



Natural Resources
Canada

Ressources naturelles
Canada

**GEOLOGICAL SURVEY OF CANADA
OPEN FILE 8862**

**A revised moment magnitude catalog of Eastern Canada's
largest earthquakes**

A.L. Bent

2022

Canada



GEOLOGICAL SURVEY OF CANADA OPEN FILE 8862

A revised moment magnitude catalog of Eastern Canada's largest earthquakes

A.L. Bent

2022

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2022

Information contained in this publication or product may be reproduced, in part or in whole, and by any means, for personal or public non-commercial purposes, without charge or further permission, unless otherwise specified.

You are asked to:

- exercise due diligence in ensuring the accuracy of the materials reproduced;
- indicate the complete title of the materials reproduced, and the name of the author organization; and
- indicate that the reproduction is a copy of an official work that is published by Natural Resources Canada (NRCan) and that the reproduction has not been produced in affiliation with, or with the endorsement of, NRCan.

Commercial reproduction and distribution is prohibited except with written permission from NRCan. For more information, contact NRCan at copyright-droitdauteur@nrcan-rncan.gc.ca.

Permanent link: <https://doi.org/10.4095/329612>

This publication is available for free download through GEOSCAN (<https://geoscan.nrcan.gc.ca/>).

Recommended citation

Bent, A.L., 2022. A revised moment magnitude catalog of Eastern Canada's largest earthquakes; Geological Survey of Canada, Open File 8862, 1 .zip file. <https://doi.org/10.4095/329612>

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

Abstract

Although there are many scales used to calculate earthquake magnitude, moment magnitude is currently considered the preferred magnitude scale for use in seismic hazard assessment in Canada. Historically, moment magnitude was not determined for eastern Canadian earthquakes although it has been routinely calculated for earthquakes of approximately magnitude 4.0 and greater, on regional magnitude scales, for the last decade. Thus, most moment magnitudes for eastern Canadian earthquakes must be obtained by converting from another magnitude scale or from felt information. This paper provides a moment magnitude catalog for the largest earthquakes in eastern Canada and vicinity. The study derives moment magnitudes for some events but also makes use of values from the published literature. Earthquakes are assessed individually using all available sources of information. The resulting catalog provides moment magnitudes for 254 events. Three additional events were evaluated but removed from the catalog as it is highly questionable whether they were earthquakes.

Introduction

Numerous magnitude scales have been developed to provide objective measurements of the sizes of earthquakes. There may be many reasons why one is preferred over another in a given situation among which are geology, distance, frequency range or depth. For seismic hazard assessments, it is crucial that the same scale be employed consistently for all earthquakes used in the assessment. Moment magnitude (Hanks and Kanamori, 1979), M_w or M , is most commonly the preferred scale at present and is the current choice for seismic hazard assessment in Canada. It can be related to the physical properties of an earthquake and, unlike many magnitude scales, it does not saturate at very high magnitudes.

Although M has been calculated almost routinely for eastern Canadian earthquakes above magnitude 4.0 on either the M_N (Nuttli, 1973) or M_L (Richter, 1935) scale for the past decade, it was calculated much less frequently in the past and is still rarely calculated for small earthquakes. Thus for most earthquakes in the (Canadian) National Earthquake Database (NEDB, see Data and Resources) moment magnitude must be obtained by converting from another magnitude scale or by estimating it from intensity data.

As a rule, the largest earthquakes occurring in any given region are of most concern for public safety and for hazard assessment as they are the ones most likely to cause damage although a recent paper by Minson et al. (2020) demonstrates that this is not always the case as larger than expected shaking from moderate earthquakes occurs more frequently than one might expect. Thus, in general, these larger events are the ones that should be prioritized as well as scrutinized most closely in the creation of a moment magnitude catalog. This study assesses existing moment magnitudes and derives new ones as needed for the largest instrumental and historical earthquakes in eastern Canada, creating a catalog for use in hazard assessments and other studies. Because there is not a 1:1 correspondence between magnitude types and because there is a degree of uncertainty associated with any magnitude calculation or conversion, there may be some events not included that perhaps should have been and there are most certainly events picked up by the initial assessment (discussed in the next section) that, upon further study, should not be considered among the largest. Nevertheless, it is unlikely that any of the very largest known historical or instrumental earthquakes have been missed. The higher the magnitude, the more complete the catalog is expected to be but the completeness magnitude and period differ by region. The reader should bear in mind that there is no real knowledge of earthquakes in the eastern Arctic prior to the instrumental era, whereas there are written descriptions of earthquakes in southeastern Canada and the adjacent United States dating from the 16th Century.

This study builds upon and updates several previous catalogs. Johnston et al (1994, hereafter referred to as EPRI) undertook a large scale study of earthquakes occurring in stable continental regions to determine their moment magnitudes as well as other source parameters. Earthquakes were evaluated on an individual basis taking into account all available sources of information. The EPRI study forms the backbone of most of those that followed. Subsequent works include Schulte and Mooney (2005) whose study included stable continental regions worldwide and Bent (2009) who focused on eastern Canada. There has also been a recent effort by the International Seismological Centre (ISC, see Data and Resources) to update its catalog of historical, global earthquakes, hereafter referred to as the GEM (Global Earthquake Model) catalog (Storchak et al., 2013, 2015; DiGiacomo et al., 2018). Many, but not all, of the magnitudes catalogued in the current study are adopted from one of these sources.

Data Selection

Earthquakes evaluated in this study are located in the region 38° - 90° N and 45° - 110° W and catalogued in the NEDB (see Data and Resources). The southern and easternmost boundaries lie outside of Canada but large earthquakes within this region impact eastern Canada and are therefore of interest. The boundaries were selected to be consistent with those used in hazard assessment (Bent, 2009). The events included in the catalog are shown in Figures 1a-d, grouped by moment magnitude and in Figures 2a-d based on the method used to determine moment magnitude.

The dataset used by Bent (2009) in an earlier, similar study, based on a search of the NEDB (see Data and Resources) for earthquakes of magnitude 5.0 on whatever magnitude scale was indicated as the event-preferred magnitude scale, forms the backbone of the current study. Events evaluated and rejected by that study are not included in this paper. The dataset was augmented by earthquakes of magnitude 5.0 or greater in the NEDB (see Data and Resources) occurring within the stated boundaries from 1 January 2009 through 30 June 2020. Additionally a suite of forty-five, predominantly pre-instrumental, earthquakes not included in the earlier study were added. They had been identified in the initial search but excluded by Bent (2009) because they did not meet the completeness criteria for use in hazard assessment in Canada, which was the primary motivation for that study. The listed magnitudes, however, indicate they should be assessed as they are likely among the largest eastern Canadian earthquakes.

A magnitude-based search of the database will be imperfect in creating a top n list for moment magnitude where n is any number larger than “a few” as it is likely to miss some events that further scrutiny shows should have been included and it will pick up some that should not have been because of mixed magnitude types in the database and *a priori* assumptions about what the moment magnitude might be are not always correct. Decreasing the magnitude threshold of the database search to ensure that no events are missed does not necessarily improve the quality of the resulting catalog as **M** for the majority of the smaller events will be based on applying a standard conversion and not on a thorough evaluation of the earthquake for which there may be little or no additional information. To at least partially correct the list for potential missed events, some earthquakes with known moment magnitudes were added. Searching the NEDB for eastern Canadian earthquakes where **M** or M_W is listed as the preferred magnitude type, twenty seven earthquakes were found. Fifteen of these are among the earthquakes found by the initial magnitude 5.0+ search. Eleven of the remaining twelve have moment magnitudes ranging from 3.8 to 4.9, well within the range of other events in the study. All of these were determined by regional moment tensor analysis and should be considered reliable. They have been added to the catalog. The final event is an **M** 2.4 earthquake that occurred on the south shore of Lake Erie on 19 June 2019. It is too small for inclusion in this catalog. An additional sixty-one events with published instrumental moment magnitudes determined by regional moment tensor analysis were also added. They are within the magnitude range of the earthquakes in this study that met the initial search criteria but the majority are at the lower end of the magnitude range and generally not considered significant earthquakes.

Moment magnitude is denoted as M_W in the NEDB (see Data and Resources) whether or not it is based on the W phase or very long period data. It is listed as the primary magnitude for only a small number of earthquakes as previously discussed. To avoid over-interpretation or misunderstanding, **M** is used in this study to denote moment magnitude. Moments and moment magnitudes in this catalog were rarely calculated at long enough periods to qualify as true M_W s. If another designation is used in the text (for example, M_{WW} , M_{WR} , M_{WC}), it is the notation used by the institution that calculated the magnitude. It should be noted that the NEDB (see Data and Resources) uses M_W for all flavors of **M**

as did Bent (2009). Any place M (unbolded) appears in the text, it used as a generic term for magnitude, usually in reference to a database of mixed magnitude types.

For recent earthquakes, the Nuttli (1973) magnitude scale, M_N , developed for use in eastern North America is most often listed as the primary magnitude for eastern Canadian earthquakes. Although Nuttli (1973), referred to the scale as m_{bLg} , the M_N designation is used to indicate that the scale is not used exactly as he intended. More discussion on this topic may be found in Bent (2011) and Bent and Greene (2014). For the purposes of this study, instrumental M_N , m_{bLg} and M_{Lg} are considered equivalent unless there is a clear reason indicating otherwise. There may be subtle differences between them and how they are applied by various institutions (Bent, 2013; Bent and Greene, 2014), a topic deserving further study. For older instrumental earthquakes and most earthquakes occurring offshore, the Richter (1935) M_L scale is used and is not modified for eastern North American attenuation. M_L is also the most commonly listed magnitude type for pre-instrumental earthquakes whose magnitudes are estimated from felt information. M_L is routinely used for earthquakes recorded only by stations at distances of less than 50 km but these events are too small to form part of the current study. For some of the larger, historical, instrumental earthquakes, teleseismic magnitudes M_S (Gutenberg 1945a) and m_b (Gutenberg 1945b,c) are listed as the primary magnitudes. Although noted as m_b , many of the body wave magnitudes would be more properly defined by the broadband version of the scale, m_B as they are based on intermediate period data recorded by the instruments of the time.

Although the event selection was based on magnitudes in the NEDB (see Data and Resources), there are several references to a JD database in the text and in the comment section of Table S1 (in the Supplement to this paper). The term is used to refer to a body of work resulting from the re-evaluation of post-1940 eastern Canadian earthquakes by J. Adams, J. Drysdale and R. Wetmiller with the assistance of many students. Of particular importance to the current study is that they determined M_N for many events for which only an M_L had been previously available. Because M_N is considered a more appropriate magnitude for eastern Canada, these JD magnitudes are preferred over the NEDB M_L magnitudes for conversion to M . The JD magnitudes have been incorporated into the dataset used for seismic hazard calculations in Canada (Halchuk, 2009). Several events evaluated in this study would not have passed the initial selection criteria had the NEDB (see Data and Resources) similarly adopted the JD magnitudes, which were lower than the initial magnitude estimates.

The descriptive names in the NEDB (see Data and Resources) for historical and offshore earthquakes are generally based on the nearest location in Canada. As such, it is not always obvious that an event occurred in or off the coast of the United States. I have modified some entries to indicate the state or region in which the earthquake occurred. Users of the data are more likely to focus on the coordinates but I raise the issue of place names because some may appear inconsistent with those resulting from a search of the NEDB (see Data and Resources). I also note that in 1999, the territory of Nunavut was created from the eastern section of the Northwest Territories whose name was retained by the western portion. The current names are used in this text regardless of the date of occurrence of the earthquake. Usage in the NEDB is inconsistent for pre-1999 earthquakes but consistent from that point on. That is, place names for some older earthquakes have been adjusted to reflect the new boundaries and some have not.

Magnitudes and Magnitude Conversions in Eastern Canada

Commonly used magnitude scales in eastern Canada were discussed in the previous section. When an instrumental moment magnitude has not been determined for an earthquake, moment magnitude is

calculated using conversion relations for other magnitudes or for intensity data. The Bent (2009) report relied on conversion equations developed for stable continental earthquakes in the EPRI report. In the decade that followed, new conversion relations, some of which are specific to eastern Canada or eastern North America, were established. They are used when available. The conversion relations used in this study are summarized below.

For instrumental M_N (Bent, 2011)

$$\mathbf{M} = M_N - 0.4 \quad <1995$$

$$\mathbf{M} = M_N - 0.5 \quad \geq 1995$$

For instrumental M_L for offshore earthquakes (Bent, 2016)

$$\mathbf{M} = M_L - 0.2$$

For most other instrumental magnitudes the conversion relations of Johnston (1996a) for stable continental regions are employed. All are expressed in terms of the log of the seismic moment (M_o) measured in dyne-cm. Logs are \log_{10} . In all cases, moment is converted to moment magnitude using the standard relation between the two (Hanks and Kanamori, 1979).

The conversion equations in Johnston (1996a) for M_S and m_b are not identical to those in the EPRI report. On the surface they appear drastically different but comparing the results from M_S and m_b values of 5.0, 5.5, 6.0 and 6.5 it was found that there was no difference in the \mathbf{M} derived from M_S but slight differences in \mathbf{M} derived from m_b , with the exact difference depending on the magnitude. The unified magnitude, M_U , is a hybrid of M_S and m_b (EPRI). The conversion equation for M_U comes from the EPRI report as it was not re-evaluated by Johnston (1996a). Given that there is little or no difference in moment magnitudes derived from M_S and m_b , moment magnitudes based on M_U , which gives a higher weight to M_S , were not re-evaluated in this study. Moment magnitudes derived by Bent (2009) or adopted by Bent (2009) from the EPRI report on the basis of M_S have also not been recalculated unless M_S has subsequently been revised. Those that were based on m_b have been reassessed. The EPRI report did not include a direct M_L - \mathbf{M} conversion relation but did provide an M_L - m_b conversion for eastern North America. Bent (2009) used a two step M_L - m_b - \mathbf{M} process. In the current paper, the direct M_L - \mathbf{M} conversion of Johnston (1996a) is applied for earthquakes occurring onshore, which generally increases \mathbf{M} with respect to the previous study.

$$M_U = (m_b + 2M_S)/2$$

$$\log(M_o) = 21.67 - 0.18(M_U) + 0.13(M_U)^2$$

$$\log(M_o) = 24.66 - 1.083(M_S) + 0.192(M_S)^2$$

$$\log(M_o) = 18.28 + 0.679(m_b) + 0.077(m_b)^2$$

$$\log(M_o) = 18.31 + 1.017(M_L) \quad \text{used in this study for onshore earthquakes only}$$

For pre-instrumental earthquakes, the EPRI conversion relations for stable continental regions based on felt area in km^2 at various intensities are applied. These are somewhat different in appearance from those published by Johnston (1996b). As for the instrumental conversions, there is little or no difference in the final results. Since moment magnitudes derived from intensity data, have a high uncertainty associated with them, previously published moment magnitudes were not recalculated. A_{felt} is the complete felt area in km^2 and A_{MMI} is the felt area at the Modified Mercalli Intensity (Wood and Neumann, 1931) indicated by the subscript.

$$\log(M_o) = 47.34 - 10.81\log(A_{\text{felt}}) + 1.17\log^2(A_{\text{felt}})$$

$$\log(M_o) = 30.62 - 4.67\log(A_{\text{IV}}) + 0.65\log^2(A_{\text{IV}})$$

$$\log(M_0) = 20.94 + 0.36\log(A_{VI}) + 0.14\log^2(A_{VI})$$

When felt or isoseismal areas are not available, moment magnitude is based on either the maximum intensity or the intensity at the epicenter. Values for these events were adopted from other sources and not directly calculated in this study.

Moment Magnitude Catalog

In the creation of this catalog, a priority scheme has been developed for assigning a preferred moment magnitude. The scheme is essentially that of Bent (2009) who based her scheme on that of EPRI. Before discussing that, a few additional words on the EPRI report are in order. It was a comprehensive study of earthquakes occurring in stable continental regions. Earthquakes were evaluated individually with all available information taken into account. When possible, moment magnitudes were assigned. Magnitude conversions for stable continental regions were also developed. The EPRI catalog assigns two decimal places to their moment magnitudes. When adopting their values, I rounded them to a single decimal place. It is debatable whether the two decimal place precision is warranted for modern earthquakes and it almost assuredly is not for magnitudes derived from scant felt reports.

Instrumentally determined moment magnitudes are given top priority. In the case of differing moment magnitudes from regional and teleseismic moment tensor inversions, the regionally derived value is given preference unless there is a clear reason to suspect it. Studies have shown that for moderate earthquakes, teleseismic moment tensor inversions, such as the Global Centroid Moment Tensor project (GCMT; Dziewonksi et al., 1981; Ekström et al. 2012; Data and Resources) and USGS (see Data and Resources) tend to overestimate the magnitude (Gasperini et al., 2012; DiGiacomo et al., 2021). For larger earthquakes, teleseismic moment magnitudes may be preferable. There are only a small number of events of magnitude 7.0 or greater in this study and their moment magnitudes were derived by other methods. Preliminary assessments for Canada (some events discussed in this paper and also Bent et al., (2019)) are consistent with the observations of Gasperini et al. (2012) and DiGiacomo et al. (2021) but further study with a larger data set is needed before making a blanket statement to that effect for Canadian earthquakes.

Other instrumentally derived magnitudes are next in terms of priority with preference given to the teleseismic magnitudes M_S and m_b as they are less sensitive than regional magnitudes to the effects of depth and local velocity structure. If both are available, the unified magnitude M_U described in the EPRI report is used. It is a weighted average with M_S being given double the weight of m_b . Otherwise, whichever of the two is available was used. The next preference is given to instrumentally derived regional magnitudes. M_N is given higher priority than M_L as it was developed for use in eastern North America and M_L for California.

If there are no instrumental magnitudes, intensity data are used to determine moment magnitude. Total felt area and isoseismal areas are preferred. The majority of magnitudes in the NEDB (see Data and Resources) for pre-instrumental earthquakes are those of Smith (1962), many of which are based on maximum intensity. Peak intensity is used only when there is no alternative. The Bent (2009) study pointed out the dangers of using peak intensity blindly. Several events in the NEDB (see Data and Resources) with magnitudes listed as M_L 5.7 were found to be small mining related events in the United States whose peak intensities were high due to a combination of shallow depth and close proximity to a community. Although such an error may be understandable for earthquakes occurring

in previous centuries, these events occurred in the 1950s and the lack of instrumental data should have served as a red flag. These were removed from the moment magnitude catalog but, unfortunately, still appear in the NEDB.

Lacking any new information relevant to a previously studied earthquake, its M value determined by Bent (2009) has been retained without further analysis. Ninety-six events fall into this category and are shown unshaded in Table S1 of the Supplement to his article. The original justification or reference for the magnitude is noted. If the source was EPRI, the basic justification (e.g. instrumental magnitude, peak intensity) is noted but readers may wish to consult the EPRI report for their sources of information. More details on earthquakes of interest may be obtained from the references therein. New events (yellow), re-evaluated events (blue), historical events not meeting completeness criteria (red) and events not meeting initial criteria but with known instrumental moment magnitudes (green) are also included as shaded entries in Table S1 in the Supplement to this article. The complete catalog of events evaluated may be found in Table S1 in the form of an Excel spreadsheet; Table 1 in the main body of the text is an abbreviated version of the spreadsheet for events for which M is greater than or equal to 5.0. The comments re shading apply only to the Supplement.

No attempt has been made to assign formal uncertainties to the magnitudes. It is the author's experience that magnitudes calculated from instrumental data at many stations tend to have uncertainties of the order of 0.2 magnitude units. For example, an evaluation of uncertainties, defined as standard deviation, for M_N in the NEDB (see Data and Resources) for a suite of over 4000 eastern Canadian earthquakes, used as part of an ongoing study, occurring over a ten year period yields a mean value of 0.14. Uncertainties associated with sparse instrumental data or felt reports are, in general, higher. Additionally, there are uncertainties associated with conversion relations. With this in mind, M values obtained directly from instrumental data should be considered the most reliable and those estimated from sparse intensity data the most uncertain. Of the 254 moment magnitudes in the catalog, 111 are instrumental moment magnitudes (Figure 2a). The remaining values are roughly equally split between those derived from other instrumental magnitudes and those from intensity data (Figures 2b-d).

New Events

The NEDB (see Data and Resources) was searched for events of magnitude 5.0 and greater on any magnitude scale from 1 January 2009 through 30 June 2020 within the boundaries discussed previously in the text. Ten events were found. Instrumental moment magnitudes were available for all except one of these events. They are primarily derived from moment tensor inversions. As previously noted, magnitudes from regional moment tensor solutions are given preference over those derived from teleseismic data for this earthquake suite. All events in this group are of M 6.0 or less.

The dates, original times and magnitudes noted in bold below are from the NEDB (see Data and Resources). All times are Universal Time (UT). The event number refers to Tables 1 and S1 (in the Supplement to this article where these events are shaded in yellow), which are sorted by moment magnitude. In the case of equal moment magnitude, they are arranged chronologically in the Tables. The events are discussed chronologically below.

2009-04-15 06:54:51 5.0mb Offshore Queen Elizabeth Islands region, NT (event 82): Both the USGS and GCMT (see Data and Resources) give moment magnitudes, derived from moment tensor inversion, of 5.0 for this earthquake. This value is adopted.

2009-07-07 19:11:45 5.9Mw 237 km SE of Craig Harbour, NU. Felt (event 23): The preferred moment magnitude for this Baffin Bay earthquake is 5.9 derived from regional moment tensor inversion (Kao et al., 2012; Herrmann – see Data and Resources). Magnitudes derived from teleseismic moment tensor inversions are similar but, on average, slightly larger: M_{WC} 6.1 and M_{Wb} 5.9 (USGS, see Data and Resources) and 6.0 (GCMT, see Data and Resources).

2010-06-23 17:41:41 5.0Mw 10 km SE of Val-des-Bois, QC, Felt (event 80): The earthquake near Val-des-Bois, Quebec on 23 June 2010 was one of the largest earthquakes in southeastern Canada in the last quarter century. Regional moment tensor inversions by Kao et al. (2012) and Herrmann (see Data and Resources) both obtained moment magnitudes of 5.0. Teleseismic moment tensor inversions by the USGS and GCMT (see Data and Resources) suggest a slightly larger value of 5.2, which is also the value adopted by the GEM catalog. The regional value is adopted in this study. Detailed studies on this earthquake refer to M as 5.0 (Atkinson and Assatourians, 2010) and 5.1 (Boore, 2012).

2011-08-23 17:51:03 5.8Mw Virginia, US. Felt (event 26): Although it occurred approximately 400 km from the Canadian border, the Mineral, Virginia earthquake of 23 August 2011 was felt throughout much of eastern Canada and is therefore included in this study. The NEDB (see Data and Resources) cites the USGS (see Data and Resources) location and magnitude as the preferred values. It is noted by the author that the latitude is just south of the boundary used in the initial search of the NEDB (see Data and Resources). The USGS gives an M_{WW} of 5.8, which is the same as Herrmann's (see Data and Resources) value from regional moment tensor inversion. The GCMT M_W is 5.7. The preferred value is 5.8. It is noted that this is also the preferred value for many in-depth studies on this earthquake (Hough et al., 2012; Hartzell et al., 2013, McNamara et al., 2014).

2013-05-17 13:43:23 5.2MN 18 km NE of Shawville, QC, Felt (event 144): This widely felt earthquake occurred in the Western Quebec Seismic Zone on 17 May 2013 near the town of Ladysmith, Quebec. It was discussed in detail by Bent et al. (2015) who obtained an instrumental moment magnitude of 4.6 from regional moment tensor analysis using a regionally appropriate velocity model. This value is consistent with moment magnitudes derived by others. These include 4.6 from PGA and 4.5 from spectral data (Atkinson et al., 2014), 4.4 from regional moment tensor inversion (Herrmann, see Data and Resources), 4.7 from teleseismic moment tensor inversion (GCMT, see Data and Resources) and 4.7 from vertical Rayleigh waves (Ma and Audet, 2014).

2017-01-08 23:47:11 5.9Mw 93 km SE of Resolute, NU. Felt (event 24): The epicenter of this earthquake was 93 km from the community of Resolute and the newly upgraded Canadian National Seismograph Network (CNSN) station RES located there. The preferred M of 5.9 is based on regional moment tensor inversion (Bent et al., 2018) using a regionally appropriate velocity model. Herrmann (see Data and Resources) also obtained an M of 5.9 based on a regional moment tensor inversion. Moment magnitudes obtained via teleseismic moment tensor inversion tend to be slightly larger with values of 6.1 by both Motazedian and Ma (2018) and the GCMT (see Data and Resources). The USGS (see Data and Resources) obtained an M_{WW} of 6.0 and M_{Wb} of 5.9. The preferred value is 5.9 from regional moment tensor inversion.

2017-01-09 17:55:35 5.0Mw 88 km SE of Resolute, NU. Aftershock (event 81): This earthquake is an aftershock of Event 24. The preferred moment magnitude of 5.0 is based on regional moment tensor inversion (Bent et al., 2018). The GMCT (see Data and Resources) M_w from teleseismic moment tensor inversion is also 5.0.

2017-01-20 01:26:15 5.1ML 97 km SW of Isachsen, NU (event 131): Bent et al. (2018) obtained a moment magnitude of 4.7 from regional moment tensor inversion and this is the preferred value. Moment magnitudes for this event were not determined by any of the other usual sources.

2017-02-10 15:01:49 5.3Mw 92 km SE of Resolute, NU. Felt (event 51): This event is another aftershock of Event 24. Its preferred moment magnitude of 5.3 is based on regional moment tensor inversion (Bent et al., 2018). Moment magnitudes were not determined by any of the other usual sources.

2018-06-04 22:49:30 5.0ML West coast of Greenland (event 132): The earthquake appears in the USGS database with an m_b of 4.5. The Geological Survey of Denmark and Greenland (GEUS) reports the magnitude as M_L 4.1 (<https://www.geus.dk/natur-og-klima/jordskaelv-og-seismologi/registrerede-jordskaelv-i-groenland/>), considerably smaller than the M_L of 5.1 in the NEDB (see Data and Resources). No instrumentally determined moment magnitude was found for this event. Using the m_b - M_W conversion relation of Johnston et al. (1996a) a moment magnitude of 4.7 is obtained.

Re-evaluated Events

The earthquakes discussed in this section were all evaluated by Bent (2009). In light of new information, such as regionally appropriate magnitude conversion relations, newly found data or an in-depth study or re-analysis of a particular earthquake their moment magnitudes were reassessed. Note that this does not mean that the preferred moment magnitude value has changed. An origin time of 00:00:00 indicates that it is unknown. Event number refers to Tables 1 and S1 (in the Supplement to this article where they are shaded in blue), where they are sorted in order of decreasing M . Events that were re-evaluated in light of new conversion relations are grouped and discussed at the end of this section. The others are discussed individually in chronological order.

1791-12-06 20:00:00 6.0ML 6 km S of Baie-St-Paul, QC (event 38): Bent (2009) adopted the EPRI M of 5.5 based on felt area. A new study by Lamontagne (2020), which provides a detailed assessment of local and regional damage, is consistent with this value.

1904-03-21 06:04:00 5.9MN 14 km SW of St. Andrew's NB (event 29): A recent paper by Ebel (2020) suggests that the epicenter might be closer to Sullivan, Maine. Since the moment magnitude of 5.7 is based on isoseismal area, it is not dependent on the epicenter and has therefore not been changed. A difference in epicenter might, however, have implications for other aspects of hazard assessment.

1933-11-20 23:21:52 6.3MS Baffin Bay (event 1): The M value of 7.4 preferred in Bent (2009) based on the moment magnitude determined by Bent (2002) by waveform modeling twelve phases (9 P, 3 SH) at nine stations is retained in this study. However, the number is sufficiently different from the M of 7.7 in the GEM catalog that it bears discussion. The GEM value comes from a compilation of moment magnitudes by Lee and Engdahl (2015). Their moment magnitude for this earthquake is based on the work of Stein et al. (1979), whose moment is derived from measurements at three stations. It should also be noted that Stein et al. (1979) obtained an erroneous depth of 65 km, which they noted as unusual, by fitting travel times to a single station.

1945-01-01 01:20:42 6.5MS Baffin Bay (event 20): The M value in Bent (2009) is the 6.5 of EPRI obtained by a conversion from instrumental M_S . This event appears in the GEM catalog with an M of

5.9. The EPRI report cites NOAA as the source and the ISC cites Pasadena. The GEM value was obtained by conversion from a recomputed M_S of 5.75 based on measurements at ten stations (D. Di Giacomo, written communication Nov 2020). It is therefore considered more reliable and the GEM magnitude has been adopted.

1951-04-22 12:36:16 5.7ML 269km E of Grise Fiord, NU (event 34): Bent (2009) adopted the EPRI M of 5.3 based on a conversion from instrumental M_L . The GEM catalog shows this event as M 5.7 based on a recomputed M_S of 5.4. The GEM value is adopted as it is based on M_S , which is higher in the priority scheme than M_L .

1957-05-02 03:55:33 6.3 MS Baffin Bay, off Cape Hunter, Baffin Island (event 27): The M of 6.4 in Bent (2009) was adopted from the EPRI report. However, Bent (2009) mistakenly stated that it was based on an instrumental M_L . The value was based on an instrumental M_S of 6.3, which they state came from a NOAA report. The GEM catalog lists this event as M 5.8 based on the ISC M_S value of 5.6. The ISC catalog, which has recently been updated, is presumed to be more complete and the GEM value is adopted.

1989-12-25 04:25:50 5.1MN Ungava, Northern QC (event 50): This event is a foreshock of event 9. The M value of 5.0 in Bent (2009) was adopted from EPRI, which was based on instrumental M_S and m_b . The GEM catalog value of 5.3 is based on an updated m_b value of 5.1 (D. Di Giacomo, written communication November 2020). The GEM value is adopted.

1989-12-25 14:24:32 6.3MS Ungava, Northern QC, felt (event 9): The M value of 6.2 in Bent (2009) was based on a detailed study of this event by Bent (1994) with the moment being determined by waveform modeling. The GEM catalog indicates a slightly smaller value of 6.0 based on the GCMT (see Data and Resources). Bent (1994) showed that the event was very shallow (~ 3 km) whereas the depth from the GCMT (see Data and Resources) is 15 km, reflecting that shallow depths are often not well resolved by long-period teleseismic data. The value of 6.2 is retained.

2008-04-18 09:36:57 5.2Mw 7km NNE of Belmont, Illinois, felt (event 60): Bent (2009) adopted the instrumental M 5.2 of the USGS based on a regional moment tensor inversion. This event appears in the GEM catalog with an M of 5.4 obtained from the GCMT (see Data and Resources). The USGS value is retained based on the priority scheme, which gives preference to regional moment tensors.

Moment magnitudes in Bent (2009) based on M_N were either adopted from another source or calculated using the EPRI conversion equation. They have been reassessed using the conversion relation of Bent (2011) for eastern Canada. In most cases, the difference between the previous and revised value is small. The mean difference is -0.16. The events in this group are **1941-06-08** (event 242) revised from 4.0 to 3.7, **1943-01-14** (event 94) revised from 5.0 to 4.9, **1943-06-25** (event 247) revised from 3.7 to 3.6, **1944-06-23** (event 185) revised from 4.3 to 4.2, **1956-06-05** (event 217) revised from 4.0 to 3.9, **1957-03-23** (event 150) revised from 4.6 to 4.5, **1957-07-21** (event 195) revised from 4.2 to 4.1, **1958-01-09** (event 248) revised from 3.8 to 3.6, **1959-01-28** (event 253) revised from 3.8 to 3.5, **1959-01-30** (163) revised from 4.5 to 4.4, **1959-10-21** (event 249) revised from 3.8 to 3.6, **1960-09-06** (event 151) revised from 4.6 to 4.5, **1963-03-08** (event 141) revised from 4.7 to 4.6 and **1966-03-22** (event 250) revised from 3.8 to 3.6.

Moment magnitudes in Bent (2009) based on M_L for offshore events were either adopted from another source or derived from a two step M_L - m_b - M conversion. They have been re-validated using the Bent (2016) conversion relation. The mean difference is +0.17. The affected events are **1915-01-22** (event

55) revised from 4.6 to 5.2, **1951-06-27** (event 107) revised from 4.6 to 4.8, **1952-10-20** (event 108) revised from 4.6 to 4.8, **1954-08-28** (event 66) revised from 4.9 to 5.1, **1954-10-16** (event 67) revised from 5.3 to 5.1, **1958-02-04** (event 95) no change from the value of 4.9 and **1962-10-26** (event 109) revised from 4.6 to 4.8.

Moment magnitudes in Bent (2009) for onshore earthquakes derived from M_L were either adopted from another source or derived from another source or from a two step M_L - m_b - M conversion. They have been re-evaluated using the Johnston (1996a) conversion relation for M_L . Note that M_L for the 1883 and 1897 earthquakes was estimated from felt reports. The affected events are **1883-02-04** (event 52) revised from 4.7 to 5.2, **1897-11-14** (event 42) revised from 4.8 to 5.4, **1925-03-01** (event 56) revised from 4.6 to 5.2, **1925-03-21** (event 57) revised from 4.6 to 5.2, **1926-03-18** (event 148) revised from 4.1 to 4.5, The moment magnitude is revised from 4.1 to 4.5, **1928-12-01** (event 58) revised from 4.6 to 5.2 and **1961-12-25** (event 49) revised from 4.7 to 5.3.

Moment magnitudes in Bent (2009) for the following events were based on m_b and have been recalculated using the Johnston (1996a) conversion relation rather than that in the EPRI report. The mean difference is -0.01. The events affected are **1937-03-02** (event 106) revised from 4.9 to 4.8, **1966-06-26** (event 186) revised from 4.0 to 4.2, **1967-11-26** (event 68) revised from 5.1 to 5.2, **1988-01-12** (event 217) revised from 4.1 to 3.9 and **2008-05-03** (event 127) revised from 4.6 to 4.7. M for events **1983-02-12** (event 153) and **1991-07-24** (event 175) was recalculated but there was no change from the previously published values of 4.5 and 4.3, respectively.

“New” Historical Events

Table 2 of Bent (2009) lists forty-five earthquakes, mostly pre-instrumental, that were not evaluated because they did not meet the completeness criteria for use in seismic hazard assessment. Their magnitudes, however, are within the range of those included in the study and therefore they should be considered among the largest eastern Canadian earthquakes unless proven otherwise. Uncertainties for pre-instrumental earthquakes are difficult to quantify but are typically greater than for instrumentally derived magnitudes as they rely primarily on felt reports often from sparsely populated regions. A brief perusal of the NEDB (see Data and Resources) magnitudes shows a preponderance of M_L 5.7 and 5.0 events (Figure 3). These values are often an indication that the magnitude is based on peak intensity. Additionally, 5.0 may be a default value for widely felt earthquakes. The EPRI report notes that many magnitude (M_L) derived from maximum or epicentral intensity, use the rough conversion of Gutenberg and Richter (1954) where MMI VI becomes M_L 5.0 and MMI VII M_L 5.7. The report also comments, that these magnitudes are likely overestimated. If the EPRI value has been adopted by this study in light of no new information, the earthquake appears only in Tables 1 and S1 (in the Supplement to this article). Events for which additional information has been obtained whether or not it is consistent with the EPRI moment magnitude or for which there are complications are discussed. The events are discussed in chronological order, with the event numbers corresponding to Tables 1 and S1 (in the Supplement to this article; these events are shaded in red).

1638-06-11 New Hampshire 20:00:00 6.3 M_L (event 11): This event is listed in both the EPRI report and the NEDB (see Data and Resources) as occurring offshore in the Cape Ann region. There is an increasing body of evidence suggesting it occurred in New Hampshire (Ebel, 1996; Ebel and Starr, 2018). The rationale for the location and magnitude (M_{Lg} 6.5) are discussed in detail in these papers but is based on where and how strongly the earthquake was felt and comparisons to recent earthquakes with better constrained source parameters. The moment magnitude of 6.1 adopted in this

study assumes a standard M_N - M (Bent, 2011) conversion but has considerable uncertainty associated with it.

1661-02-10 12:00:00 5.7ML 9 km N of Saint-Cesaire QC (event 87): Gouin (2001) suggests that the epicenter may be closer to Roxbury, Maine than to Montreal but does not attempt to estimate magnitude citing a lack of contemporary documents. The EPRI magnitude of 4.9 is retained for lack of additional information. Ebel (1996) provides a minimum m_{bLg} of 5.0 based on felt information but is not able to constrain it further. This would suggest a moment magnitude above 4.6.

1663-02-06 15:00:00 5.0ML 7 km SE of La Malbaie, QC (event 73): This earthquake is undoubtedly an aftershock of the approximately magnitude 7.0 earthquake that occurred on 5 February 1663 (event 3). It is mentioned neither in the EPRI report nor by Gouin (2001). Gouin (2001) comments briefly on aftershocks without attempting to assign magnitudes to them due to inconsistent data from contemporary sources. He notes that the largest aftershock was reportedly felt in Montreal but raises doubts about it as well. The entry in the NEDB (see Data and Resources) for this earthquake does not cite a source for the estimated M_L 5.0 although it is likely related to maximum intensity. Ebel (1996) provides a minimum magnitude, m_{bLg} , of 5.0 but cannot constrain it further. Searching the NEDB (see Data and Resources) for recent earthquakes in the Charlevoix region, a magnitude, M_N , 5.4 on 6 March 2005 was reported felt in the Montreal region. Recent earthquakes in the magnitude 4-5 range were not felt in Montreal. Taking this to be a minimum magnitude and assuming this is the largest aftershock, a moment magnitude of 5.0 is assigned to this earthquake but it the uncertainty associated with it is very high and it should be used with caution.

1665-02-24 00:00:00 5.5ML 20 km NE of La Malbaie, QC (event 133): The EPRI report assigns a moment magnitude of 5.2 to this earthquake based on maximum intensity. Ebel (1996), estimates that the magnitude (m_{bLg}) is less than 5.0 based on where it was reported felt. Gouin (2001) does not assign a magnitude to this earthquake but notes the Ebel (1996) paper. A moment magnitude of 4.6 is assigned to this earthquake assuming an m_{bLg} of 5.0 and the current conversion relation (Bent, 2011). This value should be used with caution as there is considerable uncertainty attached to it.

1668-04-13 13:00:00 5.0ML 14km N of Montamagny, QC (event 134): This event does not appear in the EPRI report. Gouin (2001) discusses it but does not assign a magnitude. Ebel's (1996) evaluation of felt information concludes that the minimum m_{bLg} magnitude is 5.0. As for the event above the value of 5.0 is assumed, converted to an M of 4.6, and it is noted that the uncertainty is high.

1727-12-28 00:00:00 5.0ML New England (event 255, removed from catalog): This event, which appears neither in the EPRI or report nor the USGS, may be an aftershock of the event that occurred on 10 November 1727 (event 101). Ebel (written communication, Sept. 2020) suggests that there are two errors associated with the date. The first is that it is probably listed using the old (Julian) calendar and second, that the date is wrong regardless of calendar. His research points to an event on 25 December 1727 (Julian), which corresponds to 5 January 1728 in the new or Gregorian calendar. With that in mind, this is almost certainly the event (#204) on 4 January 1728 (see discussion below), which would have occurred on 5 January UT/4 January local time. The event listed as 1727-12-28 is removed from the catalog and that on 1728-01-04 is retained.

1728-01-04 00:00:00 5.0ML New England (event 204): This event appears in neither the EPRI report nor the USGS. It likely occurred on 5 January (UT) as discussed above. Ebel (written communication, Sept. 2020) notes that it was felt from Casco Bay, ME to Boston, suggesting a

moment magnitude in the 4-4.5 range. The low value has been selected to allow for differences between M_{Lg} and M . The uncertainty is high.

1728-02-10 00:00:00 5.0ML New England (event 239): This event, which appears neither in the EPRI or report nor the USGS, may be an aftershock of the event that occurred on 10 November 1727 (event 102). Ebel (written communication, Sept. 2020) notes that it was reported felt from Portsmouth, NH to Westborough, MA which would be consistent with an M_{Lg} of approximately 4. This is converted to M 3.7 based on comments from Ebel (written communication, Sept. 2020) that M_{Lg} from felt area is approximately 0.3 m.u. greater than M but users of the data should note that there is considerable uncertainty attached to both numbers.

1744-06-14 22:00:00 5.0ML Massachusetts (event 205): This is likely an aftershock of event 161 that occurred at 15:00 the same day and is better documented. Ebel (written communication, Sept. 2020) notes that reference to the earthquake that occurred at 22:00 is found in a history of Salem, Massachusetts stating that it had been felt there and in adjacent towns. It is clearly smaller than event 161, which has an M of 4.4. It is difficult to assign a moment magnitude to this event. A value of 4.0 is assigned, but it should be treated as an upper limit.

1755-11-23 01:27:00 5.0ML New England (event 239): This event that appears neither in the EPRI report nor the USGS is likely an aftershock of the Cape Ann earthquake on 18 November 1755 (event 7). Ebel (written communication, Sept. 2020) says that it was reported felt from Portland, ME to Rhode Island, consistent with an M_{Lg} of approximately 4 or M 3.7. This value is adopted but should be treated as very approximate.

1766-02-02 00:00:00 5.0ML New England (event 256; removed from catalog): This event appears in neither the EPRI report nor the USGS. Ebel (written communication, Sept 2020) says that it is described by Brigham (1871) as being felt in parts of New England and accompanied by a meteor. Ebel's assessment, with which I concur, is that what was felt was likely a sonic boom from a meteor.

1791-05-18 00:00:00 6.4ML Connecticut (event 191): The NEDB (see Data and Resources) lists this event as M_L 6.4. The earthquake appears in the EPRI report with a moment magnitude of 4.1 noted as a judgement call. However, that statement is followed by a comment that this is a non-event with no explanation given. I suspect it may be a case of a wrong date becoming associated with the event that occurred on 16 May 1791 (#182) but have no concrete evidence to support this. Ebel (written communication, Sept. 2020) concurs saying that it's likely a duplicate event that worked its way into the literature, possibly stemming from reports published on the 18th referring to an event on the 16th. The event is retained with the EPRI M but it should be used with caution. Its occurrence or non-occurrence does not have a significant effect on hazard assessments for Canada.

1800-12-25 00:00:00 5.0ML New England (event 240): This event appears in neither the EPRI report nor the USGS. Ebel (written communication, Sept. 2020) comments that Brigham (1871) notes this earthquake as having been felt in Newport (RI?), Boston and Concord (presumably MA but possibly NH). His assessment is of an M_{Lg} of 4 or less. M 3.7 is adopted in this study but has considerable uncertainty associated with it.

1831-07-14 00:00:00 5.7ML 7km SE of La Malbaie, QC (event 103): Gouin (2001) asserts that this earthquake occurred during the night of 7-8 July 1831 and not on the 14th or 15th. Based on felt reports he estimates an m_{bLg} of 4.6. If the standard conversion relation for instrumental earthquakes

(Bent, 2011) applies, the EPRI moment magnitude of 4.4 might be slightly overestimated. However, the EPRI magnitude is retained for lack of strong evidence that it is incorrect.

1842-11-09 00:00:00 5.0ML 8km SW of Sorel, QC (event 170): Gouin (2001) reports an earthquake on 7 November 1842 that was felt in the region of lac Saint-Pierre. This is likely the earthquake listed in the NEDB (see Data and Resources) on the 9th. It does not appear in the EPRI catalog under either date. Gouin (2001) estimates an m_{bLg} of 4.7. Using the standard conversion (Bent, 2011) a moment magnitude of 4.3 is proposed for this earthquake but the uncertainty is high.

1855-02-06 00:00:00 5.0ML New England (event 257, removed from catalog): This event appears in neither the EPRI report nor the USGS. Ebel (written communication, Sept. 2020) says there is no mention of it in historical sources, such as Brigham (1871). It appears in the Weston Observatory catalog as occurring on 1855-02-07 at 4:30UT, which would correspond to 1855-02-06 11:30 PM local time. He notes that many of the events in the Weston catalog came from Smith's reports. There is a possibility that a wrong date has been attached to the 1855-02-08 New Brunswick earthquake (event 90) that occurred at 11:30AM local time. It is questionable whether this is a real event and no **M** has been determined for it.

1857-10-23 20:15:00 5.0ML 38 km E of Niagara-on-the-Lake, ON (event 171): The USGS (<https://earthquake.usgs.gov/earthquakes/eventpage/ushis97/executive>) derives a moment magnitude of 4.3 from felt area for this earthquake and is adopted in this paper. The epicenter matches that of the NEDB (see Data and Resources) and puts the event just on the New York side of the Ontario-New York border. This event is not discussed in the EPRI report.

1864-04-20 18:15:00 5.0ML 10km N of Quebec City, QC (event 254): Although this event appears in the NEDB (see Data and Resources) with an M_L of 5.0, Gouin (2001) suggests it is much smaller with an estimated m_{bLg} of 3.8. An **M** of 3.4 is adopted in this study assuming the standard (Bent, 2011) M_N -**M** conversion.

1933-1953 Baffin Bay: Several events occurring in Baffin Bay during this time period (events 30-33) are listed as having instrumental M_S 5.6. Given the occurrence of the **M** 7.4 event in 1933 (event #1), the occurrence of several large earthquakes in the region over the next few years is not surprising. That so many had identical magnitudes is somewhat. The ISC Bulletin (see Data and Resources) indicates that the magnitudes for this group of events are based on a single station (PAS). Three of these events (30-32) appear in the GEM catalog with moment magnitude 5.6-5.7, suggesting that with additional scrutiny, they do appear to be roughly the same size.

Other Events

Earthquakes in this category did not meet criteria of magnitude 5.0 or greater in the NEDB (see Data and Resources) but have been added to the catalog as they have instrumentally determined moment magnitudes in the range of other events on the list. The sixty-one events in this category are not discussed in detail but are flagged by green shading in Table S1 (in the Supplement to this article) where the sources are listed. All occurred since 2009 when regional moment tensor analysis became fairly routine in eastern Canada. Moment magnitude for these events range from 3.6 to 4.8.

Discussion and Conclusions

The catalog developed in the paper is certainly not complete in the sense of providing moment magnitudes for all events of moment magnitude greater than that of the smallest event in the catalog (M 3.4) or even above a specific magnitude. Rather it is an attempt to determine reliable moment magnitudes for as many of the largest events in and near eastern Canada as possible and make them available in a format that can be used in hazard assessments and research. A simple evaluation of the distribution of magnitude values suggests it is complete to approximately M 4.7 or perhaps it is more accurate to say it is incomplete below that threshold (Figure 3) but the completeness varies by region and time.

Although the moment magnitudes for many events were obtained by applying standard conversion equations, the conversions were not applied blindly. Doing so might have resulted in a more complete catalog as a larger number of events could have been included but the final product would not necessarily have been a more robust catalog. An effort was made to examine all available sources of magnitude data before reaching a final value. As direct, instrumental moment magnitudes become available for a larger number of earthquakes, there may be a benefit in re-evaluating some of the conversion relations used in this paper, particularly those derived from small, regional data sets. It is noted that moment magnitudes for the largest events, most of which had been the subjects of in depth studies, did not change with respect to those published in an earlier catalog (Bent, 2009). Revisions to moment magnitudes for many of the smaller events, on the other hand, were required. Although moment magnitudes can be derived via RCMT inversion and other waveform modeling techniques for most earthquakes considered to be among the largest or most significant in a region, there are other methods such as the coda envelope moment magnitude method (Mayeda et al. 2003, 2007) that have successfully been applied to other regions (e.g. Moasca et al., 2005; Gök et al. 2016; Holt et al., 2021) and would potentially enable the direct calculation of moment magnitudes for all earthquakes used in hazard assessments ($\sim M$ 2.5 and greater) recorded by digital data. This method is currently being investigated and showing promise for the Western Quebec Seismic Zone (Bent et al, 2021). However, the calibrations must be carried out region by region to account for differences in attenuation and we are not yet at the point of using it routinely in eastern Canada. The moment magnitudes presented in this catalog represent the best estimates based on the current state of knowledge. The catalog should not, however, be considered a static product. Just as this catalog can be described as an updated version of several that came before, there will undoubtedly be a need to for further updates at some future date as more earthquakes occur and as our understanding of magnitude related issues improves.

Acknowledgments

I thank John Ebel for digging through his notes and providing me with information on several, historical New England earthquakes and Domenico Di Giacomo for clarifying the details of some magnitudes in the GEM catalog. I also thank Michal Kolaj for his constructive review.

Data and Resources

Moment tensor solutions determined by the GCMT project, USGS and Herrmann (St. Louis Univ.)

may be found respectively at:

<http://www.globalcmt.org/CMTsearch.html>

<https://earthquake.usgs.gov/earthquakes/search/> (this link may also be used for other earthquake parameters noted as coming from the USGS or NEIC, including felt area magnitudes, USGSMFA, for pre-instrumental earthquakes)

http://eqinfo.eas.slu.edu/eqc/eqc_mt/MECH.NA

The (Canadian) National Earthquake Database may be found at

<https://earthquakescanada.nrcan.gc.ca/stndon/NEDB-BNDS/bulletin-en.php>

Note that the searchable database provides solutions only. Phase data may be obtained by sending a request to nrcan.earthquakeinfo-infoseisme.nrcan@canada.ca. Alternatively, the phase data from Canadian stations may be accessed directly via the ISC bulletin (see below).

The Bulletin of the International Seismological Centre may be accessed at

<http://www.isc.ac.uk/iscbulletin/search/>

Maps and figures in this paper were generated using GMT software.

Wessel, P. W. H. F. Smith, R. Scharroo, J. F. Luis and F. Wobbe (2013). Generic Mapping Tools: Improved Version Released, *EOS Trans. AGU*, **94**, 409-410.

The **Supplement** to this article contains the complete catalog of moment magnitudes for earthquakes evaluated in this paper in the form of an .xlsx spreadsheet. It includes source parameters, sources/justification of moment magnitudes and relevant references. A “readme” file provides additional information about the format.

References

Adams, J. and R. Wallström (1995). Revised seismicity of the Grand Banks and offshore Newfoundland, *Geological Survey of Canada Open File 3043*, 58p.

Atkinson, G. M and K. Assatourians (2010). Attenuation and Source Characteristics of 23 June 2010 M 5.0 Val-des-Bois, Quebec earthquake, *Seismological Research Letters*, **81**, 849-860, <https://doi.org/10.1785/gssrl.81.5.849>.

Atkinson, G. M., D. Morazedian and M. Lamontagne (2014). Characteristics of the 17 May 2013 M 4.5 Ladysmith, Quebec earthquake, *Seismological Research Letters*, **85**, 755-762, doi:10.1785/02201301.60.

Barstow, N. L., K. G. Brill, O. W. Nuttli and P. W. Pomeroy (1981). An Approach to Seismic Zonation for Siting Nuclear Electric Generating Facilities in the Eastern U. S., *NUERG/CR-577*, U. S. Nuclear Regulatory Commission, Washington, D.C., 143 p. plus Appendices.

Basham, P. W., D. H. Weichert, F. M. Anglin and M. J. Berry (1979). New Probabilistic Strong Seismic Ground Motion Maps of Canada: A Compilation of Earthquake Source Zones, Methods and Results, *Earth Physics Branch Open File 82-33*, Ottawa, Canada, 205 p.

Bent, A. L. (1992). A re-examination of the 1925 Charlevoix, Québec, earthquake, *Bulletin of the Seismological Society of America*, **82**, 2097-2113.

Bent, A. L. (1994). The 1989 (M_S 6.3) Ungava, Quebec earthquake: A complex intraplate event, *Bulletin of the Seismological Society of America*, **84**, 1075-1088.

- Bent, A. L. (1995). A complex double-couple source mechanism for the M_S 7.2 1929 Grand Banks earthquake, *Bulletin of the Seismological Society of America*, **85**, 1003-1020.
- Bent, A. L. (1996a). An improved source mechanism for the 1935 Timiskaming, Quebec earthquake from regional waveforms, *Pure and Applied Geophysics*, **146**, 5-20.
- Bent, A. L. (1996b). Source parameters of the damaging Cornwall-Massena earthquake of 1944 from regional waveforms, *Bulletin of the Seismological Society of America*, **86**, 489-497.
- Bent, A. L. (2002). The $M_S=7.3$ Baffin Bay earthquake: Strike-slip faulting along the northeastern Canadian passive margin, *Geophysical Journal International*, **150**, 724-736.
- Bent, A. L. (2009). A Moment Magnitude Catalog for the 150 Largest Eastern Canadian Earthquakes, *Geological Survey of Canada Open File 6080*, 23p.
- Bent, A. L. (2011). Moment magnitude (M_w) conversion relations for use in hazard assessments in eastern Canada, *Seism. Res. Lett.*, **82**, 984-990. doi:10.1785/gssrl.82.6.984.
- Bent, A. L. (2013). Evaluation of L_g Based Magnitudes for Eastern North America or Why is Your Magnitude Different from the USGS?, *Seismological Research Letters*, **84**, 317-318.
- Bent, A. L. (2015a). Regional Centroid Moment Tensor Solutions for Eastern Canadian Earthquakes: 2011-2013, *Geological Survey of Canada Open File 7726*, 71p., doi:10.4095/296795.
- Bent, A. L. (2015b). Regional Centroid Moment Tensor Solutions for Eastern Canadian Earthquakes: 2014, *Geological Survey of Canada Open File 7834*, 35 p., doi:10.4095/296822.
- Bent, A. L. (2016). Moment Magnitude (M_W) Conversion Relations for Use in Hazard Assessment in Offshore Eastern Canada, *Geological Survey of Canada Open File 8027*, 12 p., doi:10.4095/297965.
- Bent, A. L. (2017). Regional Centroid Moment Tensor Solutions for Eastern Canadian Earthquakes: 2015, *Geological Survey of Canada Open File 8050*, 26p., doi:10.4095/299816.
- Bent, A. L. (2019a). Regional Centroid Moment Tensor Solutions for Eastern Canadian Earthquakes: 2016, *Geological Survey of Canada Open File 8226*, 24 p., <https://doi.org/10.4095/314591>.
- Bent, A. L. (2019b). Regional Centroid Moment Tensor Solutions for Eastern Canadian Earthquakes: 2017, *Geological Survey of Canada Open File 8466*, 27p., <https://doi.org/10.4095/314592>.
- Bent, A. L. and H. S. Hasegawa (1992). Earthquakes along the northwestern boundary of the Labrador Sea, *Seismological Research Letters*, **63**, 587-602.
- Bent, A. L. and J. F. Cassidy (1993). The January 1992 Franklin Lake, Northwest Territories, earthquake sequence, *Bulletin of the Seismological Society of America*, **83**, 398-415.
- Bent, A. L., M. Lamontagne, J. Adams, C. R. D. Woodgold, S. Halchuk, J. Drysdale, R. J. Wetmiller, S. Ma and J.-B. Dastous (2002). The Kipawa, Québec, "Millennium" earthquake, *Seismological Research Letters*, **73**, 285-297.

- Bent, A. L., M. Lamontagne, V. Peci, S. Halchuk, G. R. Brooks, D. Motazedian, J. A. Hunter, C. Woodgold, J. Adams, J. Drysdale, S. Hayek and W. N. Edwards (2015). The 17 May 2013 Ladysmith, Quebec, Earthquake, *Seismological Research Letters*, **86**, doi:1785/0220140138.
- Bent, A. L., V. Peci and S. Halchuk (2016). The 2015 Canada Day, M_w 3.8, earthquake in Nova Scotia, *Seismological Research Letters*, **87**, 1224-1231, <http://dx.doi.org/10.1785/0220160074>.
- Bent, A. L., M. Kolaj, N. Ackerley, J. Adams and S. Halchuk (2018). The 2017 Barrow Strait, Arctic Canada, Earthquake Sequence and Contemporaneous Regional Seismicity, *Seismological Research Letters* **89**, 1977-1988, <https://doi.org/10.1785/0220180100>.
- Bent, A. L., N. Ackerley and M. Kolaj (2019). Toward Rapid Automated Moment Tensor Solutions for Canada, presented at the 2019 Fall AGU meeting, <https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/618718>
- Bent, A. L., K. Mayeda and R. I Roman-Nieves (2021). _Coda Envelope Moment Magnitudes for the Western Quebec Seismic Zone (abstract), paper presented at the 2021 Annual Meeting of the Seismological Society of America.
- Boore, D. M. (2012). Updated Determination of Stress Parameters for Nine Well-recorded Earthquake in Eastern North America, *Seismological Research Letters*, **83**, 190-199, <https://doi.org/10.1785/gssrl.83.1.190>.
- Brigham, W. T. (1871). Volcanic manifestations in New England: being an enumeration of the principal earthquakes from 1638 to 1869, *Memoirs of the Boston Society of Natural History*, **2**, 1-28.
- Di Giacomo, D., I. Bondár, D. A. Storchak, E. R. Engdahl, P. Bormann and J. Harris (2015). ISC-GEM: Global Instrumental Earthquake Catalogue (1900-2009), III- Recomputed M_s and m_b , proxy M_w , final magnitude composition and completeness assessment, *Physics of the Earth and Planetary Interiors*, **239**, 33-47, <https://doi.org/10.1016/j.pepi.2014.06.005>.
- Di Giamomo, D., E. R. Engdahl and D. A. Storchak (2018). The ISC-GEM Earthquake Catalogue (1904-2014): status after the Extension Project, *Earth System Science Data*, **10**, 1877-1899.
- Di Giacomo, D., J. Harris and D. A. Storchak (2021). Complementing regional moment magnitudes to GCMT: a perspective from the rebuilt International Seismological Centre Bulletin, *Earth System Science Data*, **13**, 1957-1985, <https://doi.org/10.5194/essd-13-1957-2021>.
- Dziewonski, A. M., T.-A. Chou and J. H. Woodhouse (1981), Determination of earthquake source parameters from waveform data for studies of global and regional seismicity, *Journal of Geophysical Research*, **86**, 2825-2852, doi:10.1029/JB086iB04p02825
- Ebel, J. E. (1996). The seventeenth century seismicity of northeastern North America, *Seismological Research Letters*, **67**, 51-68.
- Ebel, J. E. (2009). On the magnitude of the 1663 Charlevoix, Quebec earthquake, *Seismological Research Letters*, **80**, 343.

- Ebel, J. E. (2020). Using aftershocks to help locate historical earthquakes, *Seismological Research Letters*, **91**, doi:10.1785/0220200041.
- Ebel, J. E. and D. W. Chambers (2016). Using the locations of $M \geq 4$ earthquakes to delineate the extents of ruptures of past major earthquakes, *Geophysical Journal International*, **207**, 867-875, <https://doi.org/10.1093/gji/ggw312>.
- Ebel, J. E. and J. C. Starr (2018). A Geophysical and Field Survey for the Source Region of the 1638 New Hampshire Earthquake, *Seismological Research Letters*, **89**, 1197-1211, <https://doi.org/10.1785/0220170266>.
- Ekström, G., M. Nettles, and A. M. Dziewonski (2012), The global CMT project 2004-2010: Centroid-moment tensors for 13,017 earthquakes, *Physics of the Earth and Planetary Interiors*, **200-201**, 1-9, doi:10.1016/j.pepi.2012.04.002.
- EPRI (1994). see Johnston et al., 1994.
- Gasperini, P., B. Lolli, G. Vannucci and E. Boschi (2012). A comparison of moment magnitude estimates for the European-Mediterranean and Italian regions, *Geophysical Journal International*, **190**, 1733-1745, <https://doi.org/10.1111/j.1365-246X.2012.05575.x>.
- Gök, R., A. Kaviani, E. M. Matzel, M. E. Pasyanos, K. Mayeda, G. Yetirmishli, I. El-Hussain, A. Al-Amri, Farah Al-Jeri, T. Godoladze, D. Kalafat, E. A. Sandvol and W. R. Walter (2016). Moment Magnitudes of Local/Regional Events from 1D Coda Calibrations in the Broader Middle East Region. *Bulletin of the Seismological Society of America*, **106**, 1926–1938. doi: <https://doi.org/10.1785/0120160045>.
- 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*, Montreal, Guérin, 1491 p. (Bilingual text French and English)
- Gutenberg, B. (1945a). Amplitudes of surface waves and magnitudes of shallow earthquakes, *Bulletin of the Seismological Society of America*, **35**, 3-12.
- Gutenberg, B. (1945b). P, PP, and S and Magnitude of Shallow Earthquakes, *Bulletin of the Seismological Society of America*, **35**, 57-69.
- Gutenberg, B. (1945c). Magnitude determination for deep-focus earthquakes, *Bulletin of the Seismological Society of America*, **35**, 117-130.
- Gutenberg, B and C. F. Richter (1954). *Seismicity of the Earth 2nd Edition*, Princeton University Press, Princeton, NJ.
- Halchuk, S. (2009). Seismic Hazard Earthquake Epicentre File (SHEEF) used in the 4th generation seismic hazard maps of Canada, *Geological Survey of Canada Open File 6208*, 16p. and 1 CD ROM, <https://doi.org/10.4095/261333>.

- Hanks, T. C. and H. Kanamori (1979). A Moment Magnitude Scale, *Journal of Geophysical Research*, **84**, 2348-2350.
- Hartzell, S., C. Mendoza and Y. Zeng (2013). Rupture model of the 2011 Mineral, Virginia, earthquake from teleseismic and regional waveforms, *Geophysical Research Letters*, **40**, 5666-5670, <https://doi.org/10.1002/2013GL057880>.
- Holt, J. K. M. Whidden, K. D. Koper, K. L. Pankow, K. Mayeda, J. C. Pechmann, B. Edwards, R. Gök and W. R. Walter (2021). Toward Robust and Routine Determination of M_w for Small Earthquakes: Application to the 2020 M_w 5.7 Magna, Utah, Seismic Sequence, *Seismological Research Letters*, **92**, 725-740, <https://doi.org/10.1785/0220200320>.
- Hough, S. E.(2012). Initial Assessment of the Intensity Distribution of the 2011 M_w 5.8 Mineral, Virginia, Earthquake, *Seismological Research Letters*, **83**, 649-657, <https://doi.org/10.1785/0220110140>.
- Johnston, A. C. (1996a). Seismic moment assessment of earthquakes in stable continental regions I: Instrumental seismicity, *Geophysical Journal International*, **124**, 381-414.
- Johnston, A. C. (1996b). Seismic moment assessment of earthquakes in stable continental regions II: Historical seismicity, *Geophysical Journal International*, **125**, 639-678.
- Johnston, A. C., K. J. Coppersmith, L. R. Canter and C. A. Cornell (1994). *The Earthquakes of Stable Continental Regions Volumes 1, 2 and 4: Assessment of Large Earthquake Potential*, TR-102261-V1, Proprietary Report Prepared for Electric Power Research Institute, Palo Alto, California.
- Kao, H., S.-J. Shan, A. Bent, C. Woodgold, G. Rogers, J. F. Cassidy and J. Ristau (2012). Regional Centroid-Moment Tensor analysis for Earthquakes in Canada and Adjacent Regions: An Update, *Seismological Research Letters*, **83**, 505-515, doi:10.1785/gssrl.83.3.505.
- Lamontagne, M. (2020). The 1791 magnitude (M_w) 5.5 earthquake Charlevoix, Quebec: Interpretation of macroseismic information, *Geological Survey of Canada Open File 8739*, 26p., <https://doi.org/10.4095/326946>.
- Lamontagne, M., H. S. Hasegawa, D. A. Forsyth, G. G. R. Buchbinder and M. Cajka (1994). The Mont-Laurier, Québec, earthquake of 19 October 1990 and its seismotectonic environment, *Bulletin of the Seismological Society of America*, **84**, 1506-1522.
- Lamontagne, M., A. L. Bent, C. R. D. Woodgold, S. Ma and V. Peci (2004). The 16 March 1999 m_N 5.1 Côte-Nord earthquake: The largest earthquake ever recorded in the Lower St. Lawrence Seismic Zone, Canada, *Seismological Research Letters*, **75**, 299-316.
- Lee, W. H. K. and E. R. Engdahl (2015). Bibliographic search for reliable seismic moments of large earthquakes during 1900-1979 to compute M_w in the ISC-GEM Global Instrumental Reference Earthquake Catalog, *Physics of the Earth and Planetary Interiors*, **239**, 25-32, <https://doi.org/10.1016/j.pepi.2014.06.004>.

- Ma, S. and P. Audet (2014). The 5.2 magnitude earthquake near Ladysmith, Quebec, 17 May 2013: Implications for the seismotectonics of the Ottawa-Bonnechere graben, *Canadian Journal of Earth Sciences*, **51**, 439-451, doi:10.1139/cjes-2013-0215.
- Mayeda, K., A. Hofstetter, J. L. O'Boyle and W. R. Walter (2003). Stable and Transportable Regional Magnitudes Based on Coda-Derived Moment Rate Spectra, *Bulletin of the Seismological Society of America*, **93**, 224-239, <https://doi.org/10.1785/0120020020>.
- Mayeda, K., L. Malagnini and W. R. Walter (2007). A new spectral ratio method using narrow band coda envelopes: Evidence for non-self-similarity in the Hector Mine sequence, *Geophysical Research Letters*, <https://doi.org/10.1029/2007GL030041>.
- McNamara, D. E., H. M. Benz, R. B. Herrmann, E. A. Bergman, P. Earle, A. Meltzer, M. Withers and M. Chapman (2014). The M_w 5.8, Mineral, Virginia, Earthquake of August 2011 and Aftershock Sequence: Constraints on Earthquake Source Parameters and Fault Geometry, *Bulletin of the Seismological Society of America*, **104**, 40-54, <https://doi.org/10.1785/0120130058>.
- Minson, S., A. S. Baltay, E. S. Cochran, S. K. McBride and K.R. Milner (2020). Shaking is Almost Always a Surprise: The Earthquakes that Produce Significant Ground Motion, *Seismological Research Letters*, **91**, <https://doi.org/10.1785/0220200165>.
- Morasca, P., K. Mayeda, L. Malagnini and W. R. Walter (2005). Coda-derived source spectra, moment magnitudes and energy-moment scaling in the western Alps, *Geophysical Journal International*, **160**, 263-275, <https://doi.org/10.1111/j.1365-246X.2005.02491.x>.
- Motazedian, D. and S. Ma (2018). Source Parameter Studies on the 8 January 2017 M_w 6.1 Resolute, Nunavut, Canada, Earthquake, *Seismological Research Letters*, doi:10.1785/0220170260.
- North, R. G., R. J. Wetmiller, J. Adams, F. M. Anglin, H. S. Hasegawa, M. Lamontagne, R. Du Berger, L. Seeber and J. Armbruster (1989). Preliminary results from the 1988 Saguenay (Quebec) earthquake, *Seismological Research Letters*, **60**, 89-93.
- Nuttli, O. W. (1973). Seismic wave attenuation and magnitude relations for Eastern North America, *Journal of Geophysical Research*, **78**, 875-885.
- Richter, C. F. (1935). An instrumental earthquake magnitude scale, *Bulletin of the Seismological Society of America*, **25**, 1-32.
- Schulte, S. M. and W. D. Mooney (2005). An updated global earthquake catalogue for stable continental regions: reassessing the correlation with ancient rifts, *Geophysical Journal International*, **161**, 707-721, <https://doi.org/10.1111/j.1365-246X.2005.02554.x>.
- Smith, W. E. T. (1962). Earthquakes of eastern Canada and adjacent areas: 1534-1927, *Publications of the Dominion Observatory*, **26-5**.
- Storchak, D. A., D. Di Giacomo, I. Bondár, E. R. Engdahl, J. Harris, W. H. K. Lee, A. Villaseñor and P. Borrmann (2013). Public release of the ISC-GEM Global Instrumental Earthquake Catalog

(1900-2009), *Seismological Research Letters*, **84**, 810-815,
<https://doi.org/10.1785/0220130034>.

Storchak, D. A., D. Di Giacomo, E. R. Engdahl, J. Harris, I. Bondár, W. H. K. Lee, P. Borrmann and A. Villaseñor (2015). The ISC-GEM Global Instrumental Earthquake Catalogue (1900-2009): Introduction, *Physics of the Earth and Planetary Interiors*, **239**, 48-63,
<https://doi.org/10.1016/j.pepi.2014.06.009><https://doi.org/10.1016/j.pepi.2014.06.009>.

Tuttle, M. P. and G. M. Atkinson (2009). Contributions of paleoseismology to estimates of maximum earthquake magnitude, *Seismological Research Letters*, **80**, 338.

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

Table 1
Moment Magnitude for earthquakes of M 5.0 or greater in eastern Canada and Vicinity

event #	dd/mm/yyyy	OT (UT)	lat.(N)	lon. (W)	mag. (NEDB)	M	source*
1	11/20/1933	23:21:32	73.00	70.75	7.3MS	7.4	B02
2	11/18/1929	20:32:00	44.50	56.30	7.2ML	7.1	B95
3	05/02/1663	17:30:00	47.60	70.10	7.0ML	7.0	EPRI
4	20/10/1870	16:30:00	47.40	70.50	6.5ML	6.6	EPRI
5	8/31/1934	5:02:45	73.00	71.00	6.5MS	6.5	EPRI
6	16/09/1732	16:00:00	45.50	73.60	5.8MN	6.3	EPRI
7	18/11/1755	9:12:00	41.50	67.00	7.0ML	6.3	EPRI
8	12/27/1972	22:59:26	76.80	106.49	5.4MN	6.3	EPRI
9	12/25/1989	14:24:32	60.12	73.60	6.3Ms	6.2	B94
10	3/1/1925	2:19:20	47.80	69.80	6.2Mw	6.2	NEDB
11	11/06/1638	20:00:00	42.50	69.00	6.3ML	6.1	M_N-M
12	17/10/1860	11:15:00	47.50	70.10	6.0ML	6.1	EPRI
13	11/1/1935	6:03:40	46.78	79.07	6.2ML	6.1	B96b
14	9/4/1963	13:32:12	71.40	73.30	6.4MS	6.1	EPRI
15	11/18/1929	23:01:48	44.50	56.30	6.0ML	6.0	M_S-M
16	7/10/1947	10:48:45	73.00	71.00	6.0MS	6.0	EPRI
17	11/21/1972	10:06:27	76.58	106.02	5.7MN	6.0	EPRI
18	11/19/1929	2:01:28	44.50	56.30	5.8ML	5.9	M_S-M
19	1/1/1945	1:20:42	73.00	70.00	6.5MS	5.9	GEM
20	11/19/1972	17:33:44	76.55	106.33	5.6MN	5.9	EPRI
21	12/28/1972	14:36:05	76.80	106.16	5.1MN	5.9	EPRI
22	11/25/1988	23:46:04	48.12	71.18	5.9Mw	5.9	NEDB

23	7/7/2009	19:11:45	75.19	73.40	5.9Mw	5.9	K12
24	1/8/2017	23:47:11	74.27	92.13	5.9Mw	5.9	B18
25	9/5/1944	4:38:45	44.97	74.90	5.6ML	5.8	B96a
26	23/08/2011	17:51:03	37.94	77.94	5.8Mw	5.8	USGS
27	5/2/1957	3:55:33	72.31	67.52	6.3MS	5.8	GEM
28	3/21/1904	6:04:00	45.00	67.20	5.9MN	5.7	EPRI
29	5/16/1909	4:15:00	49.00	104.00	5.5MN	5.7	EPRI
30	12/19/1933	17:48:20	75.00	72.00	5.6MS	5.7	M _S - M
31	2/24/1934	0:49:03	73.50	71.50	5.6MS	5.7	M _S - M
32	6/15/1934	6:34:25	61.50	59.00	5.6MS	5.7	M _S - M
33	8/22/1935	20:30:52	73.25	71.50	5.6MS	5.7	M _S - M
34	4/22/1951	12:36:16	76.00	73.00	5.7ML	5.7	GEM
35	12/24/1940	13:43:44	43.80	71.30	5.6ML	5.6	EPRI
36	12/7/1971	12:04:18	55.09	54.51	5.6ML	5.6	EPRI
37	1/9/1982	12:53:52	47.00	66.60	5.7MB	5.6	EPRI
38	06/12/1791	20:00:00	47.40	70.50	6.0ML	5.5	EPRI
39	22/10/1869	10:45:00	45.00	67.20	5.7MN	5.5	EPRI
40	11/12/1976	14:47:19	72.30	70.43	5.6MN	5.5	EPRI
41	1/4/1992	0:56:56	66.73	94.60	5.0MB	5.5	BC93
42	14/11/1897	0:00:00	42.90	106.30	5.3ML	5.4	M _L - M
43	4/18/1935	22:15:28	70.50	73.00	5.6MS	5.4	EPRI
44	12/20/1940	7:27:26	43.80	71.30	5.0ML	5.4	EPRI
45	12/13/1987	21:05:04	74.40	92.96	5.4MB	5.4	EPRI
46	7/26/1922	6:31:08	50.00	50.00	5.3ML	5.3	M _S - M

47	12/13/1929	11:19:15	44.50	56.30	5.0ML	5.3	M _S - M
48	10/19/1939	11:53:58	47.80	69.80	5.6MN	5.3	EPRI
49	12/25/1961	19:58:29	63.90	89.30	5.1ML	5.3	M _L - M
50	12/25/1989	4:25:50	60.12	73.60	5.1MN	5.3	GEM
51	2/10/2017	15:01:49	74.29	92.17	5.4MN	5.3	B18
52	04/02/1883	5:00:00	42.30	85.60	5.0ML	5.2	M _L - M
53	5/26/1909	14:42:00	42.50	89.00	5.7ML	5.2	EPRI
54	1/22/1915	0:00:00	41.00	60.00	5.0ML	5.2	M _L - M
55	9/30/1924	8:52:30	47.80	69.80	5.5MN	5.2	EPRI
56	3/1/1925	4:30:42	47.80	69.80	5.0ML	5.2	M _L - M
57	3/21/1925	15:22:04	47.80	69.80	5.0ML	5.2	M _L - M
58	12/1/1928	0:00:00	50.00	81.50	5.0ML	5.2	M _L - M
59	8/14/2001	19:35:38	76.63	107.22	5.6MN	5.2	GCMT
60	4/18/2008	9:36:57	38.45	87.89	5.2Mw	5.2	NEDB
61	29/11/1783	0:00:00	41.00	74.50	5.0ML	5.1	USGSFA
62	15/11/1877	11:45:00	41.00	97.00	5.6ML	5.1	EPRI
63	27/11/1893	16:50:00	45.50	73.30	5.7ML	5.1	EPRI
64	2/10/1914	18:31:00	46.00	75.00	5.5ML	5.1	EPRI
65	3/9/1937	5:45:00	40.60	84.00	5.5ML	5.1	EPRI
66	8/28/1954	15:23:01	45.17	56.87	5.2ML	5.1	M _L - M
67	10/16/1954	6:45:00	44.83	56.80	5.3ML	5.1	M _L - M
68	11/26/1967	22:09:00	40.00	104.70	5.0ML	5.2	m _b - M
69	10/6/1975	22:21:41	44.71	57.07	5.7ML	5.1	EPRI
70	7/27/1980	18:52:21	38.17	83.91	5.1MB	5.1	EPRI

71	8/24/1981	11:20:33	61.32	59.29	5.5ML	5.1	M _U - M
72	4/20/2002	10:50:47	44.53	73.73	5.5MN	5.1	GCMT
73	06/02/1663	15:00:00	47.60	70.10	5.0ML	5.0	this study
74	11/18/1929	23:06:33	44.68	56.00	4.9MN	5.0	B09
75	3/8/1975	5:20:34	79.82	94.07	5.2ML	5.0	EPRI
76	6/27/1979	8:50:35	70.03	96.48	5.0MN	5.0	EPRI
77	1/11/1982	21:41:08	47.00	66.60	5.4MB	5.0	EPRI
78	3/16/1989	4:17:29	60.06	70.06	5.7MN	5.0	BH92
79	12/6/1997	8:06:47	64.84	88.19	5.7MN	5.0	K12
80	6/23/2010	17:41:41	45.88	75.48	5.0M _w	5.0	K12
81	1/9/2017	17:55:35	74.37	92.15	5.4MN	5.0	B18
82	4/15/2009	6:54:51	80.43	107.88	5.0mb	5.0	GCMT

* two magnitudes e.g. (M_S-**M**) indicate conversions, derived in this study, from another magnitude type using the conversion relations discussed in the text, EPRI (Johnston et al., 1994), NEDB (see Data and Resources), USGS/USGSFA (see Data and Resources), GCMT (see Data and Resources), GEM (Di Giacomo et al., 2015, 2018), B94 (Bent, 1994), B95 (Bent, 1995), B96a (Bent 1996a), B96b (Bent, 1996b), B02 (Bent, 2002), B09 (Bent, 2009), B18 (Bent et al., 2018), BC93 (Bent and Cassidy, 1993), BH92 (Bent and Hasegawa, 1992), K12 (Kao et al., 2012)

Figures

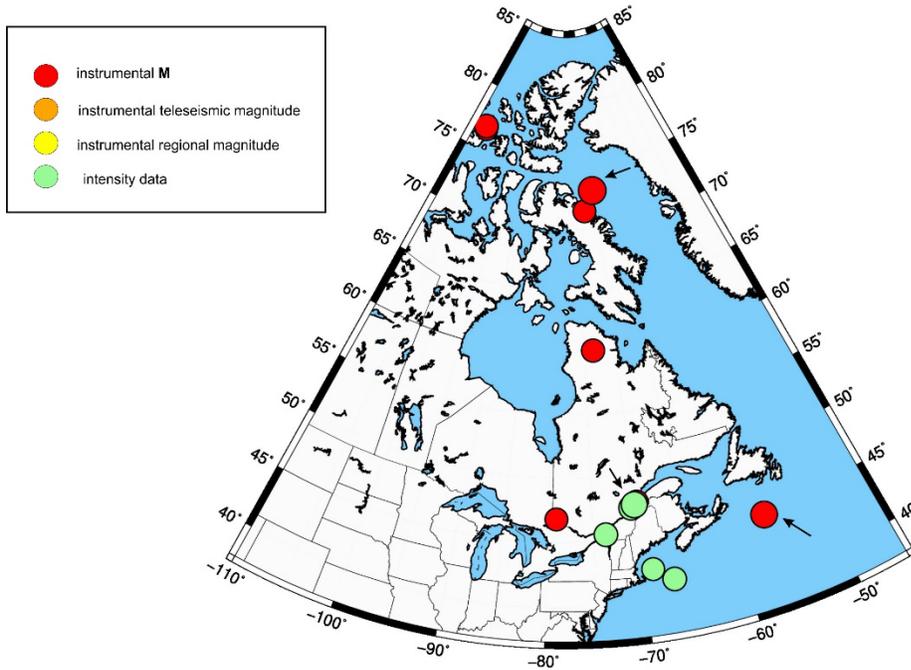


Figure 1a: earthquakes of **M** 6.0 or greater

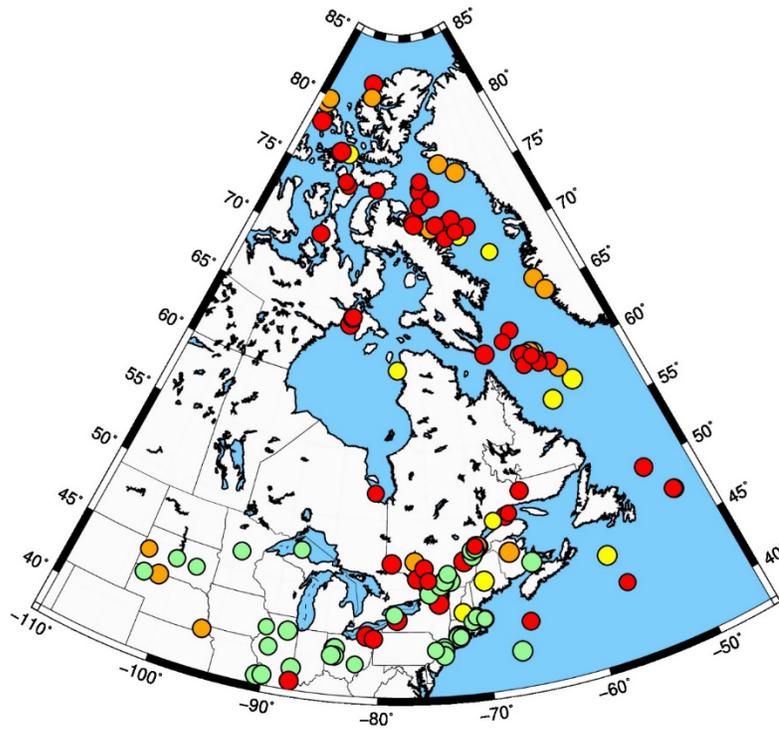


Figure 1b: earthquakes of M 5.0-5.9

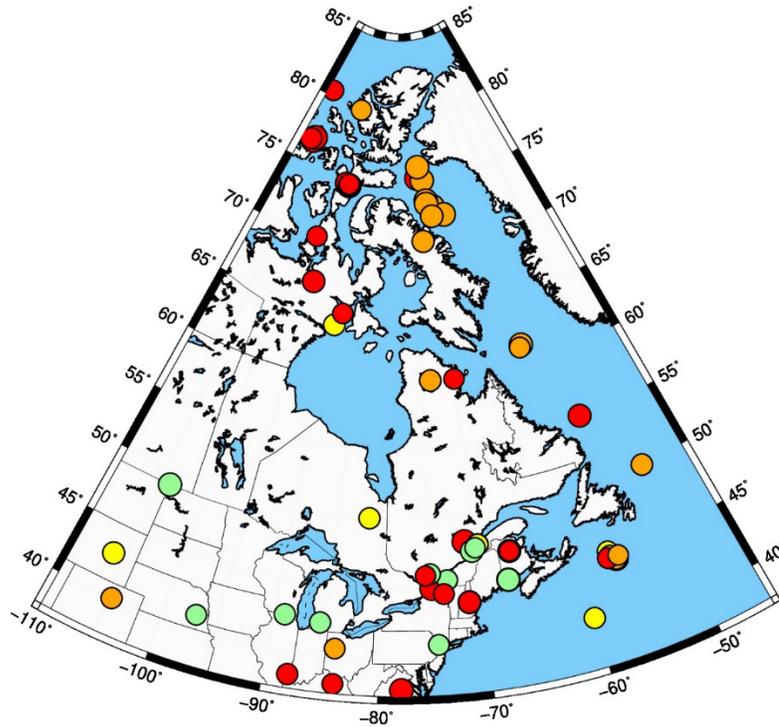


Figure 1c: earthquakes of M 4.0-4.9

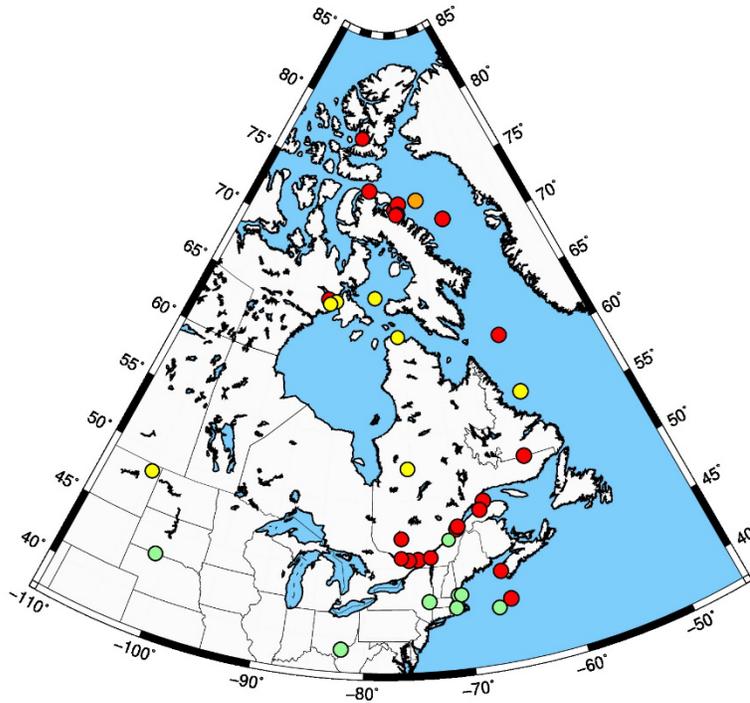


Figure 1d: earthquakes of M less than 4.0

Figure 1: Maps showing distribution of data for earthquakes evaluated in this study. The color of the symbol indicates how the moment magnitude was derived (see legend Figure 1a). a) earthquakes of M 6.0 or greater, the arrows indicate that earthquakes derived by another method are hidden by the visible symbol(s) (these can be seen in Figure 2a-d), b) earthquakes of M 5.0 – 5.9, c) earthquakes of M 4.0-4.9 and d) earthquakes of M less than 4.0.

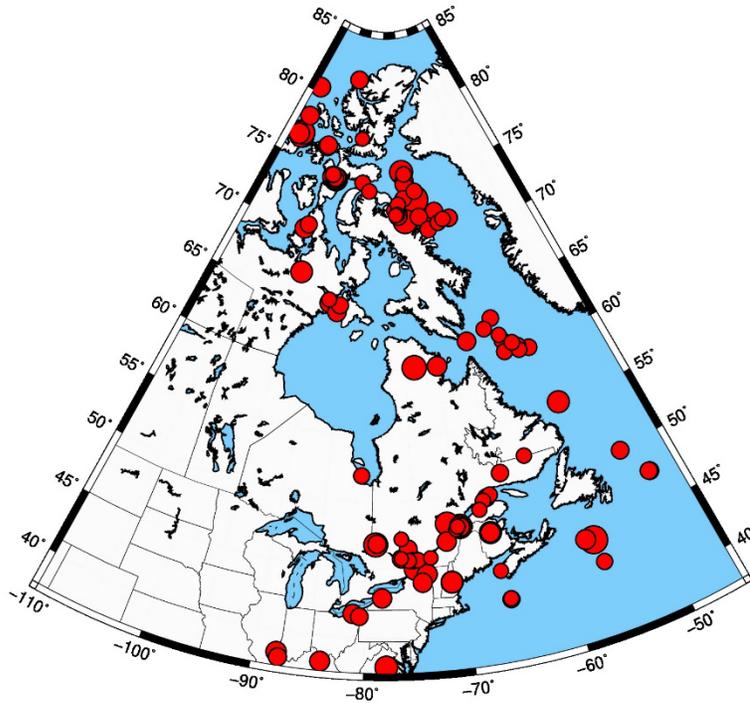


Figure 2a: M derived directly from instrumental data

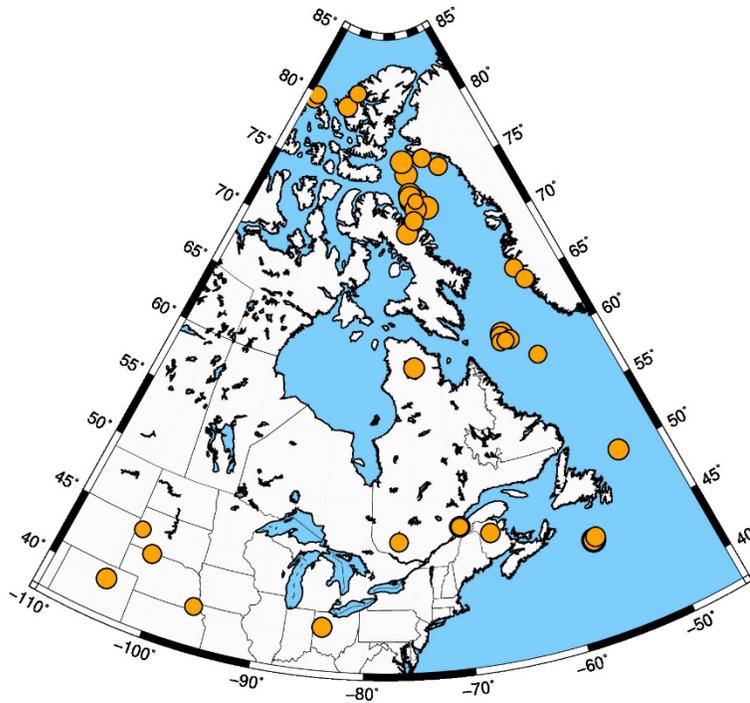


Figure 2b: M converted from teleseismic instrumental magnitude

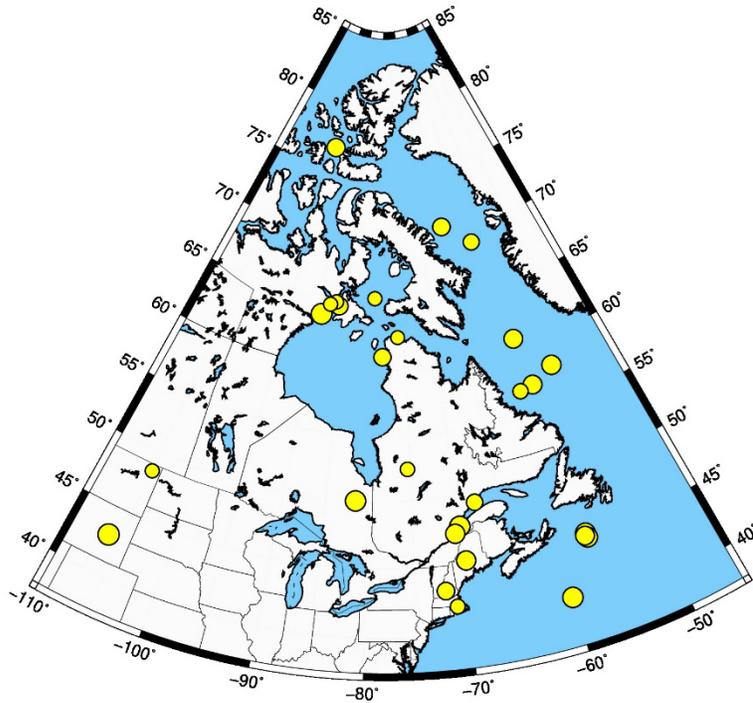


Figure 2c: M converted from regional instrumental magnitude

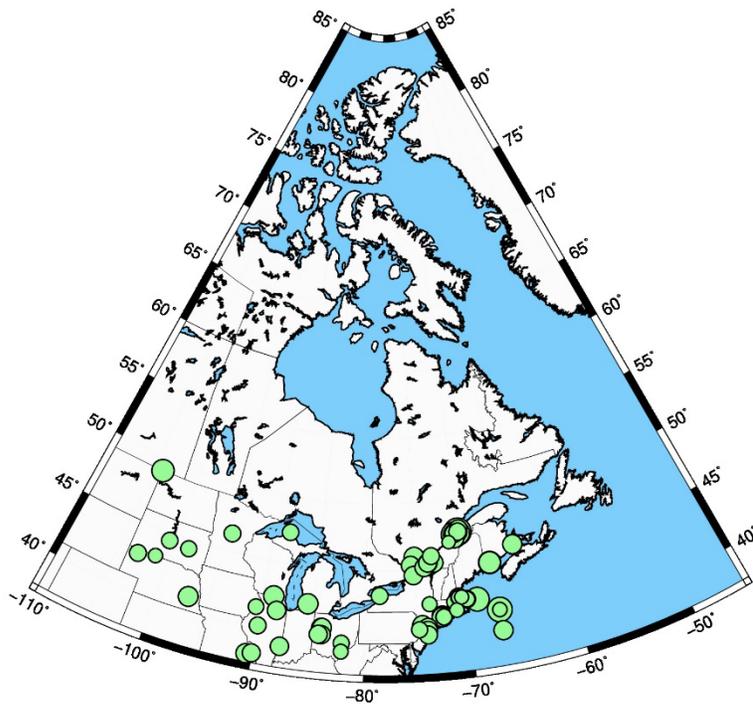


Figure 2d: M converted or estimated from intensity data

Figure 2: Maps showing the distribution of earthquakes evaluated in this study sorted based on the method used to determine moment magnitude: a) instrumental moment magnitude, b) conversion from an instrumental teleseismic magnitude, c) conversion from an instrumental regional magnitude and d) conversion from intensity data. The color scheme matches that of Figure 1.

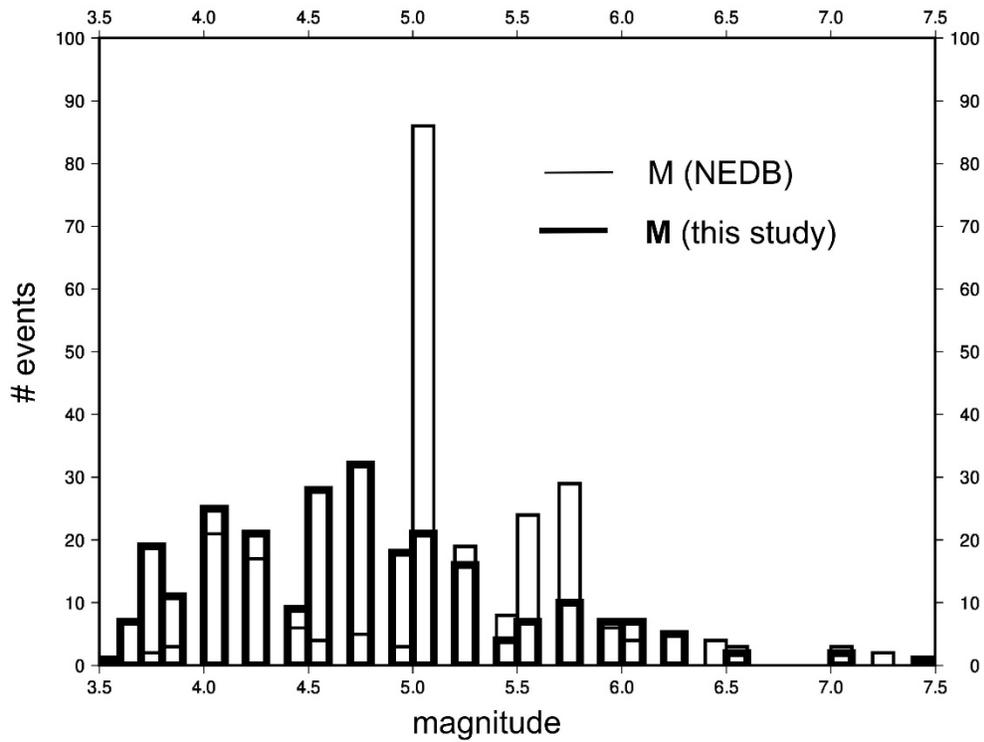


Figure 3: Data distribution by magnitude. The heavy black lines show the **M** values from the current study. The thinner lines show the primary magnitude in the NEDB (see Data and Resources), which contains a mix of magnitude types.

Supplement to **A Revised Moment Magnitude Catalog of Eastern Canada's Largest Earthquakes**
by Allison L. Bent

This Supplement contains the moment magnitude catalog discussed in the text in the form of an Excel Spreadsheet. Sheet 1 contains the catalog itself. Sheet 2 provides an explanation of columns J and K. The complete citations for references in these columns may be found in the main text.

Entries are color coded. Unshaded lines indicate that the **M** values in Bent (2009) were adopted without further analysis. Blue lines are for those events that were included in the Bent (2009) report but were re-evaluated in light of new information. This did not always result in a change in the **M** value. Events highlighted in yellow are events meeting the search criteria outlined in the text but that occurred since the publication of the Bent (2009) report. Red is for historical events that met the initial search criteria but were not evaluated by Bent (2009) as they did not meet the completeness criteria for use in hazard assessment in Canada. Finally, events highlighted in green did not meet the initial search criteria but were included in the catalog as they had instrumentally determined moment magnitudes within the range of other events evaluated and the author believes there is some benefit to having them catalogued in a single source.