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**GEOLOGICAL SURVEY OF CANADA  
OPEN FILE 8793**

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macroseismic information and interpretation**

**M. Lamontagne, K.B.S. Burke, and L. Olson**

**2021**



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**2021**

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Permanent link: <https://doi.org/10.4095/328261>

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### Recommended citation

Lamontagne, M., Burke, K.B.S., and Olson, L., 2021. The 1860 magnitude 6.1 Charlevoix, Quebec, earthquake: macroseismic information and interpretation; Geological Survey of Canada, Open File 8793, 1 .zip file. <https://doi.org/10.4095/328261>

Publications in this series have not been edited; they are released as submitted by the authors.

# The 1860 magnitude 6.1 Charlevoix, Quebec, earthquake: macroseismic information and interpretation

M. Lamontagne, K.B.S. Burke, L. Olson

## Abstract

The Moment Magnitude ( $M$ ) 6.1 Charlevoix earthquake occurred on October 17, 1860, at around 6:15 am local time. The epicentre was located in the Charlevoix Seismic Zone (CSZ), probably in the surroundings of the towns of La Malbaie, Baie-St-Paul and Rivière-Ouelle. The main shock was felt from New Brunswick to the east to Southern Ontario to the west and as far south as New Jersey, more than 800 km from the epicentre. Newspapers in Quebec City reported the damage caused by this earthquake in the regions of Charlevoix and Kamouraska, Quebec. There, damage was reported to many houses, and the intensity was greatest in the communities of Rivière-Ouelle, (south shore of the St. Lawrence River) and La Malbaie (north shore). Some damage to masonry was also reported in Quebec City, about 110 km from the epicentre. The Moment Magnitude is approximated to be 6.1 from a direct conversion from the assumed Local Magnitude ( $M_L$ ) 6.0. Based on the impact of other Charlevoix earthquakes, the region affected by the 1860 event is in general agreement with this magnitude. This Open File Report presents the macroseismic information and its ratings on the Modified Mercalli Intensity (MMI) Scale for a total of 91 locations in Canada (69) and the United States (22). For each locality, the felt information is rated on the MMI scale and tabulated in a Microsoft Excel spreadsheet. The original text of many of the newspaper accounts was copied and when possible, images of the newspaper clipping are added. The Open File also provides a GoogleEarth kmz file that allows the felt information reports to be viewed in a spatial tool.

## Résumé

Le tremblement de terre de Charlevoix s'est produit le 17 octobre 1860, vers 6 h 15, heure locale. L'épicentre était situé dans la zone sismique de Charlevoix (CSZ), probablement dans les environs des villes de La Malbaie, Baie-St-Paul et Rivière-Ouelle. Le principal choc a été ressenti du Nouveau-Brunswick à l'est au sud de l'Ontario à l'ouest et jusqu'au New Jersey au sud, à plus de 800 km de l'épicentre. Les journaux de Québec ont fait état des dégâts causés par ce tremblement de terre dans les régions de Charlevoix et de Kamouraska, au Québec. Là, de nombreuses maisons ont été endommagées et l'intensité du séisme a été la plus forte dans les communautés de Rivière-Ouelle (rive sud du fleuve Saint-Laurent) et de La Malbaie (rive nord). Des dommages à la maçonnerie ont également été signalés à Québec, à environ 110 km de l'épicentre. La magnitude du moment sismique est estimée à 6,1 par conversion directe de la magnitude locale ( $M_L$ ) 6,0. D'après l'impact d'autres tremblements de terre de Charlevoix, la région affectée par l'événement de 1860 correspond approximativement à la magnitude estimée. Ce rapport en dossier public présente les informations macroséismiques et leurs niveaux sur l'échelle d'intensité de Mercalli modifiée (MMI) pour un total de 91 localités au Canada (69) et aux États-Unis (22). Pour chaque localité, les informations ressenties sont notées sur l'échelle MMI et présentées sous forme de tableau dans un tableur Microsoft Excel. Le texte original de nombreux comptes rendus de journaux a été copié et, lorsque cela est possible, des images des coupures de presse sont ajoutées. Le dossier public fournit également un fichier kmz GoogleEarth qui permet de visualiser les renseignements macroséismiques dans un outil géospatial.

## Dedication

This Open File Report is dedicated to the memory of the late Father Pierre Gouin (Fig. 1) who has spent years of his later life documenting pre-1925 earthquakes of the Province of Quebec. His findings and analyses can be found in Gouin (2001). This Open File is largely based on his dedicated work. Highlights of his career can be found at:

<https://pubs.geoscienceworld.org/ssa/srl/article/77/4/424/143254/Pierre-Gouin-S-J-1917-2005>



Figure 1. Reverend Pierre Gouin, S.J. 1917-2005

(source of photo: <https://www.mesaieux.com/Avis-de-deces/Pierre-GOUIN/271203>)

## Introduction

The October 17, 1860 earthquake is one of the damaging earthquakes of eastern Canada. It occurred in the Charlevoix Seismic Zone (CSZ) where five earthquakes rated at moment magnitude (**M**) 5.5 or more are known to have occurred: 1663 (**M** ~ 7); 1791 (**M** ~ 5.5); 1860 (**M** ~ 6); 1870 (**M** ~ 6.6); and 1925 (**M** 6.2; Bent, 1992; 2009). Due to these damaging earthquakes and the recurring lower magnitude earthquakes, the CSZ is recognized as the most active seismic zone of eastern Canada. Macroseismic information about these earthquakes can be found in: 1663 (Lamontagne and Locat, 2021), 1791 (Lamontagne, 2020); 1870 (Lamontagne et al., 2019) and 1925 (Lamontagne et al., 2021).

The main shock occurred on October 17, 1860, at around 6:15 a.m. local time. From the available written accounts, the earthquake was felt from Saint John, New Brunswick, to the east,

to Hamilton, Ontario to the southwest and as far south as Newark, New Jersey, more than 800 km from the epicentre (Figure 2; Gouin, 2001). In these areas, its impact was reported in several newspapers and in a few diaries. For many years, the Geological Survey of Canada rated its magnitude at 6 (no digits; comparable to the local magnitude  $M_L$ ) mainly based on maximum damage estimates and felt area (Smith, 1966). Bent (2009) list the earthquake as **M** 6.1 based on felt area magnitude from Johnston et al. (1994). The latter magnitude value is discussed below.

For days, aftershocks were felt in the epicentral region, most notably in Baie-St-Paul (Trudelle et al., 1859), Rivière-Ouelle and La Malbaie. A second, weaker shock was reported shortly after the first, at 6:20 am. A third shock occurred at 6:30 am and was less violent than the first aftershock. During the following week, other tremors were felt in La Malbaie (Gouin, 2001).

The damage caused by this earthquake is mostly known from the newspapers of Quebec City. The maximum intensity (masonry damage) was reported from Rivière-Ouelle, a village built on thick unconsolidated deposits (Gouin, 2001). There, it as reported that the church cross on top of the spire about 15 chimneys fell (MMI VIII). It was reported that the first and third shocks made the furniture “dance” and pictures, clocks and other small items fell. On the north shore of the St. Lawrence River, chimneys were damaged at Baie-St-Paul and La Malbaie. The effects in Baie-St-Paul, are described in the Quebec Morning Chronicle and also, documented the first time, in the diary of the Abbé Charles Trudelle (Trudelle et al., 1859).

At La Malbaie, water gushed in the middle of a road and that some cracks in the roads were observed and reported in a 1907 personal account. Water gushing in the middle of the road should not necessarily be interpreted as liquefaction: there is no mention of sand, just water, and liquefaction has never been documented near La Malbaie (whereas it has in Baie-St-Paul during the 1870 earthquake). Cracks in the road would not be unusual: parts of La Malbaie are located on slopes underlain by thick unconsolidated deposits where lateral spreading and landslides are common.

Some 110 km away, some masonry chimneys were damaged in the lower town area of Quebec City where vibrations were stronger than in the upper town. Some chimneys sustained slight

damage, while one crumbled. Part of a chimney in Grant Street (current name Monseigneur-Gauvreau) fell to the ground, while one of the gables of the cut stone guard house at the Queen's Wood yard had been cracked by the earthquake. The panes of glass in the windows of the Presbytery adjoining the Quebec City Cathedral were broken in some places. Compared to the damage caused by the **M** 6.6 1870 earthquake, the damage was less in Quebec City and in Trois-Rivières. Assuming relatively similar sources, these observations support a lower magnitude for the 1860 earthquake (**M** 6.1) than the **M** 6.6 1870 earthquake but higher than the **M** 5.5 1791 earthquake. Assuming two relatively close epicentres and similar focal depths, Gouin (2001) suggests a magnitude slightly lower than that the **M** 5.9 Saguenay earthquake based on the respective MMI IV areas.

Though there was no significant damage at Montreal, at 350 km distance, most people awoke from sleep and were frightened. In a few cases there, dishes fell from shelves and broke on the floor and a chimney mantle was displaced (Gouin, 2001). Generally, the earthquake caused houses to tremble, doors to open and bells to ring. Again, the observations in Montreal support a smaller magnitude for the 1860 earthquake (**M** 6.1) than that of the 1870 earthquake (**M** 6.6). On the other hand, the 1860 earthquake caused damage to buildings at St-Hyacinthe, some 300 km away, which were not observed (or reported) in 1870 (Dawson, 1860; Gouin, 2001).

Based on the area of maximum damage, the epicentre is assumed to lie within the triangle Baie-St-Paul, La Malbaie and Rivière-Ouelle, i.e. at latitude 47.5°N and 70.1°W with an uncertainty of  $\pm 30$  km as published previously, including in Lamontagne et al. (2018). The fact that no damage was reported in Rivière-du-Loup suggests that the main shock did not occur in the NE portion of the CSZ, unlike the 1925 epicentre.

This Open File Report documents all felt and damage information related to this earthquake in Canada and in the United States. For this, we include for each locality, the felt information rated on the MMI scale tabulated in a Microsoft Excel sheet. Some 91 MMI reports, 69 from Canada, are listed. The Open File also provides a GoogleEarth kmz file that allows the felt information reports to be viewed in this geospatial tool.

The three main objectives of this Open File are:

- 1) To centralize in a table the felt reports and interpreted intensities on the Modified Mercalli Intensity scale for that earthquake.
- 2) To provide the scans of the original newspapers that included the felt and damage reports.
- 3) To provide a map that shows the distribution of macroseismic reports for that earthquake.

## **Data and results**

The main source of felt and damage information is Gouin (2001; references used in Appendix 1), along with a few other publications. The text of Gouin (2001) in English and in French is included. Felt information for New Brunswick was copied from Burke (2009). The impact within Quebec City was taken from Lamontagne (2007). The NOAA earthquake intensity database was referenced (Appendix 3) and there were three entries for American locations.

A Microsoft Excel spreadsheet contains the basic information on the felt reports. The MMI ratings of Gouin (2001) and Burke (2009) are provided. When a range of MMIs was given by the original authors, the highest integer value was selected. The file folder “Newspapers” contains all scanned or transcribed newspaper clippings.

## **Fields of the Table**

Using the Microsoft Excel spreadsheet, two tables were created; one for Canadian data and one for data. Together there are some 91 entries (rows). The columns are the same as published in Lamontagne and Burke (2018). The rows have different colours for each province and some cells have different colours when a special note is added.

The columns of the Excel sheet are:



1. CEEF: A date and time that refer to entries in the Canadian Earthquake Epicentre File (CEEF)
2. Date.time (UTC): date and time of the earthquake in Universal Time.
3. Year\_event: Year of the event (YYYY) (Universal Time)
4. Month\_event Month of the event (MM) (Universal Time)
5. Day\_Event: Day of the event (DD) (Universal Time)
6. Hour-Event: Hour of the event (HH) (Universal Time)
7. Minute-Event: Minute of the event (mm) (Universal Time)
8. Second-Event: Second of the event (ss.s) (Universal Time)
9. MMI Location: Community where earthquake was felt
10. Address: Address where the earthquake was felt (if known)
11. Prov/State: Province or State of the community where the earthquake was felt; NB: New Brunswick; NS: Nova Scotia; PE: Prince Edward Island; QC: Quebec; ME: Maine (USA); MA, Massachusetts (USA) and NH: New Hampshire (USA)..
12. Country: Canada or the USA
13. Postal/Zip: Postal Code or Zip Code of the community where the earthquake was felt (if known). In this Open File, no attempt was made to populate this field.
14. Latitude (°N): Latitude of the community where the earthquake was felt; taken from the original felt reports or more rarely obtained from GoogleEarth. Some latitude coordinates of Gouin (2001) which were with only one digit, were changed by the first author and documented in the excel file.
15. Longitude (°W): Longitude of the community where the earthquake was felt; taken from the original felt reports or, more rarely, obtained from GoogleEarth. Some longitude coordinates of Gouin (2001) which were with only one digit, were changed by the first author and documented in the excel file.
16. Epicentral Distance (km): distance in km between the earthquake' epicentre and the community where the earthquake was felt. The cell calculates the distance using the formula:

$$\text{Epicentral Distance (km)} = \text{ACOS}(\text{COS}(\text{RADIANS}(90-(\text{lat. site}))) * \text{COS}(\text{RADIANS}(90-(\text{lat. of epicentre}))) + \text{SIN}(\text{RADIANS}(90-(\text{lat. of site})))$$

$$*\text{SIN}(\text{RADIANS}(90-(\text{lat. of epicentre}))) * \text{COS}(\text{RADIANS}(\text{Lon of site} - (\text{Lon of epicentre}))) * 6371$$

We used the epicentre of Lamontagne (2008), i.e. Latitude 47.5°N and Longitude 70.1°W as listed in the second tab of the spreadsheet.

17. Final Numeric MMI: Based on the felt report, interpreted Intensity on the Modified Mercalli Scale of 1931. Although MMI is defined using Roman numerals, we decided to convert them to Arabic numerals for ease of use.
18. Basis for MMI (English): Aspects of the felt report in English (if available) that were used to rate the MMI (in Arabic numerals).
19. Basis for MMI (French): Aspects of the felt report in French (if available) that were used to rate the MMI (in Arabic numerals).
20. Source of felt report.
21. Precision of location (km): In some cases, it is possible to estimate the radius of uncertainty of the location.
22. Minimum MMI: The minimum value of MMI for a felt report that is interpreted to lie within a range of intensities (e.g.: MMI 3-4; in Arabic numerals).
23. Maximum MMI: The maximum value of MMI for a felt report that is interpreted within a range of intensities (e.g.: MMI 3-4; in Arabic numerals).
24. Interpreter: Author who made the interpretation.
25. Additional notes: Comments of interest on the felt report or its publication.

## **Google Earth file**

To ease the consulting of the data and put them in a geographic context, a kmz file is added and can be viewed using the GoogleEarth software that can be downloaded at <https://www.google.com/earth/> . A static image of the Google Earth display is shown as figures 3 and 4.

## **Discussion**

Figure 5 shows the MMI distribution for the 1860 earthquake with those predicted for the Central and Eastern United States by Atkinson and Wald (2007). Each MMI data point is shown as a gray circle with the median value for a given MMI as a red circle. As can be seen there is much scatter in the data but at distances greater than 200 km a better fit exists. Many intensities of MMI VI and VII exist at distances greater than predicted by the equation. These higher than expected MMIs could be due to local site conditions that amplify the ground motions.

## **Conclusions**

A new digital repository of felt reports for the 1860 Magnitude 6 Charlevoix earthquake was created. We are confident that this Open File includes all available information on how this earthquake was felt in the Maritimes and Maine, but will be amended if new information is uncovered. We hope that it will be useful for research on this earthquake as well as on other intraplate earthquakes.

## **Acknowledgments**

We thank our GSC colleague Allison Bent for her review of this Open File; and Ms. Heather Crow, the project leader, for supporting this project.

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<https://pubs.usgs.gov/of/2002/0109/> .
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- Gouin, P. 2001. Tremblements de terre historiques au Québec : de 1534 à mars 1925, identifiés et interprétés à partir des textes originaux contemporains / Historical earthquakes felt in Quebec : from 1534 to March 1925, as revealed by the local contemporary literature. Montréal : Guérin, 1491 pp.
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- Lamontagne, M. 2009. Description and analysis of the earthquake damage in the Quebec City region between 1608 and 2008, *Seismological Research Letters*, 80: 514-524.
- Lamontagne, M., Halchuk, S., Cassidy, J.F. and Rogers, G.C. 2018. Significant Canadian Earthquakes 1600-2017. Open File 8285, 2018, 37 pages, <https://doi.org/10.4095/311183>.

Lamontagne, M., Burke, K B S, Perret, D. (2019). Felt reports for the 1870 magnitude 6.5 earthquake, Charlevoix, Quebec. Geological Survey of Canada, Open File 8588, 26 pages, <https://doi.org/10.4095/314803> (Open Access)

Lamontagne, M. (2020) The 1791 magnitude (Mw) 5.5 earthquake, Charlevoix, Quebec: interpretation of macroseismic information. Geological Survey of Canada, Open File 8739, 2020, 26 pages, <https://doi.org/10.4095/326946>

Lamontagne, M. and Locat, J. (2021) Macroseismic and landslide information on the 1663 moment magnitude (M) 7 earthquake, Charlevoix, Quebec, Geological Survey of Canada, Open File 8772, 25 pages, <https://doi.org/10.4095/328121>

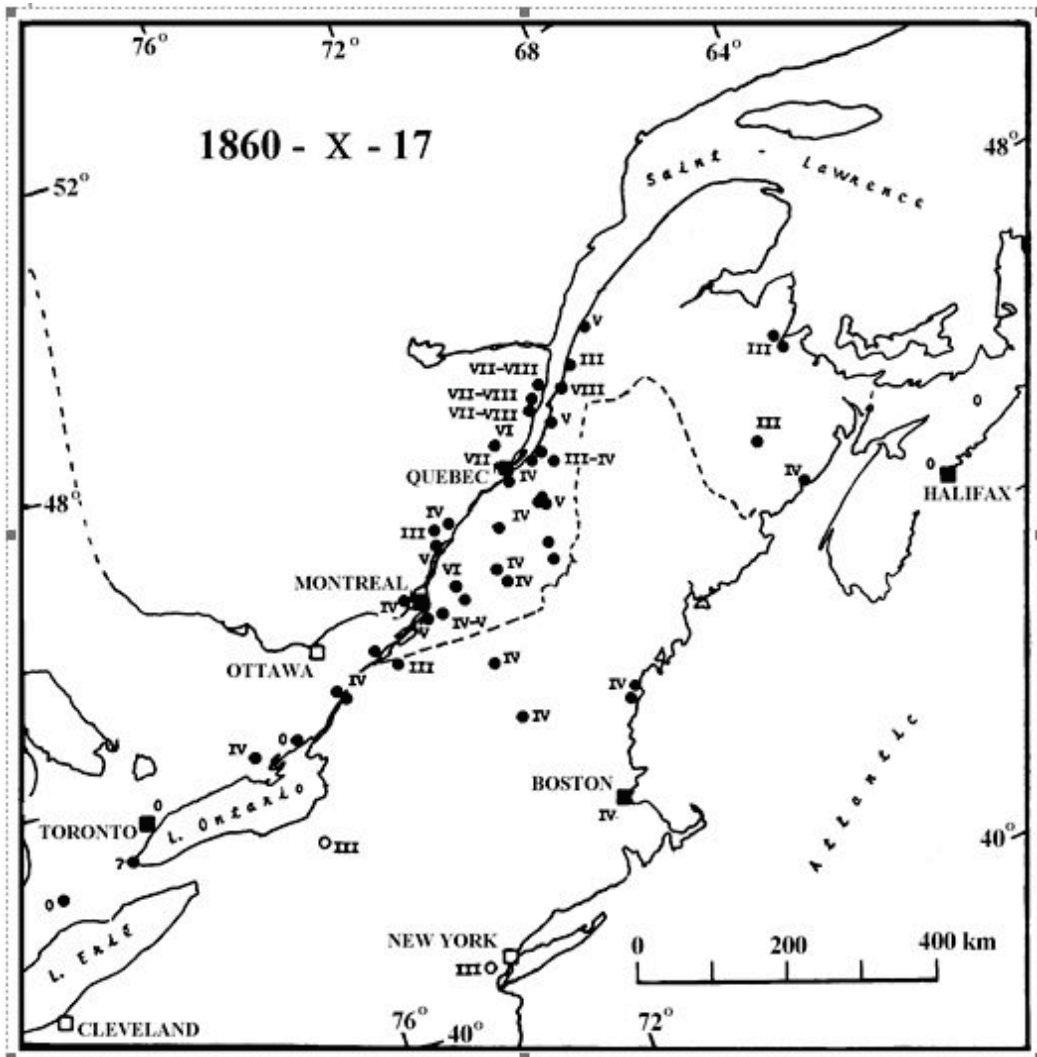
Lamontagne, M., Burke, K.B.S. and Archambault, P., Olson, L. (2021) Felt reports and damage accounts for the 1925 moment magnitude 6.2 Charlevoix, Quebec, earthquake. Geological Survey of Canada, Open File 8775, 2021, 30 pages, <https://doi.org/10.4095/328196>

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Smith, W E T, 1962. Earthquakes of eastern Canada and Adjacent areas 1534-1927, Publications of the Dominion Observatory vol. 26, no. 5.

Trudelle et al., 1859. Recueil de lettres et de notes concernant la paroisse de la Baie St Paul, Baie-Saint-Paul, Saints Pierre et Paul, Archives paroissiales, 1859-1870.

Wood, H.O. and Neumann F. 1931. Modified Mercalli Intensity of 1931. Bulletin of the Seismological Society of America, 21: 277-283.



**Figure 29:** Distribution map of the sites mentioned in contemporary documents as being shaken or not by these tremors. The sites found in contemporary documents are marked by full circles (●) and the sites found in non-contemporary documents are marked by open circles (○). The reference points are marked by full squares (■), three points such as Ottawa Cleveland and New York are marked by an open square (□).

Figure 2. Isoseismal Map of the October 17, 1860 Charlevoix earthquake (Source: Gouin (2001)).

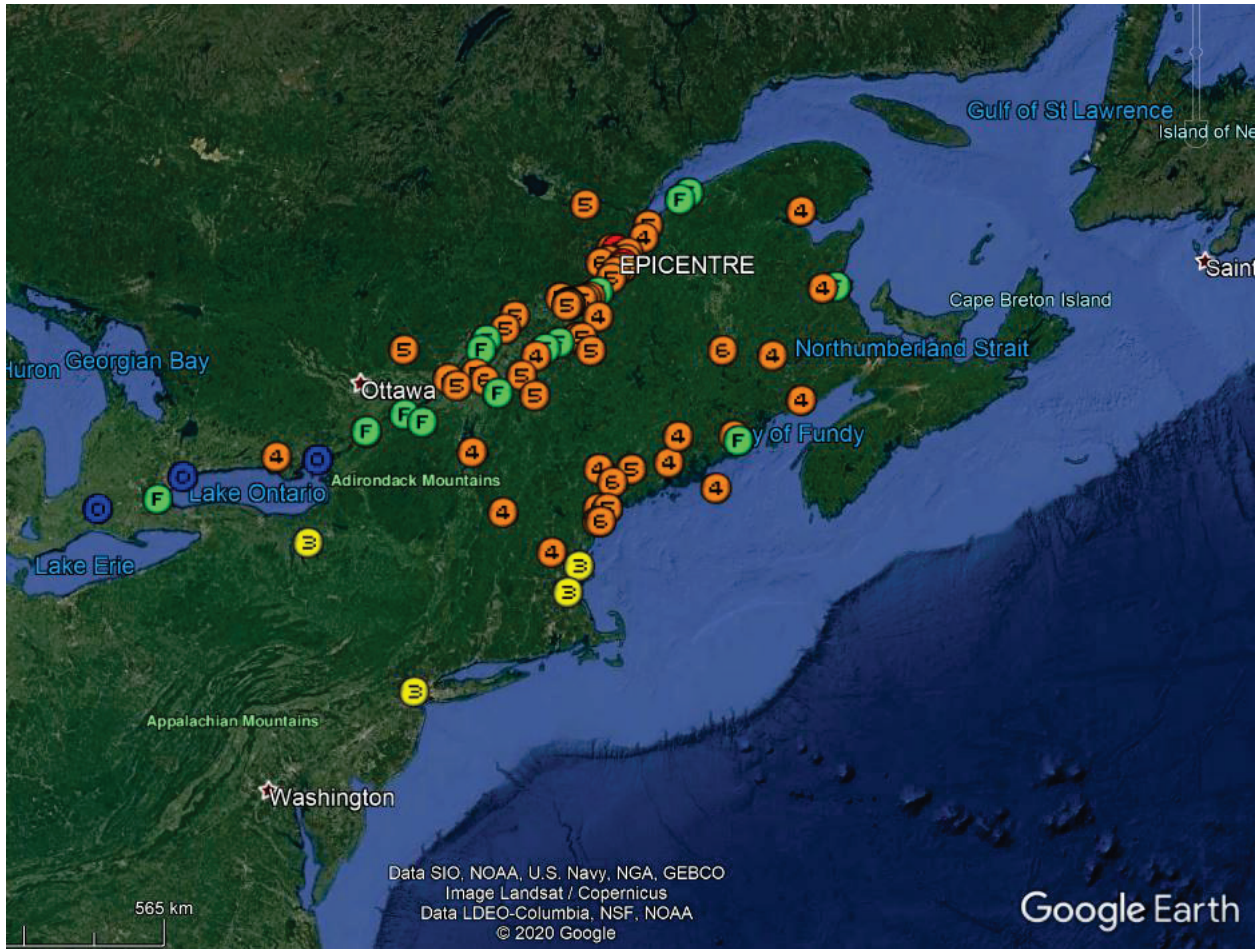
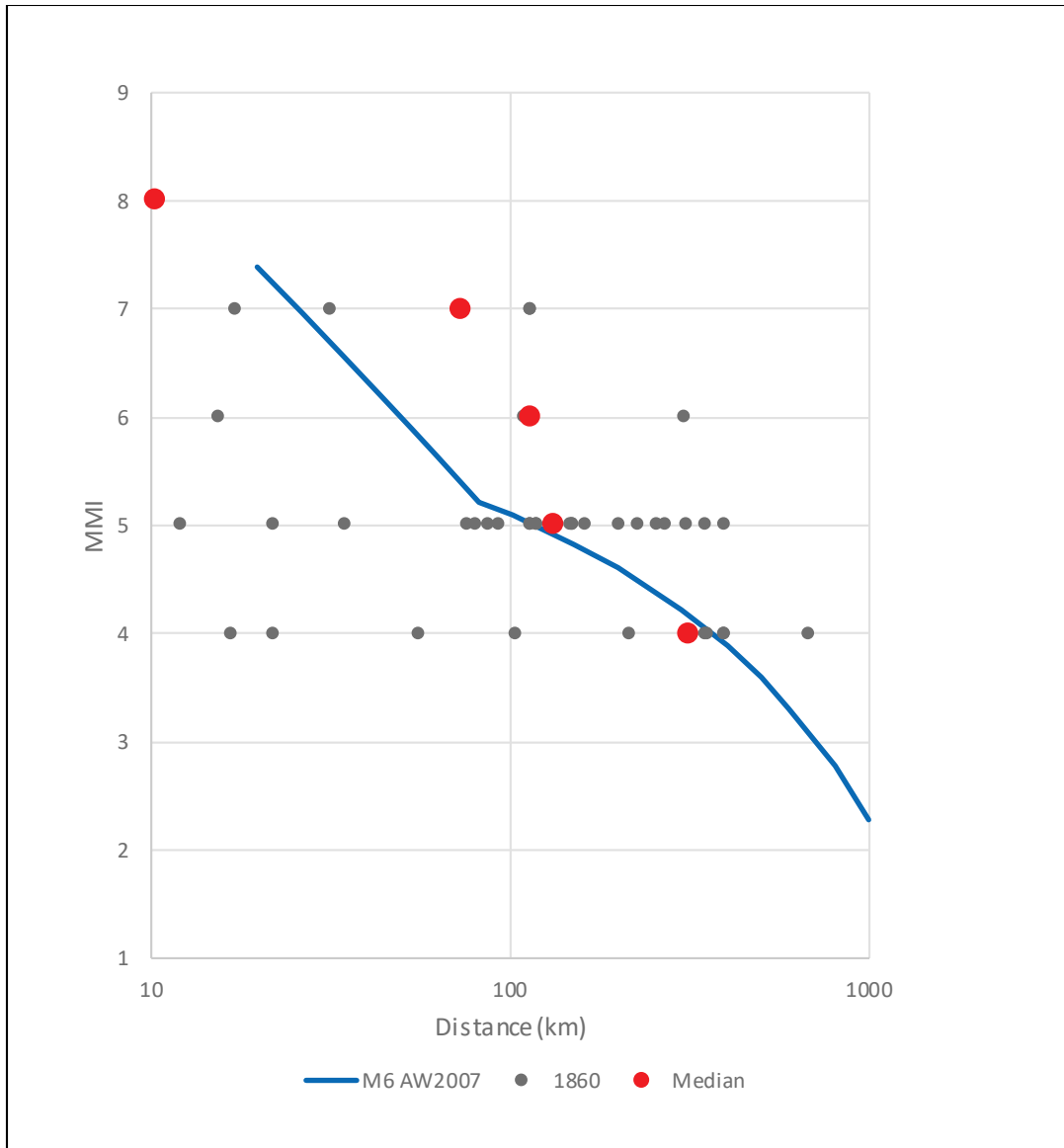


Figure 3. Static image of Google Earth view showing distribution of felt reports included in this Open File and generated from the kmzfile.



Figure 4. Static image of Google Earth view showing distribution of felt reports in the region surrounding the epicentre that are included in this Open File and were generated from the kmz file.





**Figure 5.** MMI distribution for the 1860 earthquake with those predicted for the Central and Eastern United States by Atkinson and Wald (2007). Each MMI data point is shown as a gray circle with the median value for a given MMI as a red circle.

## Appendix 1

References used by Gouin (2001). In the Excel spreadsheet, some quotes refer to the numbers below. We copy here the exact same references published in Gouin (2001).

### Primary Sources Consulted

#### Personal accounts

<sup>1</sup> *Lettre de Monsieur Louis Tremblay à Mgr Laflamme en date du 23 avril 1907.*

A photocopy of the manuscript kept at the Société Historique du Saguenay.

<sup>2</sup> *Journal du Séminaire de Québec (1860) à l'entrée du 17 octobre.*

E.-A. Taschereau's narration, in *Laflamme* (1907, p. 167).

<sup>3</sup> *Mémoires de Madame Jean Néron.*

A photocopy of an interview conducted by the team of Du Berger during the summer 1951.

#### Local newspapers

<sup>4</sup> *Montreal Pilot (The)*, Montreal, October 17, 1860 (2, 3).

<sup>5</sup> *Headquarters*, Fredericton, October 17, 1860.

Quoted or translated by many Quebec newspapers.

<sup>6</sup> *Cornwall Observer*

Published since 1830 but copies could not be found.

<sup>7</sup> *Ère Nouvelle (L')*, Trois-Rivières, du 18 octobre 1860 (2, 3).

<sup>8</sup> *Pays (Le)*, Montréal, du 18 octobre 1860 (2, 6).

<sup>9</sup> *Quebec Mercury*, Quebec, October 18, 1860 (2, 2-4).

<sup>10</sup> *Pilot (The)*, Montreal, October 18, 1860 (3, 1).

<sup>11</sup> *Minerve (La)*, Montréal, du 18 octobre 1860 (2, 6).

<sup>12</sup> *Morning Chronicle and Commercial*, Quebec, October 18, 1860 (2, 1-2).

<sup>13</sup> *Esquire or Enquirer*, Trois-Rivières.

Is not on BNQ's microfilms.

<sup>14</sup> *Événement (L')*, Québec.

Not found either at Laval or at the BNQ.

<sup>15</sup> *Canadien (Le)*, Québec, du 19 octobre 1860 (2, 1-4).

<sup>16</sup> *Pays (Le)*, Montréal, du 19 octobre 1860 (2, 3).

<sup>17</sup> DAWSON, J.W. (1860), Notes on the Earthquake of October, 1860.

\* " *The following list of places in which observations were made of the time and intensity of the shocks have been compiled chiefly from newspapers, to which credit is due for the careful and intelligent manner in which they have collected and recorded the facts.* " (p. 363)

Despite Dawson's questionable assertion about the journalists' work, his analysis carries difficulties that I often underlined; for instance, the newspapers available do not always confirm his assertions.

A second difficulty arises from the fact that Dawson appears to give an unreasonable weight to a non-scientifically controlled time of occurrence over the description of the effects. In fact, the radio time signals came later.

<sup>18</sup> *Journal de Québec*, Québec.

The contemporary issues of this newspaper do not seem to exist any more.

<sup>19</sup> *Morning Chronicle and Commercial*, Quebec, October 19, 1860 (1 and 2, 1-2).

- 20 *Minerve (La)*, Montréal, du 20 octobre 1860 (2, 3-4).
- 21 *Miramichi Gleaner*, Miramichi, October 20, 1860.  
In *Ruffman and Peterson*, 1988, I, p. 243.
- 22 *Morning Chronicle and Commercial*, Quebec, October 19, 1860 (1, 1-2).
- 23 *Ère Nouvelle (L')*, Trois-Rivières, du 22 octobre 1860 (2, 5).
- 24 *Halifax Morning Sun*, Halifax, October 22, 1860 (2, 4).  
In *Ruffman and Peterson*, 1988, I, p. 242.
- 25 *Canadien (Le)*, Québec, du 22 octobre 1860.
- 26 *Quebec Mercury*, Quebec, October 22, 1860 (2, 3).
- 27 *Minerve (La)*, Montréal, du 23 octobre 1860 (2, 4-5).
- 28 *Saint Lawrence Republican and Ogdensburg Weekly Journal*, Ogdensburg, October 23, 1860 (2, 6-7).
- 29 *Canadien (Le)*, Québec, du 24 octobre 1860.
- 30 *Halifax Morning Sun*, Halifax, October 24, 1860 (2, 5).  
In *Ruffman and Peterson*, 1988, I(242).
- 31 *Morning Chronicle and Commercial*, Quebec, October 24, 1860 (2, 2).
- 32 *Ère Nouvelle (L')*, Trois-Rivières, du 25 octobre 1860 (3, 1-2).
- 33 *British Colonist (The)*, Halifax, October 25, 1860 (4, 2).
- 34 *Halifax Acadian Recorder*, Halifax, October 27, 1860 (3, 2).  
In *Ruffman and Peterson*, 1988, I(243).
- 35 *Morning Chronicle and Commercial*, Quebec, October 29, 1869 (2, 3).
- 36 *Canadien (Le)*, Québec, du 29 octobre 1860.
- 37 *Canadien (Le)*, Québec, du 16 novembre 1860.

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BRIGHAM (1870); KAIN (1898); LAFLAMME (1907); HODGSON, E.A. (1945).  
HECK and EPPLEY (1958):

\* " 6:00. Canada, felt to the south. 47,5°N, 70,0°O. 700 000 milles<sup>2</sup>. VIII. Référence 1 (page 10) ... Center apparently near Rivière Ouelle, Canada, which was violently shaken, walls being damaged and chimneys thrown down. The shock was felt along the Atlantic coast of New England as far south as Newark, N.J., and as far west as Auburn, N.Y. In New England four moderate shocks were felt, accompanied by rumbling noise. Felt strongly at Saco, Maine." (page 15)

SMITH, W.E.T. (1962, No. 77)

Smith (1962) indicates the coordinates of near-by Rivière-Ouelle and intensity VIII-IX. Smith does not give any magnitude.

HODGSON, J.H. (1965); COFFMAN and von HAKE (1973).

BASHAM, P. W., D.H. WEICHERT and M.J. BERRY (1979).

These authors chose for their calculations the coordinates obtained by Smith (1962) and a magnitude  $M = 6.0$ .

PSS/SPS (1986)

This edition accepts the coordinates indicated by Smith (1962, No. 77) and assigns this earthquake the magnitude  $ML = 6.0$ .

RUFFMAN and PETERSON (1988, I, p. 242-246)

SMITH, D.C., C. FOX, B. CRAIG and A.E. BRIDGES (1989).

ANGLIN, F.M., R.J. WETMILLER, R.B. HORNER, G.C. ROGERS and J.A. DRYSDALE (1990), Carte 15.

Same data as Basham *et al.* (1979).

**Complementary Works**

Drysdale, J. (1990); Du Berger, R., D.W. Roy *et al.* (1991); North, R.G., R.J. Wetmiller *et al.* (1989); Nuttli, O.W. (1973); Nuttli, O.W., W. Bollinger and P. Griffiths (1979).

## **Appendix 2: Modified Mercalli Intensity Scale (Wood and Neumann, 1931)**

### **I. Not felt -- or, except under especially favorable circumstances.**

Under certain conditions, at and outside the boundary of the area in which a great shock is felt:

- sometimes birds, animals, reported uneasy and disturbed;
- sometimes dizziness or nausea experienced;
- sometimes trees, structures, liquids, bodies of water, may sway; doors may swing, very slowly.

### **II. Felt indoors by few, especially on upper floors, or by sensitive or nervous persons.**

Also, as in grade I, but often more noticeably:

- sometimes hanging objects may swing, especially when delicately suspended;
- sometimes trees, structures, liquids, bodies of water, may sway, doors may swing, very slowly;
- sometimes birds, animals, reported uneasy and disturbed;
- sometimes dizziness or nausea experienced.

### **III. Felt indoors by several, motion usually rapid vibration.**

- Sometimes not recognized to be an earthquake at first.
- Duration estimated in some cases.
- Vibration like that due to the passing of light or lightly loaded trucks or heavy trucks some distance away.
- Hanging objects may swing slightly.
- Movements may be appreciable on upper levels of tall structures.
- Rocked standing motor cars slightly.

### **IV. Felt indoors by many, outdoors by few.**

- Awakened few, especially light sleepers.
- Frightened no one, unless apprehensive from previous experience.
- Vibration like that due to the passing of heavy or heavily loaded trucks.

- Sensation like heavy body striking building or falling of heavy objects inside.
- Rattling of dishes, windows, doors; glassware and crockery clink and clash.
- Creaking of walls, frame, especially in the upper range of this grade.
- Hanging objects swung, in numerous instances.
- Slightly disturbed liquids in open vessels. Rocked standing motor cars noticeably.

V. Felt indoors by practically all, outdoors by many or most: outdoors direction estimated.

- Awakened many, or most.
- Frightened few -- slight excitement, a few ran outdoors.
- Buildings trembled throughout.
- Broke dishes, glassware, to some extent.
- Cracked windows -- in some cases, but not generally.
- Overturned vases, small or unstable objects, in many instances, with occasional fall.
- Hanging objects, doors, swing generally or considerably.
- Knocked pictures against walls, or swung them out of place.
- Opened, or closed, doors, shutters, abruptly. Pendulum clocks stopped, started, or ran fast, or slow.
- Moved small objects, furnishings, the latter to slight extent.
- Spilled liquids in small amounts from well-filled open containers.
- Trees, bushes, shaken slightly.

VI. Felt by all, indoors and outdoors.

- Frightened many, excitement general, some alarm, many ran outdoors.
- Awakened all.
- Persons made to move unsteadily.
- Trees, bushes, shaken slightly to moderately.
- Liquid set in strong motion.
- Small bells rang -- church, chapel, school, etc.
- Damage slight in poorly built buildings.
- Fall of plaster in small amount.

- Cracked plaster somewhat, especially fine cracks; chimneys in some instances.
- Broke dishes.
- Fall of knick-knacks, books, pictures.
- Overturned furniture in many instances.
- Moved furnishings of moderately heavy kind.

**VII. Frightened all -- general alarm, all ran outdoors.**

- Some, or many, found it difficult to stand.
- Noticed by persons driving motor cars.
- Trees and bushes shaken moderately to strongly.
- Waves on ponds, lakes, and running water.
- Water turbid from mud stirred up.
- Incaving to some extent of sand or gravel stream banks.
- Rang large church bells, etc.
- Suspended objects made to quiver.
- Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary buildings, considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc.
- Cracked chimneys to considerable extent, walls to some extent.
- Fall of plaster in considerable to large amount, also some stucco.
- Broke numerous windows, furniture to some extent.
- Shook down loosened brickwork and tiles.
- Broke weak chimneys at the roof-line (sometimes damaging roofs).
- Fall of cornices from towers and high buildings.
- Dislodged bricks and stones.
- Overturned heavy furniture, with damage from breaking.
- Damage considerable to concrete irrigation ditches.

**VIII. Fright general -- alarm approaches panic.**

- Disturbed persons driving motor cars.
- Trees shaken strongly -- branches, trunks, broken off, especially palm trees.
- Ejected sand and mud in small amounts.
- Changes: temporary, permanent; in flow of springs and wells; dry wells renewed flow; in temperature of spring and well waters.
- Damage slight in structures (brick) built especially to withstand earthquakes.
- Considerable in ordinary substantial buildings, partial collapse: racked, tumbled down, wooden houses in some cases; threw out panel walls in frame structures, broke off decayed piling.
- Fall of walls.
- Cracked, broke, solid stone walls seriously.
- Wet ground to some extent, also ground on steep slopes.
- Twisting, fall, of chimneys, columns, monuments, also factory stacks, towers.
- Moved conspicuously, overturned, very heavy furniture.

#### IX. Panic general.

- Cracked ground conspicuously.
- Damage considerable in (masonry) structures built especially to withstand earthquakes:
- threw out of plumb some wood-frame houses built especially to withstand earthquakes;
- great in substantial (masonry) buildings, some collapse in large part; or wholly shifted frame buildings off foundations, racked frames;
- serious to reservoirs; underground pipes sometimes broken.

#### X. Cracked ground, especially when loose and wet, up to widths of several inches; fissures up to a yard in width ran parallel to canal and stream banks.

- Landslides considerable from river banks and steep coasts.
- Shifted sand and mud horizontally on beaches and flat land.
- Changed level of water in wells.



- Threw water on banks of canals, lakes, rivers, etc.
- Damage serious to dams, dikes, embankments.
- Severe to well-built wooden structures and bridges, some destroyed.
- Developed dangerous cracks in excellent brick walls.
- Destroyed most masonry and frame structures, also their foundations.
- Bent railroad rails slightly.
- Tore apart, or crushed endwise, pipe lines buried in earth.
- Open cracks and broad wavy folds in cement pavements and asphalt road surfaces.

**XI.** Disturbances in ground many and widespread, varying with ground material.

- Broad fissures, earth slumps, and land slips in soft, wet ground.
- Ejected water in large amount charged with sand and mud.
- Caused sea-waves ("tidal" waves) of significant magnitude.
- Damage severe to wood-frame structures, especially near shock centers.
- Great to dams, dikes, embankments, often for long distances.
- Few, if any (masonry), structures remained standing.
- Destroyed large well-built bridges by the wrecking of supporting piers, or pillars.
- Affected yielding wooden bridges less.
- Bent railroad rails greatly, and thrust them endwise.
- Put pipe lines buried in earth completely out of service.

**XII.** Damage total -- practically all works of construction damaged greatly or destroyed.

- Disturbances in ground great and varied, numerous shearing cracks.
- Landslides, falls of rock of significant character, slumping of river banks, etc., numerous and extensive.
- Wrenched loose, tore off, large rock masses.
- Fault slips in firm rock, with notable horizontal and vertical offset displacements.
- Water channels, surface and underground, disturbed and modified greatly.
- Dammed lakes, produced waterfalls, deflected rivers, etc.
- Waves seen on ground surfaces (actually seen, probably, in some cases).

- Distorted lines of sight and level.
- Threw objects upward into the air.

### Appendix 3: Intensity values for the 1860 earthquake in NOAA (2021).

#### U.S. Earthquake Intensity Data Display - sorted by Date

3 U.S. Earthquake Intensity records where (Year <= 1860 and Year >= 1860) and (City Latitude <= 44 and City Latitude >= 40) and (City Longitude <= -70 and City Longitude >= -77)

View parameter descriptions by clicking on column headings.

Date							Earthquake Parameters				Felt Report Parameters					Data Source			
Year	Mo	Dy	Hr	Mn	Sec	UTC Conv	Latitude	Longitude	Focal Depth	Mag	I/G	MMI	City Name	State Code	Country		Latitude	Longitude	Epicentral Distance
1860	10	17	11	0		5	47.500	-70.000				6	SACO	ME	USA	43.500	-70.440	9178.0	H
1860	10	17	11	0		5	47.500	-70.000				3	NEWARK	NJ	USA	40.740	-74.180	822.0	H
1860	10	17	11	0		5	47.500	-70.000				3	AUBURN	NY	USA	42.930	-76.570	722.0	H

3 events returned.

[Return to U.S. Earthquake Intensity Data Search](#)