

# The September 19<sup>th</sup> 1889 rock slide along Champlain Street in Québec City, a catastrophe foretold by Charles Baillargé

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## ABSTRACT

The 1889 rock slide along Champlain Street is the one that caused the largest number of fatalities among the many landslides that took place in this area of Québec City during the 19<sup>th</sup> century. This event marked a significant step in our way of looking at these events from both technical and political viewpoints. This paper presents a historical perspective of the events leading to the 1889 slide, starting with the 1841 slide which was also quite significant. Already in 1840, signs of this major hazard along the cliff were reported. Mitigation measures were initiated mainly after 1880 but they were not sufficient to prevent the major catastrophe expected by those who did the investigation of the Champlain Cliff. Baillargé, in particular, carried out a detailed survey in 1879 and proposed mitigation measures that would have likely prevented the consequences of the 1889 slide had they been followed completely. The story of the 1889 slide ends in 1894 by an interesting judgment by the Supreme Court of Canada, in which The Queen was not held responsible for the consequences of the slide, although the main trigger was the water draining from the Citadel into the cliff fissures. It is only in 1960 that major stabilization work was carried out under the Dufferin Terrace. This paper also highlights the significant contribution of Charles Baillargé (1826-1906) in the understanding of rock slide processes along the Champlain Cliff.

## RÉSUMÉ

Le glissement rocheux de 1889 le long de la rue Champlain est celui qui a causé le plus de décès parmi les multiples glissements qui se sont produits dans cette partie de la ville de Québec au cours du 19<sup>e</sup> siècle. Ce glissement a marqué un jalon important dans notre façon de voir ces phénomènes tant du point de vue technique que politique. Cet article présente une perspective historique des événements qui ont mené à celui de 1889, et cela en commençant par celui de 1841 qui était aussi important. Des mesures de prévention ont été mises en place après 1880 mais elles n'ont pas été suffisantes pour prévenir la catastrophe de 1889 qui avait été appréhendée par ceux, incluant Baillargé en 1879, qui avaient étudié le site. L'histoire du glissement de 1889 se termine avec un jugement intéressant de la Cour Suprême du Canada en 1894 qui conclut que la Reine ne pouvait être tenue responsable des conséquences du glissement malgré le fait que la cause principale était un drain défectueux provenant de la Citadelle, lequel a permis aux eaux de drainage de s'infiltrer dans les larges fissures présentes dans le talus. Ce n'est qu'à partir de 1960 que des travaux majeurs de stabilisation ont été entrepris sous la terrasse Dufferin. Cet article illustre aussi la contribution significative de Charles Baillargé (1826-1906) à la compréhension des glissements de terrain le long de la falaise Champlain.

## 1 INTRODUCTION

Many mass movements have been reported along Champlain Street below the Québec Citadel and the Dufferin terrace since 1775 (Fig. 1, Baillargé 1893, Gale 1915, Drolet et al. 1990, Ballifard et al. 2004, Locat and Kirkwood 2004). The cliff located along the Champlain Street (today called the Petit Champlain Street) will be hereafter referred to as the Champlain Cliff and forms the slope between the Dufferin Terrace to the north and Cap Blanc to the south (Fig. 1a).

The geology of the Champlain Cliff has been detailed by Locat and Kirkwood (2004) and consists of Appalachian sedimentary rocks. The rock outcrops are mostly part of the Québec Promontory thrust sheet that contains rocks of the Citadel Formation (Gayot, 2002). The sector of the Dufferin Terrace above the Champlain Cliff is composed of mid-Ordovician limestone beds of the

Ville de Québec Formation, in a sub-vertical position. Layers of calcareous shale are interbedded within the limestone. The slope is abrupt, i.e. more than 50°, and locally nearly vertical. The crest of the cliff at the site of the 1889 slide is located 56 meters above sea level.

This paper will concentrate on the period between 1841 and 1894 for which, over a distance of less than 2 kilometres at least 76 persons have lost their life and about 68 were injured (Locat and Kirkwood 2004). To be noted is that most of the fatalities involved in the 1889 landslide were of Irish origin because at that time many people from the Irish community were working on nearby ships.

Through a historical perspective, the objectives of this paper are three folds: (1) show that the 1889 was a foretold catastrophe, (2) underline the heritage of Charles Baillargé (see below at Fig. 5), a civil engineer who likely

carried out the first detailed analysis of a rock slide in Canada and (3) provide some considerations pertaining to civil responsibilities.

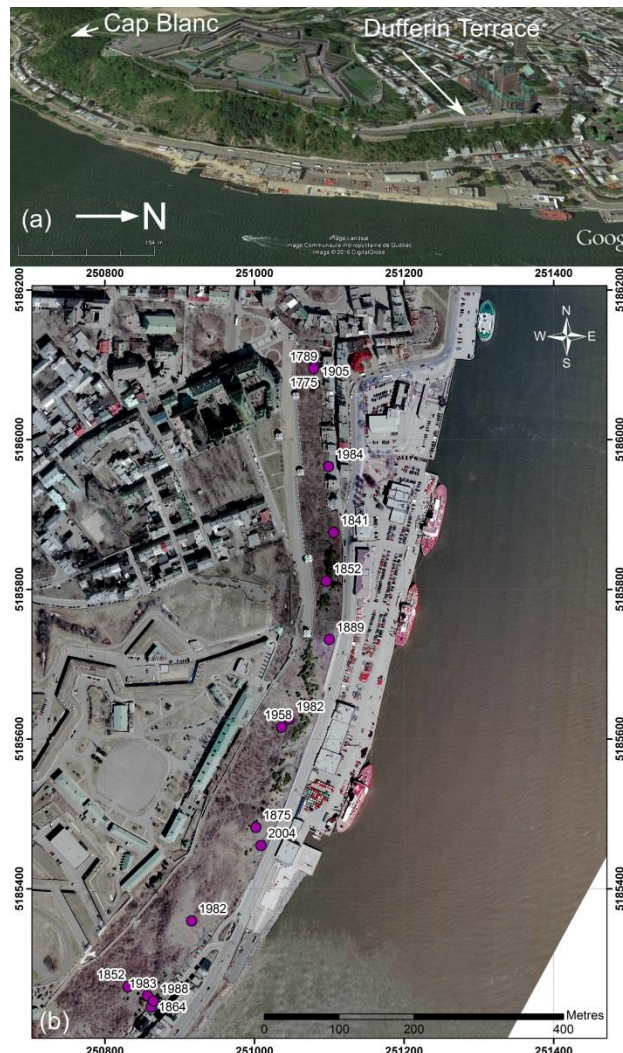


Figure 1. (a) Oblique view of the Champlain Cliff and (b) location and year of slide events in this sector along the St. Lawrence River.

## 2 THE CHAMPLAIN CLIFF BEFORE 1889

To understand the precursory conditions of the 1889 slide, we will try to document the morphology of the Champlain Cliff and some events and surveys over that period of time. The oldest information on the morphology of the Champlain Cliff has to be taken from painting until about 1870. Since then, photographs (even stereophotographs) are available for inspection. The dating of some archive photographs is not always precise and even if sometime they are said to have been taken around 1900, the clear signature left by the 1889 slide is used here to confirm that a photograph has been taken before or after the 1889 slide (see also the 1932 13c Canadian stamp of the Citadel)! The work in support of

the following description is still underway so that better evidences could be found later.

The history starts with the 1841 slide (Figs. 1b, 2 and 3), for which a very unique painting has been done by Joseph Légaré (Fig. 3). This must be the oldest visual record of such an event in Canada. It provides a detailed but somewhat artistic view of the slide sector at the time showing people searching through the debris. The buildings in the foreground and in front of the slide debris can be easily localised on more recent photographs (Fig. 1 and 'b' in Fig. 2). According to Bennet (2013), Légaré painted this rock slide as a sort of social criticism on the lack of interest by the government at the time about lower class people. Historical documents, some of which are reported below, show that it is only between 1880 and 1889, i.e. about 40 years later, that some remedial work was initiated to reduce the risk.

Apart from its location and timing, there is little information found yet on the May 17<sup>th</sup> 1841 rockslide. What is known is that it took place at about 9PM, just east of the location of the 1889 landslide, that it was caused by rainfall and that it took the life of 32 people with 32 people injured and 9 houses destroyed. Part of the fortification wall was also taken away.

The only pre-1841 information is from a report by Major Cole (July 14<sup>th</sup> 1842) who mentions an ordinance of May 18<sup>th</sup> 1840 preventing any encroaching below the Champlain Cliff as a local quarry or for increasing the size of the usable land. The report states that this ordinance should be maintained until 1843, a sign that there were some concerns about the state of the cliff. During the 19<sup>th</sup> century, extraction of stones at the toe of the cliff has always been an issue along Champlain Street.

According to Québec City archives, many petitions were made during the years following the 1841 slide by local residents along Champlain Street regarding their fear about rock falls along the cliff and asking that actions be taken to resolve the issue. On July 7<sup>th</sup> 1842, Cole wrote a letter to Lord Frederick Paulet describing the state of the cliff west of the 1841 slide and reported, using a diagram (Fig. 3), that "...I should advise that about 300 yards beyond the slip (1841) the cliff be scarped, as shown by dotted line a-b of diagram (Fig. 4) and that the face above should be carefully drained". Just few days later, on July 14<sup>th</sup> 1842, J. Hamel, road inspector for Québec City, wrote to the mayor of the City, R.-E. Caron, about the status of the Champlain Cliff. He also proposed remedial work including removal and re-sloping of the cliff. In the still inhabited part, Hamel (1842) was also wondering why people would still live under such a threat. In his letter he also noted an interesting element that according to the military government their responsibility stops at the crest of the slope and that their only power is about preventing any digging at the toe of the cliff. So, in 1842, it appears that the cliff belong to the owner of the land below it. Hamel (1842) also recommend that to the west, where there are no houses, to re-slope the cliff at about 50°. In his conclusion, he also recommended to take measures to ensure a proper diversion of the water coming from the Jardins du Gouverneur (the Citadel) and noted that the infiltration of water coming from the Citadel was the primary cause of the 1841 slide (Fig. 2)

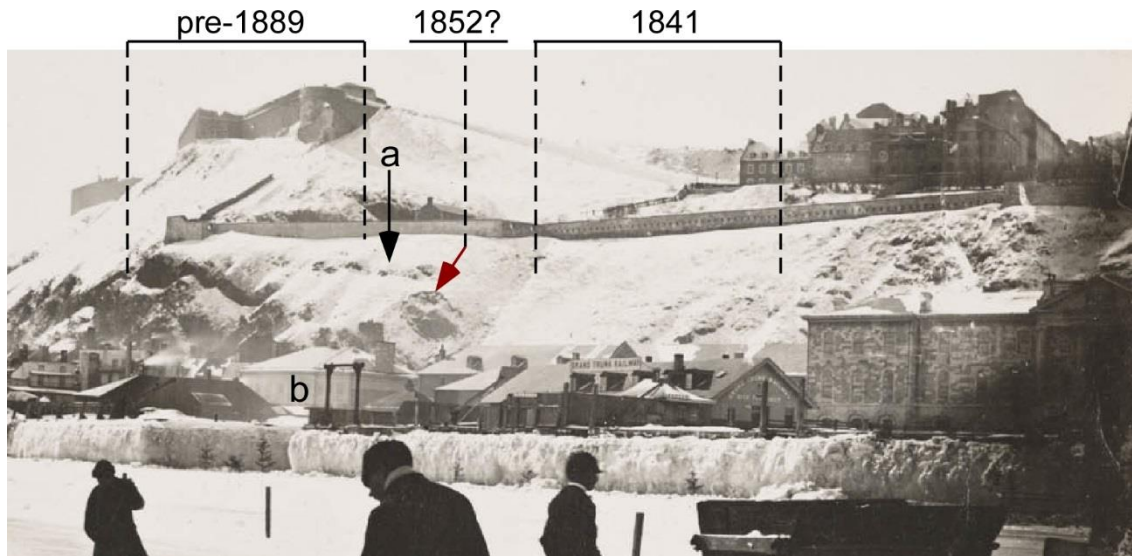


Figure 2. Extract from a photograph of the Champlain Cliff taken in 1870 from which we can see the reworked slope of the 1841 slide, the likely position of the 1852 slide (red arrow) and the slope in the pre-1889 slide area (a). Also shown is a possible fissure along 'a', evidenced by absence of snow likely due to heat being expelled along it. In 'b' is the government building seen in Fig. 3. See text for explanations. (modified after a photo taken by Livernois in 1870).



Figure 3. The 1841 slide along Champlain Street shown in a painting by Joseph Légaré. The large government building in the foreground is shown in Figure 2 with the letter 'b' (source: Le Devoir, Musée du Séminaire de Québec).

On July 7<sup>th</sup> 1848, a more detailed investigation was made by J. Hamel, who reported in his letter to G.O. Stuart,

mayor of Québec, the presence of large fissures running more or less parallel to the cliff. He also noted that in the

area to the west of the 1841 slide (future location of the 1889 slide) the rock cliff presented an overhanging of about 2 to 2.8 m over a height of about 17 m thus threatening the people leaving below it.

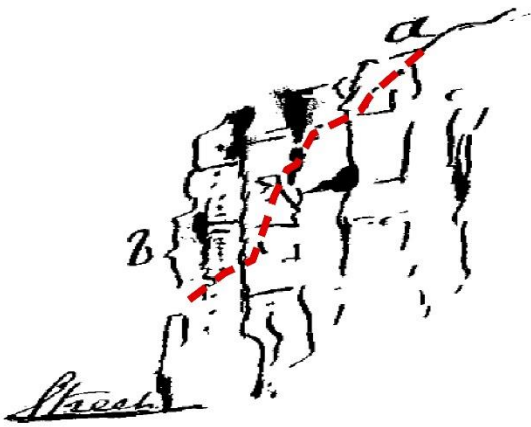


Figure 4. Sketch of the cliff west of the 1841 slide and along Champlain Street (Street on the figure). Scaling was recommended along the dashed line between 'a' and 'b'. The red dashed line is interpreted by the Author (modified after Cole 1842).

On July 14<sup>th</sup> 1852, following an intense storm, three slides were reported along the Champlain Cliff with a major one approximately located on Figures 1 and 2 which destroyed a house killing 9 people. If the semi-circular feature in Figure 2 is the head of the scarp of the 1852 slide, it would indicate that it stopped half way up in the slope.

Later, on December 2<sup>nd</sup> 1864, Hamel reminded again to the City authorities that there was still some danger along Champlain Street, in particular in the area just west of the 1841 slide. He mentioned that: "...we are of the opinion that portion of the cliff are always liable to fall in consequence of the natural cleavage of the rock, a shale formation, acted upon by veins, springs, frost and the atmosphere.

*We observed three natural fissures in the rock running nearly parallel to Champlain Street which have existed for years and have been filled in since 1848, the date of the last report on this subject, and which will not, we apprehend, lead to more serious consequences than the admission of the surface water from the cliff.*

*The excavation at the foot of the cliff, which have gone on from time to time, increase the fatality of the land slides, inasmuch as the said cliff stands some 30 or 40 feet in height and leaning some 10 degrees from the perpendicular, towards the street.*

*Under those circumstances we consider that there is danger to life to any person residing at the foot of the rock on that portion of Champlain street above described, concurring thereby with the reports hereunto annexed made on the same subject in 1848, by Capt. Beathy (?)<sup>1</sup>, the Commanding Royal Engineers at Quebec, and by the present City Surveyor."*

<sup>1</sup> Difficult to read on the hand writing. Note by the Author.

After the landslide of February 3<sup>rd</sup> 1875 in the western portion of the Champlain Cliff (Fig. 1b), causing the death of 8 people, the military authorities monitored the development of cracks near the escarpment. If they appeared to get wider, engineers filled them with cement. Also, unstable blocks were held by chains and a protection wall was erected at the base of the slope to prevent movement of the debris.



Figure 5. Charles Baillargé (1826-1906), architect, land surveyor, civil engineer and author (source: City of Québec Archives).

On January 1<sup>st</sup> 1880, Charles Baillargé reported to the Mayor of Québec City, R. Chambers, on the first detailed geological and structural investigation of the Champlain Cliff west of the 1841 slide that he carried out in 1879 at the request of Hon. Langevin of the Committee of Public Works of the Dominion who were planning to provide some funding to reduce the risk along Champlain Street. This report has not been found yet but his letter to the mayor of Québec City provides some clues as to the main observations made and the main findings which are also repeated in his 1889 report and 1893 paper following the 1889 slide (Figs. 6 to 10). Baillargé noted, in particular, the presence of fissures and overhangs within the slope. Some of the fissures reached a depth of 35 m and more than 1 m in width at the top ('D' Fig. 7 and 9). In his 1880 letter, he indicated how anxious he was working late at night to provide his report soon enough so that a decision be made in time by the government to proceed in solving the issue. He wrote "*The report and plan are exhaustive of the subject matter under consideration, they show and set forth the several properties along the line with a recommendation that the Government shall cause them to be vacated without delay, purchase the properties, demolish the building erected thereon and then proceed with the removal of so much of the rock as recommended in the report*". As an alternative to rock removal, he also proposed to put buttresses at regular interval along the cliff (Fig. 6). He also wrote that "*My first impression was, on viewing the cliff either from above or from below that it*

might go over bodily, burying in its ruins the houses on both side of the street. Since I have made the survey and section which show the cliff to have a broader base to stand on than was at first supposed, I came to fear that it has a tendency of toppling over in a body, but the danger still remains of considerable enough portions of it giving away, to damage the property beneath it and endanger the lives of our people". Clearly, the dangerous zone that would later be involved in the rock falls of 1889 was then well identified.

Following the investigation by Baillargé, the Federal government decided to take action but carried out only parts of Baillargé's recommendations. The Government bought and removed the houses below the Champlain Cliff (Y in Fig. 7), but not those across the street (X in Fig. 7), and built a small retaining wall (W in Fig. 7) put in such a way as to also increase the width of Champlain Street in that sector.

### 3 THE SEPTEMBER 19<sup>TH</sup> 1889 SLIDE

On September 19<sup>th</sup> 1889, a major slide took place exactly where Baillargé predicted it (Figs. 6 and 7). After the slide of 1889, an official inquiry was held and Baillargé (1893), who studied the 1889 landslide, attributed it to the presence of deep and vertical cracks, which were in the same orientation than the stratification, which were filled with water running down, from a broken pipe, into the various crevasses (Fig. 6).

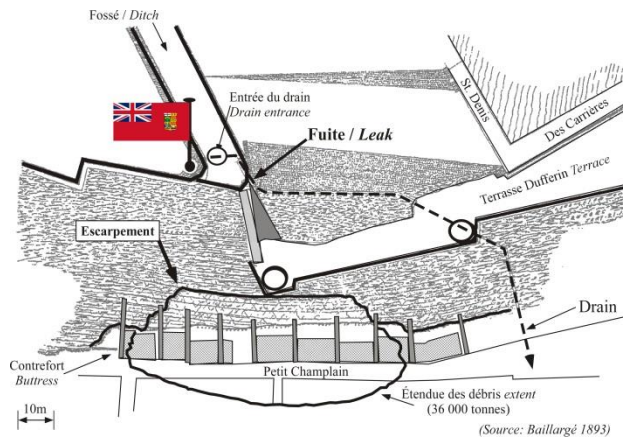


Figure 6. Plane view of the 1889 slide area also showing the remedial measures (buttresses) proposed by Baillargé in 1880. The broken drain was only identified in 1889. (modified after Baillargé 1893).

According to Baillargé (1893), a major rainfall that fell over 12 hours supplied an estimated 850 m<sup>3</sup> of water within the cracks during the preceding hours and this volume could have induced a pressure of more than 46 000 tons against the walls of the cracks (Figs. 7 to 9). Baillargé (1893) did a stability analysis and concluded that the slope failed as a toppling failure due to the presence of a set of discontinuities inclined at about 17° to 23° (shown in Fig. 7). Baillargé (1893) has a footnote indicating these lines had been inadvertently ignored by the engraver. Taking it into account in the stability analysis (forces analysis), the inclined planes made the

slope unable to sustain the water pressure exerted in the major cracks. The amount of slide debris was estimated at 36 000 tons (Baillargé 1893, Fig. 10a).

This local groundwater recharge would have been caused by a defective drain constructed around 1830 (see Fig. 6). At first, this drain was installed to divert water from cracks but it was eventually forgotten! Baillargé had noticed that, even before the slide event, water would often accumulates in deep cracks during rainfall and it could take many days for the cracks to be fully drained (see an example of these large fissures in Fig. 8).

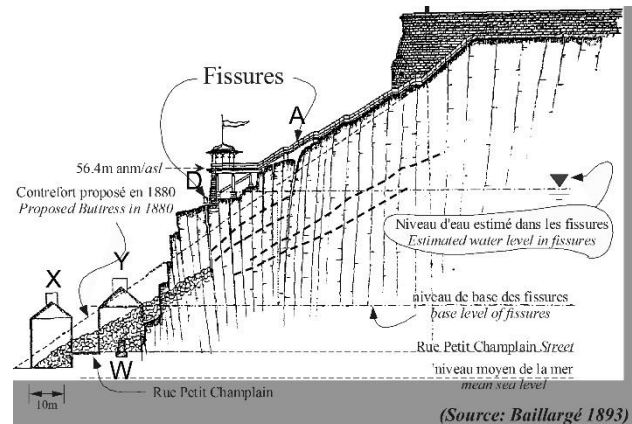


Figure 7. Section more or less perpendicular to the King's bastion at the top which is almost in the middle of the 1889 slide. Black inclined dashed lines were inserted by the Author according to the drawing of Baillargé (1889). (modified after Baillargé 1893). A and D are fissures.



Figure 8. Example of one of the large fissures (fissure A located in Figs. 7 and 9) mapped by Baillargé in 1879 and partly filled by debris. Note the wood cover near the top. Photograph likely taken while the slope was being repaired after the 1889 slide. (Source: archive of the City of Québec).

There are quite a few photographs taken at the time of the 1889 slide. Two were retained for this paper. One showing the debris (Fig. 10a), and one providing a view towards the head of the slide (Fig. 10b).

Some arguments reported by Baillargé (1893) were suggesting that the fallen portion of the cliff may have failed by sliding out of at the base (a circular failure) but according to Baillargé (1889, p. 10) "... this view can hardly be maintained, as in such a case the vegetable

mould, grasses and other growths at B (at the scarp, Fig. 9) would have been found at the P (the base, Fig. 9) while, on the contrary, they were found at the extreme outer edge of the fallen debris, showing that, as testified by several witnesses, the cliff actually fell toward from the top". From this, the 1889 Quebec slide should be considered as a toppling failure.

The slide parted along crevasse 'D' in Figure 7 (B in Fig. 9) and fell has a toppling failure on the houses on the other side of the street (X in Fig. 7) which had not been removed, contrary to the recommendation of Baillargé in 1880. In his 1893 paper, Baillargé noted that the fissure A (Fig. 9) had opened by 15.3 cm (6 inches) between 1879 and 1889.

By looking at Figure 6, it is clear that Baillargé had rightly understood the situation and proposed remedial measures that were only partly followed.

It is striking to see that the place where he suggested to put the buttresses was exactly along the final head-scarp of the slide which took place 10 years later.

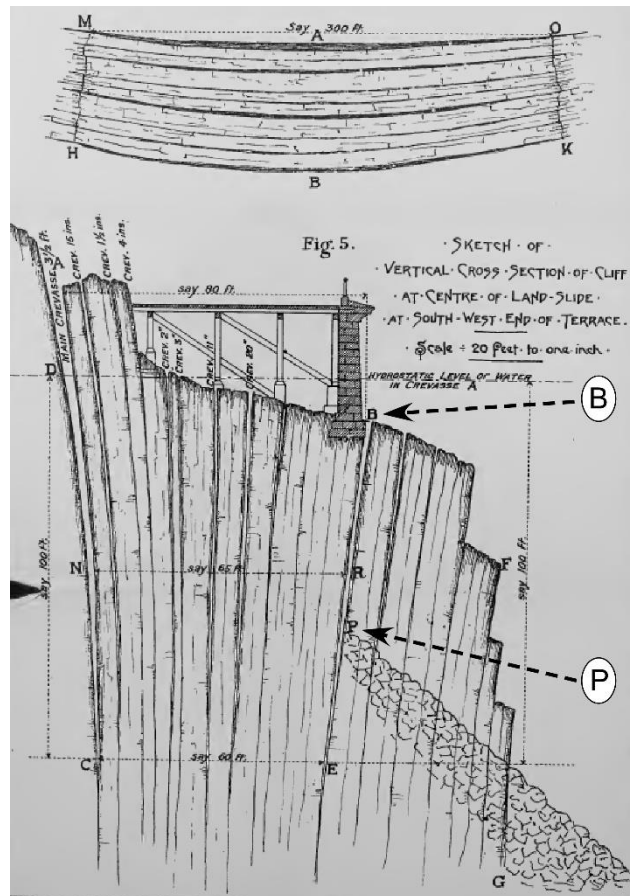


Figure 9 Detailed 1879 analysis of the main crevasses near the center line of the 1889 slide (modified after Baillargé 1893),

Later, from 1957 to 1960 other investigations were carried out along the Dufferin Terrace using measurement tools like extensometers, trenches and drilling (Brown and Casey 1960). Their investigation indicated that many cracks contributing to the movement of water and to the

instability of the slope were still present. Brown and Casey (1960) observed lateral displacement during abundant rainfall. Following these observations, 59 anchor bolts were installed to stabilize the cliff wall under Dufferin Terrace (Brown and Casey 1960). They also suggested that the drainage should be controlled to redirect the water supply away from the slope and that the performance of the system be evaluated every year. It appears that more work has been recently done along the Dufferin Terrace but these data have not been obtained yet.

Since 1980, the City of Québec provides a grant of up to 80% of the cost, not exceeding now a total of 250 000\$, to any home owner willing to improve the safety of their property in specific areas along the Quebec Promontary<sup>2</sup>. The works often consists in the installation of nets and some bolting.

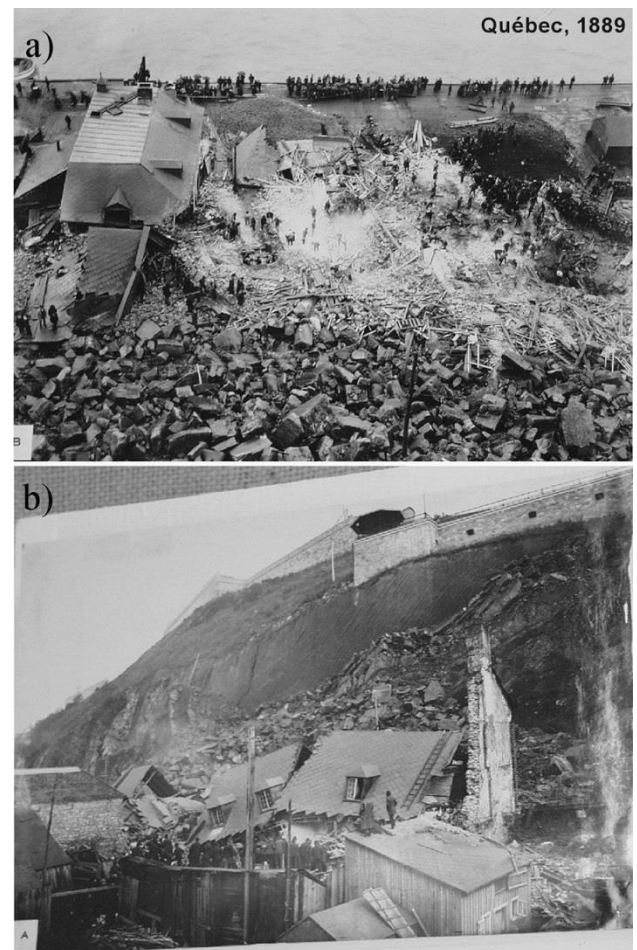


Figure 10. . Photographs of the Québec 1889 rock slide with a view in a) showing the debris over Champlain Street and in b) of the head scarp controlled by fissure 'D' in Figure 7. (source Québec City archives, photographs by Topley).

#### 4 THE 1889 SLIDE AT THE SUPREME COURT OF CANADA IN 1894

After the 1889 rock slide, the City of Québec, according to the various investigations, was convinced that the Federal government was responsible for the damages caused by the slide. The main argument for the City of Québec was that the slide was directly caused by a malfunction of a drain installed around 1830 to drain the ground of the Citadel. As part of the process, the City of Québec prepared a request to the Exchequer Court which concluded that it did not have the jurisdiction on this issue. Therefore the City of Québec went to the Supreme Court of Canada composed of five judges. Since the Author's capacity in interpreting correctly such a legal document is limited, any interested reader should read the document by consulting the following: Supreme Court of Canada, *The City of Québec v. The Queen* (1894) 24 SCR 420.

The final ruling was that three judges voted against the request of the City of Québec and two in favour, including the Chief of Justice. Two opposite arguments were presented. For *The Queen*, it was considered that there was no evidence of negligence from the officers in charge of the Citadel since they did not know about the presence of such a drain. For the City of Québec, and based on the Napoleon Code, which is the Civil Code prevailing in Québec (not the Common Law), they were using the concept of 'Bon voisinage' (good neighbours), i.e. that someone above another one which causes a change that creates damages to a person or a property below is responsible for it. It was also made clear that for *The Queen*, their property ended at the crest of the slope so that the cliff belongs to the owner of the land below.

For the records, the summary of the opinion of the judges are provided below starting with the verdict of a majority of judges (3): "*Held, per Taschereau, Gwynne, and King JJ., affirming the decision of the Exchequer Court, that as the injury to the property of the city did not occur upon a public work, subsec. (c) of the above Act did not make the Crown liable, and, moreover, there was no evidence that the injury was caused by the negligence of any officer or servant of the Crown while acting within the scope of his duties or employment.*"

Follows is the verdict by two judges: "*Held, per Strong Q.J. and Fournier J., that while subsec. (c) of the Act did not apply to the case, the city was entitled to relief under subsec. (d); that the words "any claim against the Crown" in that subsec, without the additional words would include a claim for a tort; that the added words "arising under any law of Canada" do not necessarily mean any prior existing law or statute law of the Dominion, but might be interpreted as meaning the general law of any province of Canada and even if the meaning be restricted to the statute law of the Dominion the effect of sec. 58 of 50 & 51 V. c. 16 is to reinstate the provision contained in s. 6 of the repealed Act R.S.C. c. 40 which gives a remedy for injury to property in a case like the present; that this case should be decided according to the law of Quebec, regulating the rights and duties of proprietors of land situated on different levels; and that under such law the*

*Crown, as proprietor of land on the higher level, was bound to keep the drain thereon in good repair and was not relieved from liability, for damage caused by neglect to do so by the ignorance of its officers of the existence of the drain.*

*Held also, per Strong C.J. and Fournier J., that independently of the enlarged jurisdiction conferred by 50 & 51 V. c. 16 the Crown would be liable to damages for the injury complained of not as for a tort but for a breach of its duty as owner of the superior heritage by altering its natural state to the injury of the inferior proprietor.*

The Supreme Court of Canada ruling reveals few elements that are still operating today. The first one is that people do not like to own a slope! The second is that when there is a conflict of jurisdiction involving the Federal Government and lower levels, it appears always difficult for the lower jurisdiction to win even if here the Chief of Justice considered that for the above case the law of Québec should apply. The Author knowledge in this field is very limited so that such an interpretation may be wrong but it is hoped that this judgment be commented by people that have better competences. It would be interesting to see if this judgement had any consequences later on similar cases or if it could have any in the future.

#### 5 CONCLUDING REMARKS ON A CATASTROPHE FORETOLD BY BAILLARGÉ

Already around 1840 there were some issues pertaining to the stability of the Champlain Cliff as shown by the many petitions written by the people living below the cliff and the various requests to take mitigation measures. The work of Baillargé detailed many observations made by earlier workers. He provided figures and plans which show a high and rigorous analysis that he provided to understand the situation. In his 1893 paper, Baillargé presents a very detailed account on how he evaluated the stability of the slope considering both the nature of the rock, the structural components, the role of water and the behavior of a creeping slope. This is clearly one of the first detailed analysis of a slope failure in Canada and if the 1880 recommendations had been completely followed the consequences would have been greatly reduced.

Even following the 1889 slide, apart from the landscaping work done on the slope of the 1889 slide, it is only since 1960 that major stabilization works appear to have been initiated. The Champlain Cliff is a complex geological and structural environment with many human interventions both below and above it. It is interesting to note here that on old photographs, the Champlain Cliff is treeless likely for security reasons (as a fortress) but with time this aspect does not seem so crucial since the slope is more and more vegetated. This may not be so favorable for slope stability even if there is no erosion at the toe of the slope. There is no report of earthquake induced rock fall in Québec City. With the new technologies pertaining to slope monitoring, this site shall be targeted in order to provide a better understanding of the slope response to environmental forces and the area of analysis shall extend all around the perimeter of the Québec Promontory where rock instabilities still take place from time to time (see Fig. 1b).

## ACKNOWLEDGEMENTS

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*Note: all the letters mentioned in the text are from the City of Québec Archives.*