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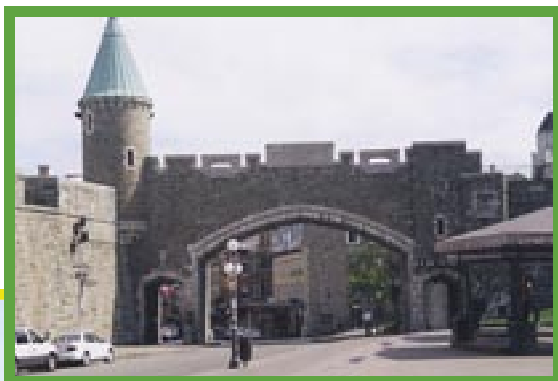
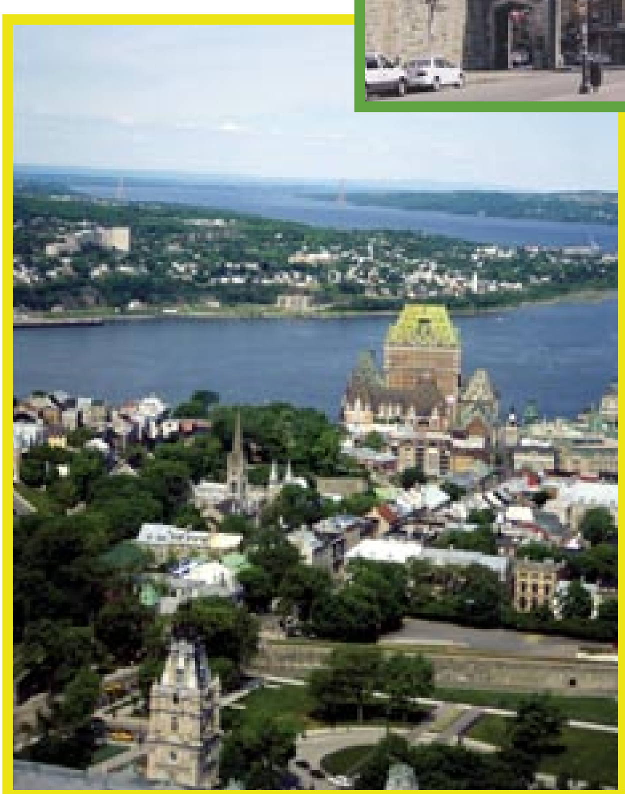
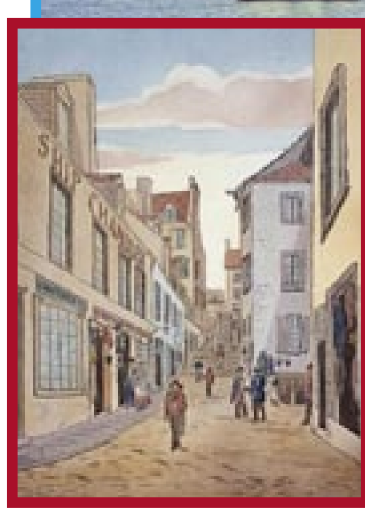
Québec fortified City:

Geological and Historical Heritage

Fieldtrip Guidebook







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This fieldtrip guidebook provides information complementing the "Geoscape Quebec" poster and website.

The "Geoscape Quebec" website is accessible at:
http://www.cgq-qgc.ca/geopanorama/qc

The double-sided colour poster measuring 67 cm X 97 cm can be ordered from the Quebec Geoscience Centre's distribution centre:

Telephone: (418) 654-2677
Email: **gscqbookstore@nrcan.gc.ca**

The Earth Sciences Sector of Natural Resources Canada covered the cost of reproducing this guidebook in connection with the activities of National Science and Technology Week. NRCan activities hold considerable importance for the economy, promote the maintenance of strong communities, foster advances of knowledge, innovation and technology, support sustainable development and give NRCan a leading role in the international scientific community.

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Ce document est aussi disponible en français

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INTRODUCTION

This fieldtrip provides an overview of geology with reference to landscapes in the Quebec City area. The geoscape of this region provides the backdrop for explaining how landscape components come into being or change over time. The notions of geology that we will discuss are linked to our immediate environment, Old Quebec, and to the spectacular events that sometimes make regional headlines, such as earthquakes and rock slides. We will weave together these various aspects of Quebec's geological history and general history to show how they are connected and to learn new facts.

The itinerary comprises a tour of Old Quebec with 10 stops. Scientific concepts will be explained in detail at every stop. Historical information is supplied in text boxes. Complementary points of interest or landmarks will be mentioned along the route, between stops, but without going into detail.

 *Points of interest on the routem, between two stops*

Historical vignette

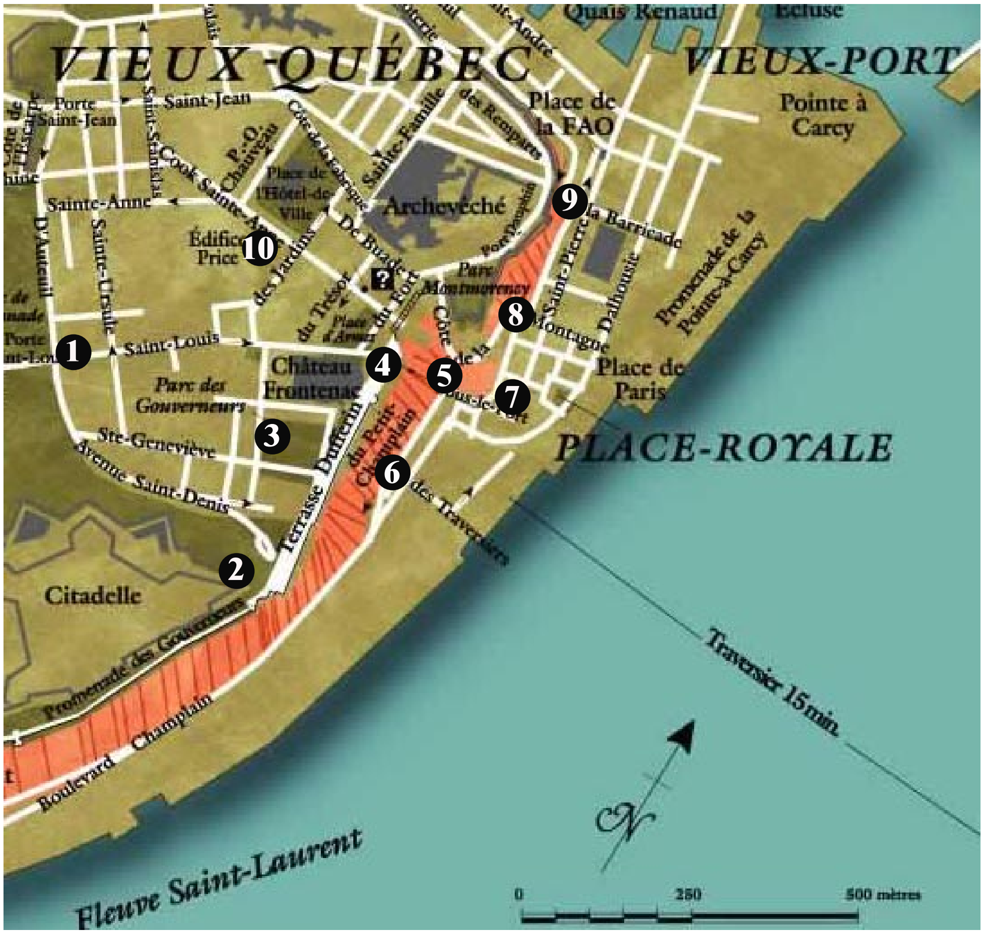
All the information on the dimension stones has been graciously provided by Robert Ledoux, professor at the department of geology and geological engineering at Université Laval. The information comes from the sources listed in the reference section or from personal communications. All the information, visual elements and vignettes related to history have been provided by Parks Canada. All the visual elements, graphs and diagram, unless otherwise specified, have been produced by the Québec Geoscience Centre.

This document has four appendices. The first is a simplified depiction of the geologic time scale. The second appendix provides complementary information on the use of dimension stones in the architecture of Old Quebec. The third appendix deals with the fossil species that can be observed in the Quebec City area and the fourth appendix describes rock slide and earthquake events from a historical perspective. The glossary defines the specialized terms used in the text.

We hope that you will find this guide useful for the fieldtrip that you are about to embark on. Teachers should find it a help as it gives examples drawn from the local urban and natural environment that support teaching of earth sciences material.

Enjoy your fieldtrip and happy reading.

FIELDTRIP



Built atop a rocky promontory, the Fortifications of Quebec tower over the St. Lawrence River. Visitors can stroll along the 4.6-km-long walkway and enjoy the splendid views. Like nowhere else in North America, the City of Quebec's defence system follows a classic urban style, characterized by flanking and defence in depth, and was adapted to the city's topography. More than just the vestiges of the military art of war, the Fortifications of Quebec also bear witness to the era of fortified cities between the 17th and 19th centuries. Inside Quebec's walls, you get a feel that the military's presence dominated the city. The parade grounds, esplanades, military arteries, barracks and warehouse, in which munitions and artillery paraphernalia were stored in the 18th and 19th centuries, are remnants of a city's past that was punctuated by the beat of the war drum.

Quebec, a UNESCO World Heritage Site, is the only city in North America to have retained the major parts of its defence system. This picturesque setting with its superb vistas serves as the backdrop for an exploration of the region's billion-year-old geological history. At different sites, visitors can discover traces of an ancient ocean, the transportation of enormous rocky masses over long distances to the threshold of the city itself, and the passage of colossal glaciers that covered the area for thousands of years. The legacy of this eventful past is some of the most spectacular attractions in the region, along with an environment that is occasionally at the mercy of nature's whims.

Departure point: Parking lot at Parc de l’Esplanade

National arvhices Canada, c. 1830, J.P. Cockburn

Between the St. Louis and Ursulines bastions, stands the Esplanade Powder Magazine (1815), restored and open to the public. The effectiveness of fortifications largely depends on the location of their powder magazines. That is why the British would distribute them strategically around the city, while at the same time avoiding having an overly large concentration of gun powder in one place. In 1816, there were 12 powder magazines in the City of Quebec. To protect the surrounding area, the walls of the powder magazines are 1.5 metres thick, their ceilings are arched and they are surrounded by a thick outer wall.

Stop 1 : Maison Cureux

Building made of black Cap stone

The Cureux House, at 86 Rue St. Louis, was built in 1729 by innkeeper Michel Cureux. It is the second oldest residence on Rue St. Louis. The house standing today is a reconstruction of the original, which was destroyed in 1709 to make way for fortifications. It was only after a long trial followed by the whole colony that the French government was forced to back down and rebuild the house.

Maison Cureux is one of the rare examples of houses constructed from what was called “pierre du cap“ or “Cap stone,” the first type of building stone used in Quebec City. When the early settlers built their homes on the promontory, they dug the foundations, reserving the excavated stone for use in building the walls. This very fissile stone becomes weakened and splits easily when exposed to air and water. It therefore is not conducive to providing good quality exterior masonry. To ensure that houses made of cap stone will last longer, they must be sheathed in wood or covered with parget, as was done with this house up until 1968.

69 rue d’Auteuil: Built in 1867 by Thomas Fuller, one of the architects of the original Parliament Buildings in Ottawa. The facade is made of buff-coloured sandstone from the Nepean area, near Ottawa. The same stone was used to build the Parliament Buildings in Ottawa. Cross-bedded structures can be seen in the blocks of stone. As the richly ornamented facade shows, this type of stone can be finely sculpted..

At the corner of rues d’Auteuil and Saint-Louis : fossiliferous limestone containing lacy, branched or domed bryozoans along with stylolites (compression structures).

91 rue d’Auteuil: predominance of Ange Gardien sandstone which exhibits a rust brown alteration. The stratification (bedding), or division into strata, is visible in the blocks of stone.

28 rue Saint-Denis: fossiliferous limestone containing the large white shells of brachiopods.

Stop 2 : Quebec Citadel

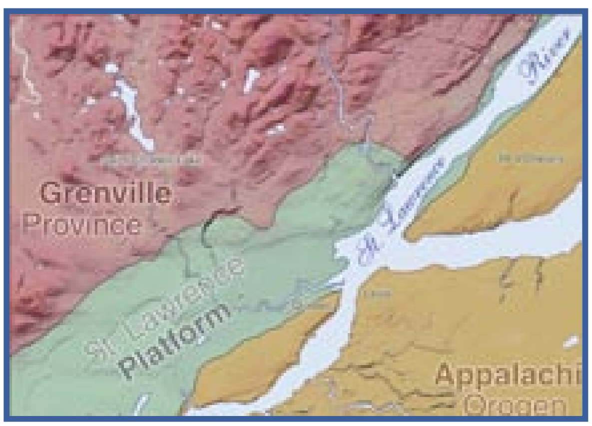
Overview of the geology of the Quebec City area

Parks Canada/P. Lahoud

Engineers and military strategists have always considered the heights of the Plains of Abraham to be a strategic location. The French occupied the heights as early as 1693, when they built the Cap Diamant Redoubt. The redoubt is one of the oldest military structures in Canada and remains an integral part of the Quebec Citadel. The British also sought to fortify the strategic site. In 1789, they built a temporary citadel, which they replaced in 1832 with the permanent one that still stands today. After the construction of the Citadel, Quebec City became known as the Gibraltar of the Americas. Nowadays, the Citadel is home to the Royal 22nd Regiment and is the location of one of the official residences of Canada's Governor General.

Did you know that the Citadel is the largest fortification in Canada built during the English regime? The star-shaped stone polygon was built to protect the city against a possible American attack, but also to contain a rebellion by the city's French-speaking population. This is why the Citadel faces Old Quebec's centre as much as its periphery.

The Quebec Citadel was constructed from Sillery sandstone obtained from quarries located between Cap-Rouge and the promontory of Quebec as well as in the Lévis region. Since Sillery sandstone is no longer quarried to obtain building stone, a similar type of stone must be found to replace damaged blocks.

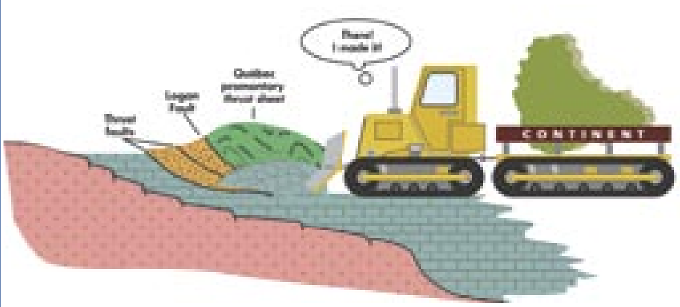


From this vantage point, we can get a general idea of the diversity of the Quebec City area's geology. Three different physiographic regions can be identified: the Canadian Shield, the St. Lawrence Lowlands and the Appalachians: they correspond roughly to geological provinces. A geological province is characterized throughout by a similar geologic history and similar structural features. Nonetheless, the boundaries of a geological province may differ from those of a physiographic region.

The **Canadian Shield** is represented here by the Laurentians. This chain of mountains corresponds to the **geological province of Grenville**, the youngest of the Canadian Shield provinces. The rocks of the Grenville Province are the oldest in the region. They are metamorphic rocks, i.e. igneous rocks or sedimentary rocks that were transformed and modified at great depths in the Earth, under high pressures and high temperatures. The Grenville rocks represent the deep roots of a mountain chain that has been completely flattened by erosional processes. Although some high peaks still exist, such as Mont Ste Anne, their current elevation is merely a fraction of what is was about a billion years ago. At that time, Mont Ste Anne was part of a chain of mountains similar to the Himalayas. The rocks of the Grenville Province stretch over an area of more than 4,000 km (from Labrador to Texas); in some areas they are overlain by younger rocks while in other areas they are exposed at the surface.

The **St. Lawrence Lowlands**, wedged between the Laurentians and the Appalachians, are made up of sedimentary rocks that have undergone little or no deformation. Fossils are especially abundant in some layers of limestone, a very common type of rock in the Quebec City area. Long ago when the limestones of the St. Lawrence Lowlands were forming, life was restricted to the oceans, and marine species are the only fossil species found in the Quebec City area. These limestones formed in a rift valley, on the continental shelf of an ancient continent. The Lowlands are part of the geological province of the **St. Lawrence Platform**, and they form a plain that can be seen north of Ile d'Orléans and in the municipalities of Beauport, Vanier, Ancienne-Lorette and St-Augustin. These rocks formed over a period of 150 million years and are much younger than the rocks of the Canadian Shield.

The relief of the Appalachian mountains can be seen in the distance. Yet the **Appalachians Province** reaches right into Quebec City, where it is represented by the thrust sheets, or "nappes", of the Quebec promontory, Lévis and Ile d'Orléans. The entire south shore of the St. Lawrence and most of Ile d'Orléans are part of the Appalachians, although the relief is fairly flat. Quebec City is located at the northern edge of the maximum extent of the Appalachians. The boundary between the Appalachians and the St. Lawrence Platform is marked by a major fault, called Logan's Line. This fault runs to the north of the promontory of Quebec, and, from our present vantage point, we can see the relief that it forms on the Sainte-Pétronille side of Ile d'Orléans. For geologists, the Appalachians are more than the mountains; they encompass all the thrust sheets or "nappes" that were transported over great distances, on the rocks of the St. Lawrence Platform, as this mountain range was forming. The rocks of the Appalachians comprise deformed and folded sedimentary rocks, which were transported over dozens of kilometres along nearly horizontal faults during the mountain-building process.



When climbing from the Lower Town to the Upper Town, we are actually moving between the St. Lawrence Platform and the Appalachians. The steep hills of the Quebec promontory resulted from the formation of the Appalachians. When climbing the bluffs in Quebec City, i.e. Côte Salaberry, Côte d'Abraham and Henri IV Boulevard, like the stairs from the Lower Town, we are moving from one geological environment to another.

The fact that Quebec is located at the junction of three geological provinces indicates that it must have had a very tumultuous past. Its geological history can be explained with reference to plate tectonics. According to the theory of plate tectonics, the Earth's crust is broken into moving plates that rub against one another and become modified over time. In the area where Quebec City lies, mountains rose up when the continents collided and oceans formed when they split apart. These phenomena occur at an imperceptible rate of 4 cm to 6 cm per year, which is about how fast our fingernails grow. After tens of millions of years, however, the position of the continents may have changed substantially. During this time frame of millions of years, the position of the continents relative to the poles and the equator changed, affecting the climate. Remember, even if the continents appear to be stationary, they have moved over time and have experienced different climatic conditions.

FROM OBSERVATION TO INTERPRETATION:

THE GEOLOGICAL HISTORY OF THE QUEBEC CITY AREA

In Grenville times: Quebec at the foot of the highest peaks

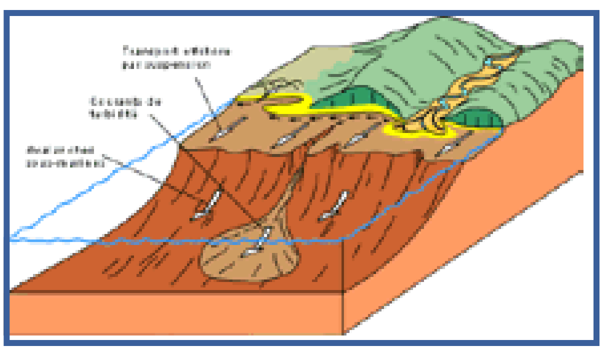
The Canadian Shield has not always existed in its present form; it arose from the continent called Laurentia, which was part of the supercontinent Rodinia, i.e. a group of continents that joined together. This supercontinent existed a billion years ago (in the Proterozoic era). When Laurentia collided with some other continents, a mountain chain similar to the Himalayas was created; this was the Grenville mountain range, now completely eroded..

The St. Lawrence Platform: Quebec in the Tropics

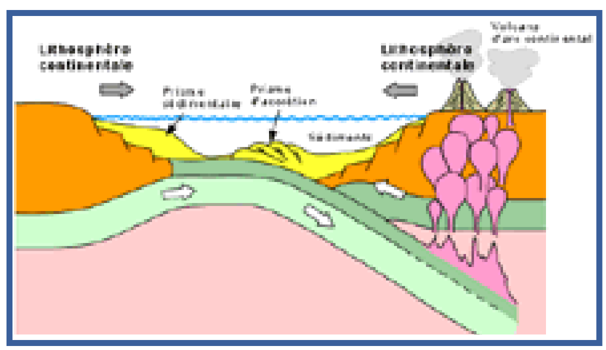
Some 900 million years ago, the Grenville Mountain range dominated Laurentia. The continent gradually became unstable, broke apart and sank. After that, the motion of the tectonic plates reversed and a new cycle began as the continents started to drift apart. About 500 million years ago (in the Paleozoic era), sediments accumulated on the continental shelf in the Iapetus Ocean, the forerunner of the present-day Atlantic. This was a passive continental margin environment. This assemblage was centred on the Equator; hence, the area that is now Quebec City was located in a tropical sea environment much like present-day Rio de Janeiro. The rocks of the St. Lawrence Platform are all that remain of the vast sedimentary cover that blanketed much of the Canadian Shield and can be detected as far away as Lac Saint-Jean and Lac Manicouagan. This sedimentary cover resulted from erosion of the Shield (detrital sediments) and the accumulation of calcareous sediments from the shells of marine organisms (algae, corals, etc.) that populated the warm, calm and shallow sea.

Origin of the Appalachians: mountain building forces

Some 450 million years ago (in the Paleozoic era), the tectonic plates began moving in the opposite direction once again and a new cycle began. The Iapetus Ocean closed up again and a new chain of mountains formed (in an active continental margin environment). Sea bottom sediments from dozens of kilometres off Laurentia were pushed toward the continent and forced up onto the rocks of the St. Lawrence Platform. The Quebec City area was once again situated at the base of mountains, which reached right up to it. The mountain building process for the Appalachians, which stretch 3,500 km from Newfoundland to Alabama, took place over a period of 250 million years.

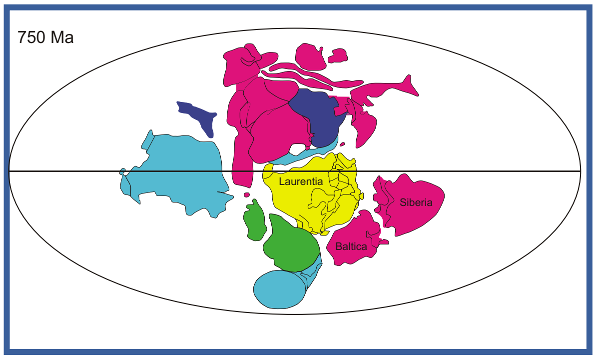


Morphology of the passive continental margin, during the formation of the St. Lawrence Platform. Adapted from: http://www.ggl.ulaval.ca/personnel/bourque/intro.pt/planete_terre.html

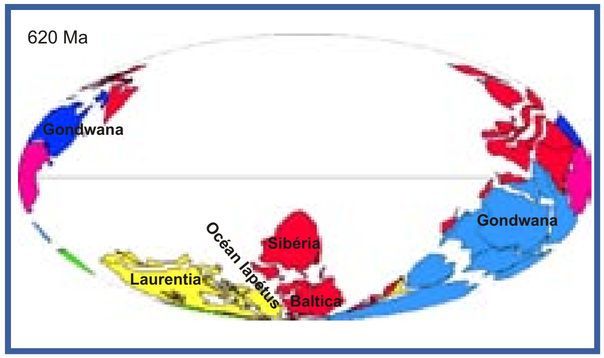


Formation of the Appalachians around the Quebec City region. This episode is represented by the advent of the Quebec City thrust sheet, creating the promontory on which we now stand. http://www.ggl.ulaval.ca/personnel/bourque/intro.pt/planete_terre.html

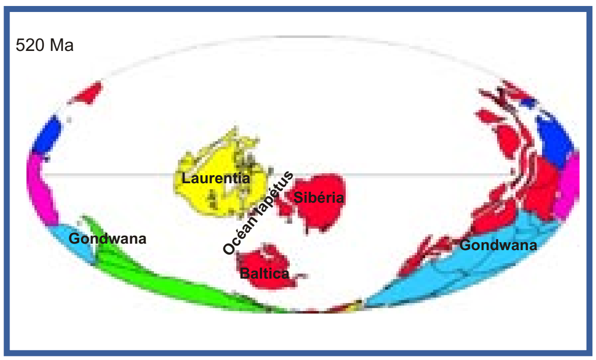
PAST AND PRESENT ... PLATE TECTONICS



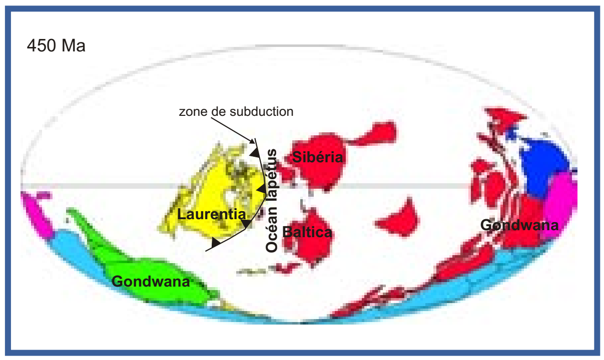
Rodinia is the oldest known supercontinent. It formed some 1,100 million years ago and then split apart 750 million years ago.



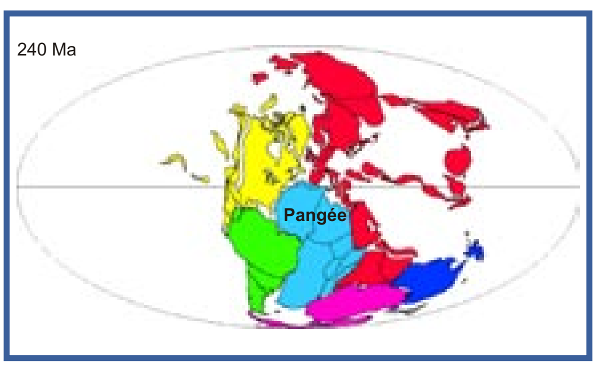
About 650 million years ago, the supercontinent broke up into different pieces, including Baltica, Siberia and Laurentia (Canadian Shield), and the Iapetus Ocean was born.



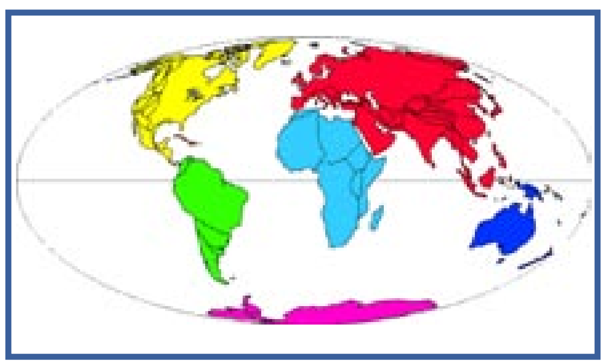
Over a period of 100 million years, the Iapetus Ocean kept spreading and the rocks of the St. Lawrence Platform were formed.



510 million years ago, the Iapetus Ocean closed up. The Appalachians formed.



Then, 250 million years ago, after the Appalachians formed, all the continents once again came together, forming the supercontinent Pangaea, which subsequently broke up into the continents as we know them today.



The natural environment is not static. The landscape has changed drastically over time. Mountain ranges have been created and then eroded and new mountains are still forming.

In fact, the landscape is constantly changing, but on a human time scale these changes are not very noticeable. Geological time is measured in thousands or millions of years. Nothing is static in nature, not even rocks. The major cycles during which the continents came together and then separated have occurred and will continue to occur on a very large scale and over a very long time period. They can be likened to other broad natural cycles, such as the water cycle and the rock cycle. The Earth is a dynamic planet that seeks to maintain equilibrium. From time to time, sudden events remind us of this fact, such as earthquakes, floods or landslides which brutally change the landscape. During this fieldtrip in Old Quebec, examples will be given of the influence that Quebec's geological heritage has had on the town's history and development, with reference to the use of resources and human safety issues.

Black cap stone can be seen on the trail near the park

Stop 3 : Rue des Carrières

Former dimension stone quarry

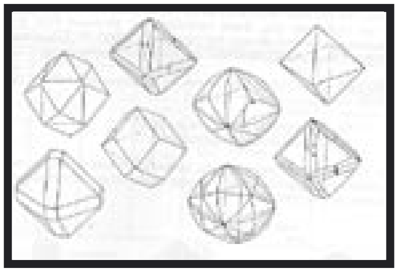
At the base of the park, take the stairs leading to rue des Carrières. At the foot of the staircase, on the left, there is an outcrop of fine grained argillaceous limestone. When two pieces of cap stone are struck together, the sound is like porcelain breaking and the break has a conchoidal appearance (rounded like a broken bottle base). Cap stone reacts with hydrochloric acid, indicating the presence of calcite. There is an odour of methane and sulphurous gas when the rock is broken.

This is the site where black cap stone was quarried beginning in the 17th century, under the French regime. The quarry workers nicknamed this stone "stinking stone" because of the odour of methane and sulphur that is released when the stone is crushed. This odour is due to the fossil fuels (gas, oil) that are present in the folded sedimentary rocks of the Appalachians, but the quantities encountered are rarely sufficient for development purposes. Bedding or stratification is very evident along with organ-pipe structures on some surfaces (rounded structures). Quarry development within the town entailed many risks, particularly rock slides. It appears that one of the most important black cap stone quarry sites of the time was on rue Berthelot, or more precisely Ilot Berthelot. In this pretty little park, there is a panel describing this use of the stone, and outcrops can be seen there.

The dark-coloured rocks of Cap Diamant contain numerous fissures, crevasses and cavities, in which a number of minerals can be identified. The best known of these is bipyramidal quartz crystals, many of which are well formed. When Jacques Cartier found some of these crystals in New France, in 1542, he thought he had discovered diamonds—hence the French expression "Faux comme les diamants du Canada," which means "as phony as Canadian diamonds." (As an aside, following many years of geological research, we now know that quality diamonds do exist in Canada, and even in Quebec, at suitable sites in the North.) There is also a local legend which says that the good fairy waved her magic wand, causing a star to burst, the fragments of which created the diamonds of Cap Diamant.

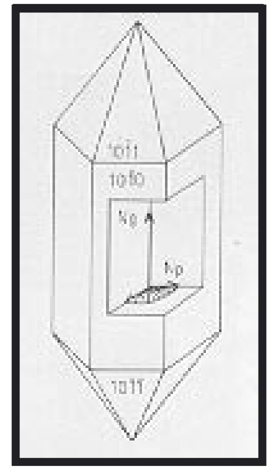
How to distinguish between diamond and quartz ?

Diamond is harder than quartz, in fact it is the hardest mineral in existence (hardness of 10). Quartz has a hardness of 7. Their crystal structure and their composition differ greatly as well. Quartz (SiO_2: silica and oxygen) has a hexagonal structure, whereas diamond (C: carbon) has a cubic structure.



Diamond

Quartz



Rue des Carrières separates the Dufferin Terrace from the Governors' Garden. The Garden dates back to the colony's early days, first appearing on maps in 1660. Under the Iroquois threat, French authorities decided to build enclaves, and later a wooden palisade in the park to protect the inhabitants. Other defensive structures were also built in the Governor's Garden, including several stone structures. In the 18th century, the privacy of the governor and his guests was ensured by the walls enclosing the area. The Garden was first opened to the public in 1838, on Lord Durham's orders.

National Archives of Canada, 1829,J.P. Cockburn

The obelisk in the Jardin des Gouverneurs (or Governor's Garden), west of the Château Frontenac, is the oldest monument in Quebec City. It was built from Pointe-aux-Trembles limestone in 1828 to commemorate Wolfe and Montcalm.

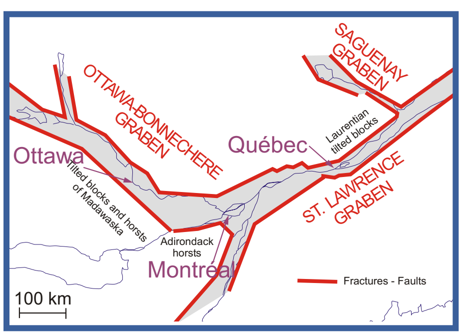
At the Château Frontenac, two large gastropods can be seen in the wall, which is made of limestone from a former quarry on the Island of Montreal. One can also see stones that were not laid on bed (i.e. they were laid perpendicular to the strata) and stones that were laid on bed (parallel with the bedding planes and in a better position to support the weight of a building). Limestone can be identified by its brown alteration and honeycomb weathering of the dolomitic nodes. The greenish tinge of the walls was caused by copper leaching from the roof. The bricks that make up most of the walls were kiln-fired, making them better able to withstand inclement weather and the passing of time. This can be likened to the process of metamorphism, which makes rocks more resistant.

The remains of the St. Louis forts and chateaux, the governors' residences until 1834, can be found under the Dufferin Terrace. Fort St. Louis was first built in 1621 by Samuel de Champlain, and was modified and repaired several times, by both the French and the British, to adapt it to its new functions. In fact, it was in the Château St. Louis that Governor Frontenac made his infamous 1690 statement: "Je vous répondrai par la bouche de mes canons." ["I will reply from the mouth of my cannons."] The structure burned down in 1834, and Lord Durham had a terrace built in 1838 to cover the ruins of Château St. Louis. The terrace was extended in 1878, and was henceforth known as the Dufferin Terrace..

Parks Canada/S. Derome

A key part of the St. Louis Forts and Châteaux National Historic Site, the Dufferin Terrace is one of the most popular tourist attractions in Quebec City. It has been open to the public since 1838, when it was 50 metres long, and has since been extended to its current length of 433 metres [1,420 feet]. Since its official inauguration on June 9, 1879, the Terrace has offered a panoramic view of the St. Lawrence River and Quebec City's surroundings to the millions of visitors that stroll down the boardwalk every year.

The position of the St. Lawrence Valley is dictated by the location of an ancient system of downthrow faults. The St. Lawrence rift system, as it is called, formed during the break-up of Laurentia that led to the formation of the Iapetus Ocean some 500 million years ago. Crustal subsidence along these faults led to the development of a topographic trench, which was invaded by a shallow sea in which the limestones of the St. Lawrence Valley eventually formed.



As Laurentia broke up, the Canadian Shield became dislocated along three fault systems, tilted approximately 120°, causing a large piece of the continent to split off. The Ottawa River Valley represents a fault system. The faults that formed the scarped relief on the north shore of the St. Lawrence and mark the boundary with the Laurentians are the expression of another of these systems. The third fault system is probably buried under the Appalachians south of Quebec and in New England.

At this stop, we will introduce the Quaternary, the geological period extending right to the present which was characterized by extensive glaciations. The course of the St. Lawrence River will be used to illustrate the history of deglaciation in the Quebec City area. Indeed, the river's position can be linked to ancient fractures of the Earth's crust, but its current location is an artifact of the last period of glaciation, as we will explain below.

18,000 years ago, Quebec City sleeps under tons of ice

After being located successively in Tropics and then at the foot of tall mountain peaks, the Quebec City area lay under tons of ice. 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 build-up of ice. The most recent of these glacations, the Wisconsin glaciation, began nearly 75,000 years ago and ended about 10,000 years ago. Some 18,000 years ago, the region lay under an ice sheet 3,000 metres thick. This was the glacial maximum. The weight of this ice sheet depressed the continent, and Quebec City was located more than 200 m below sea level.

Like a gigantic bulldozer, the glaciers flattened everything in their path. The slowly creeping ice sheets, or continental glaciers, helped flatten and erode the Grenville and Appalachians mountains and plateaus. The glaciers scoured debris from the bedrock, leaving behind till deposits (a heterogeneous mixture of clay, sand, gravel and boulders) and erratic blocks which are scattered over the three physiographic regions. The Jacques-Cartier and Montmorency river valleys have the typical U-shape of glacial cut valleys. Striae and grooves bear witness to the direction of ice sheet movement.

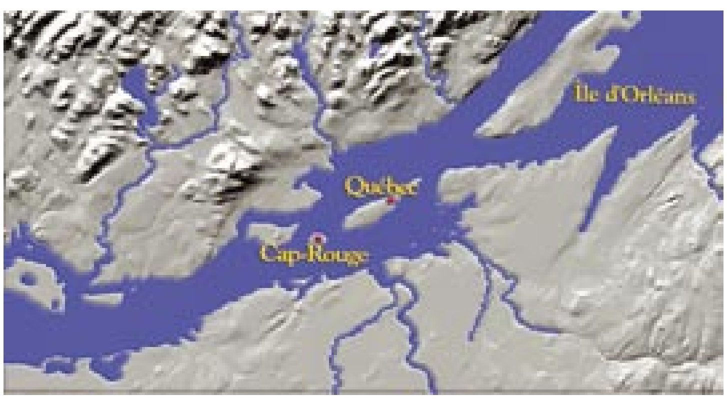
The Quaternary is also the period during which the first inhabitants of America emigrated from Asia. During the major periods of glaciation, and especially during the most recent glaciation, the huge amount of water stored in the continental glaciers caused sea level to drop so drastically that the Bering Strait linking the Chukchi Peninsula, in Siberia, and the Seward Peninsula, in Alaska, dried up. Humans crossed this land bridge between 30,000 and 20,000 years ago to expand their territory. Once they reached the North American continent, they migrated southward. According to the findings from many years of research, the itinerary they followed went along the ice-free corridor between the Laurentide Ice Sheet, which extended into Alberta, and the Cordilleran Ice Cap. Although signs of human occupation have been found in this region, it appears that the environment was not particularly favourable for survival and there was little plant and animal life to meet daily subsistence needs. Another potential route has recently been proposed, for which the environmental conditions seem to have been better. This is the coastal route, between the Pacific, whose level was much lower than today, and the western extension of the Cordilleran Ice Cap. Food could be obtained not only through fishing but also through trapping of small animals, whose skeletal remains have been found in coastal caves.

The migration did not stop then… Some peoples also travelled along the southern edge of the Laurentide Ice Sheet, as evidenced by signs of human occupation in New England dating back about 12,000 years. There is every indication that the Paleo-Indians, the earliest occupants of Quebec, arrived from the Chaudière River valley. An archaeological site on the south shore, at Saint-Romuald, provides evidence suggesting that humans occupied the shores of the Champlain Sea at least 8,000 years ago. The Champlain Sea was home to an abundance of marine animals including fish, walruses and whales. Therefore, the Paleo-Indians would have had sufficient food resources. Although the history of human occupation of the Quebec City area is still incomplete, it seems that the region did not remain deserted for long after the glaciers retreated.

12,000 years ago, Quebec City under water

The glaciers retreated as the Earth's climate experienced a warming trend, leaving behind depressions deeper than sea level. The waters of the Atlantic Ocean then invaded the St. Lawrence Valley, forming the Champlain Sea. As the glacial melt waters mixed with the seawater, the Champlain Sea eventually reached its maximum extent 12,000 years ago.

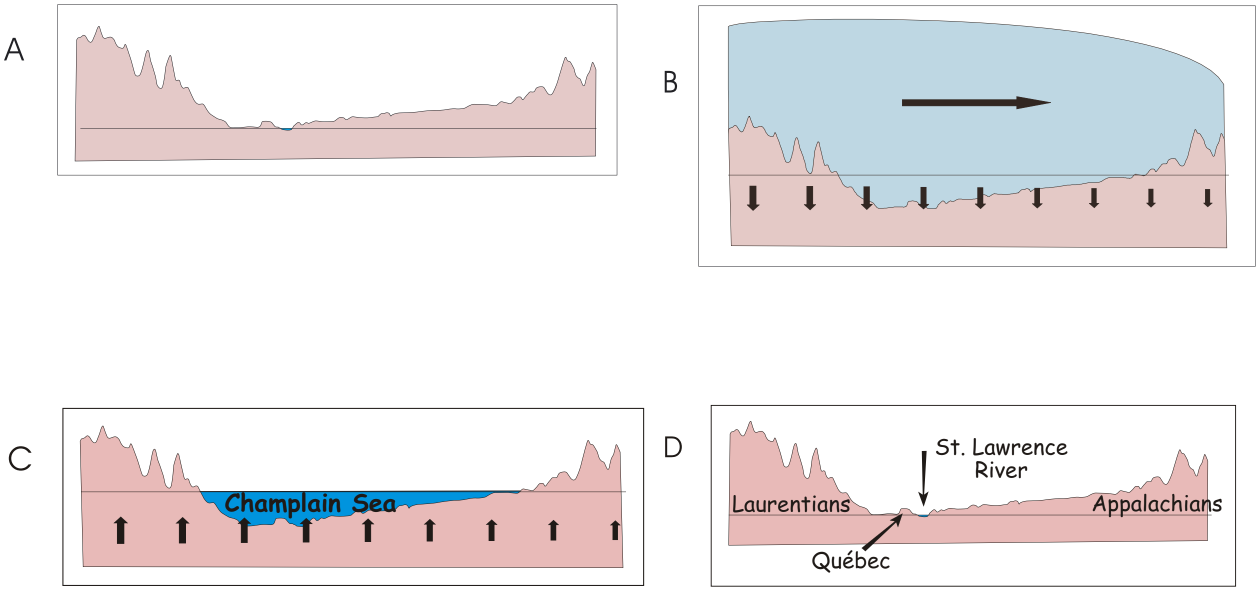
The area that is now Quebec City gradually rose as a result of isostatic rebound, and the Champlain Sea began receding. The first two high points on Ile d'Orléans emerged.



The sea kept receding, making way for an estuary and then a system of rivers representing the forerunner of the St. Lawrence. This happened 9,500 years ago. The highest points in the region, namely Saint-Augustin, Cap-Rouge, Sainte-Foy, Quebec City and Lévis, existed as islands at one point in their history. Today, ÎIe d'Orléans alone bears witness to the islands scattered around Quebec City long ago. As it retreated, the Champlain Sea covered the St. Lawrence Lowlands with a thick layer of sediments, which gave rise to the fertile soils of today

The level of the St. Lawrence has fluctuated, changing by tens of metres several times over the last 9,000 years, in response to climatic changes which were minor compared with the glaciations but had a considerable effect on riparian ecosystems. The present-day course of the St. Lawrence is the result of a long tectonic, glacial and marine history!

tory of an ephemeral sea : An animated version of the retreat of the Champlain Sea can be accessed on the "Geoscape Quebec" Web site at: **http://www.cgcq.rncan.gc.ca/geopanorama/qc**, under the heading "A vital corridor."



The Champlain Sea occupied the St. Lawrence Valley, sea level declined gradually, isostatic rebound occured.

The circle is completed in the space of 80,000 years and equilibrium is attained.

Isostasy is the response of the Earth's crust to being depressed by (subsidence) or relieved of (rebound) an enormous weight that disrupts crustal equilibrium. More specifically, glacio-isostasy is due to the development and the melting of Quaternary ice caps. Under the weight of an ice cap that was 2 km to 3 km thick at its maximum extent, the original topography of the St. Lawrence Valley (A) was depressed by several hundred metres (B). When the glacier melts, since glacio-isostatic rebound does not occur instantly, the depressed valley becomes invaded by a postglacial sea (C). Freed from the weight of the glacier, the crust rises as it seeks to regain its former state of equilibrium (D), and the sea is forced to recede towards the ocean. The time it takes the Earth's crust to regain its equilibrium in the new situation created by the formation or retreat of an ice cap has been estimated at 20,000 years.

The Champlain Monument on the esplanade in front of the Château Frontenac is a gift from France that was made out of Château-Landon limestone in 1898 and has a stepped base made of Vosges granite. This is the same limestone that was used for the Arch of Triumph in Paris and for the Montmartre Basilica. Time has taken its toll on the monument, as evidenced by the many signs of age and wear.

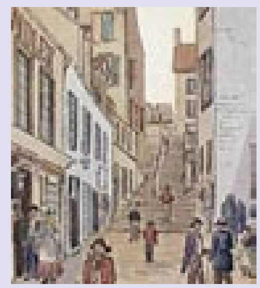
Did you know that no official portrait of Quebec City's founder exists? A false portrait of Samuel de Champlain bears the features of Michel Particelli, an unscrupulous French finance inspector, from a 1654 portrait. The monument was created by Paul Chevré, a survivor of the 1912 Titanic shipwreck off the coast of Newfoundland.

The thrust sheets of the Appalachians are what gave rise to the city's scarped relief. The stairs from the Lower Town and the steep hills allow us to climb up or down the thrust sheet forming the promontory of Quebec. The funicular also provides a way to go between these two different levels. The geology of Quebec City has played a role in urban development. At the start of the colony, most of the houses were located in Place-Royale and in the Petit-Champlain district. This facilitated port exchanges along with access to water supplies and resources. Only dignitaries and government and religious institutions were located in the Upper Town, which guaranteed their safety and set them apart socially.

National archives of Canada, 1873, W.O. Carlile

Not far away, in Côte de la Montagne, General Prescott ordered the 1797 construction of a gate that would better control access to the Upper Town, and to which he lent his name. The Prescott Gate is one of five entrances to the Upper Town, along with the St. Louis, St. Jean, Hope and Du Palais gates. The original gates were far narrower than those that exist today. After it was demolished in 1871, a footbridge was erected by Parks Canada in honour of the Prescott Gate, during the 375th anniversary of the City of Quebec. The new gate's architecture blends stone and concrete. Its construction, however, made use of the geological resources of the Quaternary period: sand and gravel

The Break-Neck Steps were one of the first links between the Lower and Upper Towns. On a 1660 map of the city, the steps are known as "l'escalier Champlain." The current name dates back to the 19th century and stems from a nickname given to the steps by American visitors to the city.



NAC. 1830, J.P. Cockburn

Stop 5 : Verrerie La Mailloche building

Fossiliferous sedimentary rocks

This building, located at the intersection of rue Sous-le-Fort and the Break-Neck Steps (escalier Casse-Cou) is constructed of very fossiliferous limestone in which brachiopods are visible. This limestone from Saint-Marc-des-Carrières was used in preference to Beauport limestone, because it occurs in massive banks from which large solid blocks can be cut.

The Ecology of fossils

Brachiopods were small invertebrates with a shell. The drawing on the left shows their habitat (d, e, f), among the marine fossil species that populated the Iapetus Ocean in the Paleozoic era. See Appendix 3 for more information.

Stop 6 : Parc Félix-Leclerc

Former dimension stone quarry
Natural hazards

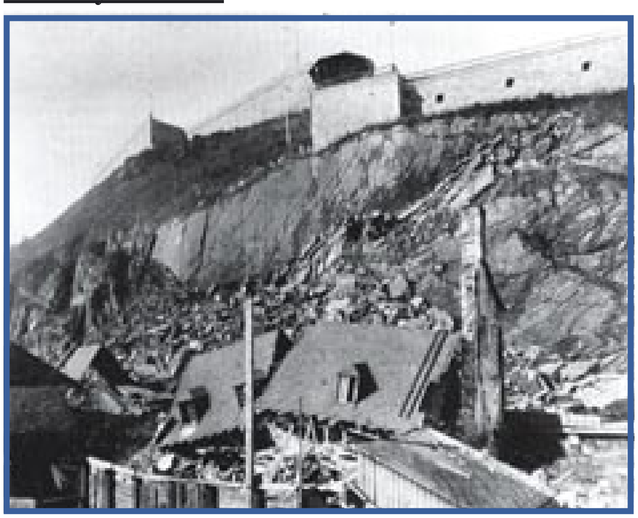
This stop marks the site of a former quarry where the black stone (called "Cap stone") typifying Quebec was extracted. Back in the days when the quarry was in operation, the waters of the St. Lawrence River reached the foot of the cliff. It is believed that ships took on loads of stone during low tide and set sail at high tide. The river is now some distance from the cliff. Besides the fill that was dumped in the river to create land on which to build Champlain Boulevard, natural variations in sea level, such as those associated with the most recent glacio-isostatic adjustments, help to explain the river's retreat since colonial times.

Current ripples in the rocks that form the pavement of the park are evidence of a former beach environment.

You are currently in the Petit Champlain district, which was long held to be the gateway of Irish immigrants in the 19th century. It topped all other districts with a 72% Irish population. The nearby harbour, shipyard and lumber coves provided employment for the district's low-skilled workers. Managed by Parks Canada, the Old Port of Quebec Interpretation Centre located on Quai Saint-André is a testament to the golden age of Quebec City's timber trade in the 19th century.

NAC, 1833, J.P. Cockburn

Gravity at work

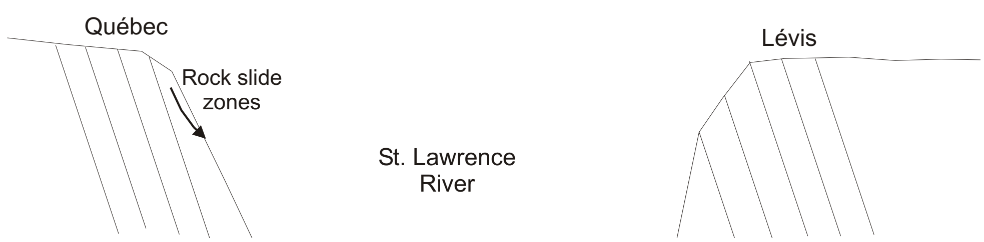


Société historique de Québec

Landslide of September 19, 1889.

The landslides at Cap Diamant caused numerous deaths and considerable property damage, particularly in the early days of the colony. The two most serious slides on the site of present-day Champlain Boulevard were the one on May 17, 1841, in which six houses were destroyed and 27 people killed, and the one on September 19, 1889, in which 45 people lost their lives. The area around rue du Petit-Champlain has also seen some dramatic events, the most memorable of which took place in 1841 and 1889. A number of conditions led to these catastrophic slides: the very steep cliff and unstable slope, the highly friable sedimentary rocks (argillaceous limestone and shales) and the bedding plane (corresponding to the plane of weakness) was parallel to the slope. Vegetation that would otherwise help to retain the debris and stabilize the slope could not become established easily. Furthermore, in the early days of settlement, the river waters lapped against the houses at high tide. Owing to the limited space available for building, workers would excavate deeply into the cliff base, thereby increasing the instability of the upper slope. Climatic conditions such as heavy rains and frost–thaw action played a role in triggering landslides, as did the vibrations associated with earthquakes or, historically, cannon shots..

Effective techniques were employed to minimize the risk of landslides all along Champlain Boulevard and rue Sault-au-Matelot : unstable material was removed in order to create a gentler slope, and draped wire mesh, rock bolts and fences were installed.



Tilting or dipping layers on the south shore pose less of a landslide hazard compared with the situation on the north shore. On the north shore, the strata tilt toward the river, or into the void, amplifying the landslide hazard, whereas on the south shore they tilt inland, giving greater stability.

About seismicity in Quebec

Seismic activity in Quebec is centred in the Charlevoix/Kamouraska region where a meteorite once struck, weakening the Earth's crust. It is expressed mainly through reactivation of the faults that delimit the St. Lawrence rift valley, which is undergoing readjustment owing to isostatic rebound. In Quebec City, the seismic risk is limited and the effects are weak. However, the city is not immune to earthquakes. On November 5, 1997, an earthquake of magnitude 5.2 shook the city and even stopped the parliament clock at 9:34 pm, which is when the event occurred. Its epicentre was located in the Cap-Rouge area. In 1988, it was an earthquake centred in the Saguenay that rattled the capital. The sectors at risk in Quebec City are the Cap Diamant cliff (risk of landslide) and the Saint-Charles River valley, whose clay sediments tend to amplify seismic waves and cause liquification. Buildings constructed directly on bedrock can withstand seismic waves better.

Stop 7 : Maison Parent

Diversity of sedimentary rocks

To see all of the rocks that typify the Quebec City region, it is necessary to cover a lot of ground. Many of them were used in constructing the Maison Parent. Located at the corner of rue Saint-Pierre and rue Sous-le-Fort, this house was rebuilt in 1761, after being demolished during the siege of Quebec City by the British in 1759. The exterior wall coverings contain various stones, some of which were salvaged from the former building. They include Ange-Gardien calcareous sandstone of varying grain size whose ochre and red coloration is attributable to oxidation of ferruginous minerals, Beauport limestone, Sillery sandstone, Rivière-à-Pierre granite and "cap stone." The door and window frames are made of Pointe-aux-Trembles limestone.

The Royal Battery can be found right next door to the Parent House. Built in 1691 on Governor Frontenac's orders, it was intended to fill a defensive void. The British invasion led by Phips in 1690, though driven back, pushed Frontenac to improve Quebec's defences. The Royal Battery was in the shape of a bastion, as can be seen from its present-day configuration, and was once at risk of falling into the St. Lawrence River. It was reconstructed in 1977 and now includes replicas of French cannons. Remarkably, the space has encroached on the St. Lawrence River over the years.

S. Careau

It was only in 1967 that the Quebec government decided to restore Place Royale and its surroundings. Since the neighbourhood was poor and dilapidated, the provincial government took charge of the restoration and reconstruction of the buildings in the area to restore the New France ambience, and thus recall the urban development of Quebec's beginnings. Nowadays, Place Royale is largely a tourist and commercial district; the site of the city's early colonization now lives to the rhythm of the tourist season, because few people live there.

The bust of Louis XIV is anchored on Stratford Green granite, the pillar is made out of royal Canadian red granite from Manitoba and the base is made of grey Saint-Sébastien granite. The steps in the circular base are made of grey Stanstead granite and the middle of the upper level in Royal Canadian Red granite. Granite, an igneous rock with large crystals, is highly resistant in cold temperate climates, and resistant to water, more so than sedimentary rocks like sandstone and limestone. That is why the piers of the Pont de Québec (Quebec Bridge) were carved from Rivière-à-Pierre granite.

Place de Paris. The monument entitled "Dialogue avec l'histoire" features white marble blocks from Greece. Marble is limestone that has undergone metamorphism. The marble blocks are separated by bands of black South African granite

Stop 8 : Côte de la Montagne

Tectonic activity and sedimentation

The cliff located at the junction of Côte de la Montagne and rue Sault-au-Matelot displays an olistostrom, a rock that features blocks of various sizes contained in a matrix of argillaceous rock. The argillaceous matrix originated as mud deposited in the depths of an ancient ocean. This ocean was flanked by a mountain range in formation (the Appalachians). Because of the relief resulting from the rising mountain range, and gravity-induced erosion, large rock masses were detached from the flanks of thrust sheets and slided to the sea. These blocks slided then were stuck in the mud, similar to chocolate chips in cookie dough. They were gradually buried under sediments, that continued to accumulate above them, then the nappes themselves overthrusted them. Submitted to high pressures and temperatures due to burial, the sediments were transformed into rock (diagenesis).

Place d'Armes, located close to the Château Saint-Louis, once the seat of political and military power, was the main assembly grounds for the soldiers who were needed to respond quickly in the event of an attack. Quebec's main streets (Saint-Jean, Saint-Louis and Sainte-Anne) lead away from Place d'Armes toward the fortifications, in the European tradition. During the British period, in the 19th century, Place d'Armes became an urban park complete with horseback riding and public hangings. Nowadays, the centre of Place d'Armes features the Monument de la Foi [Monument to Faith], built in 1916 to commemorate the 300th anniversary of the Récollet fathers' arrival in Quebec City.

Société historique de Québec

Côte de la Montagne was built by Champlain in 1620. It was the first official link between the city's Lower and Upper Towns. The different levels modelled Quebec City's development along the lines of a medieval town: an Upper Town for the political, military and religious elite, and a Lower Town for the merchants, craftspeople and workers.

On rue Saint-Pierre, note the different finishes of the limestone blocks in the building facades: hammered, sanded, vermiculated, etc.

The position of rue Saint-Pierre is the exact extent of high tides in the beginnings of the colony. Markers have been installed in the cobblestones in rue Saint-Antoine where the water was at its maximum in 1700, 1800, and 1900. A portion of the lowering of the St. Lawrence level indicated by the markers is due to the fact that all the houses east of rue St-Paul were built on embankments. In addition, work conducted in the Montmagny area has shown that since the ice retreat, the level of the St. Lawrence level has fluctuated several times compared to today's level. The sea retreat is thus another factor that contributes to the lowering of the level of hight tides.

Stop 9 : Rue Sous-le Cap

Landslide hazards

In rue Sous-le-Cap and at the intersection of rue Barricade and rue Sault-au-Matelot, there is an outcrop of the thrust sheet that forms the Quebec promontory. Massive argillaceous limestone is interbedded with thin layers of black shale and there are vein veneers on some beds. The rocks underwent considerable deformation (folding, faulting).

The lane between rue Sous-le-Cap and rue Sault-au-Matelot is now blocked and fencing was recently installed to prevent accidents connected with the landslide hazard. Draped wire mesh, rock bolts and fences installed in the cliff along rue Sault-au-Matelot serves as a reminder that the Place-Royale sector of Cap Diamant is unstable. Corrective work was carried out to make the site safer, including the removal of unstable boulders, the construction of a retaining wall (rue Sault-au-Matelot) and the installation of rock bolts.

When the Americans invaded Quebec City in 1775, during the American Revolution, Benedict Arnold's troops landed with the intention of overtaking the city and preventing the British from deploying reinforcements to the 13 colonies. Arnold was joined by General Richard Montgomery, who had already conquered Montreal in early December. While Montgomery launched an attack on the Cap Diamant side, Arnold attacked near Rue Sous le Cap, at the Sault au Matelot barricade on the other side of town. Arnold succeeded in seizing several barricades, but in the end was defeated by Captain Dumas and his militia.

The Library of Congress, 1786, J. Trumbull

The Americans laid siege to the City of Quebec in 1775. Knowing that the contracts of several of their soldiers would expire at the end of the year, the two American generals launched the attack on December 31, 1775 during a snowstorm. The Rue Sous le Cap attack was a complete failure and marked the end of the American military drive.

After going up Côte de la Montagne, we climb up the Baillargé staircase beside the Main Post Office. Note that the wall of the staircase is made of Rivière-à-Pierre granite.

The main post office of Quebec City, also called the Louis-S.-Saint-Laurent building, was constructed between 1871 and 1873. It is faced with hammered fossiliferous limestone blocks from Saint-Marc-des-Carrières. The interior walls and counter are made out of grey-blue marble (metamorphosed limestone) from Philipsburg in the Eastern Townships containing contains mounds of algae (thrombolites). The lower part of the counter is made of black marble.

The Daily Telegraph building, constructed in 1907, is located at the corner of rue Buade and rue du Trésor. It is a brick building with olive green stone from the Miramichi region of New Brunswick, which forms the string course, lintels and the pediments of the facade. This very porous sandstone is not very resistant to freeze–thaw activity and road salt, both of which cause it to disintegrate. Some stones have been replaced with buff-coloured limestone, which contrasts sharply with the olive green.

The old Quebec Palais de Justice (courthouse) was built between 1883 and 1887. The architectural style is that of French Renaissance châteaux. Quite a variety of stones were used in its construction (three types of sandstone, a limestone and three types of granite). Can you identify them?

The Maisons de Beaucours, at 33 rue Saint-Louis, was constructed from limestone that comes from Chambord, in the Saguenay region. Many fossils can be seen in the stones with sanded surfaces: cephalopods, gastropods, etc. The stone is very clayey and hence vulnerable to alteration.

At 26 rue Saint-Louis, bryozoans stand in contrast to the altered surface of the stone.

Musée d'art inuit. Tourist attraction with an interesting collection of Inuit soapstone sculptures.

Aux anciens Canadiens. The oldest house on the promontory, made of cap stone covered with parget.

Stop 10 : Price building

Fossiliferous sedimentary rocks

The Price Building was built in 1929 by the Price Brothers pulp and paper company, at a cost of $1 million. The 17-storey building was the tallest in Old Quebec for a long time, and spawned a 1932 municipal by-law prohibiting the construction of any building taller than 20 metres [65 feet], to protect the visual landscape of the Old Town.

The building's exterior covering consists partly of Saint-Marc-des-Carrières limestone and Queenston limestone from the Niagara escarpment. Queenston limestone is pearl-gray in colour on a fresh surface, and pink calcite crinoid stalks are easy to identify in the columns. Queenston limestone is rougher to the touch and it is more altered than Saint-Marc-des-Carrières limestone. The latter develops a light beige patina, whereas Queenston limestone takes on a brownish-buff colour as it becomes altered. Stone from Ontario was probably used because the quarries in Saint-Marc-des-Carrières could not meet the demand. Note that this resource is non-renewable and it is important to preserve it.

The Ecology of Fossils

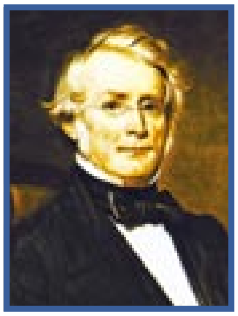
Crinoids belong to the class of echinoderms, as do sea urchins. They typically have a calyx composed of regularly arranged plates, movable arms and a stalk for attaching themselves. Though they may in rare cases be found whole, they are usually found as debris, particularly stalk fragments called entrochites. The drawing on the left shows their habitat (e), among the marine fossil species that lived in the Iapetus Ocean during the Paleozoic era. See Appendix 3 for more information.

The Jesuit College could once be found across from the Price Building, where City Hall currently stands. Following the 1759 Conquest, British military authorities transformed the Jesuit College into soldiers' barracks. As was the case for the Dauphine Redoubt and the new barracks in the Artillery Park in the Old Town, the British occupied the Jesuit College until 1871. In addition to the barracks, the site holds a guardhouse, an armourer shop, a bakery and a parade ground, among others. The Jesuit College was destroyed in 1877 to make room for City Hall.

National archives of Canada, 1761,E. Haberer

CONCLUSION

But just who was Logan ?



Providing an introduction to William Logan is a fitting way to end this geological overview of the Quebec City region. He was one of the first geologists to study the diverse geology of the area and the fault that bears his name. In 1842, Logan founded the Geological Survey of Canada (GSC), which he directed for 27 years. He was a well-known geologist and a great explorer whose studies took him across Canada from the Atlantic to the Pacific.

Logan was born in Montreal in 1798, the son of a baker who had immigrated to Canada from Scotland. After studying for a short time at the University of Edinburgh and working in England and Wales, Logan became interested in how to find coal and began studying geology, which at the time was a young discipline. Logan was 44 years old in 1842, when he was appointed to conduct a geological survey of the Province of Canada. During his early years with the Geological Survey, Logan and an assistant travelled across much of the Province of Canada, which at the time consisted of the southern half of the present-day provinces of Ontario and Quebec. During the period spanned by Logan's career, the GSC offices were located in Montreal.

Although William Logan was a rich man, he paid little attention to his physical well-being and his attire. At times he was taken for a vagabond, and there are many confirmed cases where his appearance led strangers to believe that he was mentally unbalanced. On one of these occasions, Logan was doing some field work while staying in a hotel in Quebec City. On the first morning, he asked the hotel clerk to arrange for a horse-drawn carriage, or calèche, to pick him up. At the sight of Logan coming out of the hotel, the driver immediately assumed that this was a patient from the insane asylum in Beauport coming back from an outing. Without heeding Logan's protests, the driver began heading for the asylum. Logan's problem was that people thought he was crazy. So the founder of the GSC decided to take advantage of this situation. He pulled out his geologist's hammer, and brandishing it near the driver's head, he demanded to be taken to his chosen destination. The driver obeyed. At the end of the day, Logan asked the driver to take him back to the hotel. While the director of the GSC unloaded his rock samples, the driver told his fellow drivers about the awful day he had spent in the company of this dangerous lunatic. Without saying a word, Logan went up to the driver, paid him his due and added a large tip. Upon leaving his hotel the next morning, he found a crowd of drivers all wanting to provide conveyance for a generous lunatic.

For more information:

Sir William Logan 1798-1875: **http://cgc.rncan.gc.ca/hist/logan/index_e.php**

No stone unturned. The first 150 years of the Geological Survey of Canada :
http://cgc.rncan.gc.ca/hist/150_e.php

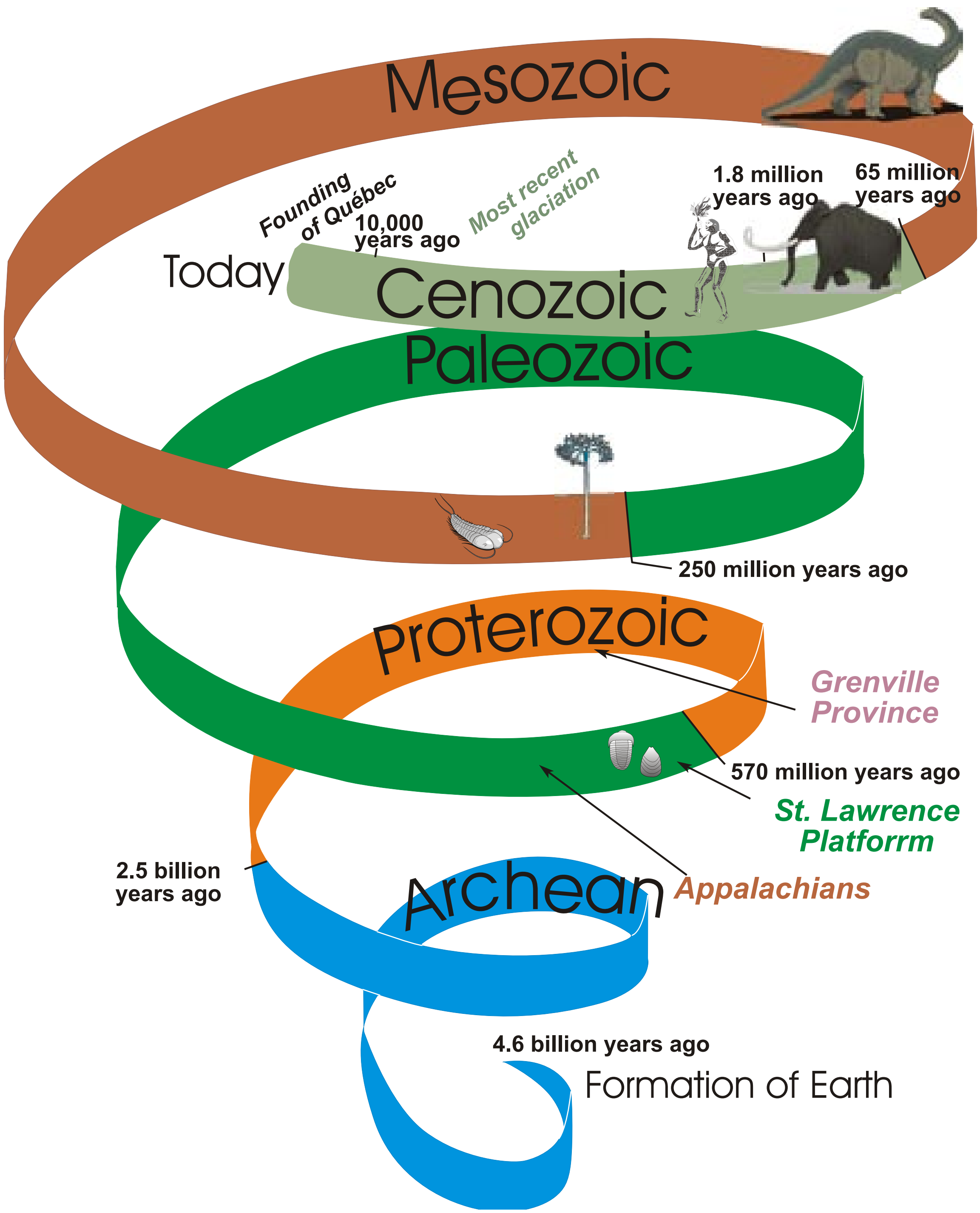
William E. Logan and the Geological Survey of Canada: Written in stone :
http://www.collectionscanada.ca/logan/index2-e.html

Life of a Rock Star: **http://www.collectionscanada.ca/rock/index2-e.html**

APPENDIX 1 : Geologic time scale

Earth's history began 4,500 million years ago, and the Quebec City area's history spans a large part of the geologic time scale.

Some 570 million years ago, living organisms were essentially marine; they included sponges, corals and trilobites [animals with a carapace similar to that of crustaceans]. About 350 million years ago, life forms such as ferns, reptiles and amphibians moved onto the land. Then, some 65 million years before present, the dinosaurs and large reptiles became extinct. Humans appeared 1.6 million years ago.



APPENDIX 2 : Resources linked to Quebec City's history

On a stroll through Old Quebec, you will quickly discover that a great variety of stones have been used for building purposes over the centuries. Limestone, sandstone, shale, granite are the building materials used locally. While it may not be evident, the use of these stones is intimately connected with the area's history.

In the early days of settlement, builders used the stone from Cap Diamant, near the inhabited areas of Place Royale. It was called "cap stone." This was the least expensive and most readily exploitable stone. Beauport limestone, then Côte-de-Beaupré limestone, limestone from Pointe-aux-Trembles at Neuville, Ange-Gardien sandstone, Sillery sandstone and finally Saint-Marc-des-Carrières limestone were successively used.

As travel was made easier by new means of transportation, particularly when the railway opened up in 1875, increasing use was made of Rivière-à-Pierre granite, Eastern Townships grey granite and grey stone from Montreal, together with dimension stones from the United States and from other Canadian provinces. Today, building stones come from all over the world. For example, Scottish slate was recently used to build the courthouse (Palais de Justice).

Below is a brief history of the stones used to build Quebec City. Building materials were taken from all three of Quebec's broad geological assemblages.

Building stones from the Appalachians

For the earliest colonists who came to New France, the quest for suitable building materials was a serious one. The earliest houses consisted of stone-filled frames, attesting to the proximity of the supply of timber and stone. They were constructed by positioning wooden posts and filling in the spaces with stone and mortar. After the Lower Town fire of 1682, people were encouraged to build stone houses. This led to a diversification of the sources of supply of building stone. The number of masonry houses thus increased considerably until about the 1750s when the majority of houses were made of stone.

Cap stone

The first stone used came from the Promontory of Quebec, right in the heart of the town. This black calcareous shale, which can be cut easily, does not permit good quality masonry because it does not bind well with mortar. Furthermore, following exposure to water and air, it splits into thin sheets along the bedding planes.

This stone, which became known as cap stone or Quebec stone, was used mainly for the interior facings of buildings. When used for exterior facing purposes, the stones was placed so that they would be parallel to the quarry bedding planes, and the walls were parged. On some buildings the front facade or the side facing the river was faced with higher quality stone and the other facades with cap stone. Why was this stone so popular in spite of its poor quality during the French regime? Simply because of the proximity of the supply and, hence, the lower cost.

There were actually many quarry sites: at the foot of Cap Diamant and the Côte d'Abraham, in the Upper Town near the Saint-Louis Gate and near what is now rue des Carrières. Quarrying stone in or near the town nonetheless created problems such as landslide hazard.

Sillery Cap-Rouge sandstone

It wasn't until the end of the French regime, around 1740, that quarrying of this stone began between Sillery and Cap-Rouge. This greenish sandstone is part of the Chaudière thrust sheet. Here and there, the rock contains quartz pebbles and shale fragments. Its hardness makes it difficult to cut and its tendency to split into thin layers at the surface explain why it has not been used much so far, despite its proximity to Quebec City. Chaussegros de Léry used this stone to build part of the Quebec fortifications. The British used it extensively in their military works. Signs of the former quarry operations can be seen along Champlain Boulevard and this stone is exposed along the trails near the Quebec City Aquarium.

The stones of the St. Lawrence platform

Beauport limestone

This fine-grained limestone, which is a dark brownish blue, is of better quality and can be carved more easily. It is part of the Neuville Formation of the St. Lawrence Platform. This stone was used in the 17th century and the early 18th century in exterior facings, as dimension stone and to make lime.

In Beauport, the limestone quarries of the St. Lawrence cement factories were located in an area about 3 km long and 500 m wide.

The quarries were located mainly along the Beauport River, at Beauport, which was very far from the downtown core. At this time, the Chemin du Roy linked Beauport and Quebec. It was more economical, however, to transport the limestone by barge. Under the French regime, this limestone was widely used to build the fortifications of Quebec. Until very recently, it was also used by the Beauport quarry, which supplied the St. Laurent cement factory.

Deschambault limestone at Pointe-aux-Trembles (Neuville)

The first mention of the use of limestone from the Deschambault Formation of the St. Lawrence Platform for building purposes goes back to 1714. It is the best quality limestone to be found in the Quebec City area. The limestone is generally very fossiliferous and massive and occurs in light grey beds of uniform thickness, which can be easily carved. At first, it was generally the well-to-do who used this quality stone in building their homes. In a number of buildings, only the door and window frames or the load-bearing partitions were made of this stone. The use of Beauport limestone gradually gave way to this better quality limestone, which was first quarried from Pointe aux Trembles (Neuville). This same limestone formation is exploited at Saint-Marc-des-Carrières, where it has been quarried for 135 years.

Ange-Gardien sandstone on the Côte-de-Beaupré

The engineer Chaussegros de Léry made abundant use of this yellowish sandstone in building military works. As of the second quarter of the 18th century, this stone was used for the exterior facing of buildings and, particularly, on the exposed faces of walls, fences and wharves. It was also used to make fireplaces, chimneys, fire walls and cobblestone streets in Quebec. Although the site where this sandstone was quarried has not been determined, it is believed to have been near the town of Ange-Gardien, in the escarpment and along the St. Lawrence.

Stones of the Canadian Shield

With the development of the railroad, an ever greater diversity of stones came into use. The granites from Rivière-à-Pierre were highly prized for use in cobble streets and for monuments.

Stones from afar

Recent buildings reflect our international reach: granite from Finland, Brazil, anorthosite from Lac Saint-Jean, the North Shore and so on. A type of stone that will achieve a particular effect is sought out, regardless of its origin.

Source : Pierrette Tremblay,
The Québec City Area Through the Eyes of a Geologist **http://cgq-qgc.ca/english/outreach/geotour**

Unconsolidated Materials of the Quaternary

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

On the right side of the road to Sainte-Brigitte-de-Laval, many sandpits can be seen. The sand became deposited in an ancient delta, which constituted the mouth of the Montmorency River some 5,000 or 6,000 years ago. The deposits reveal stratification. This sand is quarried for use as aggregate for concrete and for road building and repair. On the opposite side, vestiges of former quarry activity can be seen on which vegetation is now growing.

APPENDIX 3 : Complementary information on fossils

The fossils you will have the opportunity to see during the two tours described in this guide are the remains of marine invertebrates (brachiopods, bryozoans, cephalopods, crinoids, gastropods, trilobites) and calcareous red algae (Solenopora) which, in Ordovician times (Lower Paleozoic), inhabited the sea bottom in a subtropical sea that covered the region now known as the Lower St. Lawrence Lowlands. Rapid burial of the organisms' skeletons in sediment helped to ensure their fossilization by protecting them from necrophagous organisms, bacteria and the oxidizing environment. The fossils you will see come mainly from a type of sedimentary rock that geologists call limestone.

In Old Quebec, you will note that the building facades are composed of a type of limestone that was frequently used as building stone. This limestone is unique in that it contains large numbers of bryozoan fossils. These colonial animals can be found as encrusting, branched or fan-shaped structures (at 78 rue Saint-Louis: building that was the first Town Hall (1840-1896); at 85 rue Dalhousie: Musée de la Civilisation (constructed in 1981).

You will also see other fossilized marine invertebrates, albeit less often. Brachiopods are bivalved but also bilaterally symmetrical, which allows them to be distinguished from pelecypods, or bivalves, such as mussels, oysters and clams, which have two asymmetrical valves. Brachiopods thrived in the benthic environments (sea bottom) of the Paleozoic seas. They can be useful for determining the age of ancient marine sediments.

Mollusca fossils that can be see in building stones include the spirally coiled shells of gastropods as well as cephalopods, some of which reached a length of 20 centimetres. These cephalopods, which lived in the marine environments of the St. Lawrence Platform (Ordovician), can be distinguished by their conical, nonspirally coiled shell (Orthocones). In the region, these fossils can give an indication of the direction of the ancient marine currents in the Ordovician when they are found preserved and aligned on some rocky planes. These orthocones can be distinguished from another extinct group of cephalopods, the ammonites. On account of their very rapid evolution and restricted time window, the ammonites constitute an important fossil group for use in dating marine sedimentary rocks of the Mesozoic era. They have a flattened shell, which is coiled in a spiral. Did you know that squids and octopuses are present-day cephalopods?

Trilobites are a fossil group belonging to the phylum Arthropoda (like the insects, spiders and crustaceans). This group has proven to be very useful for age determination of marine sedimentary rocks of the Lower Paleozoic era (Cambrian, Ordovician, Silurian and Devonian). These fossils are characterized by the three-lobe structure of their skeleton, with a cephalon (head), thorax and a pygidium (tail). This division, together with the segmentation of the thorax and pygidium, explain why they are often found in separate pieces in certain rocks at the Parc de la chute Montmorency.

When perfectly preserved as fossils, crinoids look like flowers, which is how they came to be called sea lilies. Crinoids still contribute biological sediments in some present-day marine carbonate environments. They form a class separate from the echinoderms (sea urchins, sea stars and sea cucumbers). Crinoids have calcareous external plates, which are articulated and separate, and which easily become disarticulated under conditions of turbulent mixing of the marine environment. This largely explains why visitors will see only fossil remains consisting of small disks (with a central cavity filled with calcite) on visits to Old Quebec or the Parc de la chute Montmorency. Did you know that a number of Canadian and international museums have some very beautiful specimens of crinoids from the Burgess Shales site? In 1981, UNESCO declared this fossiliferous site, located in British Columbia, the 86th World Heritage Site (**http://www.burgess-shale.bc.ca**).

At the Parc de la chute Montmorency, you will no doubt notice some small bulbous concretions in rocks. These are vestiges of the structures built by red algae of the genus Solenopora, which in Ordovician times, thrived in clear marine waters subject to mixing.

Source: Esther Asselin, Geological Survey of Canada, GSC-Quebec

APPENDIX 4 : The whims of Nature

List of the landslides that have occurred in Quebec City (excerpt from: The Québec City Area Through the Eyes of a Geologist: http://cgq-qgc.ca/english/outreach/geotour)

Yeard	Place	Damage	Cause
October 2, 1775	Champlain Blvd	One house dammaged	Cannon shot
June 22, 1779	Cap Diamant	Two hangars damaged	Torrential rains
May 14, 1789	Cap Diamant	One house damaged	
May 17, 1841	Champlain Blvd	27 deaths, 6 houses destroyed	Heavy rainfall
July 14, 1852		5 deaths	Torrential rains
October 11, 1864		4 deaths, 2 houses destroyed	
September 19, 1889	Champlain Blvd, under the terrace	45 deaths	Heavy rainfall
November 9, 1905		Two houses damaged	
June 28, 1957	Champlain Blvd	Several houses damaged	
March 28, 1958	Champlain Blvd		
April 24-25, 1979		No damage	Frost-thaw action
April 1, 1982		No damage	
September 10, 1982		No damage	Heavy rainfall, cleaning of scree slope
March 18-19, 1983		One house destroyed	Heavy rainfall
April 4, 1984		No damage	
February 20, 1994		No damage	Rapid thawing

The earth quarkes under Quebec City, a few accounts from the past

Le Courrier du Canada, October 17, 1860: Fortunately the earth quake was not equally strong in all areas of town. We say fortunately because had the shock been as severe in the Upper Town and in the St. Roch, St. Sauveur and Au Palais districts, this would probably have caused a rock slide on Cap Diamant with possible loss of life.

Le Canadien, October 19, 1860: One man, who found himself in rue Saint-Vallier, reported seeing swaying homes that reminded him of waves in the ocean...

La Tribune, April 20, 1864: Panic spread along rue Champlain with people fearing that a rock slide on Cap Diamant was imminent

Le Courrier du Canada, October 20, 1870: For a minute – some people said a minute and a quarter – Quebec City was shaken with such violence that people believed that no buildings would be left standing in some districts.

Le Soleil, March 3, 1925: One victim in Quebec

Le Soleil, Thursday, January 8, 1931: In the St-Roch district, where the building foundations are fairly solid, the walls swayed appreciably

Le Soleil, October 14, 1952: It appears that the epicentre was located between the Laurentians and the Appalachians… The residents of the Palais and Remparts districts seem to have experienced the worst of the tremor

Excerpt from the "archives" section under the theme "The earth quakes under Québec": (**www.cgq-qgc.ca/geopanorama/qc**)

GLOSSARY

Translation of the French text, which is adapted from Foucault, A. and Raoult, J.F. (2001) or from Jacob H.-L. and Ledoux R. (1998)

Active continental margin: Continental margin where an ocean plate is subducted beneath the continental crust.

Brachiopod: Small invertebrate that has a bivalved shell (one valve is larger than the other) and is bilaterally symmetrical.

Bryozoan: Colonial animals that build a branched or mounded calcareous skeleton comprising thousands of box-like divisions, each housing an individual animal.

Cephalopod: One of the Cephalopoda, a class of marine molluscs. Most fossil forms are characterized by the presence of a straight or spirally coiled, calcareous shell divided into numerous interior chambers.

Continental shelf: Submerged region on the edge of a continent. Syn: Continental margin.

Crinoid: An invertebrate with a cup (head) and a stalk comprising many small disks by which the animal attaches itself.

Diagenesis: Processes that alter a sedimentary deposit, gradually transforming it into solid sedimentary rock.

Erratic block: A large rock fragment transported over a great distance by a glacier; it differs from the substratum on which it lies.

Fault: A fracture in the Earth's crust involving relative displacement of the two blocks of rock parallel to the fracture.

Fissile: As applied to rocks, easily split into thin sheets.

Fossil: Object or substances of biological origin that have become enclosed in rocks through burial or infiltration: animal fossils, trace fossils, fossil fuel, etc.

Gastropod: One of the Gastropoda, a class of molluscs characterized by a foot used for creeping and normally by a shell which is more or less spirally coiled.

Gneiss: A coarse-grained metamorphic rock that shows banding or alternating dark and light-coloured beds.

Graben: Tectonic structure composed of a down-dropped crustal block that is lower in the centre and that is bounded by two parallel normal faults.

Granite: A homogeneous, coarse-grained, intrusive igneous rock composed mainly of quartz and feldspars, with one or more black silicate minerals.

Graptolite: One of a class of predominantly pelagic marine animals found solely as fossils. Their remains resemble lace-like crayon marks.

Isostasy: State of hydrostatic equilibrium that is attained at a depth inside the Earth called the compensation depth.

Limestone: Sedimentary rock composed of over 50% calcium carbonate.

Nappe: A large sheetlike body of rock (= allochtonous) that has been moved far from its original position and covers another assemblage (= autochtonous). Syn. thrust sheet.

Outcrop: A segment of bedrock that can be seen at the Earth's surface.

Passive continental margin: Continental margin where the continental crust and the ocean crust are part of the same plate.

Perpendicular to bed: The laying of sedimentary rocks on a plane that is perpendicular to the bedding plane. Antonym: Bed.

Sandstone: Sedimentary rock composed of rounded or angular grains about the size of sand, bound together by a cement of carbonate or silica.

Thrusting: Tectonic movement during which one block override another along a gently inclined abnormal contact (thrust plane or fault).

Olistostrome: Chaotic mixture of rocks from the leading edge of a thrust sheet that becomes deposited in a sedimentary basin as a result of submarine gravity sliding. An "olistolith" is a large block that is transported as part of this gravity sliding or slumping and that becomes embedded in the sediment deposited.

Quartz: Most common form of silica.

Shale: Very fine-grained sedimentary rock which is homogeneous, clayey and often calcareous.

Stratification: The layering or bedding of sedimentary rocks.

Stratigraphy: Science that studies the succession of sedimentary deposits, which are generally laid down in strata or layers.

Stylolite: A seam of insoluble material that forms by pressure solution among calcareous rocks.

Subduction: The sinking of an oceanic plate beneath an overriding, usually continental, plate, which gives rise to a subduction zone, a deep-sea trench and active volcanoes.

Plate tectonics: Widely accepted theory according to which the solid outer shell of the Earth (lithosphere) is composed of rigid plates that are about a hundred kilometres thick and float on the weak and deformable asthenosphere.

Till: Unstratified drift (rock debris) deposited by a glacier without appreciable reworking by melt water.

Trilobite: A group of fossil arthropods whose body, protected by a shell, is divided into three longitudinal lobes, whence their name.

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USUFUL LINKS IN EARTH SCIENCE

Science and Technology at NRCan:
http://www.nrcan.gc.ca/dmo/scitech

Sustainable Development:
http://www.nrcan-rncan.gc.ca/sd-dd

Climate Change:
http://climatechange.nrcan.gc.ca

Posters depicting climate change in Canada:
http://adaptation.nrcan.gc.ca/posters

Teaching tool for climate change:
http://adaptation.nrcan.gc.ca/posters/teachers/guide_e.asp

Minerals and metal statistics online:
http://mmsd1.mms.nrcan.gc.ca/mmsd

Geographical Names of Canada:
http://geonames.nrcan.gc.ca

Origins of Canada's Geographical Names:
http://geonames.nrcan.gc.ca/education/index_e.php

Topo 101 - Topographic Maps, The Basics:
http://maps.nrcan.gc.ca/topo101/index_e.php

Outreach materials, Canada Centre for Remote Sensing :
http://www.ccrs.nrcan.gc.ca/resource/index_e.php

Ask-A-Geologist:
http://sst.rncan.gc.ca/esic/askgeo_e.php

Information for collectors:
http://cgc.rncan.gc.ca/bookstore/collect/index_e.php

Canada's Geoscience Heritage :
http://collections.ic.gc.ca/geoscience/index.html

Geoscape Canada:
http://geoscape.nrcan.gc.ca

Canada's earth materials :
http://geoscape.nrcan.gc.ca/canada/index_e.php

Waterscapes:
http://geoscape.nrcan.gc.ca/h2o/index_e.php

Canadian Landscapes:
http://gsc.nrcan.gc.ca/landscapes

Frequently Asked Questions about Earthquakes:
htt http://seismo.nrcan.gc.ca/questions/faq_e.php

Qu/bec Geoscience Centre
Educational Resources in Earth Sciences
www.cgq-qgc.ca

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www.cgq-qgc.ca/tous/terre

The Québec and Montréal Geoscapes show the diversity of the geological heritage by presenting practical themes linked to the immediate surroundings. Building stones, whims of nature, the islands and Mount Royal, crops, water, the St. Lawrence, the evolution of landscapes.

www.cgq-qgc.ca/geopanorama/qc
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