE PROVINCE

R. Ledoux

The first meeting between white man and Native American, Cartier-Brébœuf Park — Québec Bridge — Saint-Coeur-de-Marie Church, 580, Grande-Allée Est

The opening of a railway in 1875 meant that the Rivière-à-Pierre granite could be mined. This rock, which is twice as old as the other rocks of the Québec region, is also much more resistant. It is highly valued for use as paving stones and monument bases. The piers of the Québec Bridge were carved from Rivière-à-Pierre granite, as was the pedestal for the Statue of Liberty in New York.

BUILDING STONE FROM THE ST. LAWRENCE PLATFORM

R. Ledoux

The limestone trim of the Château Frontenac, one of the most photographed hotels in the world, came from the Saint-Marc-des-Carrières quarry. — The architecture of the Grande-Allée Armoury is reminiscent of a French château. — The origins of Place-Royale and the neighbouring rue du Petit-Champlain area date back to the early days of the colony.

In the seventeenth and early eighteenth centuries, Beauport limestone was quarried and transported by barge to Québec to be used primarily as dimension stone and to produce lime for masonry work. Beauport limestone was used extensively to build the Québec fortifications. Until very recently, it was also used by the Beauport quarry, which supplied the Saint-Laurent cement factory. The armoury and several of the dwellings around Place-Royale were constructed of Beauport limestone. Later on, the Côte-de-Beaupré, Pointe-aux-Trembles, and Saint-Marc-des-Carrières limestones, and the Ange-Gardien sandstone, were used for building purposes.

BUILDING STONE FROM THE APPALACHIAN OROGEN

R. Ledoux

Martello Tower No. 2 was part of a line of defence consisting of four towers that was set up in response to a feared American invasion. — Today's medieval Saint-Jean Gate dates from 1938. Initially built in 1693, it has been demolished and rebuilt several times. — The architecture of the Musée de l'Amérique française is similar to that of the Maison Livernois, and both are constructed of Sillery sandstone.

After the 1682 fire in Québec's Lower Town, people were encouraged to build stone houses. The first stone used came from the Québec promontory, right in the heart of the city, and was referred to as cap stone or Québec stone. Around 1740, builders began to work with the greenish Sillery-Cap-Rouge sandstone that now forms part of the Québec fortifications and the walls of the Citadel, and that was used to rebuild the Saint-Jean Gate in 1938.

THE UNCONSOLIDATED QUATERNARY MATERIALS

Grand Théâtre de Québec — Rebuilding autoroute Charest — Marie-Guyart Building

The sand and gravel deposits left behind by glacial meltwater are now the site of gravel pits and are being used as a source of aggregate for concrete and road construction.

The whims of nature

GRAVITY AT WORK

On September 19, 1889, part of the rocky promontory above rue Champlain at the west end of terrasse Dufferin collapsed, crushing seven houses. The toll: 35 deaths, numerous injuries, and significant property damage. This part of the Québec promontory, better known as cap Diamant, was one of the most dangerous inhabited areas of the region, where rockslides claimed at least 85 victims during the nineteenth century. The area around rue du Petit-Champlain has also seen some dramatic rockslides, the most memorable of which took place in 1841 and 1889. The promontory was formed by the interplay of tectonic uplift and erosion that created the Appalachians. As a result, the layers of sedimentary rock that make up this feature now dip parallel to the slope, and in places are even vertically inclined. As a result, gravity is able to cause some layers to slide along other layers. Rockslides often occur after heavy rains, when water infiltrates the crevices, or during periods of successive freezing and thawing.

Société historique de Québec

ICE DAMS

The Montmorency River is known for more than its famous falls. It is also renowned for the spectacular ice jams that regularly form along its length. During a winter or spring thaw, the ice cover breaks up into blocks that are transported by the current and pile up where the river narrows. In this way, a temporary dam can form, causing the water to rise and upstream shoreline areas to flood. This hummocky ice can sometimes reach heights of 5 to 7 m, or twice that of a house. Occasionally, an ice dam breaks suddenly under the pressure of the water behind it, sending an outburst flood surging downstream to inundate the lower reaches.

MRNQ

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The earth quakes under Québec

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EARTHQUAKES FELT IN THE QUÉBEC REGION.

The yellow circles mark the locations of past earthquakes for which historical documents have been used to approximate the epicentres and magnitudes. The pink circles represent earthquakes whose epicentres and magnitudes have been calculated on the basis of instrument data. The years indicate the occurrence of the strongest earthquake in a given period of time.

LOCATION OF THE EPICENTRES OF EARTHQUAKES ORIGINATING IN THE QUÉBEC REGION.

The red dots represent aftershocks from the Cap-Rouge earthquake. An earthquake must have a magnitude greater than 2.5 in order to be felt.

THE SOURCE OF THE SHAKING CAN BE ELSEWHERE...

Historically, the epicentres of earthquakes felt strongly in the Québec region have been located in the Charlevoix–Kamouraska region and, to a lesser extent, in the Saguenay region. In 1663, 1791, 1860, 1870, and 1925, earthquakes with a magnitude greater than 6, with epicentres in the Charlevoix–Kamouraska region, strongly shook the city, causing damage and frightening citizens. In 1988, it was an earthquake in the Saguenay region that rattled the capital. But from time to time, milder tremors with epicentres closer to the city have also shaken the region without causing any appreciable damage.

QUAKE PERIL HERE MOST REMOTE QUEBEC HAS A "FAULT LINE"

Eastern Canada Subject to Shocks — St. Lawrence Gulf Slipping

EARTH CRUST THICK HERE

Ranges From Forty to Seventy Miles—Prof. Coleman Is Reassuring

(The Evening Telegram, March 2, 1925)

... OR RIGHT BENEATH OUR FEET

The vast majority of earthquakes in eastern Canada are caused by sudden movements along ancient faults associated with the St. Lawrence rift, a structure related to the basins of the Ottawa and Saguenay rivers. Although faults are found throughout the Canadian Shield, for reasons unknown only some are active. In the Charlevoix region, for example, the impact of an enormous meteorite some 350 million years ago may have contributed to the activation of the faults in this region. The Logan Fault is a major feature of the geology of the St. Lawrence valley, but we know now that it is not involved in the earthquakes that occur there. The Cap-Rouge earthquake of November 5, 1997, occurred at a depth of 22 km. Studies of the main shock and some 50 aftershocks enabled scientists to link this earthquake to reactivation at depth of a fracture in the Canadian Shield that may be the Neuville Fault.

CERTAIN MATERIALS AMPLIFY VIBRATIONS

We have learned from strong earthquakes in the past that the extent of earthquake damage is often a function of the type of geological materials on which a building is constructed. For example, given two similar buildings located at equal distances from the epicentre of an earthquake of magnitude 6, a building situated on thick deposits of clay or sand will be subject to more significant vibrations than one constructed on bedrock. Such an amplification of seismic waves generally results in more significant damage, which explains why most of the destruction caused by earthquakes in the Québec area has occurred in parts of the Lower Town and the Port of Québec. In the vicinity of steep inclines, the impact of an earthquake can vary. Along a rocky incline, rock falls may occur, while clay or sand slopes may be the setting for landslides.

L'Événement, October 20, 1870

"At 11:25 a.m. today, our city was shaken by a fairly strong earthquake. The quake lasted a good 22 seconds. Happily, no serious accidents ensued... women lost consciousness in the street in Saint-Roch. Workers at the MM Woodley factory in Saint-Roch jumped from the windows. As it can be seen, the shock was felt more violently in this district than elsewhere... From Saint-Roch Church to the park, barely a single chimney has been left standing."

Le Canadien, October 19, 1860

"Wednesday morning's earthquake was felt over a wide area... One man, who found himself in rue Saint-Vallier, reported seeing swaying homes that reminded him of waves in the ocean... Captain D. Wilson of the 'Great Britain' was making the ferry crossing and, feeling the underground shock at 6:00 a.m., he concluded that his vessel had run aground and made note of the fact in his location log."

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